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Effect of sowing time, plant growth regulators and nipping on yield attributes and yield of chickpea (*Cicer arietinum* L.) under south saurashtra condition

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Abstract
A field experiment entitled "Effect of sowing time, plant growth regulators and nipping on growth, yield and quality of chickpea (*Cicer arietinum* L.) under South Saurashtra condition" was carried out under medium black calcareous soil and slightly alkaline soil in reaction during *rabi* seasons of 2019-20 and 2020-21 at the Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh. The experiment consisting of 36 treatment combinations, comprising 4 sowing time treatments (1st week of October, 3rd week of October, 1st week of November and 3rd week of November) in main plots and 3 treatments of plant growth regulators (water spray, NAA @ 50 ppm and GA_3 @ 50 ppm) along with 3 treatments of nipping (no nipping, one nipping at 30 DAS and one nipping at 40 DAS) in sub plots was laid out in split plot design with 3 replications. Yield attributes *viz*., numbers of pods per plant, seed, stover and biological yields were significantly higher in sowing of chickpea during 3rd week of October as compared to other sowing time. However, different sowing treatments did not influence significantly the number of seeds per pod, seed index, harvest index. Foliar application of NAA @ 50 ppm significantly increased yield attributes *viz*., number of pods per plant, seed index and seed, stover and biological yields. Results further indicated that one nipping at 30 DAS significantly enhanced yield attributes *viz*., number of pods per plant and seed, stover and biological yields. The treatment combination of 3rd week of October sowing and nipping at 30 DAS significantly increased number of pods per plant, seed, stover and biological yields. Further, treatment combination of 3rd week of October sowing and foliar spray of NAA @ 50 ppm recorded maximum biological yield. While crop sown during 3rd week of October along with foliar spray of GA_3 @ 50 ppm, being at par with 50 ppm NAA spray produced significantly higher stover yield over other treatment combinations.

Keywords: Plant growth, nipping on yield, yield of chickpea

Introduction
Gram commonly known as chickpea or bengal gram (*Cicer arietinum* L.) belongs to genus "*Cicer*", tribe *Cicereae*, family *Leguminoceae* and sub family *Papilionaceae* is the most important pulse crop of India. Chickpea is an annual, self pollinated, diploid (2n=16) grain legume crop. It is one of the important pulse having high nutritional quality i.e. 17-21% protein, 61.50% carbohydrate, 4.50% fat, 0.49% lysine, 0.11% methionine, 0.04% tryptophan and rich in Ca, P, Fe, niacin etc., (Singh, 2009) [7]. Poor agronomic practice such as seed rate, date of sowing, selection of suitable genotypes, fertilizer management, *etc.* are also responsible for low productivity of chickpea in India. There is need to adopt a multipronged strategy to meet the challenges of low production and local requirements of chickpea. Amongst the agronomic practices, sowing methods and proper sowing time are of great importance. Another measure to improve the production and the value of chickpea would be the use of plant growth regulators and some management practices like nipping. It is also necessary to understand the morpho physiological parameters associated with yield of chickpea which may help to monitor these parameters efficiently to increase the yield of chickpea. Therefore, adoption of proper sowing time, use of plant growth regulators and nipping practices may provide greater options for achieving maximum economic yield in chickpea.

Materials and Methods
The experiment entitled **"**Effect of sowing time, plant growth regulators and nipping on growth, yield and quality of chickpea (C*icer arietinum* L.) under south Saurashtra condition" was conducted during *rabi* season of the year 2019-20 and 2020-21 at C-8 plot of Instructional Farm, Department of Agronomy, Junagadh Agricultural University, Junagadh. Geographically,

Junagadh is situated at 21.50 N latitude and 70.50 E longitude with an altitude of 60 m above the mean sea level. The soil of the experimental plot was clayey in texture (in both the years), medium in organic carbon (0.66 and 0.62% in 2019-20 and 2020-21, respectively), slightly alkaline in reaction with pH (8.16 and 7.92 in 2019-20 and 2020-21, respectively) and EC (0.46 and 0.51 dS/m in 2019-20 and 2020-21, respectively). The soil was medium in available nitrogen (253.20 and 258.13 kg/ha in 2019-20 and 2020-21, respectively), medium in available phosphorus (37.12 and 35.47 kg/ha in 2019-20 and 2020-21, respectively) and medium in available potash (269.10 and 275.30 kg/ha in 2019-20 and 2020-21, respectively). The experiment consisting of 36 treatment combinations, comprising 4 sowing time treatments (1st week of October, 3rd week of October, 1st week of November and 3rd week of November) in main plots and 3 treatments of plant growth regulators (water spray, NAA @ 50 ppm and GA_3 @ 50 ppm) along with 3 treatments of nipping (no nipping, one nipping at 30 DAS and one nipping at 40 DAS) in sub plots was laid out in split plot design with 3 replications. Gram variety Gujarat Gram-5 was used for sowing with seed rate of 60 kg/ha during *rabi* season of 2019-20 and 2020-21.

Effect of sowing time

Significantly higher number of pods per plant was obtained in (D_2) October third week sowing (66.99, 65.90 and 66.45) as compared to other sowing dates (Table 1) during both the years and in pooled results. However, October third week sown crop was remained at par with October first week sown crop (D_1) during first year of experimentation. Moreover, significantly lower number of pods per plant were recorded under third week of November sowing (D_4) during 2019-20, 2020-21 and in pooled results. Sowing time could not bring significant improvement in number of seeds per pod, seed index and harvest index during both the years of investigation and in pooled analysis. Significantly higher seed yield (Table 4) of (2788, 2629 and 2709 kg/ha) was recorded with 3rd week of October sowing (D_2) as compared to other sowing times during individual years as well as in pooled analysis. The pooled mean seed yield was higher by 7.80, 10.21 and 22.91 per cent due to 3rd week of October sowing (D_2) as compared to sowing time D_1, D_3 and D_4. Significantly superior stover yield (3502, 3286 and 3394 kg/ha) was obtained when crop was sown during 3rd week of October (D_2) than 3rd week of November (D_4) during both years and in pooled analysis (Table 4). Whereas, it remained at par with 1st week of October (D_1) and 1st week of November (D_3) sowing during first year and with D_1 during second year as well as in pooled analysis. Crop sown during 3rd week of November recorded the lowest stover yield. Crop sown during 3rd week of October registered pooled mean increase of 4.72, 8.33 and 21.95 per cent stover yield over sowing during 1st week of October, 1st week of November and 3rd week of November, respectively. Crop sown during October third week (D_2) produced significantly higher biological yield of chickpea as compared to rest of the sowing dates during both the years of experimentation as well as in pooled analysis but was at par with D_1 during first year of study. The pooled mean biological yield obtained with treatment D_2 (6103 kg/ha) was 6.07, 9.16 and 22.38 per cent higher over D_1 (5754 kg/ha), D_3 (5591 kg/ha) and D_4 (4987 kg/ha), respectively (Table 8). The improvement in seed yield in second date of sowing over other dates of sowing was due to better availability of moisture and congenial temperature prevailing at the time of germination and seedling establishment might have contributed better growth, development of yield attributes and thus higher seed yields. These findings are in agreement with those of Sharma and Sharma (2002) [6] and Kumar *et al.* (2018) [4].

Effect of plant growth regulators

Treatment G_3 (foliar application of NAA @ 50 ppm at 40 and 60 DAS) found significantly superior over water spray (G_1) and recorded 61.10 pods per plant but remained at par with treatment G_2 *i.e.* GA_3 during individual years of experiment and in pooled basis (Table 1). Foliar spray of plant growth regulators (NAA and GA_3) did not exert any significant effect on number of seeds per pod and harvest index during both the years of the examination and in pooled analysis. Significantly higher 100 seed weight (22.63, 21.45 and 22.04 g) was noticed under treatment G_3 (NAA @ 50 ppm) sprayed at 40 and 60 DAS as compared to control (G_1) during both the years and in pooled analysis but it remained at par with G_2 (GA_3 @ 50 ppm) during the second year of experimentation and in pooled results (Table 3). The application of NAA @ 50 ppm increased 100 seed weight to the tune of 9.54 per cent over control (water spray). Foliar spray of NAA @ 50 ppm (G_2) twice at 40 and 60 DAS, being at par with application of 50 ppm GA_3 significantly produced higher seed yield (2598 kg/ha) over control (2293 kg/ha) (Table 4). The application of NAA and GA_3 @ 50 ppm increased seed yield to the tune of 13.30 and 9.99 per cent, respectively over control. The foliar spray of NAA and GA_3 increased the stover yield of chickpea significantly in both the years over control and the pooled mean also exhibited similar trend. Significantly the highest stover yield (3258 kg/ha) recorded under NAA @ 50 ppm spray over control and remained statistically at par with 50 ppm GA_3 spray. On pooled mean basis, the increase registered in stover yield due to G_3 was to the tune of 11.58 per cent over G_1. Maximum biological yield (6047, 5664 and 5856 kg/ha) was recorded with the foliar spray of 50 ppm NAA at 40 and 60 DAS which was significantly higher over water spray but found at par with 50 ppm GA_3 spray in both the years as well as in pooled results (Table 8). The increase in pooled mean biological yield under foliar application of 50 ppm NAA and GA_3 was 12.33 and 10.44 per cent, respectively over control. The significant increased seed yield and yield attributes obtained with the application of NAA and GA_3 might be attributed to more number of productive branches per plant, pods per plant and 100 seed weight. Further, growth regulators influence carbon cycle in plant with higher CO_2 fixation and efficient translocation of synthates towards developing seed (Menon and Shrivastava, 1984 and Tripathi, *et al.*, 2001) [5, 8] in chickpea. Similar results were also observed by Chauhan *et al.* (2018) [1] and Gnyandev *et al*. (2019) [2].

Effect of nipping

The data showed that, nipping at 30 DAS (N_2) recorded significantly higher number of pods per plant (61.62, 60.20 and 60.91) (Table 1) than non-nipping treatment (N_1) during 1st year, 2nd year and in pooled results, respectively. However, it remained at par with nipping done at 40 DAS (N_3) during second year of experiment. The increase in number of pods per plant with nipping at 30 DAS was 17.68 per cent over non- nipping. Nipping treatment found non-significant with respect to number of seeds per pod, seed index and harvest

index during 2019-20, 2020-21 and on pooled basis. Nipping at 30 DAS (N_2) noted significantly higher seed yield (2731, 2542 and 2637 kg/ha) over no nipping (N_1) and nipping at 40 DAS (N_3) during both the years of investigation and in pooled analysis (Table 4). The observed increase in seed yield due to nipping done at 30 DAS was 14.80 per cent over no nipping. Nipping at 30 DAS, being at par with nipping at 40 DAS registered significantly higher stover yield (3422, 3136 and 3279 kg/ha) as compared to non-nipping treatment (3053, 2844 and 2948 kg/ha) during both the years and in pooled analysis (Table 4). The per cent increase in stover yield due to nipping at 30 DAS was 11.23 over non-nipping. Nipping done at 30 days after sowing significantly increased the biological yield of chickpea during both the years as well as in pooled analysis over no-nipping but remained at par with one nipping at 40 DAS during second year of experimentation (Table 8). The pooled mean increase due to nipping at 30 DAS was to the extent of 12.77 per cent over non - nipping. The higher yield attributing parameters noticed with nipping at 30 DAS may be due to increase in photosynthetic area leading to higher photosynthetic rate, better assimilation and accumulation of more photosynthates resulting into better seed development as evident with numerically higher test weight. Results are in confirming with findings of Joshi (2020) [3].

Interaction effect

The treatment combination D_2N_2 (sowing at 3rd week of October and nipping at 30 DAS) recorded higher number of pods per plant (70.81) (Table 2) as compared to other treatment combinations but remained at par with D_2N_3 and D_1N_2. The least number of pods per plant (44.60) was noted under treatment combination D_4N_1. The interaction effect between sowing time and nipping was found significant on seed yield of chickpea. The pooled analyzed data of two years indicated that treatment combination D_2N_2 (3rd week of October sowing and one nipping at 30 DAS) gave significantly highest seed yield (3045 kg/ha) over all other treatment combinations (Table 5). The pooled data showed that treatment combination D_2N_2 recorded significantly higher stover yield (3723 kg/ha) as compared to rest of the treatment combinations and remained at par with treatment combination D_2N_3 (3518 kg/ha) (Table 6). The treatment combination D_4N_1 registered remarkably the lowest stover yield of chickpea (2704 kg/ha). The combination effect of 3rd week of October and foliar spray of GA_3 (D_2G_2) recorded significantly stover yield over rest of the treatments except D_2G_3 and D_1G_2 (Table 7). It is quite evident from the data (Table 9) that treatment combination D_2N_2 recorded significantly higher biological yield (6767 kg/ha) as compared to rest of the treatment combinations. The lowest biological yield of chickpea (4762 kg/ha) was registered with treatment combination D_4N_1. Significantly the higher biological yield was obtained in treatment combination D_2G_3 (3rd week of October sowing and NAA @ 50 ppm) over all other treatment combinations except treatment combination D_2G_2 and D_1G_2 and the lowest biological yield was noticed under treatment combination D_4G_1 (Table 10).

Table 1: Effect of sowing time, plant growth regulators and nipping on yield attributes of chickpea

Treatments	Number of pods per plant			Number of seed per pod		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Sowing time						
D_1: 1st week of October	63.00	60.51	61.76	1.87	1.81	1.84
D_2: 3rd week of October	66.99	65.90	66.45	1.88	1.84	1.86
D_3: 1st week of November	52.36	52.20	52.28	1.87	1.75	1.81
D_4: 3rd week of November	46.06	47.53	46.79	1.85	1.78	1.82
S.Em ±	1.53	1.39	1.03	0.03	0.03	0.02
CD (P = 0.05)	5.28	4.80	3.18	NS	NS	NS
CV (%)	13.88	12.76	13.34	7.85	7.56	7.71
Plant growth regulators						
G_1: Water spray (control)	49.12	51.34	50.23	1.86	1.77	1.82
G_2: GA_3 (50 ppm)	60.25	58.00	59.13	1.86	1.79	1.82
G_3: NAA (50 ppm)	61.94	60.27	61.10	1.88	1.83	1.86
S.Em ±	1.15	0.98	0.76	0.02	0.02	0.02
CD (P = 0.05)	3.24	2.78	2.11	NS	NS	NS
Nipping						
N_1: No nipping	51.93	51.59	51.76	1.85	1.77	1.81
N_2: One nipping at 30 DAS	61.62	60.20	60.91	1.88	1.82	1.85
N_3: One nipping at 40 DAS	57.76	57.81	57.79	1.87	1.80	1.84
S.Em ±	1.15	0.98	0.76	0.02	0.02	0.02
CD (P = 0.05)	3.24	2.78	2.11	NS	NS	NS
CV (%)	12.05	10.43	11.28	7.17	7.48	7.32

Table 2: Interaction effect of sowing time and nipping on number of pods per plant of chickpea (pooled)

Treatments	Nipping		
Sowing time	**N_1**	**N_2**	**N_3**
D_1	51.85	68.18	65.25
D_2	60.54	70.81	67.99
D_3	50.06	53.80	52.98
D_4	44.60	50.85	44.94
S.Em ±	1.51		
CD (P = 0.05)	4.22		

Table 3: Effect of sowing time, plant growth regulators and nipping on seed index of chickpea

Treatments	Seed index (g)		
	2019-20	2020-21	Pooled
Sowing time			
D_1: 1st week of October	21.56	20.76	21.16
D_2: 3rd week of October	22.31	21.02	21.66
D_3: 1st week of November	21.24	20.58	20.91
D_4: 3rd week of November	20.80	20.25	20.53
S.Em ±	0.40	0.36	0.27
CD (P = 0.05)	NS	NS	NS
CV (%)	9.74	8.97	9.38
Plant growth regulators			
G_1: Water spray (control)	20.48	19.76	20.12
G_2: GA_3 (50 ppm)	21.31	20.75	21.03
G_3: NAA (50 ppm)	22.63	21.45	22.04
S.Em ±	0.32	0.29	0.22
CD (P = 0.05)	0.90	0.83	0.60
Nipping			
N_1: No nipping	21.22	20.54	20.88
N_2: One nipping at 30 DAS	21.74	20.84	21.29
N_3: One nipping at 40 DAS	21.47	20.58	21.03
S.Em ±	0.32	0.29	0.22
CD (P = 0.05)	NS	NS	NS
CV (%)	8.89	8.51	8.71

Table 4: Effect of sowing time, plant growth regulators and nipping on seed yield and stover yield of chickpea

Treatments	Seed yield (kg/ha)			Stover yield (kg/ha)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Sowing time						
D_1: 1st week of October	2594	2431	2513	3418	3065	3241
D_2: 3rd week of October	2788	2629	2709	3502	3286	3394
D_3: 1st week of November	2543	2373	2458	3283	2982	3133
D_4: 3rd week of November	2241	2168	2204	2829	2736	2783
S.Em ±	49	51	36	100	87	66
CD (P = 0.05)	171	178	110	345	301	204
CV (%)	10.12	11.13	10.61	15.92	14.96	15.49
Plant growth regulators						
G_1: Water spray (control)	2369	2217	2293	3044	2796	2920
G_2: GA_3 (50 ppm)	2575	2470	2522	3365	3105	3235
G_3: NAA (50 ppm)	2681	2514	2598	3366	3150	3258
S.Em ±	41	42	29	67	52	43
CD (P = 0.05)	116	119	82	190	148	119
Nipping						
N_1: No nipping	2340	2254	2297	3053	2844	2948
N_2: One nipping at 30 DAS	2731	2542	2637	3422	3136	3279
N_3: One nipping at 40 DAS	2553	2405	2479	3299	3072	3186
S.Em ±	41	42	29	67	52	43
CD (P = 0.05)	116	119	82	190	148	119
CV (%)	9.68	10.57	10.11	12.40	10.40	11.53

Table 5: Interaction effect of sowing time and nipping on seed yield (kg/ha) of chickpea (pooled)

Treatments	Nipping		
Sowing time	**N_1**	**N_2**	**N_3**
D_1	2323	2686	2528
D_2	2397	3045	2684
D_3	2410	2513	2452
D_4	2058	2303	2252
S.Em ±	59		
CD (P = 0.05)	165		

Table 6: Interaction effect of sowing time and nipping on stover yield (kg/ha) of chickpea (pooled)

Treatments	N_1	N_2	N_3
D_1	3046	3374	3305
D_2	2942	3723	3518
D_3	3103	3098	3198
D_4	2704	2922	2721
S.Em ±	85		
CD (P = 0.05)	238		

Table 7: Interaction effect of sowing time and plant growth regulators on stover yield (kg/ha) of chickpea (pooled)

Treatments	Plant growth regulators		
Sowing time	**G_1**	**G_2**	**G_3**
D_1	2914	3478	3332
D_2	3046	3573	3563
D_3	3053	3071	3274
D_4	2667	2817	2863
S.Em ±	85		
CD (P = 0.05)	238		

Table 8: Effect of sowing time, plant growth regulators and nipping on biological yield and harvest index of chickpea

Treatments	Biological yield (kg/ha)			Harvest index (%)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Sowing time						
D_1: 1st week of October	6012	5496	5754	43.20	44.09	43.64
D_2: 3rd week of October	6290	5915	6103	44.45	44.52	44.48
D_3: 1st week of November	5826	5355	5591	43.68	44.34	44.01
D_4: 3rd week of November	5070	4904	4987	44.42	44.40	44.41
S.Em ±	93	120	76	1.17	0.57	0.65
CD (P = 0.05)	322	416	234	NS	NS	NS
CV (%)	8.33	11.53	9.96	13.88	6.64	10.85
Plant growth regulators						
G_1: Water spray (control)	5412	5014	5213	44.00	44.17	44.08
G_2: GA_3 (50 ppm)	5939	5575	5757	43.39	44.37	43.88
G_3: NAA (50 ppm)	6047	5664	5856	44.42	44.47	44.44
S.Em ±	79	81	57	0.73	0.49	0.44
CD (P = 0.05)	223	230	158	NS	NS	NS
Nipping						
N_1: No nipping	5393	5098	5246	43.62	44.16	43.89
N_2: One nipping at 30 DAS	6153	5678	5916	44.52	44.81	44.66
N_3: One nipping at 40 DAS	5852	5477	5665	43.67	44.04	43.85
S.Em ±	79	81	57	0.73	0.49	0.44
CD (P = 0.05)	223	230	158	NS	NS	NS
CV (%)	8.16	9.01	8.57	10.02	6.62	8.48

Table 9: Interaction effect of sowing time and nipping on biological yield (kg/ha) of chickpea (pooled)

Treatments	Nipping		
Sowing time	**N_1**	**N_2**	**N_3**
D_1	5369	6060	5833
D_2	5339	6767	6202
D_3	5512	5611	5650
D_4	4762	5225	4973
S.Em ±	113		
CD (P = 0.05)	317		

Table 10: Interaction effect of sowing time and plant growth regulators on biological yield (kg/ha) of chickpea (pooled)

Treatments	Plant growth regulators		
Sowing time	**G_1**	**G_2**	**G_3**
D_1	5150	6074	6038
D_2	5592	6325	6391
D_3	5374	5570	5828
D_4	4735	5060	5166
S.Em ±	113		
CD (P = 0.05)	317		

Conclusion

On the basis of two years experimentation it can be concluded that chickpea crop sown during 3rd week of October along with one nipping at 30 days after sowing and foliar spray of NAA @ 50 ppm twice at 40 and 60 DAS were found effective in improving the yield of chickpea under irrigated conditions of South Saurashtra condition.

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