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Effect of Sowing Dates on Yield and Yield Components of Some Selected Chickpea (*Cicer arietinum* L.) Varieties

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Authors' contributions

This work was carried out in collaboration and equal contribution between both authors, we do not wish take any special credit for any work. This research was done primarily to enhance chickpea production and productivity in Ethiopia which has a significant role in ensuring food and nutritional security among a large starving and malnourished population. Moreover, we would like to add to the research literature and knowledge base for the benefit of students and researchers working in these regions where there is substantial shortage of quality literature as well as research potential. Both authors read and approved the final manuscript.

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ABSTRACT

Most suitable sowing date and high yielding varieties are the primary agricultural practices to enhance production and productivity of chickpea. Hence, a field experiment was carried out to evaluate the effect of sowing dates on yield and yield components of chickpea varieties in the main cropping season of 2019 at Toke Kutaye, Ethiopia. Treatments consisted of four sowing dates (September 4th, September 14th, September 24th, and October 5th) and four kabuli varieties of chickpea; namely Dube (standard check), Dalota, Teji and Ejere. The experiment was laid out in split plot design using factorial arrangement with three replications where sowing date treatments were assigned to the main plots and varieties to sub plots. Dalota variety produced the highest number of pods (79.7) per plant. the main effects of sowing date and varieties were significantly different on biological yield. Highest biological yield (3776.9 kg ha^{-1} and 3761 kg ha^{-1}) were recorded from September 24th and September 14th sown plots, respectively. Among varieties tested, the highest biological yield (3723.8 kg ha^{-1}) was obtained from local variety. Highest grain yield (2415.4 kg ha^{-1}) was recorded from plots sown on September 14th whereas Dalota variety

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produced highest grain yield (2051.25 kg ha^{-1}). In case of harvest index, highest (67.9% and 59.6%) was recorded from September 14th sown plots and Dalota variety, respectively. Therefore, Dalota variety and September 14th sowing date emerged as best among all tested treatments and could be recommended for chickpea production in the study area.

Keywords: Chickpea; sowing dates; yield components and yield.

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the third largest food legume globally in terms of production, after common bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.). In Ethiopia, chickpea is one of the most important pulses grown widely over an area of 178,000 ha with more than 4 milion quintal production and productivity of 21 quintal per hectare across the highlands and semi-arid regions of the country [1].

Ethiopia is the largest producer of chickpea in Africa accounting for about 46% of the continent's production [2]. The total area covered by chickpea in Ethiopia is estimated 258,486.29 ha and from which annual production of 472,611.39 ton of chickpea grain is produced [3]. About 85% of Ethiopian chickpea production is predominated by Desi type. However, in recent years there has been an increase in the interest of farmers in growing large seeded Kabuli type varieties due to their higher price in the market.

Lack of viable seed supply system has affected the availability of improved Kabuli and Desi types of chickpea to smallholder producers. The national average yields of chickpea in Ethiopia under farmers' production condition remains less than 2.1 tons per hectare [1]. On the other hand, the potential of the crop under improved management condition is more than 3 tons per hectare. It is crucial to examine the differential performance of chickpea varieties when subjected to different levels of management regimes such as sowing dates. Among the limitations in chickpea production water logging and drought are critical. In tropical region, the climate is hot with summer rainfall, chickpea is conventionally seeded in spring; therefore, the crop faces high temperature and water stress towards maturity which resulted in low and variable yields.

To overcome the effect of high temperature, adjustments in sowing dates could be used as a strategy to increase chickpea production. Time of sowing will depend on the interaction of environment and the available varietal germplasm. The main reason of chickpea flower abortion has been reported when mean daily temperature is less than 15^{0}C. Flower development is a crucial stage because fluctuation in environment affects it, which ultimately influences crop production. Flowering initiation in chickpeas is dependent on photo-thermal reaction, which is the main determinant. The optimum sowing date results in timely initiation of flowering by minimizing threats of cold temperatures which could retard the growth of chickpea plants. Early sowing of chickpea could expose it to heavy rainfall which results in lodging, diseases occurrence, and moisture deficit during grain fill stage. Late sowing could effect on plant height which may reduce vegetative cover and water use efficiency and increase the incidence of insects. Sowing time and high yielding varieties are two important factors which could affect the growth and yield of chickpea. The most vital step towards enhancing yield of chickpea is to ensure that the phenology of the crop is well in line to resources and constraints of the production environment [4].

2. MATERIALS AND METHODS

A field experiment was conducted at Toke Kutaye District in Nega-file kebele on farmer's field during September, 2019 to November, 2019 under rain fed conditions of the main cropping season. The area is located at about 137 km west of Addis Ababa and 12 km from Ambo town. It lies between 8^{0}58'N 37^{0}46E latitude and 8.967^{0}N 37.767^{0}E longitude. The dominant soil types of the district are red (48%), grey (25%), clay loam (5%) and black (26%), while the study area has a soil of vertisol. The study site is located at an altitude of about 2168 *m.a.s.l.* The total annual rainfall of the study area in 2019 was 950 mm with the minimum and maximum temperature 10^{0}C and 30^{0}C, respectively. Onset of rainfall in the district occurs normally in April and extends up to mid-October during crop growing period.

Four Kabuli types of chickpea varieties namely *Dalota, Ejere, Teji and Dube (local check)* used for this experiment were obtained from Debre Zeyit Agricultural Research Center (DZARC). The treatments consisted of two factor factorial arranged in split-plot design with four sowing dates (*September 4th, September 14th, September 24th, and October 5th*) in main plot and four Kabuli chickpea varieties (*Dalota, Teji, Ejere and one Dube/local check*) distributed in sub-plots with each treatment replicated three times. Plot size of each plot was 2m x 3m ($6m^2$). Spacing of 0.5 m and 1 m were allocated between plots and blocks, respectively.

2.1 Data Collection, Measurement and Recording

Number of pods per plant: This was recorded by counting the total number of pods of ten randomly taken plants and the average was recorded.

Biological yield/Above ground dry biomass yield (kg ha^{-1}): This was determined by drying and uprooted the above ground biomass from the whole net plot area in an open air (including the seed yield) and weighed using spring balance.

Hundred seed weight (g): This was counted by taking sample seeds randomly per net plot area at harvest and the weight of hundred seeds was taken and adjusted to 10% moisture level.

Grain yield/ Seed yield (kg ha^{-1}): Seeds harvested from the net plot area were dried for 5 - 6 days in sun and were cleaned, weighed and converted in to seed yield in $kgha^{-1}$. The weight was adjusted to 10% moisture level.

Harvest index%: Harvest index% was computed as the ratio of seed yield to biomass yield.

2.2 Statistical Analysis

All the data collected were analyzed using SAS software. Further analysis was carried out as per need using appropriate statistical packages and using statistical procedures out lined by Gomez and Gomez. Least significance difference (LSD) was used for the mean comparison both at 1% and 5% probability level.

3. RESULTS AND DISCUSSION

3.1 Number of Pods per Plant

Analysis of variance table depicted that the main effect and interaction effect of sowing date and varieties exhibited significant differences ($P<0.05$) regarding number of pods $plant^{-1}$ (Table 1). The maximum number of pods $plant^{-1}$ (79.7) were recorded from Dalota when planted during second week of September (September 14th) whereas the lowest number of pods $plant^{-1}$ (31.7 and 34.3) were recorded from Teji variety when planted during the second week of September (14th) and first week of September (4th), respectively (Table 1). Similarly, Ejere variety produced the lowest number of pods per plant (34.3 and 34.7) when sown during third week and first week of September (September 24th and September 4th), respectively which was statistically at par with Teji variety (Table 1). This might be due to the fact that suitable weather condition favors growth and development of plants which leads to higher number of pods $plant^{-1}$ as compared to adverse conditions under delayed sowing which results in reduced growth and yield. Similar results were also reported by Shamsi et al. [5] who noted showed that varietal differences had substantial influence on number of pods $plant^{-1}$. Ideal weather condition favors better growth and development of plants which leads to more number of pods $plant^{-1}$ as compared to moisture stress due to delayed sowing resulting in poor growth and productivity. The beneficial effect of early sowing on higher pods $plant^{-1}$ was also reported by Felton et al., [6].

3.2 Hundred Seed Weight

Analysis of variance depicted significant ($P< 0.01$) differences among the main effect and interaction effects of sowing dates and varieties on hundred seed weight of chickpea (Table 2). Among different sowing time, it was clear from the means that significantly higher 100 seed weight was recorded in Dalota variety sown during 2nd week of September (34.4 and 33.8 g) followed by Ejere variety sown during second week of September (Table 2). Minimum 100 seed weight was recorded from chickpea sown during 1st week of October which was significantly different as compared to other sowing dates. The 100-seed weight which was an important yield component was favorably influenced due to sowing dates. Timely sowing provides favorable weather condition for growth and development of seeds leading to bolder and heavy seeds. Similar findings were previously reported by Parihar [7] who reported that minimum hundred seed weight was obtained from early sowing dates. On an average, all the varieties produced heavier 100 seed weight when sown during the third week of September.

Table 1. Main effect and interaction effect of sowing dates and varieties on number of pods per plant of chickpea during 2019/20 cropping season

Treatments	September 4th	September 14th	September 24th	October 5th	Means
Dube/standard	49.7^{ef}	54.0^{de}	57.7^{cd}	36.0^{hi}	49.33^{b}
Dalota	71.0^{b}	79.7^{a}	63.9^{c}	54.7^{de}	67.31^{a}
Teji	34.3^{i}	31.7^{i}	44.3^{fg}	50.0^{ef}	40^{c}
Ejere	34.7^{i}	42.3^{gh}	34.3^{i}	36.33^{hi}	36.9^{c}
Mean	47.4^{bc}	51.9^{a}	50.1^{ab}	44.3^{c}	
LSD (0.05)	7.04				
CV	8.4				

CV=Coefficient of variance, LSD=Least Significant Difference, NS=Non-significant. Values with the different letter (s) in a column are significantly different at 5% probability level

Table 2. Interaction effect of sowing dates and varieties on hundred seed weight of chickpea during 2019/20 cropping season

Treatments	September 4th	September 14th	September 24th	October 5th	Mean
Dube/Local	28.2^{cde}	28.5^{cde}	28.5^{cde}	24.3^{e}	27.4^{c}
Dalota	32.8^{ab}	34.4^{a}	32.8^{ab}	30.5^{abc}	32.63^{a}
Teji	33.4^{ab}	30.9^{abc}	31.3^{abc}	30.8^{abc}	31.64^{ab}
Ejere	25.7^{de}	29.3^{bcd}	33.8^{a}	32.2^{abc}	30.25^{b}
Mean	30.1^{a}	30.8^{a}	31.5^{a}	29.5^{a}	
LSD (0.05)	4.2				
CV	8.2				

CV=Coefficient of Variation, LSD=Least Significant Difference, NS= Non-significant. Values with the different letter (s) in a column are significantly different at 5% probability level

3.3 Biological Yield (kg ha-1)

Sowing dates and varieties, and their interaction showed highly significant (P<0.01) effect on biological yield of chickpea in this study (Table 3). The maximum biological yield (5304.2 and 4843.3 Kg ha^{-1}) were recorded when chickpea varieties were sown during first week of October and second week of September for Dube (local check) and Ejere variety, respectively. However, the least biological yield (2162.5 Kg ha^{-1}) was recorded from late sown (October 5th) from Ejere variety but statically non-significant variations were recorded when chickpea planted on September 4th for Dube/local check and Teji September 14th for Dalota, and October 5th for Teji verities, respectively.

3.4 Grain Yield

Grain yield showed significant differences (P< 0.05) among sowing dates and varieties, and their interactions (Table 4). The maximum grain yield (2415.42 Kg ha^{-1}) was recorded from plots sown during second week of September (September 14th), while the minimum grain yield (1448.5 Kg ha^{-1}) was recorded from first week of September sown plots (Table 4). Similar results were reported by Ozdemir and Karadavut [4] from chickpea sown on 14th September producing highest grain yield. Chaitanya and Chandrika [8] reported that lower 100-seed weight and seed yield from early and late spring sowing dates due to flowering and fertilization stages occurring under high variation in temperatures, water logging and moisture stress. Saxena and Singh [9] reported overall higher yields produced from the 14th and 24th September sown chickpea, as compared to the 4th September and 5th October sown crop due to favorable growing periods. During extremely low temperatures, frost could be harmful for late-spring sowing due to its occurrence during the early stages of vegetative growth. Early spring sowing usually allows the crop to escape ill effects of frost, unless there was a late frost. Autumn-sown chickpea may face water shortages in the later part of the crop's growth. Shamsi et al. [5] also reported highest grain yields due to timely sown chickpea in their studies.

The highest grain yield was recorded from Dalota variety (2051.25 Kg ha^{-1}) whereas lowest seed yield was recorded from the Ejere variety (1690.62 Kg ha^{-1}) (Table 4). This finding is in accordance with the findings of Sadeghipour and Aghaei [10], who reported that sowing date and varietal difference could affect grain yield.

Table 3. Interaction effect of sowing dates and varieties on biological yield of chickpea during 2019/20 cropping season

Treatments	September 4th	September 14th	September 24th	October 5th	Mean
Dube/Local	2512.5gh	3685.0de	4521.9bc	5304.2a	4005.9a
Dalota	3729.2de	2249.2h	2925.0fg	4427.1bc	3332.6b
Teji	2332.5gh	4266.7bcd	3952.5cde	2380.2gh	3233.0b
Ejere	3404.2ef	4843.3ab	3708.3de	2162.5h	3529.6b
Mean	2994.6b	3761.0a	3776.9a	3568.5a	
LSD(SD)	301.83				
LSD (SD*V) (0.05) 606.5					
CV	10.16				

CV=Coefficient of Variation, LSD=Least Significant Difference. Values with the different letter (s) in a column are significantly different at 5% probability level

Table 4. Interaction effect of sowing sates and varieties on grain yield (Kg ha^{-1}) of chickpea during 2019/20 cropping season

Treatments	September 4th	September 14th	September 24th	October 5th	Mean
Dube/Local	1904.2e	1766.7ef	1412.5gh	2544.8b	1907.03b
Dalota	1195.8hi	2231.7cd	2360.8bc	2416.7bc	2051.25a
Teji	1128.3i	3311.7a	1965.0de	1167.5hi	1893.13b
Ejere	1565.8fg	2351.7bc	1837.5ef	1007.5i	1690.62c
Mean	1448.54c	2415.42a	1893.96b	1784.11b	
LSD(0.05)	136.94				
LSD (SD*V) (0.05) 273.72					
CV (%)	8.62				

CV=Coefficient of Variation, LSD=Least Significant Difference. Values with the different letter (s) in a column are significantly different at 5% probability level

3.5 Stover Yield

Stover yield showed significant differences (P<0.05) among varieties, and their interactions. However, sowing dates had no significant effect on stover yield (Table 5). The maximum stover yield (2887.5 Kg ha^{-1}) was recorded from plots sown during first week of October (October 5th) from Dube (local check) variety which was at par with Ejere (2491.7) when planted on September 14th (Table 5). While the minimum stover yield (482.5 Kg ha^{-1}) was recorded from Dalota variety when planted on September 14th which was at par with Teji (955.0 kg/ha) planted on the same day.

3.6 Harvest Index (%)

Analysis of variance revealed that the main effect of variety had significant (P< 0.01) difference among varieties and sowing dates on harvest index and their interactions (Table 6). The effect of sowing dates depicted significant difference (P<0.01) on harvest index of chickpea. The highest harvest index (67.89%) was recorded from chickpea sown during second week (September 14th) whereas the lowest harvest index was recorded (48.19%) from the plot sown during first week September (early sowing) followed by 49.77% harvest index from third week of sown chickpea (September 24th) and October 5th sown crop which were statistically at par with first sowing date (Table 6).

Dalota variety produced the highest harvest index (59.6%) which was statistically at par with Teji (57.1%) while the lowest harvest index (47.8%) was recorded from Ejere variety which were statistically similar (51.53%) to Dube (local check) variety (Table 6). Shamsi et al. [5] reported highly significant difference in harvest index due to sowing dates and genotype interactions. Overall poor yield of the chickpea varieties might be due to the higher evaporation rate and depletion of soil moisture over time as there was no substantial rainfall during the growing period. The difference in seed y ield might be due to variation in genetic make-up of the varieties.

Table 5. Interaction effect of sowing dates and varieties on stover yield (kg ha^{-1}) of chickpea during 2019/20 cropping season

Treatments	September 4th	September 14th	September 24th	October 5th	Mean
Dube/Local	1316.7^{e-h}	1453.3^{d-h}	2161.1^{bc}	2887.5^{a}	1954.7^{a}
Dalota	1825.0^{c-g}	482.5^{i}	1512.5^{c-h}	1882.3^{b-e}	1425.6^{b}
Teji	1204.2^{fgh}	955.0^{hi}	1987.5^{bcd}	1212.7^{fgh}	1339.8^{b}
Ejere	1838.3^{b-g}	2491.7^{ab}	1870.8^{b-f}	1155.0^{h}	1839.0^{a}
Mean	1546.0^{bc}	2415.42^{a}	1345.6^{c}	1784.4^{ab}	
LSD(SD)	136.94				
LSD(V)	310.8				
LSD (SD*V) (0.05)	658.22				
CV	24.0				

CV=Coefficient of Variation, LSD=Least Significant Difference NS=Non-significant. Values with the different letter (s) in a column are significantly different at 5% probability level

Table 6. Interaction effect of sowing dates and varieties on harvest index of chickpea during 2019/20 cropping season

Treatments	September 4th	September 14th	September 24th	October 5th	Mean
Dube/Local	39.8^{fg}	60.73^{b}	52.34^{bc}	65.7^{b}	51.54^{bc}
Dalota	50.89^{bc}	81.45^{a}	40.3^{gh}	57.57^{bc}	59.56^{a}
Teji	71.3^{ab}	80.81^{a}	49.77^{bc}	59.36^{b}	57.06^{ab}
Ejere	30.8^{i}	48.57^{bc}	84.9^{a}	27.03^{i}	47.83^{c}
Mean	48.19^{c}	67.89^{a}	61.31^{b}	49.92^{c}	
LSD(SD)	136.94				
LSD(V)	6.68				
LSD (SD*V) (0.05)	14.87				
CV	22.5				

CV=Coefficient of Variation, LSD=Least Significant Difference, NS=Non-significant. Values with the different letter (s) in a column are significantly different at 5% probability level

4. CONCLUSIONS

To sum-up the main findings of this study, the result showed that mid-spring (September 14) sowing improved the productivity of chickpea as compared to early and late sowing. Nonetheless, early spring sowing date (September 4) resulted in plant lodging and flowering under low temperatures resulting in low yield. Late sowing date (October 5) resulted in lower growth and yield of chickpea due to frost damage and exposure to moisture stress. Among the tested verities, Dalota variety produced the highest grain yield and found suitable for Toke Kutaye and similar agro-ecologies. But, this finding based on one season requires confirmation with further studies over years and different chickpea varieties to suggest a valid recommendation. Hence, Dalota variety and September 14th sowing date emerged as best among all tested treatments and could be recommended for chickpea production in the study area. Conclusive recommendation could be drawn by the repeated trials at more locations and seasons in the future.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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