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Effect of sowing time and seed rate on growth and yield of chickpea cultivars

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ABSTRACT : Current investigation on effect of sowing time and seed rate on growth and yield of chickpea cultivars was conducted during the *Rabi* season. The soil of experimental field was sandy loam in texture with high pH. Soil was tested low in organic carbon and available nitrogen and high in available phosphorus and potassium. The experiment was laid out in a Split Plot Design with sowing time (1st fortnight of November and 1st fortnight of December) and cultivars (H09-23, H08-18, C-235 and HC-1) kept in main plots while three seed rates *viz*., 40kg ha^{-1}, 50 kg ha^{-1} and 60 kg ha^{-1} were kept in sub-plots and replicated thrice. Cultivar H09-23 emerged significantly earlier than H08-18 and C235 but, it was at par with HC-1. Cultivar C235 took significantly higher number of days to 50 per cent flowering and 50 per cent podding than other cultivars.

KEY **W**ORDS : Chickpea, DAS, H09-23, C235, H08-18

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Pulses, once referred to as the poor man's meat are becoming increasingly important in crop production systems. They fix atmospheric nitrogen. The per capita availability of pulses progressively declined from 70g in 1956 to 34g in 1998 against the recommended requirement of 80g /day/ capita. Inclusion of legume in a particular cropping system improves the soil health depending upon its duration, fertilization, nature and purpose for which that is grown. Chickpea (*Cicer arietinum* L.) is the most important *Rabi* pulse crop. In India, it accounts for more than one third of the area and about 50 per cent of the production of pulses. India accounts for 65 per cent of the world acreage and 67 per cent production of chickpea at present. In India, it is grown over an area of 8.22 million hectares with productivity of 881 kg ha^{-1} and production of about 9.93 million tonnes. Its high nutritive value can be judged by the fact that it contains 20 per cent protein, 5 per cent fats and 55 per cent carbohydrates. Therefore, it is an inexpensive, high-quality source of protein. It is not only an important source of protein in human diets, but it also plays a significant role in maintaining soil fertility, through biological nitrogen fixation. It is also rich in calcium, iron and niacin. In Rajasthan, it is grown over an area of 107,000 hectares with total production of 91,000 tonnes and productivity of 850 kg ha^{-1}. It is usually grown after rainy season on conserved soil moisture, during winter in tropics and spring in temperate and the Mediterranean regions. Studies have shown that early winter sowing (mid-October to mid-November) is the optimum period. Late sowing, after November 18 reduced yield by 28 per cent for every 10 day interval delay. In Kenya, it is a relatively new crop with a high grain yield potential. However, late-sown crops may experience high temperatures during the reproductive phase. Despite its economic and nutritive importance, the yield of chickpea

is very low in India. There are many factors responsible for the low yield. The use of traditional or low yielding varieties and adoption of poor management practices are of great importance. Amongst the agronomic practices, sowing methods and proper seed rate are of great importance. Since very little scope exists for horizontal growth, the alternative seems by achieving vertical growth through increasing its productivity level. Thus, there is need to adopt suitable management practice like proper sowing time and to use high yielding varieties. Sowing date is one of the most important agronomic factors affecting chickpea productivity. It is an important non-cash input which has been recognized as the most critical factor in influencing its yield. Sowing of chickpea at optimum time ensures a better harmony among soil, plant and atmospheric system. The two major constraints to chickpea production in the northern cropping region are disease and frost. In both the cases, sowing date can be used as a strategy to influence yield through avoidance of cold temperature during flowering and to reduce the effect of disease. The optimum sowing date results in flowering occurring when the risk of cold temperature is low, which it is especially important to avoid frost during flowering? In northern part of India, it is normally sown during second fortnight of October. Sometime its sowing is delayed depending upon the withdrawal of monsoon and late harvest of preceding *Kharif* crop, which ultimately results in poor seed yield. With the development of new genotypes, it becomes essential to test them at different sowing dates to exploit their full production potential. Hence, various genotypes which have been developed by the breeders and genotypes may behave differently due to their plant architecture particularly under late sown condition because of poor plant growth. Under such situation plant population play an important role in improving the productivity of crop. The agronomic requirements of these cultivars also need to be worked out. There are many factors responsible for the low yield, but among those factors, the use of traditional or low yielding varieties and poor adaptation of management practices is of main importance. Keeping in view the importance of sowing time, seed rate and varieties of chickpea and their effects on growth and yield, the present study has been planned to evaluate the "Effect of sowing time and seed rate on growth and yield of chickpea cultivars" with the following objectives: (i) To study the effect of different sowing times and seed rates on growth and yield of chickpea cultivars, (ii) To work out the economics of various treatments.

RESEARCH PROCEDURE

The field experiment on effect of sowing time and seed rate on growth and yield of chickpea cultivars was conducted during *Rabi* (winter) season of 2015-2016. The details of experimental material used and methods adopted during the course of investigation are described in this chapter.

Experimental site and location:

The field experiment was conducted at Pulses Research Area of Bhagwant University Farm, Ajmer which is situated in the sub-tropical region at 26º 44´ N latitude and 74º 63´ E longitude with an elevation of 480 meter (1.570 ft) above mean sea level in Rajasthan State of India.

Climate and weather conditions:

Ajmer has a semi-arid and sub-tropical climate with hot, dry and desiccating winds during summer and severe cold during winter season. The mean monthly maximum temperature during summer months of May to June is around 40ºC to 45ºC while the minimum temperature during winter months of December and January sometimes goes as low as 1ºC or less than this. The average annual rainfall is about 450mm which is mainly received during monsoon months of July to September with a few showers of cyclonic rains received during winter months of December and January or early spring. Mean weekly values of important weather parameters during the crop season recorded at the Meteorological observatory of Bhagwant University Farm, Ajmer.

Observations to be recorded :

Growth parameters :

Plant population at 15 days after sowing (DAS), plant height (cm) at 30, 60, 90, 120 DAS and at harvest and dry matter accumulation (g) at 30, 60, 90, 120 DAS and at harvest.

Phenological observation:

Days taken to seedling emergence, days taken to 50 and flowering, days taken to 50 per cent podding and days taken to maturity.

Yield attributes and yield:

Numbers of pods per plant, numbers of grains per pod,100 grains weight (g), biological yield (kg ha^{-1}), grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) and harvest index (%).

Nodulation studies:

Numbers of nodules per plant at 60 and 90 DAS, nodules weight per plant at 60 and 90 DAS.

Nutrients analysis:

N, P, K content and uptake by grain and straw.

Soil studies:

N, P and K in soil before sowing and after harvest.

Economics :

Gross returns (Rs./ha), net returns (Rs./ha) and benefit-cost ratio.

Days taken to 50 per cent flowering:

Visually flowering appears in 50 per cent plants, the date was noted and days taken to flowering were calculated for each sowing date and genotype.

Days taken to 50 per cent podding:

Visually podding appears in 50 per cent plants, the date was noted and days taken to podding were calculated for each sowing date and genotype.

Days taken to maturity:

When almost all the plants become brown/grey and dried, the dates were noted and the days taken to maturity were calculated for each sowing date and genotype.

Root nodule studies:

Number of nodules per plant:

Three plants taken for dry matter accumulation were removed very carefully along with roots at flowering. The roots were washed in clean water in the bucket in order to remove the soil particles adhered to the roots and then number of nodules was counted of all the three plants. Average was worked out and expressed as nodules per plant.

Dry weight of nodules:

After counting the nodules, they were removed from the roots and sun dried for some time and nodules were oven dried at 60°C for 48 hours and their constant weight was recorded. The average dry weight of nodules per plant was worked out and expressed in mg per plant.

Yield attributes:

Number of pods per plant:

All the effective pods from three representative plants were counted and their average over per plant was recorded.

Number of seeds per pod:

Average numbers of seeds per pod were calculated from ten pods picked up randomly from the total pods of three tagged plants from each plot.

Test weight:

A composite seed sample was drawn from the individual plot yield and 100 seeds for chickpea. The counted seeds were sun dried and their weight was taken. The weight was expressed in grams.

Yield:-

Biological yield:

After harvesting the net area of crop as per their maturity the plants were sun dried for 4-5 days and weight from each plot was recorded separately with the help of weighing balance and converted into kg ha^{-1}.

Grain yield:

The biomass obtained for individual net plot after sun drying was threshed, winnowed and cleaned and weighed for grain yield. Grain yield thus obtained were converted into kg ha^{-1}.

Stover yield:

The stover yield plot wise obtained by subtracting grain yield from biological yield and converted into kg ha^{-1}.

Harvest index:

It was calculated by dividing the grain yield (economic yield) by the total dry matter (biological yield) and multiplied by 100, Donald (1962).

$$\text{Harvest index}(\%) = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Chemical analysis:

Plant analysis:

The oven dried samples taken at harvest were ground and 0.2 g for straw and 0.1 g for grain of each ground sample was digested in di-acid mixture of H_2SO_4 and $HClO_4$ (9:1) for N, P and K estimation. After digestion, a known volume was made with distilled water and filtered through Whatman filter paper No. 42. All the estimation in aliquot was made according to following procedure.

Nitrogen content and uptake at harvest:

Per cent nitrogen content was determined by Nessler's Reagent Method as described by Jackson (1973). The total nitrogen uptake at harvest was calculated as under:

$$\text{N uptake by grain (kg ha}^{-1}) = \frac{\text{N content (\%) x grain yield (kg ha}^{-1})}{100}$$

$$\text{N uptake by straw (kg ha}^{-1}) = \frac{\text{N content (\%) x straw yield (kg ha}^{-1})}{100}$$

Phosphorus content and uptake at harvest:

Per cent phosphorus content was determined by vane domolybdo phosphoric acid yellow colour method. The total P uptake at harvest was calculated as under:

$$\text{P uptake by grain (kg ha}^{-1}) = \frac{\text{P content (\%) x grain yield (kg ha}^{-1})}{100}$$

$$\text{P uptake by straw (kg ha}^{-1}) = \frac{\text{P content (\%) x straw yield (kg ha}^{-1})}{100}$$

Potassium content and uptake at harvest:

Per cent potassium content was determined by Flame Photometric Method. The total P uptake at harvest was calculated as under:

$$\text{K uptake by grain (kg ha}^{-1}) = \frac{\text{K content (\%) x grain yield (kg ha}^{-1})}{100}$$

$$\text{K uptake by straw (kg ha}^{-1}) = \frac{\text{K content (\%) x straw yield (kg ha}^{-1})}{100}$$

Protein content:

The protein content (%) of grain and stover were worked out by multiplying the nitrogen percentage in grain and stover with 6.25, a conversion factor for estimation of protein content.

Soil analysis:

The composite soil samples from 0 – 15cm depth were analysed before sowing and after harvesting for determining the available nitrogen, phosphorus and potassium. Available N in soil was determined according to alkaline permanganate method by Subbiah and Asija (1956). Available P in soil was determined by Olsen's method (Jackson, 1973). Available K in soil was extracted by neutral normal ammonium acetate and estimated by flame photometer (Piper, 1966).

Economics of treatments:

The expenditure incurred on individual treatment was worked out from the detail assessment of the fixed and variable costs involved such as land preparation, seed, plant protection, chemicals and labour engaged in different operations. Gross income for all treatment was calculated separately taking into consideration grain and stover yield of individual crop. Thereafter, net returns were calculated after subtracting expenditure incurred on the individual treatment from the gross expenditure of the same treatment.

The benefit: cost was calculated as follows:

$$\text{B : C} = \frac{\text{Gross return (Rs. ha}^{-1})}{\text{Cost of cultivation (Rs. ha}^{-1})}$$

Statistical analysis:

The data presented in this thesis are the mean values of different measurements. The statistical method described by Panse and Sukhatme (1961) was followed for statistical analysis and interpretation of the experimental results. In order to evaluate the comparative performance of the various treatments, the data were analysed by the technique of analysis of variance described by Fisher (1950). All the tests of significance were made at 5 per cent level of significance. To judge the significance of difference between two treatments, critical difference (CD) was worked out by the following formula:

$$\text{CD} = \sqrt{\frac{2 \text{ x Error variance}}{\text{n}}} \text{ x t value at error of d. f.}$$

where, n = Number of observation averaged, t = Value from Fisher's and Yates's table (1947) for error degree of freedom at 5 per cent level of significance and CD = Critical difference.

RESEARCH ANALYSIS AND REASONING

The results of field study on effect of sowing time

and seed rate on growth and yield of chickpea cultivars for crop season *Rabi* 2015-2016 are presented in this chapter with the help of appropriate tables.

Phenological studies:

The data pertaining to days taken for the four phenological stages *i.e.* emergence, days to 50 per cent flowering, days to 50 per cent podding and maturity under different treatments presented in Table 1.

Days taken to emergence:

Perusal of data reveals that emergence of coleoptiles from the soil took significantly less number of days when chickpea was shown on 1st fortnight of November. Number of days to emergence of coleoptiles increased significantly with the delay in sowing time. Cultivar H09-23 emerged significantly earlier than H08-18 and C235 however, it was at par with HC-1. Days taken to emergence of chickpea were not significantly influenced by varying seed rates.

Days to 50 per cent flowering:

Chickpea sown on 1st fortnight of November took significantly higher number of days to 50 per cent flowering as compared to delayed sowing. Days taken to 50 per cent flowering were significantly curtailed with the delay in sowing. Cultivar C235 took significantly higher number of days to 50 per cent flowering than other cultivars. Days taken to 50 per cent flowering of chickpea were not significantly influenced by different seed rates.

Days to 50 per cent pod initiation:-

Days taken to 50 per cent podding were significantly influenced due to sowing time. Chickpea sown on 1st fortnight of November took significantly higher number of days to 50 per cent podding as compared to delayed sowing. Cultivar C235 took significantly more days to 50 per cent podding than rest of the cultivars. Varying seed rates did not differ significantly for number of days taken to 50 per cent pod initiation.

Days to maturity:

Days taken to maturity were significantly curtailed with the delay in sowing of chickpea. More number of days was taken to maturity in case of 1st fortnight of November as compared to late sown chickpea. Chickpea cultivar H09-23 took significantly less number of days to attain maturity followed by C235, HC-1 and H08-18, respectively. Days taken to maturity by chickpea cultivars were not significantly influenced by varying seed rates.

Table 1 : Effect of various treatments on different phenological stages

Treatments	Phenological events (DAS)			
	Seedling emergence	50% flowering	50% Podding	At maturity
Date of sowing				
1st fortnight of November	11.5	99.2	114.8	139.2
1st fortnight of December	13.6	82.1	105.9	135.5
S.E. ±	0.259	0.679	0.378	0.827
C.D. (P=0.05)	0.785	2.06	1.15	2.507
Cultivars				
H08-18	12.5	90.9	109.3	140.5
H09-23	11.7	87.3	103.3	133.7
C235	13.7	93.5	115.8	136.7
HC-1	12.4	90.7	112.9	138.6
S.E. ±	0.366	0.960	0.535	1.169
C.D. (P=0.05)	1.11	2.91	1.622	3.546
Seed rates				
40kg ha^{-1}	12.6	89.6	110.7	137.5
50kg ha^{-1}	12.4	90.6	110.1	137.9
60kg ha^{-1}	12.7	91.6	110.2	136.7
S.E. ±	0.252	0.805	0.224	0.389
C.D. (P=0.05)	NS	NS	NS	NS

NS= Non-significant

Growth studies:

Plant population:

A perusal of data in Table 2 on plant population of chickpea cultivars revealed that plant population differed significantly due to time of sowing and seed rates. Increasing level of seed rate resulted in significant increase in plant population at both the stages, however, the differences among seed rate of 40 and 50kg ha^{-1} were no significant in this respect.

Table 2 : Effect of sowing time and seed rate on plant stand (Number of plant/meter row length) of chickpea cultivars

Treatments	Initial (15DAS)	At harvest
Date of sowing		
1st fortnight of November	14.08	11.83
1st fortnight of December	12.25	10.50
S.E. ±	0.29	0.28
C.D. (P=0.05)	0.87	0.84
Cultivars		
H08-18	13.06	10.83
H09-23	12.33	10.67
C235	13.72	11.72
HC-1	13.56	11.44
S.E. ±	0.40	0.39
C.D. (P=0.05)	NS	NS
Seed rates		
40kg ha^{-1}	12.37	10.62
50kg ha^{-1}	12.79	10.75
60kg ha^{-1}	14.33	12.12
S.E. ±	0.50	0.42
C.D. (P=0.05)	1.43	1.11

NS= Non=significant

Plant height:

Data pertaining to plant height at different stages of crop growth as influenced by sowing time, cultivars and seed rates are presented in Table 3. Perusals of data indicate that irrespective of the treatments, height of chickpea plant increased with the advancement of crop age. Sowing chickpea on 1st fortnight of November resulted in significantly taller plants as compared to delayed sowing. Significantly taller plants at all the growth stages were recorded in H09-23 than all other cultivars. A comparatively taller plant at 90 DAS was recorded with 50 and 60kg ha^{-1} seed rates.

Dry matter accumulation per plant:

Effect of seed rates and sowing time on dry matter accumulation per plant at different stages of crop growth are presented in Table 4. Dry matter accumulation of chickpea cultivars was affected significantly from 30 DAS onwards upto harvesting due to sowing time. Dry matter accumulation per plant at 30 DAS to 90 DAS did not differ significantly in all cultivars, though among different

Table 3 : Effect of sowing time and seed rate on plant height (cm) of chickpea cultivars

Treatments	30 DAS	60 DAS	90 DAS	120 DAS	At maturity
Date of sowing					
1st fortnight of November	12.49	19.71	46.13	70.26	70.51
1st fortnight of December	7.47	15.42	40.90	65.07	65.85
S.E. ±	0.118	0.41	0.90	1.53	1.13
C.D. (P=0.05)	0.358	1.23	2.73	4.65	3.44
Cultivars					
H08-18	10.07	16.94	43.20	66.43	67.75
H09-23	11.50	20.33	55.26	75.43	75.66
C235	9.18	16.82	34.52	65.70	65.86
HC-1	9.18	16.18	41.09	63.11	63.46
S.E. ±	0.167	0.58	1.27	2.17	1.60
C.D. (P=0.05)	0.506	1.75	3.86	6.58	4.87
Seed rates					
40kg ha^{-1}	9.73	17.36	42.21	67.59	67.96
50kg ha^{-1}	10.15	17.44	44.19	67.58	67.78
60kg ha^{-1}	10.07	17.90	44.15	67.83	68.80
S.E. ±	0.128	0.216	0.623	0.73	0.82
C.D. (P=0.05)	NS	NS	1.79	NS	NS

NS= Non-significant

cultivars, H09-23 showed the significantly superiority in dry matter accumulation per plant and accumulated highest dry matter as compared to other cultivars at 120 DAS to maturity of crop. The lowest dry matter was accumulated in C235. Dry matter accumulation of chickpea cultivars were not influenced by varying seed rate during the entire crop season (Berger *et al.,* 2011 and Hassan and Khan, 2007).

Yield and yield attributes:

Number of pods per plant:

Number of pods in chickpea was significantly influenced by sowing time. Chickpea sown on 1st fortnight of November produced significantly higher number of pods per plant than delayed sowing. Maximum number of pods was recorded in H09-23 and least number of pods per plant was obtained by the cultivar C235. Maximum number of pods per plant was produced with seed rate of 40kg ha^{-1} which was significantly higher than other two seed rate.

Number of grain per pod:

A close perusal of the data in Table 5 on number of grains per pod reveal that sowing time and seed rate influenced the number of grains per pod significantly. Seed rates at 50kg ha^{-1} produced maximum number of grains per pod which were significantly higher than other seed rates. There was no significant difference in number of grains per pod due to various cultivars.

100 grain weight :

100 grain weight of chickpea recorded under different treatments is presented in Table 5. Perusal of data revealed that the 100 grain weight of chickpea cultivars was not significantly affected either by different time of sowing or seed rate (Fazlulkabir *et al.*, 2009; Hassanuzzaman *et al.*, 2007 and Machado *et al.*, 2006).

Biological yield:

Sowing of chickpea on 1st fortnight of November produced higher biomass than sowing on 1st fortnight of December. Sowing with 60 kg ha^{-1} seed rate resulted in significantly higher biological yield than at lower seed rate. The data indicate that different cultivars did not affect the biomass production of chickpea significantly.

Grain yield:

A perusal of data of Table 6 revealed that sowing time and cultivars influenced chickpea grain yield significantly. The crop sown on 1st fortnight of

Table 4 : Effect of sowing time and seed rate on dry matter accumulation per plant (g) of chickpea cultivars

Treatments	30 DAS	60 DAS	90 DAS	120 DAS	At maturity
Date of sowing					
1st fortnight of November	0.98	1.63	13.28	21.38	31.40
1st fortnight of December	0.16	0.98	8.16	17.47	24.27
S.E.±	0.03	0.105	0.580	0.839	0.696
C.D. (P=0.05)	0.1	0.318	1.760	2.544	2.110
Cultivars					
H08-18	0.59	1.33	10.97	19.67	30.19
H09-23	0.57	1.33	11.39	22.09	31.02
C235	0.56	1.27	10.20	16.66	23.62
HC-1	0.57	1.30	10.33	19.29	26.54
S.E.±	0.044	0.148	0.821	1.19	0.984
C.D. (P=0.05)	NS	NS	NS	3.60	2.985
Seed rates					
40kg ha^{-1}	0.56	1.34	10.75	19.30	28.70
50kg ha^{-1}	0.57	1.35	11.21	19.47	28.36
60kg ha^{-1}	0.56	1.23	10.21	19.51	26.44
S.E.±	0.04	0.07	0.88	0.90	1.34
C.D. (P=0.05)	NS	NS	NS	NS	NS

NS= Non-significant

Table 5 : Effect of sowing time and seed rate on yield attributes of chickpea cultivars

Treatments	Pods/plant (Number)	Grains/pod (Number)	100 grain (wt.(g)
Date of sowing			
1st fortnight of November	38.39	1.50	14.27
1st fortnight of December	28.83	1.24	14.24
S.E. ±	0.48	0.027	0.16
C.D. (P=0.05)	1.47	0.083	NS
Cultivars			
H08-18	35.01	1.39	15.83
H09-23	36.68	1.35	15.66
C235	29.62	1.39	12.19
HC-1	33.10	1.36	13.33
S.E. ±	0.69	0.04	0.23
C.D. (P=0.05)	2.09	NS	0.70
Seed rates			
40kg ha^{-1}	36.27	1.45	14.04
50kg ha^{-1}	33.00	1.47	14.42
60kg ha^{-1}	31.53	1.23	14.3
S.E. ±	0.58	0.03	0.17
C.D. (P=0.05)	1.67	0.08	NS

NS= Non-significant

Table 6 : Effect of sowing time and seed rate on biological, grain, stover yield and harvest index of chickpea cultivars

Treatments	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
Date of sowing				
1st fortnight of November	11,010	2063	8,947	23.66
1st fortnight of December	7,513	1567	5,946	28.39
S.E. ±	294	35.90	296	1.60
C.D. (P=0.05)	891	109	898	NS
Cultivars				
H08-18	9,629	1932	7,696	25.17
H09-23	9,200	1995	7,204	28.21
C235	9,045	1498	7,547	20.63
HC-1	9,172	1834	7,337	30.08
S.E. ±	415	50.77	418	2.26
C.D. (P=0.05)	NS	154	NS	NS
Seed rates				
40kg ha^{-1}	8,829	1832	6,997	28.43
50kg ha^{-1}	9,408	1869	7,539	26.23
60kg ha^{-1}	9,547	1743	7,803	23.40
S.E. ±	135	36.27	128	0.66
C.D. (P=0.05)	389	105	369	1.91

NS= Non-significant

November gave significantly higher grain yield as compared to delayed sowing. Cultivar H09-23 produced significantly higher grain yield than other cultivars.However, the difference of grain yield between H09-23 and H08-18 were statistically at par. Lowest grain yield was obtained in C235. Crop sown with 50kg ha^{-1} seed rate produced significantly higher grain yield than that of 60kg ha^{-1}.

Stover yield:

The data on stover yield of chickpea under different treatments reveal that stover yield was significantly influenced by sowing time.Significantly higher stover yield was recorded with 1st fortnight of November sown chickpea as compared to 1st fortnight of December sowing. Maximum stover yield was recorded with seed rate of 60kg ha^{-1}. Among cultivars, the non-significant differences were observed in stover yield.

Harvest index:

Sowing time and cultivars did not have significant effect on harvest index, however, it differed significantly with varying seed rate. Highest harvest index was recorded with seed rate of 40kg ha^{-1}.

Interaction effect of sowing time and cultivars on grain yield:

A perusal of data presented in Table 7 indicates the significant interaction between sowing date and cultivars on the grain yield. Cultivar H09-23 produced highest grain yield when sown in 1st fortnight of November. However, the difference of grain yield between the cultivars H09-23 and H08-18 were statistically at par. Delay in sowing time significantly reduced the grain yield of C235. In case of 1st fortnight of December sowing, cultivar HC-1 performed better in terms of grain yield followed by H09-23.

Interaction effect of sowing time and cultivars on stover yield:

A perusal of data presented in Table 8 indicates the significant interaction between sowing date and cultivars on the stover yield. With all the cultivars, delay in sowing reduced the stover yield and it was significantly reduced with 1st fortnight of December sowing of all the cultivars. Maximum stover yield was recorded with cultivar HC-1 at 1st fortnight of November sowing and minimum being with the same variety at 1st fortnight of December sowing.

Nodule studies:

Number of nodules/plant:

The perusal of data on number of nodules per plant at 60 and 90 DAS revealed that more number of nodules at both the stages was recorded in 1st fortnight of November sowing as compared to delayed sowing. Significantly higher number of nodules at both the stages was recorded in H09-23 followed by H08-18 and HC-1. Numbers of nodules at 60 and 90 DAS were not significantly different due to seed rates.

Nodule dry weight per plant:

The data indicate that date of sowing significantly influenced the dry weight of nodule at 60 and 90 DAS.

Table 7 : Interaction effect of sowing time and cultivars on grain yield of chickpea (kg ha^{-1})

Date of sowing	Cultivars				
	H08-18	H09-23	C235	HC-1	Mean
1st fortnight of November	2,270	2,314	1,737	1,928	2,062
1st fortnight of December	1,593	1,675	1,257	1,740	1,566
Mean	1,932	1,995	1,497	1,834	

(i) S.E.± (D) = 36 (ii) S.E.± (V) = 51(iii) S.E.± (DxV) = 72 (iv) C.D. (P=0.05) (D) = 109 (v) C.D. (P=0.05) (V) = 154 (vi) C.D. (P=0.05) (DxV) = 218

Table 8 : Interaction effect of sowing time and cultivars on stover yield of chickpea (kg ha^{-1})

Date of sowing	Cultivars				
	H08-18	H09-23	C235	HC-1	Mean
1st fortnight of November	8,507	8,229	9,077	9,977	8,948
1st fortnight of December	6,887	6,180	6,018	4,699	5,946
Mean	7,697	7,205	7,548	7,338	

S.E.± (D) = 296 S.E.± (V) = 419 S.E. ± (DxV) = 592 C.D. (P=0.05) (D) = 898 C.D. (P=0.05) (V) = NS C.D. (P=0.05) (DxV) = 1796

Higher value was recorded at both the stages in early sown as compared to late sown chickpea. Significantly higher dry weight of nodules at both the stages was recorded in H09-23 followed by H08-18, HC-1 and C235. There was no significant difference observed due to seed rate on dry weight of nodule (Table 9).

Table 9 : Effect of sowing time and seed rates on number of nodules plant^{-1} and nodule weight (mg plant^{-1}) of chickpea cultivars

Treatments	Number of nodules plant^{-1}		Nodule weight	
	60 DAS	90 DAS	60 DAS	90 DAS
Date of sowing				
1st fortnight of November	7.25	6.09	39.69	34.55
1st fortnight of December	5.83	5.06	20.71	23.38
S.E. ±	0.311	0.238	1.47	1.58
C.D.(P=0.05)	0.942	0.695	4.47	4.78
Cultivars				
H08-18	6.76	5.89	32.23	30.69
H09-23	7.36	6.57	34.63	33.05
C235	5.60	4.85	26.57	23.48
HC-1	6.46	4.98	27.38	28.63
S.E. ±	0.439	0.277	2.09	2.23
C.D.(P=0.05)	1.33	0.851	6.33	6.76
Seed rates				
40kg ha^{-1}	6.53	5.79	30.03	28.90
50kg ha^{-1}	6.49	5.48	29.97	28.00
60kg ha^{-1}	6.61	5.44	30.60	29.99
S.E. ±	0.406	0.280	1.53	1.75
C.D.(P=0.05)	NS	NS	NS	NS

NS= Non-significant

Fig. 1 : Effect of cultivars of chickpea on number of nodules/plant

N P K content and its uptake:

N content and its uptake in grain and stover:

The data pertaining to nitrogen content and uptake in grains and straw are presented in Table 10. The data indicate that date of sowing significantly influenced the N content and its uptake in grain, N uptake in stover and total N uptake. Higher values were recorded in early sown as compared to late sown condition. Various cultivars failed to influence N content in grain and stover or N uptake by stover. N uptake by grain and total N uptake were significantly higher in H09-23 as compared to other cultivars. The difference between the cultivar H09-23 and H08-18 for total N uptake was, however, non significant. N content and its uptake by stover and total N uptake were not influenced by seed rates. While N content and its uptake by grain were significantly higher with seed rate of 50kg ha^{-1} as compared to others. The differences between the seed rate of 40 and 50kg ha^{-1} were, however, non-significant.

P content and its uptake in grain and stover:

The data presented in Table 11 reveal that date of sowing did not influence P content in grain and stover. Sowing chickpea on 1st fortnight of November resulted in significantly higher P uptake in grain and stover and total P uptake as compared to delayed sowing. P content in grain and Stover, P uptake in stover and total P uptake of chickpea was not influenced by various cultivars. Among different cultivars, H09-23 showed the superiority in P uptake by grain as compared to other cultivars. Among different seed rates, there were no significant differences observed in P content in grain and stover and P uptake in stover. Sowing chickpea with seed rate of 50 kg ha^{-1} resulted in significantly higher P uptake in grain and total P uptake as compared to other two seed rates.

K content and its uptake in grain and stover:

The data pertaining to potassium content and uptake in grain and straw indicate that date of sowing did not significantly influence the K content in grain and stover. K uptake in grain and stover and total K uptake were recorded higher in early sown as compared to late sown chickpea. K content in grain and stover, K uptake in stover and total K uptake of chickpea were not influenced by different chickpea cultivars. Among different cultivars, H09-23 showed the superiority in K uptake in grain which was

Table 10 : Effect of sowing time and seed rates on N content (%) and its uptake (kg ha^{-1}) of chickpea cultivars

Treatments	N content (%)		N uptake (kg ha^{-1})		Total N uptake (kg ha^{-1})
	Grain	Stover	Grain	Stover	
Date of sowing					
1st fortnight of November	3.30	0.60	68.15	51.94	120.09
1st fortnight of December	3.25	0.58	51.04	34.65	85.69
S.E.±	0.006	0.016	1.21	2.17	2.53
C.D. (P=0.05)	0.018	NS	3.66	6.58	7.66
Cultivars					
H08-18	3.28	0.59	63.42	46.36	109.78
H09-23	3.30	0.62	65.86	41.57	107.43
C235	3.26	0.58	49.10	44.27	93.39
HC-1	3.27	0.58	60.00	40.97	100.97
S.E.±	0.008	0.022	1.71	3.07	3.57
C.D. (P=0.05)	NS	NS	5.17	NS	10.84
Seed rates					
40kg ha^{-1}	3.27	0.60	60.03	42.20	102.25
50kg ha^{-1}	3.30	0.61	61.73	45.42	107.15
60kg ha^{-1}	3.27	0.58	57.03	42.26	99.29
S.E.±	0.005	0.020	1.19	2.34	2.24
C.D. (P=0.05)	0.016	NS	3.422	NS	NS

NS= Non-significant

Table 11 : Effect of sowing time and seed rates on P content (%) and its uptake (kg ha^{-1}) of chickpea cultivars

Treatments	P Content (%)		P uptake (kg ha^{-1})		Total P uptake (kg ha^{-1})
	Grain	Stover	Grain	Stover	
Date of sowing					
1st fortnight of November	0.429	0.129	8.85	11.29	20.14
1st fortnight of December	0.415	0.126	6.70	7.49	14.18
S.E. ±	0.009	0.005	0.148	0.489	0.481
C.D. (P=0.05)	NS	NS	0.450	1.484	1.460
Cultivars					
H08-18	0.431	0.127	8.30	9.83	18.13
H09-23	0.434	0.129	8.65	8.79	17.44
C235	0.422	0.126	6.34	9.48	15.82
HC-1	0.401	0.128	7.81	9.45	17.26
S.E. ±	0.013	0.007	0.210	0.692	0.962
C.D. (P=0.05)	NS	NS	0.636	NS	NS
Seed rates					
40kg ha^{-1}	0.427	0.127	7.807	8.95	16.76
50kg ha^{-1}	0.433	0.132	8.090	9.87	17.96
60kg ha^{-1}	0.405	0.124	7.427	9.33	16.76
S.E. ±	0.012	0.005	0.183	0.267	0.357
C.D. (P=0.05)	NS	NS	0.527	NS	1.03

NS= Non-significant

Table 12: Effect of sowing time and seed rates on K content (%) and its uptake (kg ha^{-1}) of chickpea cultivars

Treatments	K content (%)		K uptake (kg ha^{-1})		Total K uptake (kg ha^{-1})
	Grain	Stover	Grain	Stover	
Date of sowing					
1st fortnight of November	0.747	1.69	15.34	150.69	166.05
1st fortnight of December	0.691	1.53	10.82	91.87	102.69
S.E.±	0.020	0.080	0.458	7.975	7.832
C.D. (P=0.05)	NS	NS	1.389	24.19	23.755
Cultivars					
H08-18	0.723	1.62	14.11	125.99	140.10
H09-23	0.732	1.62	14.59	114.51	129.10
C235	0.704	1.59	10.51	122.16	132.66
HC-1	0.716	1.61	13.12	122.45	135.61
S.E.±	0.029	0.114	0.647	11.278	11.08
C.D. (P=0.05)	NS	NS	1.96	NS	NS
Seed rates					
40kg ha^{-1}	0.713	1.62	13.12	115.29	128.41
50kg ha^{-1}	0.739	1.65	13.71	127.14	140.87
60kg ha^{-1}	0.704	1.59	12.41	121.41	133.82
S.E.±	0.031	0.080	0.625	6.222	6.11
C.D. (P=0.05)	NS	NS	NS	NS	NS

NS= Non-significant

statistically at par with H08-18 and lowest in C235 cultivar (Table 12).

Grain and stover protein of chickpea cultivars:

The data pertaining to grain and stover protein of chickpea cultivars indicate that time of sowing, cultivars and seed rates did not influence protein content in stover of chickpea. But, grain protein content of chickpea cultivars was found significantly higher in early sown as compared to late sown chickpea (Table 13). Grain and stover protein content was not influenced by cultivars. Among different seed rates, 50kg ha^{-1} showed the superiority in grain protein content of chickpea as compared to other two.

N P K status in soil:

Before planting of crop the N P K status in soil was not significantly differ due to time of sowing, cultivars and seed rates. There was no significant difference observed due to time of sowing, cultivars and seed rates on nutrient status of the soil after crop harvesting (Table 14).

Table 13: Effect of sowing time and seed rates on grain and stover protein of chickpea cultivars

Treatments	Grain protein (%)	Stover protein (%)
Date of sowing		
1st fortnight of November	20.65	3.77
1st fortnight of December	20.35	3.64
S.E. ±	0.038	0.100
C.D. (P=0.05)	0.115	NS
Cultivars		
H08-18	20.49	3.72
H09-23	20.61	3.87
C235	20.46	3.64
HC-1	20.43	3.60
S.E. ±	0.054	0.141
C.D. (P=0.05)	NS	NS
Seed rates		
40kg ha^{-1}	20.45	3.74
50kg ha^{-1}	20.62	3.78
60kg ha^{-1}	20.42	3.60
S.E. ±	0.034	0.127
C.D. (P=0.05)	0.099	NS

NS= Non-significant

Table 14 : Effect of sowing time and seed rates on NPK status in soil of chickpea cultivars

Treatments	N (kg ha^{-1})		P_2O_5 (kg ha^{-1})		K_2O (kg ha^{-1})	
	Before	After	Before	After	Before	After
Date of sowing						
1st fortnight of November	184.20	208.42	30.26	35.69	252.68	210.78
1st fortnight of December	190.77	211.26	28.82	41.86	244.79	219.67
S.E.±	8.44	8.44	3.73	3.80	5.19	5.19
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Cultivars						
H08-18	199.76	216.89	33.21	39.69	251.87	217.86
H09-23	191.67	218.80	32.95	39.82	249.10	217.08
C235	182.52	199.65	30.53	37.40	244.94	210.93
HC-1	196.89	204.02	31.30	38.17	251.03	215.02
S.E.±	11.94	11.94	5.27	5.37	7.34	7.34
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Seed rates						
40 kg ha^{-1}	193.07	210.20	32.44	39.31	249.51	215.50
50 kg ha^{-1}	194.14	211.27	33.30	40.17	250.35	216.34
60 kg ha^{-1}	190.92	208.05	30.25	36.83	247.84	213.83
S.E.±	8.97	8.97	1.89	1.89	6.71	6.72
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS

NS= Non-significant

Economics:

Cost of cultivation (*Rs. ha^{-1}*):

The data pertaining to cost of cultivation are presented in Table 15. The data indicate that cost of cultivation was same due to sowing time and genotype, whereas, it was more with higher seed rate than the lower ones.

Gross returns (*Rs. ha^{-1}*):

1st fortnight of November sowing recorded significantly higher gross returns as compared to crop sown on 1st fortnight of December. Cultivars H08-18 recorded significantly higher gross returns and at par with H09-23 compared to other cultivars. Cultivars C235 recorded significantly lowest gross returns followed by HC-1. Gross returns were not significantly differed due to varying seed rates.

Net returns (*Rs. ha^{-1}*):

A significant variation in net returns was also observed due to sowing time and cultivar. 1st fortnight of November sowing resulted in higher net returns compared to delayed crop. Cultivars H08-18 recorded significantly higher net returns and at par with H09-23 compared to other cultivars. Cultivars C235 recorded significantly the lowest net returns followed by HC-1.

Benefit cost ratio:

Significantly higher B:C was recorded in 1st fortnight of November sowing. Among the different cultivars, H08-18 resulted in highest B:C and it was at par with H09-23 compared to other cultivars. B:C was higher with seed rate of 50kg ha^{-1} as compared to other two. More or less similar findings were also obtained by different scientises Akbar *et al.* (2011); Chaitanya and Chandrika (2006) Kumar and Kadian (2006) Kumar *et al.* (2006) Prasad *et al.* (2012) and Yadav *et al.* (2007).

Conclusion :

Current investigation on effect of sowing time and seed rate on growth and yield of chickpea cultivars was conducted during the *Rabi* season at Bhagwant University Farm, Ajmer the soil of experimental field was sandy loam in texture and high pH. Soil tested low in organic carbon and available nitrogen and high in available phosphorus and potassium. The experiment was laid out in a split plot design with two sowing time and cultivars kept in main plots while three seed rates *viz*., 40kg ha^{-1}, 50kg ha^{-1} and 60kg ha^{-1} were kept in subplots and

Table 15 : Effect of sowing time and seed rates on economics of chickpea cultivars

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B: C
Date of sowing				
1st fortnight of November	32750	101,254	68,504	3.09
1st fortnight of December	32750	73,161	40,411	2.23
S.E. ±		1,580	1,581	0.048
C.D. (P=0.05)		4,794	4,794	0.146
Cultivars				
H08-18	32750	91,826	59,076	2.81
H09-23	32750	91,549	58,799	2.79
C235	32750	78,136	45,386	2.39
HC-1	32750	87,320	54,570	2.67
S.E. ±		2,235	2,235	0.07
C.D. (P=0.05)		6,779	6,780	0.21
Seed rates				
40 kg ha^{-1}	31950	85,743	53,793	2.68
50 kg ha^{-1}	32750	89,253	56,503	2.72
60 kg ha^{-1}	33550	86,628	53,078	2.58
S.E. ±		1,251	1,251	0.04
C.D. (P=0.05)		NS	NS	0.11

NS= Non-significant

replicated thrice. All recommended cultural practices and plant protection measures were followed throughout the crop season. The finding of the present investigation is summarized here under. Based on one year data it may be concluded that sowing of chickpea on 1st fortnight of November was found better as compared to 1st fortnight of December in terms of yield attributes and yield of genotypes. Among the various chickpea cultivars, H09-23 produced highest grain yield; however highest gross, net returns and BC ratio was recorded with H08-18. Highest stover yield was recorded with seed rate of 60kg ha^{-1}. Among the various chickpea cultivars, H09-23 sown on 1st fortnight of November recorded relatively higher grain yield which was statistically at par with H08-18 than other cultivars grown. However, in case of delayed sowing chickpea genotype HC-1 should be preferred followed by order H09-23, H08-18 and C235.

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