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Effect of sowing dates and micronutrient on growth and yield of chickpea varieties (*Cicer arietinum* L.) Under changing climatic conditions

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Abstract
The field experiments were conducted at Student Instructional Farm, Department of Agronomy CSAUAT Kanpur, during *rabi* seasons in the year 2017-18 and 2018-19. The objective of investigation was to study the effect of basal application of boron (3.0 kg ha^{-1}) and molybdenum (2.5 kg ha^{-1}) on plant traits (morphological, physiological, phenological, biochemical, yield and its components) of three chickpea varieties under early, timely and late sown condition. It was designed in double split plot design with three replications. The three dates of sowing i.e., Early (D_1), timely (D_2) and late sown (D_3) conditions were allocated in the main plots and three chickpea varieties *i.e.*, V_1 (KWR-108), V_2 (Awarodhi) and V_3 (Radhey) in sub plot and for each plot both chemical treatments were applied as basal at sowing time.
Results revealed that growth in terms of plant height, number of primary branches, yield and its components varied significantly all the treatments during both year of cropping seasons. The results indicated application of boron (@ 3.0 kg ha^{-1}) with three condition of sowing i.e., early (D_1) timely (D_2) and late (D_3) of chickpea crop. Among cultivars, maximum responsive was V_3 (Radhey) in most of traits and gave significantly higher higher value of plant height, number of primary branches, number of seeds plant^{-1}and ultimately higher seed yield (g) plant^{-1} as compared to all other corresponding tested treatments. Among cultivars, maximum responsive was Radhey (V_3) in most of traits and gave significantly higher grain yield (19.24 & 20.17 q ha^{-1}) and followed by KWR-108 (V_1) *i.e*, 17.93 & 18.76 q ha^{-1}, and minimum in Awarodhi (V_2) *i.e*.. 15.96 & 16.76 q ha^{-1} with both is concerning experimental years.

Keywords: Experiments, investigation, seasons, (morphological, replications, yield

Introduction
Pulses occupied an area of about 95.16 million hectares contributing 95.97 metric tonnes of production to the world food basket (FAO, 2020). It is mainly grown in more than 50 countries including India, Pakistan, Turkey, Iran, Myanmar, Australia, Ethopia, Canada, Mexico and Iraq. India shared 36.76 per cent of area and 26 per cent of global pulses production. Thus, India is the largest producer of pulses in the world occupying an area of about 34.99 million ha with total production of 24.21 million tonnes with productivity of 806 kg ha^{-1} (Agricultural Statistics at a Glance, 2019).
Chickpea (*Cicer arietinum* L.) the premier pulse crop of Indian subcontinent, is predominantly consumed as a pulse; dry chickpea is also used in preparation of a variety of snacks, sweets and condiments and green fresh chickpea are commonly consumed as a vegetable. It is one of the most important pulse crop grown in semi-arid and tropical climate. India is the largest chickpea producer as well as consumer in the world. India is a premier chickpea growing country in the world, accounting 76% of total area and production of the world. In India it occupies about 7.58 million ha area with an average production of 10.73 million tonnes and productivity 780 kg ha^{-1}

Experimental details
The experiment was laid out in double split plot design having twenty one treatments combinations which were replicated thrice. The treatments and layout plan have been given in Table (1) respectively.

Treatments

A. Varieties -3 (main-plots)

V_1 - KWR- 108
V_2 - Awarodhi
V_3 - Radhey

B. Micronutrients -2 (sub-plots)

M_1- Molybdenum
M_2-Boron

C. Different date of sowing

D_1- First date of sowing
D_2- Second date of sowing
D_3- Third date of sowing

Table 1: Treatments combinations

S. No.	Treatment	Treatment Combination
1	T_1	$D_1V_1M_1$
2	T_2	$D_1V_1M_2$
3	T_3	$D_1V_2M_1$
4	T_4	$D_1V_2M_2$
5	T_5	$D_1V_3M_1$
6	T_6	$D_1V_3M_2$
7	T_7	$D_2V_1M_1$
8	T_8	$D_2V_1M_2$
9	T_9	$D_2V_2M_1$
10	T_{10}	$D_2V_2M_2$
11	T_{11}	$D_2V_3M_1$
12	T_{12}	$D_2V_3M_2$
13	T_{13}	$D_3V_1M_1$
14	T_{14}	$D_3V_1M_2$
15	T_{15}	$D_3V_2M_1$
16	T_{16}	$D_3V_2M_2$
17	T_{17}	$D_3V_3M_1$
18	T_8	$D_3V_3M_2$

Field preparation

The experimental field was prepared after pre-sowing irrigation for chickpea; the field was prepared following pre-sowing irrigation. At proper moisture condition, first ploughing was done with tractor drawn soil turning plough, followed by two cross harrowing with tractor drawn harrow for both the crops. Planking was done after each ploughing to make the field friable, well levelled and to conserve the moisture for proper germination of the seeds.

Weeding and Intercultural Operations

To maintain the plots weed-free for good crop growth, immediately after sowing pre-emergence herbicide, Pendimethalin @ 1.0 to 1.5 L/acre was sprayed. After that, three manual weeding were carried out in the experimental field. The first weeding was done at the time of thinning *i.e.* a week after emergence. Subsequent weeding was done at 35 and 55 DAS. Other intercultural operations were done as and when necessary.

Seed and sowing

The Chickpea (*Cicer arietinum* L.) was sown on November 01, 2017 and November 10, 2018 with maintaining row to row spacing of 30 cm and plant to plant spacing of 10 cm. The optimum plant population of maize was maintained during both the years by thinning extra plants during seedling emergence. The recommended seed rate @ 75-100 kg ha^{-1} was used for sowing purpose.

Application of fertilizer

The Urea, Di-ammonium phosphate, Muriate of potash and micronutrients (Molybdenum and Boron) fertilizers *i.e.*, were used as a source of N, P, K, Mo and B, respectively. Full dose of P and K was applied as a basal dose amounting 60 and 40 kg per hectare after field preparation. It is well known fact that all the crops belonging to family leguminoseae in general and Fabaceae in particular requiring less amount of fertilizer N due to their biologically active N fixation mechanism. So, less amount of N was supplemented through inorganic sources, it was calculated 40 kg per hectare. In which half of N doses were applied as basal and remaining amount of nitrogen was top dressed at grain filling stage. However, the micronutrients namely Molybdenum and Boron were applied @ 2.5 kg $^{-1}$ and 3.0 kg $^{-1}$, respectively. The N, P_2O_5 and K_2O were given @ 20, 60 and 60 kg ha^{-1}, respectively.

Experimental procedure

Plant height (cm)

The height of the three randomly selected and tagged plants in each net plot were measured at 30, 60, 90 DAS and at maturity stage from ground level to apex of the main axis and average plant height was expressed as cm $plant^{-1}$.

Number of primary branches $plan^{-1}$

The number of primary branches per plant were worked out from the three randomly selected plants and tagged for measurement at 30, 60, 90 DAS and at maturity stage thereafter the average was expressed as number of primary branches $plant^{-1}$

Seed weight $plant^{-1}$

The weight of seeds from tagged plants in each plot was weighed, averaged and expressed as weight of seeds $plant^{-1}$.

Seed yield (q ha^{-1})

The pods collected from the harvested plants of each net plot, thereafter treatment wise in all the three replications were shelled to collect the seeds. The seeds obtained were cleaned, dried and weighed to obtain the seed yield. From this, seed yield ha^{-1} was computed and expressed in q ha^{-1}.

Result and Discussion

Plant height (cm): The data showed on the effect of foliar spray of molybdenum and boron on varieties, sowing dates, and treatments to plant height (cm) at 30, 60, 90 DAS and at maturity in Table 2.

Marked variations in plant height were recorded due to different varieties at all the growth stages during both the years. The mean value of varieties observed significantly higher to plant height with variety V_3 (Radhey) 11.05 and 11.73 cm at 30 DAS, 48.87 and 50.08 cm at 60 DAS, 52.73 and 53.18 cm at 90 DAS, 53.45 and 53.82 cm at maturity followed by variety V_1 (KWR-108) 10.29 and 10.53 cm at 30 DAS, 45.52 and 46.62 cm at 60 DAS, 49.18 and 49.59 cm at 90 DAS, 49.84 and 50.19 cm at maturity. The minimum value observed in variety V_2 (Awarodhi) 9.16 and 9.78 cm at 30 DAS, 40.53 and 41.52 cm at 60 DAS, 43.73 and 44.17 cm at 90 DAS, 44.33 and 44.81 cm at maturity, respectively.

Effect of sowing dates: The mean value of sowing dates to plant height was recorded statistically maximum in the (D_1) with 11.37 and 11.64 cm at 30 DAS, 50.31 and 51.52 cm at 60 DAS, 54.35 and 54.76 cm at 90 DAS, 55.08 and 55.38 cm at maturity followed by (D_2) with 10.13 and 10.36 cm at 30 DAS, 44.79 and 45.89 cm at 60 DAS, 48.32 and 48.76 cm at 90 DAS, 48.97 and 49.42 cm at maturity while, minimum in late sowing date (D_3) with 9.01 and 8.64 cm at 30 DAS, 39.83 and 40.81 cm at 60 DAS, 42.97 and 43.42 cm at 90 DAS, 43.56 and 44.03 cm at maturity stage for both concerning years

Effect of Micronutrients also showed significant variation in plant height at periodic intervals during both the years. Highest plant height recorded (M_2) boron 3.0 kg^{-1} (10.51 and 10.57 cm at 30 DAS, 46.68 and 47.63 cm at 60 DAS, 50.19 and 50.64 cm at 90 DAS, 50.87 and 51.28 cm at maturity) However, least plant height was recorded under (M_1) molybdenum 2.5 kg^{-1} *i.e.* 9.83 and 9.86 cm at 30 DAS, 43.67 and 44.52 cm at 60 DAS, 46.89 and 47.32 cm at 90 DAS, 47.54 and 47.94 cm at maturity stage of chickpea crop during both the years.

The interactive effect of varieties, dates of sowing and micronutrients was found to be non-significant.

Table 2: Effect of varieties, dates of sowing and micronutrients on plant height (cm) of chickpea at 30, 60, 90 DAS and at maturity stage

Treatment	30 DAS 2017-18	60 DAS 2017-18	90 DAS 2017-18	Harvest time 2017-18	30 DAS 2018-19	60 DAS 2018-19	90 DAS 2018-19	Harvest time 2018-19
Varieties								
KWR-108	10.29	45.52	49.18	49.84	10.53	46.62	49.59	50.19
AWARODHI	9.16	40.53	43.73	44.33	9.78	41.52	44.17	44.81
RADHEY	11.05	48.87	52.73	53.45	10.73	50.08	53.18	53.82
SE(d)	0.25	0.92	1.03	1.22	0.29	0.99	1.13	1.37
CD (0.05)	0.53	1.99	2.34	2.66	0.63	2.17	2.45	2.99
Date of sowing								
1 November	11.37	50.31	54.35	55.08	11.64	51.52	54.76	55.38
10 November	10.13	44.79	48.32	48.97	10.36	45.89	48.76	49.42
20 November	9.01	39.83	42.97	43.56	8.64	40.81	43.42	44.03
SE(d)	0.34	1.09	1.37	1.71	0.41	1.22	1.57	1.92
CD (0.05)	0.95	3.04	3.79	4.74	1.14	3.39	4.36	5.31
Micronutrient								
Molybdenum	9.83	43.67	46.89	47.54	9.86	44.52	47.32	47.94
Boron	10.51	46.68	50.19	50.87	10.57	47.63	50.64	51.28
SE(d)	0.33	0.85	1.09	1.33	0.33	0.97	1.19	1.43
CD (0.05)	0.68	1.77	2.31	2.79	0.68	2.04	2.52	3.01

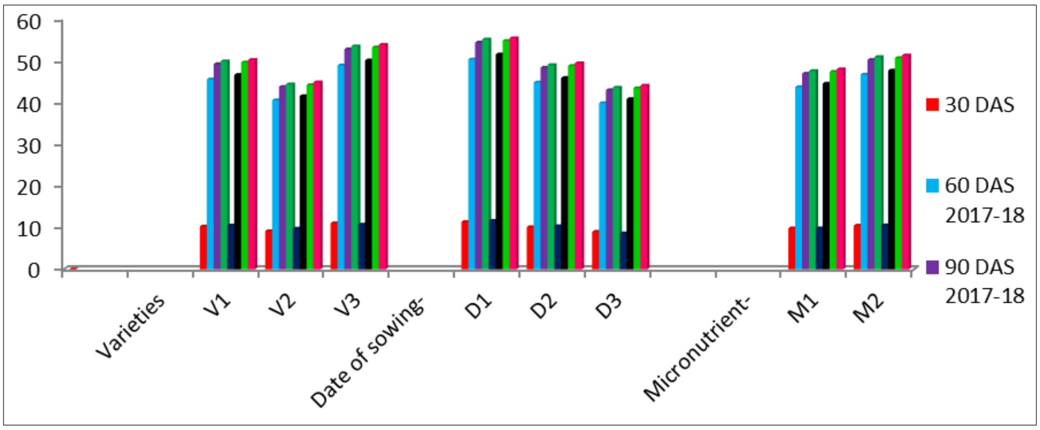

Fig 1: Effect of varieties, dates of sowing and micronutrients on plant height (cm) of chickpea at 30, 60, 90 DAS and at maturity stage

Number of primary branches $plant^{-1}$

Number of primary branches per plant were recorded at 30, 60, 90 DAS and at harvest time and the data obtained are presented in Table 3. The number of primary branches showed increasing trend up to maturity.

Among the different varieties variations in number of primary branches were recorded at all the growth stages during both the years. The mean value of varieties observed significantly higher to number of primary branches with variety V_3 (Radhey) 5.42 and 5.56 at maturity stage followed by variety V_1 (KWR-108) 5.05 and 5.16 the least value of number of primary branches observed in variety V_2 (Awarodhi) 4.53 and 4.67 during cropping seasons, respectively.

In case of date of sowing the higher number of primary branches found (D_1) with 5.57 and 5.69 followed by (D_2) with 4.98 and 5.11 the lowest number of primary branches 4.45 and 4.58 in (D_3) at maturity stage during 2017-18 and 2018-19.

In case of micronutrients, (M_2) Boron @ 3.0 kg^{-1}) recorded significantly higher number of branches plant^{-1} (5.17 and 5.32) followed by (M_1) molybdenum @ 2.5 kg^{-1} (4.83 and 4.95**)** at harvest stage during both the years of investigations Similar trend was observed at 30, 60 and 90 DAS during both the concern of years.

The interaction effect of varieties, dates of sowing and micronutrients was found to be non-significant at all the stages.

Table 3: Effect of varieties, dates of sowing and micronutrients on number of primary branches plant^{-1} of chickpea at 30, 60, 90 DAS and at maturity stage

Treatment	30 DAS 2017-18	60 DAS 2017-18	90 DAS 2017-18	Harvest time 2017-18	30 DAS 2018-19	60 DAS 2018-19	90 DAS 2018-19	Harvest time 2018-19
Varieties								
KWR-108	2.57	4.64	4.78	5.05	2.62	4.76	4.91	5.16
AWARODHI	2.28	4.14	4.25	4.53	2.33	4.26	4.39	4.67
RADHEY	2.78	4.99	5.13	5.42	2.81	5.14	5.29	5.56
SE(d)	0.08	0.17	0.18	0.19	0.09	0.16	0.19	0.19
CD (0.05)	0.18	0.37	0.39	0.39	0.19	0.35	0.39	0.41
Date of sowing								
1 November	2.83	5.13	5.26	5.57	2.89	5.26	5.42	5.69
10 November	2.52	4.57	4.69	4.98	2.58	4.70	4.86	5.11
20 November	2.24	4.08	4.19	4.45	2.29	4.19	4.32	4.58
SE(d)	0.11	0.23	0.26	0.28	0.13	0.21	0.27	0.27
CD (0.05)	0.31	0.62	0.73	0.76	0.35	0.58	0.74	0.73
Micronutrient								
Molybdenum	2.45	4.44	4.56	4.83	2.49	4.51	4.70	4.95
Boron	2.62	4.74	4.87	5.17	2.67	4.93	5.03	5.32
SE(d)	0.08	0.13	0.15	0.16	0.09	0.19	0.15	0.17
CD (0.05)	0.16	0.26	0.33	0.33	0.17	0.39	0.31	0.35

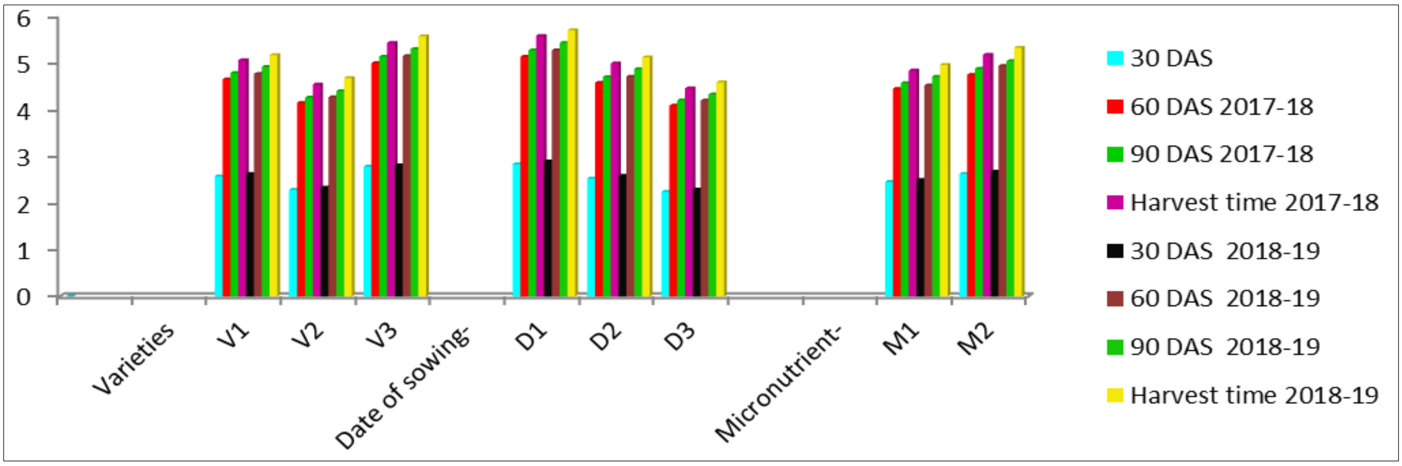

Fig 2: Effect of varieties, dates of sowing and micronutrients on number of primary branches plant^{-1} of chickpea at 30, 60, 90 DAS and at maturity stage

Number of pods plant^{-1}

The observations regarding total number of pods plant^{-1} is the most important component amongst the yield attributing characters. Different varieties, dates of sowing and micronutrients significantly affected the number of pods plant^{-1}. The data have been presented in Table 4. Maximum number of pods plant^{-1} recorded in second year as compared to first year in the treatments imposed.

The data showed that significantly higher number of pods plant^{-1} (49.22 and 51.60) was produced with variety V_3 (Radhey). The second-best improvement number of pods plant^{-1} (45.86 and 47.99) was recorded with variety V_1 (KWR-108). The lowest number of plant^{-1} (40.84 and 42.81) was recorded in V_2 (Awarodhi), respectively.

The result also showed that significantly higher number of pods plant^{-1} (50.68 and 53.12) was noted in date of sowing (D_1) which was statistically at par with date of sowing (D_2) over date of sowing (D_3) during both the year of investigations. However, least number of pods plant^{-1} (40.12 and 42.04) was observed with date of sowing (D_3) during both the experimental years.

Statistically, M_2 (boron @ 3.0 kg ha^{-1}) recorded significantly higher number of pods plant^{-1} (46.84 and 49.08) during both the experimental years. However, minimum number of pods plant^{-1} (43.78 and 45.86) was observed with M_1 (molybdenum @ 2.5 kg ha^{-1}).

The combined effect of varieties, dates of sowing and micronutrients was found to be non-significant

Table 4: Effect of varieties, dates of sowing and micronutrients on number of pods plant^{-1} of chickpea

Treatment	2017-18	2018-19
Varieties		
KWR-108	45.86	47.99
AWARODHI	40.84	42.81
RADHEY	49.22	51.60
SE(d)	0.94	1.07
CD (0.05)	2.04	2.33
Date of sowing		
1 November	50.68	53.12
10 November	45.12	47.26
20 November	40.12	42.04
SE(d)	1.32	1.49
CD (0.05)	3.65	4.16
Micronutrient		
Molybdenum	43.78	45.86
Boron	46.84	49.08
SE(d)	1.12	1.23
CD (0.05)	2.35	2.58

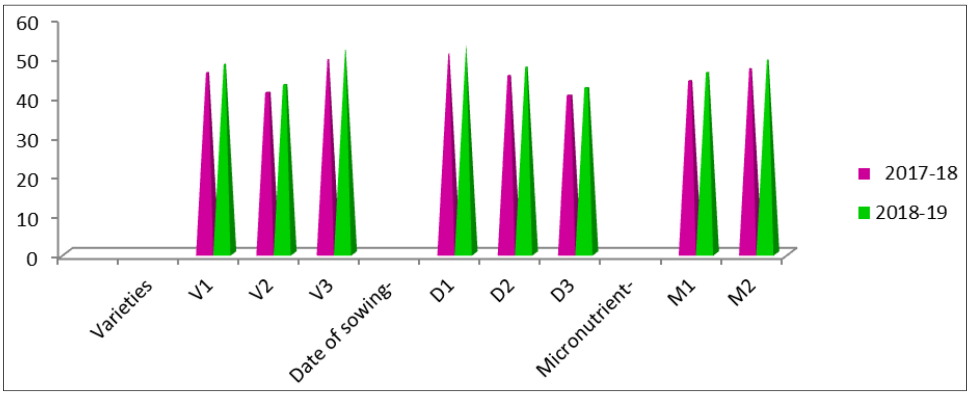

Fig 3: Effect of varieties, dates of sowing and micronutrients on number of pods plant^{-1} of chickpea.

Seed yield (q ha^{-1})

Seed yield is a function of various growth and yield attributing parameters like dry weight, number of branches, number of pods plant^{-1}, number of seeds pod^{-1} and seed weight plant^{-1}. It is the most important parameter to compare effectiveness of different treatments. Influence of varieties, dates of sowing and micronutrients on seed yield are depicted in Table 5. Effect of varieties: Significantly higher seed yield of chickpea (19.24 and 20.17 q ha^{-1}) was recorded with variety V_3 (Radhey) which was statistically at par with V_1 (KWR-108) than V_2 (Awarodhi) during both the concern years, respectively.

In case of different dates of sowing, (D_1) recorded significantly higher seed yield of chickpea (19.81 and 20.76 q ha^{-1}). Followed by date of sowing (D_2) seed yield of chickpea with (17.64 and 18.47 q ha^{-1}) during both the years. However, lowest seed yield of chickpea (15.68 and 16.42 q ha^{-1}) was noted with date of sowing (D_3) during both the concern years.

Application of micronutrients also caused significantly influenced on seed yield of chickpea, M_2 (boron @ 3.0 kg ha^{-1}) recorded higher seed yield of chickpea (18.30 and 19.18 q ha^{-1}). However, least seed yield of chickpea (17.12 and 17.92 q ha^{-1}) were observed with M_1 (molybdenum @ 2.5 kg ha^{-1}) during both the year of investigations.

The interaction effect of varieties, dates of sowing and micronutrients was found to be non-significant.

Straw yield (q ha^{-1})

The data regarding straw yield are presented in Table 5, revealed that straw yield of chickpea followed a similar trend of observations as observed in respect of seed yield with varieties, dates of sowing and application of micronutrients during 2017-18 and 2018-19.

Results revealed that significantly higher (21.07 and 21.88 q ha^{-1}) straw yield of chickpea was recorded with variety V_3 (Radhey) which was statistically at par with V_1 (KWR-108) over V_2 (Awarodhi) during both the experimental years.

Screening of the data also influenced straw yield of chickpea significantly. Significantly higher straw yield of 21.78 and 22.22 q ha^{-1} was observed with date of sowing (D_1) followed by date of sowing D_2 (19.78 and 20.24 q ha^{-1}) However, minimum straw yield was observed with date of sowing (D_3) 17.88 and 18.65 q ha^{-1}. During both *rabi* season, 2017-18 and 2018-19, respectively.

Statistically, the highest straw yield was recorded when boron was applied @ 3.0 kg ha^{-1} (20.32 and 20.90 q ha^{-1}) and lowest value was found when molybdenum was applied @ 2.5 kg ha^{-1} (19.30 and 19.83 q ha^{-1}) during both the year of experimentation.

The interaction data reveal that the non-significant effect of varieties, dates of sowing and micronutrients during both the year of experimentation.

Table 5: Effect of varieties, dates of sowing and micronutrients on seed yield and straw yield (q ha^{-1}) of chickpea

Treatment	Seed yield (q ha^{-1})		Straw yield (q ha^{-1})	
	2017-18	2018-19	2017-18	2018-19
Varieties				
KWR-108	17.93	18.76	20.14	20.53
AWARODHI	15.96	16.73	18.25	18.72
RADHEY	19.24	20.17	21.07	21.88
SE(d)	0.34	0.45	0.66	0.72
CD (0.05)	0.74	0.98	1.44	1.57
Date of sowing				
1 November	19.81	20.76	21.78	22.22
10 November	17.64	18.47	19.78	20.24
20 November	15.68	16.42	17.88	18.65
SE(d)	0.52	0.68	0.84	0.90
CD (0.05)	1.44	1.88	2.32	2.52
Micronutrient				
Molybdenum	17.12	17.92	19.30	19.83
Boron	18.30	19.18	20.32	20.90
SE(d)	0.44	0.54	0.48	0.49
CD (0.05)	0.90	1.13	1.02	1.05

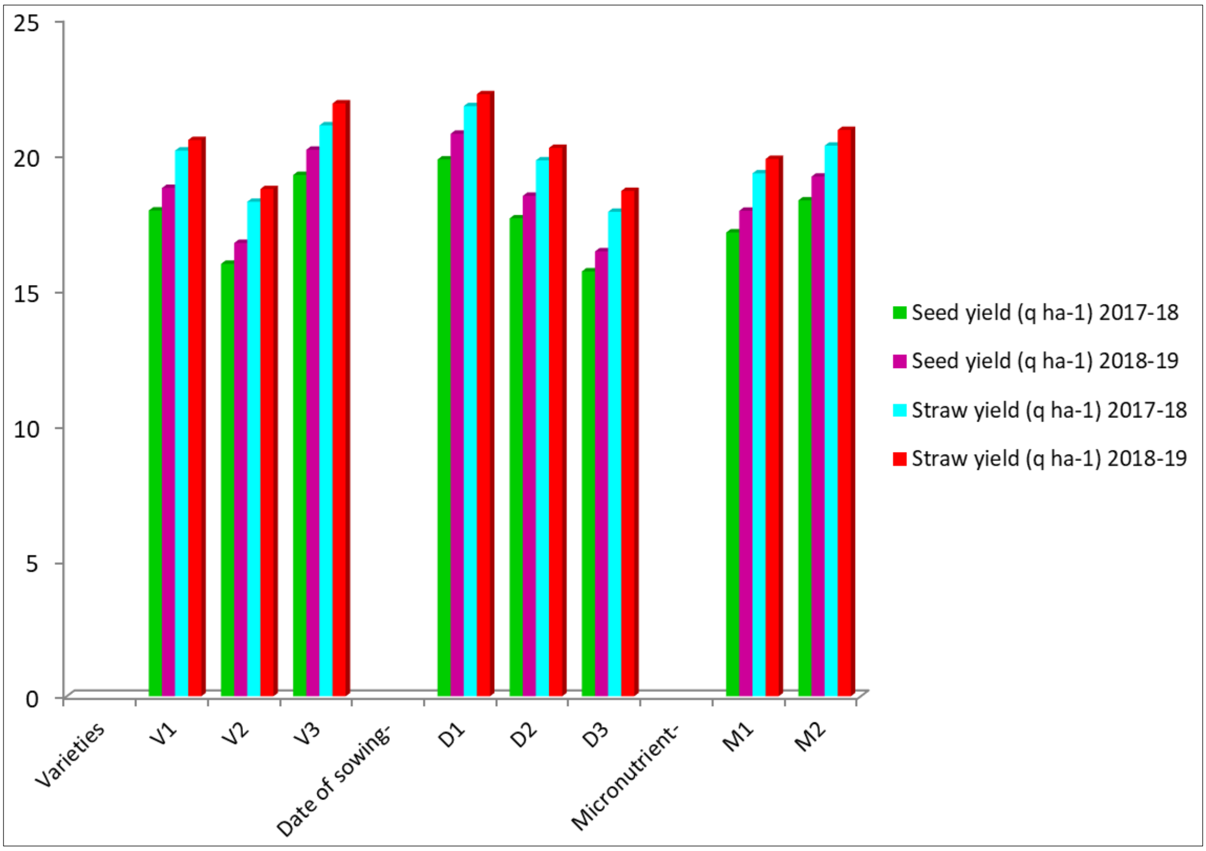

Fig 4: Effect of varieties, dates of sowing and micronutrients on seed yield and straw yield (q ha-1) of chickpea

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