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Research Article

LEAF N-P-K CONTENT AS INDICATORS OF YIELD, TOTAL PROTEIN AND SUGAR CONTENT OF SEEDS OF BENGAL GRAM (*CICER ARIETINUM* L.)

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ABSTRACT

A pot experiment was conducted at the Department of Botany, AMU, Aligarh in the *'rabi'* season to evaluate the effects of gibberellic acid (GA_3) on growth, leaf neutra-ceuticals, harvesting attributes and quality parameters of chickpea. Seeds were soaked in four concentrations of GA_3 (0, 10^{-7}, 10^{-6} and 10^{-5}M GA_3) for 4, 8, or 12 h and sown in pots filled with sandy loam soil. The potted plants were then analysed at 90 and 100 days after sowing (DAS) for shoot length per plant, leaf area index (LAI), and leaf N, P and K content. In contrast, the seed number per pod, 100-seed weight, biological yield (BY), harvest index (HI) seed yield per plant and seed protein, fibre and starch content were estimated at maturity. All parameters were found to be significantly enhanced by the seed priming application of different concentrations of GA_3, with maximum induction being reported following the 8 h soaking treatment with 10^{-6}MGA. Moreover, shoot length per plant and LAI were stimulated by 70%, 140.99%, respectively whereas N-P-K reported to be non-significant at interaction. Among the yield and quality attributes, the seed number per pod, BY, HI and seed protein content were stimulated by 300%, 64%, 44% and 26.% respectively except seed yield per plant, fibre content and starch content.

Keywords: Leaf Area Index, Neutral-Ceuticals, Protein, Shoot Length, Seed Yield.

INTRODUCTION

The pulses having almost doubled the amount of protein than cereals make a major contribution to human diet in developing countries of world where their nutritional contribution is of great importance[1]. Among the pulse, chickpea (*Cicer arietinum* L.) is an important *rabi* crop of Uttar Pradesh in general and that of Central India in particular. Chickpea seed's are an energy-giving product and a protein source to human nourishment mainly in developing countries[2]. Chickpea is the second most important pulse crop in the world, grown in at least 33 countries [3]. Though chickpea is grown in our country in the largest area in comparison with the other countries of the world, but her productivity at 911 kg/ha is much less than those of the developed countries such as 2833.3 kg/ha of China,1668.4 kg/ha of Canada and 1488.6 kg/ha of USA[4].

Uttar Pradesh grows chickpea on 0.66 m hectares area and produces 0.61 m tones annually with 953 kg/ha productivity (2010-12). This productivity level is also quite low against the yield potential of available varieties. The productivity of chickpea is low for two reasons: cultivation on agriculturally marginal soils and little if any crop inputs. Instead of this, there has been no substantial rise in its production chiefly on account of soil moisture deficit mostly at critical stages. Besides this, other important factors for stepping up the yield of this crop are nutrient management[5]. Chickpea fix atmospheric N, the predominant mechanism to meet their N requirement. However, this capability is jeopardized through insufficient supply of plant nutrients. An adequate supply of mineral nutrients to chickpea enhances N-fixation[6]. Chickpea can fix atmospheric N through its symbiosis with *rhizobia* and increases the input of usable N into the soil and therefore can enable cultivation of crops in many N poor soils. Cultivation of chickpea in rotation with cereal crops can also contribute to the total pool of N in the soil and improve yield[7-8]. From an agronomic point of view, nutritional deficiency is likely to depress its N-fixing role and may, in turn, limit crop yield[9].

Now-a-days, a number of improved chickpea varieties are available for growing under different agroclimatic zones. The need is to select and use suitable variety in a particular area with proper agronomic and physiological management. In recent years, the importance of PGRs particularly GA_3 for various crops has been well recognized[10-12]. To attain such goal, the use of GA_3 may play an important role. GA_3 was also presumed that the concentrations as well as durations of pre-sowing seed treatment of the GA_3 will affect the performance of chickpea greatly. To start with author framed the hypothesis and planned a pot experiment to test GA_3 efficacy in this concern. On other hand, soaking concentrations of GA_3 should be easily absorbed by the plants, rapidly transported, & should be easily release their constituents to affect the plant[13-14]. Also, the effect of GA_3 has at least three important actions, the first is intensify the ability of organ to be as a nutrient sink; secondly, increasing the synthesis of IAA in plant tissues; the third, it involves synthesis acceleration of hydrolytic enzymes in aleurone cells[16-17].

MATERIALS AND METHODS

Experimental site, climatic conditions and experimental design

Aligarh district has the same soil composition and the appearances as those found generally in the plains of western Uttar Pradesh. 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. Its climate is sub-tropical, with severest hot dry summers and intense cold winters. The average temperatures for December and January are about 15˚C and 13˚C respectively. The average rainfall is 847.3 mm. More than 85% of the total rainfall occurs during June to September and the remaining showers are received during winter, useful for *rabi* crops. 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.

Plant materials and preparation of solution

An authentic seeds of the high yielding cultivar, DCP 92-3 was obtained from the IIPR, Kanpur. Seeds were inoculated with the strain of *Rhizobium TAL 1148* and then were sown in pots. Prior to the treatments, 100 milli-litre (Ml) stock solutions of GA_3 (SIGMA USA) at 10^{-3}M were prepared. Four concentrations of aqueous solution of GA for treatment, viz. 0 (water), 10^{-7}, 10^{-6} and 10^{-5}M GA and the three soaking durations, i.e. 4, 8 and 12 hours (h). A uniform recommended dose of 17.9 mg N+13.4 mg P/kg soil was used 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 20 DAS. Finally, four plants per pot were maintained. A water-sprayed control was also included in the scheme of treatments and was taken four replicates for each treatment.

Sampling techniques and pooled data collection

One plant from each replicate was uprooted randomly at the sampling stages to assess the performance of the crop on the basis of growth, physiology and quality parameters. Growth characters and physico-biochemical characteristics were studied at 90 and 100 DAS while yield and quality parameters at harvest.

Growth and biochemical parameters

Length of shoot on per plant basis was determined separately with the help of a metre scale. LAI is the ratio of foliage area to ground area. It is determined by the following formula suggested by Watson[18].

$$LAI=\frac{\text{Leaf area}}{\text{Ground area}}$$

N, P and K were estimated in dried powder of leaves obtained from each replicate. The sampled plant leaves were dried in an oven at 80˚C for 24 h. The dried leaves from each sample were finally powdered and then passed through a 72-mesh screen. For the estimation of these nutrients the leaf powder was first digested according to the standard techniques. After a long procedure, N and P were estimated according to the methods of Lindner[19] and Fiske and Subbarow[20] respectively whereas K was estimated flame photometrically.

Yield and quality attributes

To assess the yield performance of the crop, the remaining two plants from each pot were harvested. The harvested plants were sun-dried in a net-house to prevent losses. After drying the crop, each sample was threshed individually. The seeds were utilized for assessing the other characteristics. 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 BY 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 proportions of the BY representing the economic yield is called HI. The HI was computed by dividing the seed yield (economic yield) of a plant by the BY of the plant and expressed on per cent basis. HI was calculated by the following formula:

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

The total protein, starch and fibre content in the dry seeds were estimated by adopting the methodology of Lowry [21] and Sadasivam and Manickam[22].

Data analysis

All data were analysed statistically adopting the analysis of variance technique, according to Gomez and Gomez[23]. 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

For growth parameters, the effect of the pre-sowing seed-soaking concentrations of GA and of the soaking durations, alone or in combination, was significant at both sampling stages and interaction effect on shoot length per plant, LAI at 100 DAS. For biochemical parameters, it was significant on all concerned parameters studied at both sampling stages, except the soaking duration effect on N and K content at 100 DAS, and the interaction effect on N and P content at 90 as well as 100 DAS, and K at 100 DAS.

In case of yield attributes, its effect was found significant on all attributes, except the interaction effect on 100-seed weight and seed yield per plant. The effect of pre-sowing concentrations of GA_3 and soaking durations alone or in combination on fibres, starch and seed protein content was also found significant. The results (Tables 1-9; Fig. 1-4) are summarized below.

Growth and Biochemical characteristics

Soaking concentration 10^{-6}M GA ($S_{10^{-6}M\ GA}$) proved best at 90 as well as 100 DAS and gave 66.95% and 43.35% higher value at 90 and 100 DAS respectively than the water-soaking treatment (S_W). Soaking for S_{8h} gave 11.09 % and 5.00% higher value than the least value giving soaking duration S_{12h} at 90 DAS and S_{4h} at 100 DAS respectively. Interaction $S_{10^{-6}M\ GA}\times S_{8h}$ gave 69.33% higher value for shoot length per plant than the minimum value giving interaction $S_W\times S_{8h}$ at 90 DAS. However, interaction effect on this parameter was not found significant at 100 DAS (Table 1). Soaking treatment $S_{10^{-6}M\ GA}$ gave the maximum value for LAI at both stages and gave 107.85 and 102.76% higher value at 90 and 100 DAS respectively than S_W. Soaking duration S_{8h} gave 10.30 and 7.45 % higher value than the least value giving soaking duration S_{12h} at 90 DAS and S_{4h} at 100 DAS respectively. Interaction $S_{10^{-6}M\ GA}\times S_{8h}$ gave the maximum value at 100 DAS and gave 140.99% higher value than $S_W\times S_{4h}$ at the same stage. However, the effect of interaction treatments was not found significant at 90 DAS (Table 2).

Table 1: Effect of concentrations (C) and durations of pre-sowing seed treatment (D) of GA on shoot length per plant (cm) of chickpea cultivar DCP 92-3 at two growth stages (mean of four replicates)

Soaking durations (S_h)	Soaking concentrations ($S_{M\ GA}$)				Mean
	S_W	$S_{10^{-7}M\ GA}$	$S_{10^{-6}M\ GA}$	$S_{10^{-5}M\ GA}$	
			90 DAS		
S_{4h}	41.4s0	58.30	66.20	56.59	55.57
S_{8h}	37.80	63.30	70.10	60.80	58.00
S_{12h}	40.97	53.42	64.34	50.10	52.21
Mean	40.06	58.34	66.88	55.76	
C.D. at 5%		C = 2.176	D = 2.513	C x D = 4.241	
			100 DAS		
S_{4h}	46.20	62.90	70.10	59.30	59.63
S_{8h}	49.20	64.30	71.83	65.10	62.61
S_{12h}	51.30	61.80	68.49	60.40	60.50
Mean	48.90	63.00	70.14	61.60	
C.D. at 5%		C = 2.364	D = 2.730	C x D = NS	

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 (C) and durations of pre-sowing seed treatment (D) of GA on leaf area index of chickpea cultivar DCP 92-3 at two growth stages (mean of four replicates)

Soaking durations (S_h)	Soaking concentrations ($S_{M\ GA}$)				Mean
	S_W	$S_{10^{-7}M\ GA}$	$S_{10^{-6}M\ GA}$	$S_{10^{-5}M\ GA}$	
			90 DAS		
S_{4h}	19.93	39.45	47.00	38.15	36.13
S_{8h}	25.45	42.45	51.40	40.10	39.85
S_{12h}	24.20	38.29	46.20	37.40	36.52
Mean	23.19	40.06	48.20	38.55	
C.D. at 5%		C = 1.500	D = 1.732	C x D = NS	
			100 DAS		
S_{4h}	22.49	43.40	51.47	41.10	39.62
S_{8h}	25.10	47.80	54.20	43.19	42.57
S_{12h}	29.39	42.80	50.42	40.10	40.68
Mean	25.66	44.67	52.03	41.46	
C.D. at 5%		C = 1.693	D = 1.893	C x D = 3.194	

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

Treatment $S_{10^{-6}M\ GA}$ gave the maximum value for leaf N content at both stages and gave 28.53% and 18.96% higher value respectively than S_W. Soaking duration S_{8h} proved best at 90 DAS and gave 6.54% higher value than S_{12h} at the same stage. Soaking durations did not affect this parameter at 100 DAS. The interaction effect was, however, not found significant at both stages (Table 3). Soaking treatment $S_{10^{-6}M\ GA}$ gave the maximum value for leaf P content at both stages. Soaking with $S_{10^{-6}M\ GA}$ gave 39.89 and 34.16% higher value at 90 and 100 DAS respectively than S_W. Soaking duration S_{8h} proved best at both stages and gave 12.68 and 7.61% higher value at 90 and 100 DAS respectively than the lowest value giving duration S_{12h}. The interaction effect was found not-significant at both stages (Table 4).

Soaking treatment $S_{10^{-6}M\ GA}$ gave the maximum value for leaf K content at both stages. Soaking with $S_{10^{-6}M\ GA}$ gave 18.57 and 9.6% higher value at 90 and 100 DAS respectively than S_W. Soaking duration S_{8h} proved best at 90 DAS, gave 12.17% higher value than S_{4h} at this stage. Interaction $S_{10^{-6}M\ GA}\times S_{8h}$ gave the maximum value at 90 DAS and gave 24.17% higher value than the lowest value giving interaction $S_W \times S_{8h}$ at the same stage. However, the effect of interaction treatment was not found significant at 100 DAS (Table 5). Soaking treatment $S_{10^{-6}M\ GA}$ gave the maximum value for number of seeds per pod and gave 133.34% higher value than S_W. Soaking duration S_{8h} gave the maximum value and registered 44.00% higher value than S_{12h}. Interaction $S_{10^{-6}M\ GA} \times S_{8h}$ gave the maximum value for number of seeds per pod, however its effect was at par with that of $S_{10^{-6}M\ GA} \times S_{4h}$ and $S_{10^{-6}M\ GA} \times S_{4h}$. Interaction $S_{10^{-6}M\ GA} \times S_{8h}$ gave 300.00 % higher value than $S_W \times S_{12h}$ (Table 6).

Table 3: Effect of concentrations (C) and durations of pre-sowing seed treatment (D) of GA on leaf nitrogen content (%)of chickpea cultivar DCP 92-3 at two growth stages (mean of four replicates)

Soaking durations	Soaking concentrations ($S_{M\ GA}$)				
(S_h)	S_W	$S_{10^{-7}M\ GA}$	$S_{10^{-6}M\ GA}$	$S_{10^{-5}M\ GA}$	Mean
			90 DAS		
S_{4h}	3.21	3.84	4.12	3.73	3.73
S_{8h}	3.34	4.00	4.34	3.98	3.91
S_{12h}	3.24	3.74	4.10	3.62	3.67
Mean	3.26	3.86	4.19	3.78	
C.D. at 5%		C = 0.145	D = 0.168	C x D = NS	
			100 DAS		
S_{4h}	3.61	3.38	4.10	3.71	3.81
S_{8h}	3.31	3.99	4.22	4.00	3.88
S_{12h}	3.52	3.71	4.10	3.70	3.76
Mean	3.48	3.85	4.14	3.80	
C.D. at 5%		C = 0.147	D = NS	C x D = NS	

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 (C) and durations of pre-sowing seed treatment (D) of GA on leaf-phosphorus content (%) of chickpea cultivar DCP 92-3 at two growth stages (mean of four replicates)

Soaking durations	Soaking concentrations ($S_{M\ GA}$)				
(S_h)	S_W	$S_{10^{-7}M\ GA}$	$S_{10^{-6}M\ GA}$	$S_{10^{-5}M\ GA}$	Mean
			90 DAS		
S_{4h}	0.387	0.420	0.520	0.410	0.434
S_{8h}	0.400	0.475	0.570	0.440	0.471
S_{12h}	0.357	0.400	0.510	0.405	0.418
Mean	0.381	0.432	0.533	0.418	
C.D. at 5%		C = 0.017	D = 0.020	C x D = NS	
			100 DAS		
S_{4h}	0.393	0.510	0.535	0.500	0.485
S_{8h}	0.402	0.545	0.570	0.520	0.509
S_{12h}	0.407	0.505	0.510	0.470	0.473
Mean	0.401	0.520	0.538	0.497	
C.D. at 5%		C = 0.019	D = 0.022	C x D = NS	

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

Table 5: Effect of concentrations (C) and durations of pre-sowing seed treatment (D) of GA on leaf potassium content (%) of chickpea cultivar DCP 92-3 at two growth stages (mean of four replicates)

Soaking durations	Soaking concentrations ($S_{M\ GA}$)				
(S_h)	S_W	$S_{10^{-7}M\ GA}$	$S_{10^{-6}M\ GA}$	$S_{10^{-5}M\ GA}$	Mean
			90 DAS		
S_{4h}	3.31	3.62	3.81	3.59	3.58
S_{8h}	3.12	3.87	4.11	4.00	3.78
S_{12h}	3.27	3.43	3.57	3.21	3.37
Mean	3.23	3.64	3.83	3.60	
C.D. at 5%		C = 0.138	D = 0.159	C x D = 0.268	
			100 DAS		
S_{4h}	3.78	3.91	4.10	4.00	3.95
S_{8h}	3.57	4.12	4.13	4.11	3.98
S_{12h}	3.89	4.11	4.10	3.99	402
Mean	3.75	4.04	4.11	4.03	
C.D. at 5%		C = 0.153	D = NS	C x D = NS	

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

Table 6: Effect of concentrations (C) and durations of pre-sowing seed treatment (D) of GA on seed number per pod of chickpea cultivar DCP 92-3 at harvest (mean of four replicates)

Soaking durations (S_h)	Soaking concentrations ($S_{M\ GA}$)				Mean
	S_W	$S_{10^{-7}M\ GA}$	$S_{10^{-6}M\ GA}$	$S_{10^{-5}M\ GA}$	
S_{4h}	0.50	0.75	1.75	1.00	1.00
S_{8h}	0.75	1.75	2.00	1.25	1.44
S_{12h}	1.00	1.25	1.50	0.75	1.33
Mean	0.75	1.25	1.75	1.00	
C.D. at 5%		C = 0.048	D = 0.056	C x D = 0.094	

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

Soaking treatment $S_{10^{-6}M\ GA}$ gave the maximum value and gave 60.58% higher value than S_W. Soaking duration S_{8h} proved best and gave 13.34% higher value than S_{12h}. The interaction effect was not found significant (Table 7). Soaking treatment $S_{10^{-6}M\ GA}$ gave the maximum value for seed yield and gave 86.69% higher value than S_W. Soaking duration S_{8h} gave the maximum value and gave 5.44% higher value than S_{12h}. The interaction effect on this parameter was not found significant (Fig. 1). Soaking treatment $S_{10^{-6}M\ GA}$ gave the maximum value for BY per plant and gave 46.01 % higher value than S_W. Soaking duration S_{8h} gave 11.92% higher value than S_{12h}. Interaction $S_{10^{-6}M\ GA} \times S_{8h}$ gave 63.67 % higher value than $S_W \times S_{4h}$ (Table 8). Soaking treatment $S_{10^{-6}M\ GA}$ gave the maximum value for HI and gave 24.19% higher value than S_W. Soaking duration S_{8h} proved best and gave 7.84% higher value than S_{12h}. Interaction $S_{10^{-6}M\ GA} \times S_{8h}$ gave 43.46% higher value than the lowest value giving interaction (Table 9).

Table 7: Effect of concentrations (C) and durations of pre-sowing seed treatment (D) of GA on 100-seed weight (g) of chickpea cultivar DCP 92-3 at harvest (mean of four replicates)

Soaking durations (S_h)	Soaking concentrations ($S_{M\ GA}$)				Mean
	S_W	$S_{10^{-7}M\ GA}$	$S_{10^{-6}M\ GA}$	$S_{10^{-5}M\ GA}$	
S_{4h}	13.80	20.20	22.30	21.00	19.33
S_{8h}	15.20	21.10	23.90	21.30	20.38
S_{12h}	12.80	18.50	20.90	19.70	17.98
Mean	13.93	19.93	22.37	20.67	
C.D. at 5%		C = 0.754	D = 0.871	C x D = NS	

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

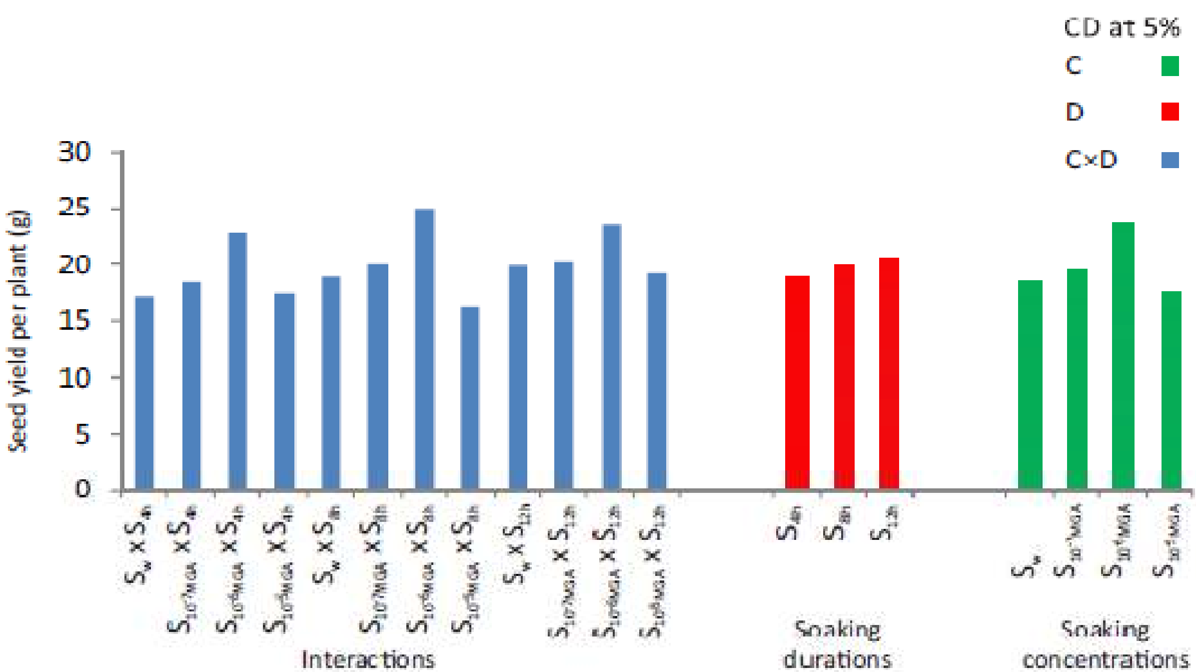


Figure 1: Effect of concentrations and durations of pre-sowing seed treatments of GA on seed yield per plant of cultivar DCP 92-3 of chickpea

Table 8: Effect of concentrations (C) and durations of pre-sowing seed treatment (D) of GA on biological yield per plant (g) of chickpea cultivar DCP 92-3 at harvest (mean of four replicates)

Soaking durations (S_h)	Soaking concentrations ($S_{M\,GA}$)				Mean
	S_W	$S_{10^{-7}M\,GA}$	$S_{10^{-6}M\,GA}$	$S_{10^{-5}M\,GA}$	
S_{4h}	5.45	7.21	8.75	6.80	7.05
S_{8h}	6.37	8.54	8.92	6.97	7.70
S_{12h}	5.85	7.42	8.12	6.14	6.88
Mean	5.89	7.42	8.60	6.63	
C.D. at 5%		C = 0.281	D = 0.324	C x D = 0.547	

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

Table 9: Effect of concentrations (C) and durations of pre-sowing seed treatment (D) of GA on harvest index (%) of chickpea cultivar DCP 92-3 at harvest (mean of four replicates)

Soaking durations (S_h)	Soaking concentrations ($S_{M\,GA}$)				Mean
	S_W	$S_{10^{-7}M\,GA}$	$S_{10^{-6}M\,GA}$	$S_{10^{-5}M\,GA}$	
S_{4h}	37.20	40.10	41.45	40.00	39.69
S_{8h}	34.21	41.20	47.20	42.40	41.25
S_{12h}	32.90	40.00	40.90	39.20	38.25
Mean	34.77	40.43	43.18	40.53	
C.D. at 5%		C = 1.532	D = 1.769	C x D = 2.986	

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

Quality parameters

Soaking treatment $S_{10^{-6}M\,GA}$ gave the maximum value for seed protein content and gave 27.34% higher value than S_W. Soaking duration S_{12h} gave the maximum value and registered 78.89% higher value than S_{4h}. Interaction $S_{10^{-6}M\,GA} \times S_{8h}$ gave the maximum value and increased the protein content by 26.01% over $S_W \times S_{12h}$ and by 54.32% over the least value giving combination $S_{10^{-5}M\,GA} \times S_{8h}$ (Fig. 2). Soaking treatment $S_{10^{-6}M\,GA}$ gave the maximum value for seed starch content and gave 35.23% higher value than S_W. Soaking duration S_{12h} gave the maximum value and registered 22.34% higher value than S_{4h}. Interaction $S_{10^{-6}M\,GA} \times S_{8h}$ gave the maximum value and increased the starch content by 29.91% over $S_W \times S_{12h}$ and by 45.23% over the least value giving combination $S_{10^{-5}M\,GA} \times S_{8h}$ (Fig. 3). Soaking treatment $S_{10^{-6}M\,GA}$ gave the maximum value for seed crude fibre content and gave 3.45% higher value than S_W. Soaking duration S_{12h} gave the maximum value and registered 8.29% higher value than S_{4h}. Interaction $S_{10^{-6}M\,GA} \times S_{8h}$ gave the maximum value and increased the fibre content by 12.89% over $S_W \times S_{12h}$ and by 14% over the least value giving combination $S_{10^{-5}M\,GA} \times S_{8h}$ (Fig. 4).

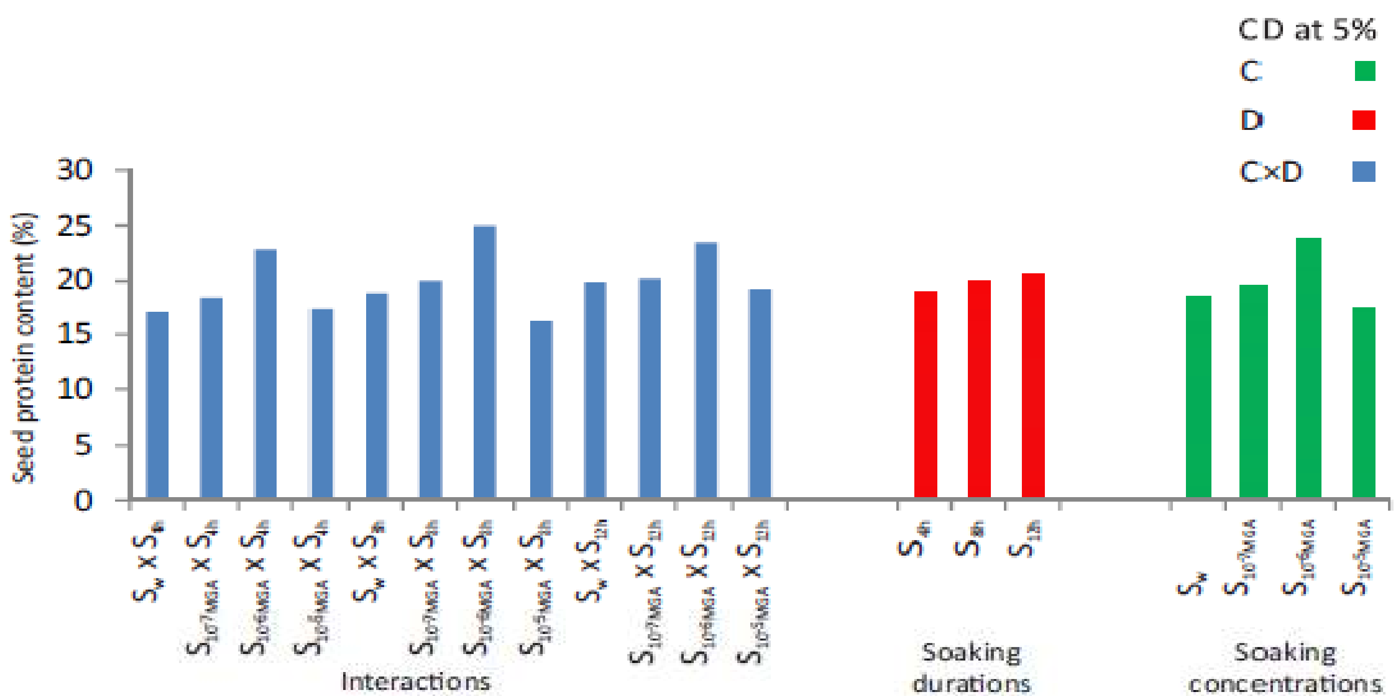
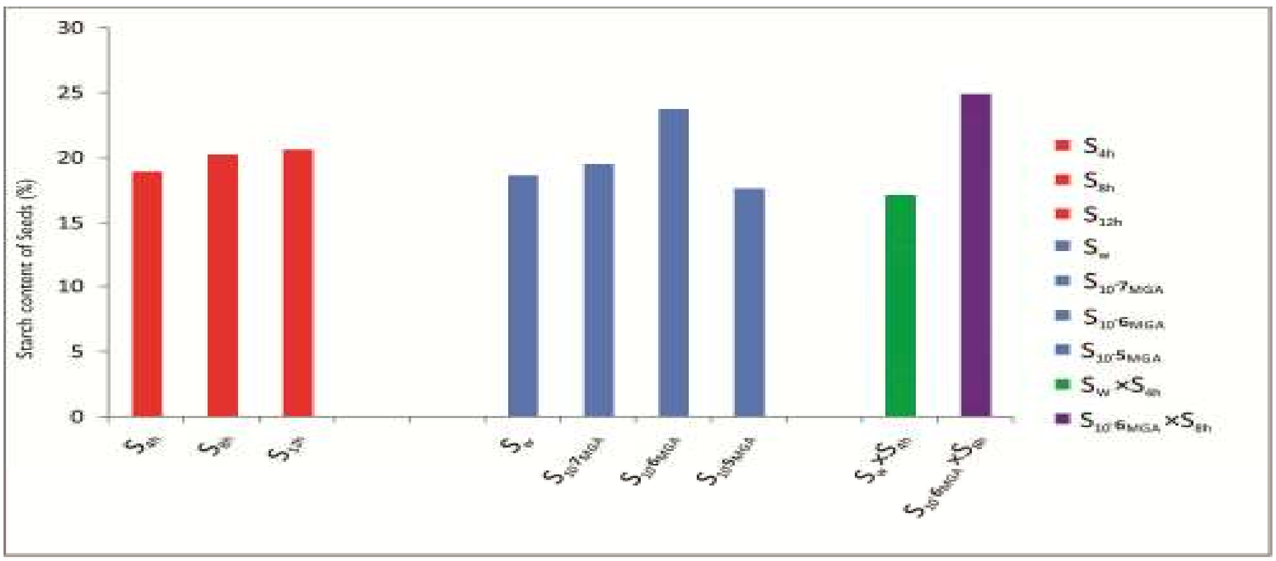


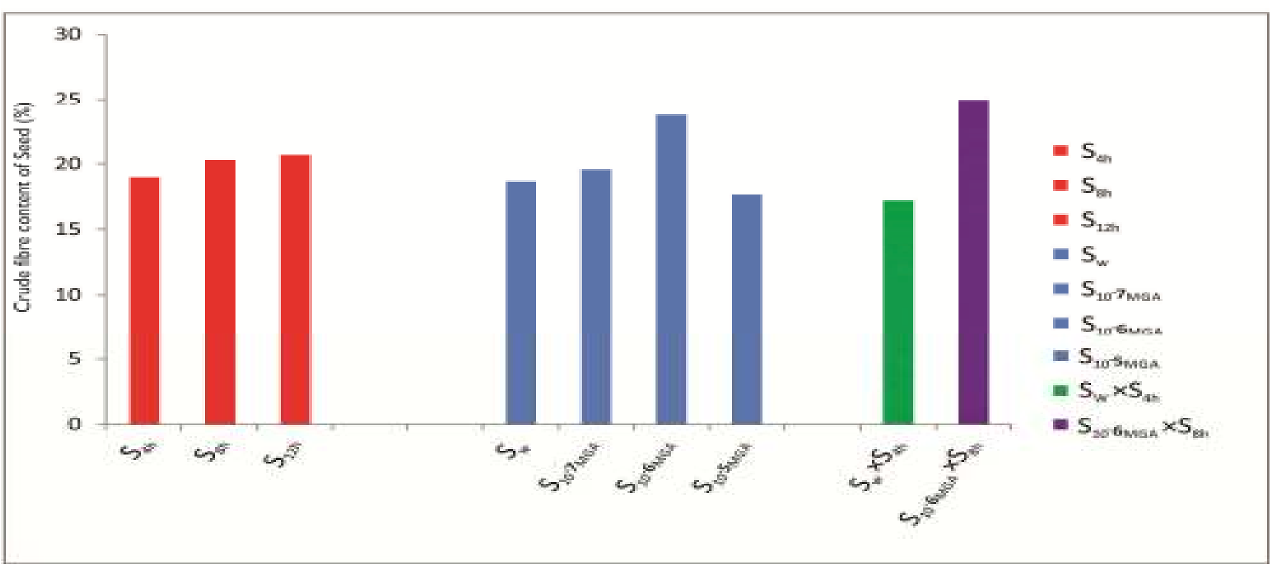
Figure 2: Effect of concentrations and durations of pre-sowing seed treatments of GA on seed protein content of cultivar DCP 92-3 of chickpea

DISCUSSION

The improvement of a crop depends to a larger extent on the genetic variability as it provides us the raw materials for selection of better genotypes. Little natural variability is found in chickpea for conspicuous morphological and physiological characters. GA_3 serve manifold growth related functions in plants by enhancing replication, transcription and different enzymatic systems[24]. It is already stated that GA_3 occupies a prominent position in mediating a variety of plant physiological processes including translocation of food material and synthesis of mRNA coding for hydrolytic enzymes[25]. The major metabolic processes influenced in the hormone treated plants are the C-assimilation, distribution of metabolites into the plant organs, and subsequent utilization by biosynthetic pathways[26]. 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[27].

The enhancing effect of application of GA_3 improves absorption and nutrient use efficiency[28], activity of enzymes[29], cell division and cell enlargement[30], chlorophyll content, elongation of internode[31], membrane permeability[32], DNA, RNA and protein synthesis[33-35], and transport of photosynthates[36]. Also, GA_3 treatment produced marked phenotypic changes such as pale yellow leaves showing serrated white midrib, long internodes, and elongated plants as compared to untreated plants. Instead of this, earlier studies have reported that GA_3 as foliar spray on transplanted cutting increased the plant height and leaf length. An increase in growth parameters like shoot and root lengths, fresh and dry weights in plants treated 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.





Figures 3-4: Effect of concentrations and durations of pre-sowing seed treatments of GA on seed starch content and crude fibre content of cultivar DCP 92-3 of chickpea.

Application of GA_3 caused significant improvement in various growth characters viz., shoot length, and LAI which were significantly affected at pooled data basis with graded levels of GA_3 at different time intervals (Fig. 5). The total LAI increased linearly by 10^{-6}M GA_3 x 8h interaction. The growth improving effect of seed priming treatment for 8h with 10^{-6}M GA_3 over their respective water treated control on plant height, and LAI of chickpea grown with the recommended basal dose of N and P could be explained on the basis of its roles mentioned earlier and the fact that the supply of GA_3 by pre-sowing treatment would more than compensate the 'hidden hunger' of concerned crop for GA_3. Similar results have also been obtained by a few workers[37-40]. Improvement in shoot length, and LAI of chickpea would have contributed in improving the ability of treated plants for nodule and biomass production. In addition, GA_3 promote the growth through cell wall expansion by stimulating the destruction of growth-repressing proteins[41-43].

The enhancing effect of pre-sowing seed treatment for 8 h with 10^{-6}M GA over their respective water treated control on N-P-K content is a noteworthy observation. This may also be attributed, as for growth characters, to its roles on one hand and compensation of the 'hidden hunger' for GA_3 by its pre-sowing seed treatment. These results also corroborate the findings of Jafri[39]. Improvement in N, P and K content would also have enhanced content of chlorophylls on one hand and leghaemoglobin content in chickpea[11-12, 44]. However, a higher concentration of nutrients was recorded in the plants supplemented with the seed priming effect of GA_3. 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. As nutrients are components of many metabolically active compounds and participate in several physiological and biochemical functions[44-46], their enhanced contents in plants may have directly or indirectly helped in enhancing the crop productivity in terms of protein synthesis and process of N-fixation.

These findings are in accordance with the data on GA_3 effects reported regarding plant nutrient elements. Acquisition and assimilation of N is a fundamental process that is essential for the growth and development of plants. N is available to plants mainly in the form of nitrate (NO_3). The NO_3 taken up by the plants is first reduced to NH_3 by the enzyme namely, nitrate reduction (NR) and nitrite reductase (NiR). N assimilating enzymes which are crucial for plant growth and also provide effective targets for herbicide development[47-48].

Source-sink relationship is significantly influenced by hormones including GA_3 hence distribution of C^{14} assimilates to roots was analysed. The biomass accumulation depends on photosynthetic efficiency that is reduced by GA_3 treated plants. This is an imperative association between inter-organ assimilation and transports particularly shoot and root partitioning of metabolites, and biomass production. Moreover, GA_3 enhances metabolic activity within pathways leading to accumulation of secondary metabolites, e.g., steroids, anthocyanin, protein, essential oil. Moreover, ontogenic studies have revealed that young rather than old leaves of chickpea efficiently utilize CO_2 assimilates for metabolites production. Study of Khan[48] indicates that GA_3 treatment on whole plant produced phenotypic response in total biomass production with positive response in the total seed protein content.

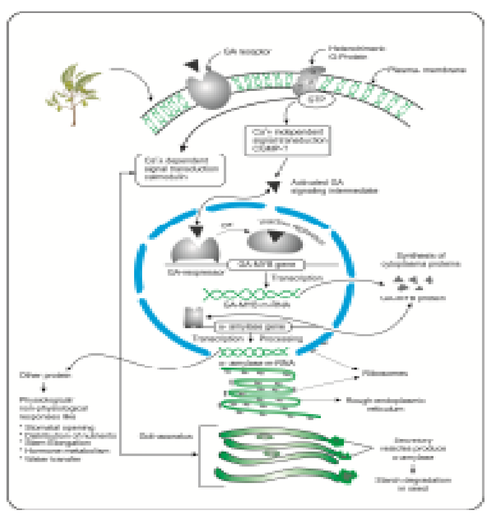


Figure 5: Modulation of gibberellic acid mechanism of action along with the GA-MYB protein and representing the role of GA-repressor in the process of growth stimulation

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. This sustained increase in the N-P-K contents of the treated plants which is expected to culminate the maximization of the seed yield and seed protein, starch and fibre content. Furthermore, comprehensive studies in grasses show that GA_3 play a role as a florigen[49]. GA_3 might have increased the translocation of assimilates to the reproductive organ which is resulted in the maximum number of pods per plant up to a certain levels of GA_3 application[50]. Mazid [51]also reported that beneficial effect of GA_3 on prolonged period of water availability, which gives favorable effect at later stages of plant growth on pod formation and seed development stages. Needless to say, GA_3 might be involved in formation of seeds in pods and their optimum nourishments have resulted in less number of aborted seeds and thus maximized the survival of fertile seeds/pods in chickpea[52], are also in accordance of our results. Similar results were also obtained by earlier workers[53].

The improvement in pods per plant, seeds per pod and 100-seed weight of chickpea grown with the recommended basal dose of N and P, due to the soaking of GA_3 over the respective control is not far to seek. The improvement in growth, physiological and biochemical parameters resulted from the soaking of various concentrations of GA_3 together with enhancement in differentiation may lead to the improvement in yield parameters, hence higher values for seeds per pod and 100-seed weight. Lastly, Makarem and Mokhtar[54] reported that GA_3 could lead to an increase in fruit set of deciduous trees and played a major role in enlarging fruit size. Similarly, El-Seginy and Khalil[55] reported also that GA_3 application increased fruit set, fruit weight, and as a result increased the yield. However, GA_3 treatment leads to reduce in fruit drop and improving most fruit characteristics on pear trees[56-58].

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 (Figs. 1). 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, starch and fibre content due to pre-sowing seed treatment of GA_3 is not surprising. An improvement in protein and starch synthesis may result from the application of GA_3[59] and hence higher values for seed protein, starch and fibre content (Figs. 2-4). These results broadly corroborate with the findings of Khafagy[60-63].

CONCLUSION

The best concentration (10^{-6}M) and duration (8 h) of pre-sowing treatment of the GA_3 have been established for the optimum performance of the chickpea, cultivar - DCP 92-3.

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