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Performance of Chickpea Varieties Based on Growth and Yield Parameters Influenced by Different Sowing Dates at Toke Kutaye District, Ethiopia

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Authors' contributions

This work was carried out in collaboration and equal contribution among all 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. All authors read and approved the final manuscript.

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ABSTRACT

One of the basic agronomic practices to improve the yield of chickpea are ideal sowing date and high yielding varieties. Thus, a field experiment was conducted to assess the effect of different sowing dates on yield and yield components of chickpea varieties in the main cropping season of 2019 at Toke Kutaye District. Four sowing dates (September 4th, September 14th, September 24th, and October 5th) and four kabuli varieties. Four Kabuli types of chickpea varieties were Dalota, Ejere, Teji and Dube (local check). Experiment was laid out in split plot design using factorial arrangement with three replications and sowing date treatments were assigned to the main plots and varieties to sub plots. The main effect of sowing date showed highly significant effect on days to emergence, days to 50% flowering and physiological maturity. Highest days to emergence (12.4 days) were recorded from a plot sown on October 5th, while longest days to 50% flowering (54.92 days) and physiological maturity (122.5 days) were recorded from a plot sown on September 14th. Moreover, varieties had significant effect on days to physiological maturity of chickpea. Longest

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days to physiological maturity (133 days) were recorded from local variety and early days to physiological maturity (113.3 days) was recorded from Dalota variety. The main effects of sowing date and variety were significant on plant height, as the tallest plant height (42.75 cm) was recorded from September 24th sown plants. Similarly, the tallest (41.42 cm) plant was recorded from Dalota variety. In addition, the highest number of primary branches (6.83) and secondary branches (16.42) per plant were recorded from Dalota variety, while the lowest number of primary branch (5.5) and secondary branches (8) were scored from Ejere and Teji varieties, respectively. Highest grain yield (2415.4 kg ha^{-1}) was obtained from plots sown on September 14th whereas Dalota variety produced highest grain yield (2051.25 kg ha^{-1}). Hence, Dalota variety and September 14th sowing date emerged as best among all tested treatments and can be recommended for chickpea production in the study area and similar agro-ecologies. Conclusive recommendation could be obtained if the study is repeated at more locations and seasons in the future.

Keywords: Chickpea; sowing dates; varieties; and Yield.

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is cultivated mostly in the Mediterranean basin, the Near East, Central and South Asia, East Africa, South America, North America and, more recently, in Australia. It accounts for 12% of the world's pulse crop production. The Asian region contributes 70% to the total world's chickpea production. Chickpea (*Cicer arietinum* L.) is the second most important cool season food legume crop after common bean (*Phaseolus vulgaris* L.) followed by field pea (*Pisum sativum*) and third in production among the food legumes grown worldwide. In Ethiopia it is one of the most important pulses grown widely over an area of 178,000 ha with more than 4 million quintals production and productivity of 21 quintal per hectare across the highlands and semi-arid regions of the country [1].

Based on differences in seed types, the cultivated chickpeas are distinguished as Desi and Kabuli types. The Desi types have small darker multicolored seeds with a rough seed coat while the Kabuli types have larger beige to white colored seeds with smoother seed coat. Existence of a pea-shaped third type characterized by medium to small seed size and creamy color has also been recognized which may be the result of intercrossing between Desi and Kabuli types that has resulted in a sort of intermediate group types.

Shortage of high yielding seed 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 [2]. 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.

However, with new cultivars, summer seeding of chickpea in tropical environments has recently been augmented, since summer sowing provides higher and more stable yield and growth. To overcome the effect of high temperature, adjustments in sowing date can 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 15^0C. 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 can retard the growth of chickpea plants. Early sowing of chickpea can expose it to heavy rainfall which results in lodging, diseases occurrence, and moisture deficit during grain fill stage. Late sowing can 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 can 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 [3].

2. MATERIALS AND METHODS

The 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 10^0C and 30^0C, respectively. Onset of rainfall in the district occurs normally in April and extends up to mid-October during crop growing period.

The overall objective of the study was to evaluate the effect of different sowing dates on productivity of chickpea varieties in the study area and similar agro-ecologies. The specific objective was to determine the effect of sowing dates on yield and yield components of chickpea varieties and to identify the best performing chickpea variety and sowing date for the study area.

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 sub plot was 2m x 3m (6m^2). Spacing of 0.5 m and 1 m were allocated between plots and blocks, respectively.

The seeds were sown after plowing two times before sowing, using the ox-drawn hand plough. At each sowing date, the plots were prepared by hand using hand hoes. Similarly, a hand hoe was used to disturb the soil before each sowing for the flat seedbed treatments seeds on land that was kept fallow during the heavy rains from June to August.

The cultivars were planted in different sowing dates starting from September to early October with a recommended dose of 100 kg NPS per hectare which was sown before sowing of the seed then all varieties were covered with soil to give a good seed-soil contact. Sowing was done with a seed rate of 90 – 150 kg/ha as recommended by Agricultural Transformation Agency. Plot-wise harvesting was done by hand at the time of 95% physiological maturity. All necessary agronomic practices as required by the crop (weeding, disease and insect management) were carried out two times as per the standard procedure.

Harvesting of the crop was done starting from mid-December to early January until the last sown varieties reach at appropriate stages of maturity which was identified by drying and shading of leaflets, drying and loss of green color of pods and reduced moisture content of seeds to 20-25%. Finally, threshing and winnowing were done using mechanical methods and seeds were dried under sunlight to the required moisture level before the weight was recorded for each net area plots.

2.1 Data Collection, Measurement and Recording

Emergence rate: This was taken as the number of days from planting to the period when 50 % of the plants in a plot emerged above the ground.
Days to 50% flowering: This was recorded as the number of days from planting to the period when 50 % the plants in plot developed first flower.
Days to physiological maturity: This was recorded in each plot, as the number of days from planting to when 90% of the plants in a plot showed drying of the leaves and the pods turned to yellow color. **Plant height (cm):** This was recorded from 10 randomly sampled plants per net plot at physiological maturity where plants were measured from the base to the tip of main stem and was expressed on per plant basis.
Number of primary branches per plant: The numbers of branches arising directly from the main stem was counted at the time of maturity for 10 randomly taken plants found in net plot and the average was recorded.
Number of secondary branches per plant: The numbers of all branches arising from the primary branches was counted at the time of maturity for

10 randomly taken plants found in net plot and the average was recorded.

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 [4]. Least significance difference (LSD) was used for the mean comparison both at 1% and 5% probability level.

3. RESULTS AND DISCUSSION

3.1 Phenological Parameters

3.1.1 Days to emergence

The analysis of variance showed significant (P<0.01) effect of sowing date on emergence .However, the main effect of variety and the interaction effect of sowing date as well as variety did not affect days to emergence (Table 1). This data was recorded the longest day to emergence was recorded at sowing date 4 (October 5th 2019) which took 12.4 days to emerge and the shortest days to emergence was recorded at sowing date 1 (September 4th) which took 8 days to emerge.

3.1.2 Days to 50% flowering

Significant variation was observed in days to 50% flowering among the various sowing days. However, there was no significant difference among varieties and the interaction between sowing date and varieties on days to 50% flowering (Table 1).The longest days to 50% flowering (54.92 days) were recorded at sowing date 2 (September 14th), whereas the shortest days to 50% flowering (48 days) were recorded at sowing date 4 (October 5th) which is statistically at par with days to flowering recorded with sowing of chickpea on September 24th (Table 1). It was observed that, the delay in sowing date shorten the days to 50% flowering. The probable reasons for reduction in days to 50% flowering may be due to the fact that depletion of reserve moisture resulted in less moisture availability which hastens plants to flower early. Flowering time is important because environmental conditions during the reproductive phase have a major impact on seed yield. The onset of flowering often determines the entire crop duration [5]. Similar, results were reported by Ali and Singh [6] who reported that late sowing of chickpea reduced days to flowering due high temperature.

3.1.3 Days to 90% physiological maturity

Number of days to physiological maturity of the tested chickpea varieties was significantly (P<0.01) affected by the main factors (sowing date and varieties) and the interaction effect of sowing dates and varieties (Table 1). Delay in days to physiological maturity (133 and 130.7 days) was recorded from local variety when planted on September 4th and September 14th, respectively. However, Dalota variety took shorter days to maturity than the other verities when planted on September 14th, September 24th and October 5th, respectively (Table 1). As depicted in Table 2, as the sowing date was delayed from early September when relatively high moisture was available as compared to early October for the crop than when planted in early October, the crop matured early. This is due to the fact that, when there is moisture deficit, plants are forced to mature early and it will significantly affect maturity day. Hence, Dalota variety produced good results when there was shortage of moisture as compared to other varieties under Toke Kutaye condition. This finding is in agreement with Gan et al. [7] who reported differences among varieties of chickpea in days to physiological maturity.

Table 1. Main effects of sowing dates and varieties on days to emergence and days to 50% flowering of chickpea during 2019/2020 cropping season

Treatments	Days to Emergence	Days to 50% Flowering
Sowing Date		
September 4th	8[c]	52.58[b]
September 14th	9.66[b]	54.92[a]
September 24th	10[b]	49[c]
October 5th	12.4[a]	48[c]
LSD (5%)	0.4	0.78
CV	11.8	7.0
Variety		
Dube/standard check	10.08	51.42
Dalota	9.83	51.17
Teji	10.08	50.92
Ejere	10.08	51
LSD (5%)	NS	NS
CV	4.9	1.82

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 2. Interaction effect of sowing dates and varieties on days to physiological maturity of chickpea during 2019/2020 cropping season

Treatments	September 4th	September 14th	September 24th	October 5th	Mean
Dube/Local	133.0[a]	130.7[a]	123[de]	120[ef]	126.7[a]
Dalota	119.7[f]	115.0[g]	113.3[g]	107.7[g]	113.9[d]
Teji	127.7[bc]	124.7[cd]	128.7[b]	119.33[f]	125[b]
Ejere	124.0[d]	120[ef]	118.33[f]	118.33[f]	120.2[c]
Mean	126.0[a]	122.58[b]	120.0[c]	116.3[d]	
LSD (0.05)	3.004				
CV	1.47				

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

3.2 Growth Parameters

3.2.1 Plant height (cm)

Analysis of variance showed a significant (P<0.05) variation for plant height of chickpea due to sowing dates and varieties (Table 3). However, non-significant variations were observed for plant height in chickpea due to interaction effect of both factors. The tallest plant (42.8 cm) was recorded when chickpea was planted on September 24th which was statistically non-significant with plant height recorded on September 14th and October 5th planted chickpea. While the shortest plant (34.4 cm) was recorded when planted on September 4th (Table 3). Allam (2002) reported that chickpea sown on 20th November produced taller plants.

Plant height of chickpea was significantly affected by varietal differences among the tested four varieties. Dalota Variety recorded the tallest plant height (41.42 cm) followed by Teji and Dube (standard check) varieties which were statistically similar with 40.5 cm and 39.75cm, respectively while Dube (standard check) variety was the shortest (37.58 cm) (Table 3). The variation in height might be due to genetic characteristics of the varieties for this trait. Anbessa and Geletu [8] reported that drought stress reduced plant height by 4% and 8% at vegetative and anthesis stage, respectively.

3.2.2 Number of primary branches per plant

Number of primary branches plant^{-1} of chickpea was not significantly influenced (P> 0.05) by sowing date and interaction effect of both factors (Table 3) but there was a significant difference between varieties. Maximum number of primary branches plant^{-1} (6.83) was recorded from Dalota variety which was statistically similar with

dube/standard check and Teji varieties; while the minimum number of branches plant^{-1} (5.5) were recorded in Ejere variety (Table 3). The possible reason is due to genetic makeup of the cultivars. In agreement with this result, significant variations in number of primary and secondary branches per plant among different genotypes of chickpea were reported by Ali and Singh [6] however they did not find significant difference due to sowing dates.

3.2.3 Number of secondary branches per plant

Analysis of variance depicted significant (P< 0.05) differences due to varieties and interaction effects of sowing dates and varieties on number of secondary branches per plant. But the effect of sowing date is not significant for this parameter (Table 4). The highest number of secondary branches plant^{-1} (16.7) were recorded from Dalota variety planted on October 5th and from Dube (standard check) variety (16.33) planted on September 24th which were not statistically different while the lowest number of secondary branches plant^{-1} (8) recorded in Teji which is at par the number of secondary branches per plant when planted on September 14th and 24th (Table 4). The possible reason for this observation could be the distinction in genetic makeup of the cultivars. In agreement with this result, significant variations in number of primary and secondary branches per plant among the different genotypes of chickpea were reported by Ali and Singh [6].

Table 3. Main effects of sowing dates and varieties on plant height and number of primary branches per plant of chickpea during 2019/2020 cropping season

Treatments sowing date	Plant height (cm)	No. of primary branches
September 4th	34.4^{b}	6.42
September 14th	40.0^{a}	5.92
September 24th	42.8^{a}	6.08
October 5th	41.1^{a}	6.5
LSD (5%)	3.04	NS
CV	8.5	17.4
Variety		
Dube/Local check	39.75^{ab}	6.67^{ab}
Dalota	41.42^{a}	6.83^{a}
Teji	40.5^{ab}	5.92^{ab}
Ejere	37.58^{b}	5.5^{b}
LSD (1%)	3.04	1.17
CV	9.07	22.34

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. Main effect and interaction effect of sowing dates and varieties on number of secondary branches per plant of chickpea during 2019/2020 cropping season

Treatments	September 4th	September 14th	September 24th	October 5th	Mean
Dube/Local	12.67^{drfg}	11.7^{defg}	16.33^{ab}	10^{fgh}	12.67^{b}
Dalota	13.7^{bcde}	14.7^{abc}	14.0^{abcd}	16.7^{a}	14.75^{a}
Teji	10.3^{fgh}	8.0^{h}	8.0^{h}	15.0^{abc}	10.33^{c}
Ejere	9.7^{gh}	11.0^{efg}	10.3^{fgh}	9.7^{gh}	10.17^{c}
Mean	11.6^{ab}	11.3^{b}	12.2^{ab}	12.8^{a}	
LSD (0.05)	2.92				
CV	13.5				

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

3.3 Yield Attributes

3.3.1 Grain yield

Grain yield showed significant differences (P< 0.05) among sowing dates and varieties, and their interactions (Table 5). The maximum grain yield (2415.5 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 5). Similar results were reported by Ozdemir and Karadavut [3], from chickpea sown on 14th September producing highest grain yield. Chaitanya and Chandrika [9] 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 [10] 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 is a late frost. Autumn-sown chickpea may face water shortages in the later part of the crop's growth. Shamsi et al. [11], 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 grain yield was recorded from the Ejere variety (1690.62 Kg ha^{-1}) (Table 5). This finding is in accordance with the findings of Sadeghipour and Aghaei [12], who reported that sowing date and varietal difference could affect grain yield.

3.3.2 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 6). 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)

Table 5. 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	1904.2^{e}	1766.7^{ef}	1412.5^{gh}	2544.8^{b}	1907.03^{b}
Dalota	1195.8^{hi}	2231.7^{cd}	2360.8^{bc}	2416.7^{bc}	2051.25^{a}
Teji	1128.3^{i}	3311.7^{a}	1965.0^{de}	1167.5^{hi}	1893.13^{b}
Ejere	1565.8^{fg}	2351.7^{bc}	1837.5^{ef}	1007.5^{i}	1690.62^{c}
Mean	1448.54^{c}	2415.42^{a}	1893.96^{b}	1784.11^{b}	
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

Table 6. 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

variety which was at par with Ejere (2491.7) when planted on September 14th (Table 6). 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. Felton et al. [13] reported similar findings in their research in chickpea.

4. CONCLUSIONS

To conclude, the result showed that mid-spring (September 14) sowing improves 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. Therefore, Dalota variety and September 14th sowing date emerged as best among all tested treatments and can be recommended for chickpea production in the study area. Conclusive recommendation could be obtained if the study is repeated at more locations and seasons in the future.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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