

## Research Article

# Effects of Sowing Time on Agronomic Traits, Yield and Nutritive Quality of Fodder Oat at Dodola and Kofele Districts of West Arsi Zone of Oromia, Ethiopia

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## Abstract

To tackle the feed shortage, fodder oat is one of improved fodder crops highly recognized mainly in the highland areas. However, the performance of fodder oat sown in different time vary in yield and quality parameters and hence identifying the proper time of sowing date is critical for production of high biomass and quality fodder oat. Thus, the study was conducted to determine the appropriate sowing time of oat. Accordingly five sowing times (mid-June, late June to early July, mid-July, late July to early August and mid-August) were laid out in Randomized Complete Block Design (RCBD) with three replications. The results indicated that sowing time had a significant ( $p < 0.05$ ) effect on plant height and number of tillers per plant. Leaf to stem ratio was significantly ( $p < 0.05$ ) affected due to sowing time only at Kofele site. Dry matter (DM) and seed yield were also significantly ( $p < 0.05$ ) different among sowing time at both sites with the maximum yield recorded at early sowing time. The maximum DM yield (7.5 t/ha to 13.9 t/ha) was recorded from oat sown in mid-June followed by oat sown in late June to early July (8.0 t/ha to 10.8 t/ha) at both sites, while the lowest DM yield (1.13 to 3.3 t/ha) were obtained from oat sown in mid-August. Likewise, the highest seed yield (20.1 to 22.8 qt/ha) were recorded from oat sown in mid-June followed by (18.9 qt/ha to 21.8 qt/ha) in late June to early July while the least seed yield (4.1 qt/ha to 4.8 qt/ha) produced from oat sown in mid-August. The higher yield in earlier sowing time may be due to the good weather conditions that prevailed during the earlier sowing period which favors for plant height and number of tillers per plants. On the other hands, ADF and CP contents of oat were significantly ( $p < 0.05$ ) influenced by sowing times. Therefore, it can be concluded that sowing oat from mid-June to early July is recommended to maximize both the yield and nutritive value of oats in the study areas. To minimize the risks of lodging while sustaining high yield performance, further study is required on agronomic management and to select lodging tolerant oat varieties.

## Keywords

Dry Matter Yield, Seed Yield, Sowing Time, Oat, Lodging

## 1. Introduction

In most areas of the country, livestock are mainly dependent on naturally available feed resources [1]. Nowadays, the highland agro-ecologies of the country are put under cultiva-

tion of food crops. This resulted in keeping a large number of livestock in limited grazing areas, leading to overgrazing and decreased productivity. Cereal crop residues are also im-

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portant feed resources but they are characterized by low quality and consequently could not support reasonable animal performance [2]. Improved forage crops such as fodder oats are highly recognized mainly in intensively cultivated highlands for enhancing livestock production. Oat is an essential fodder crop that is commonly planted for green fodder as well as seed in many parts of the world. It is a fast-growing, palatable, succulent, and nutritive fodder [3, 4].

Although fodder oat is not as widely grown as other cereals, its increasing popularity as a fodder crop in recent years has emphasized the need for more research, particularly in terms of selecting appropriate production strategies for various agro-climatic zones. One of the important yield contributing factors is the time of sowing which is governed by soil moisture and temperature [5]. Sowing time also influences the quality of fodder since it affects the succulent, dry matter, crude protein, and others. Sowing time is important for plant growth because it offers a favorable environment for the plants and allows them to grow taller. [6] also indicated that time of sowing is one of the important factors for higher production of the crop. Cultivation of oats at proper time of sowing and harvesting schedule can help in improving the yield and quality as well as the availability of green fodder during different times.

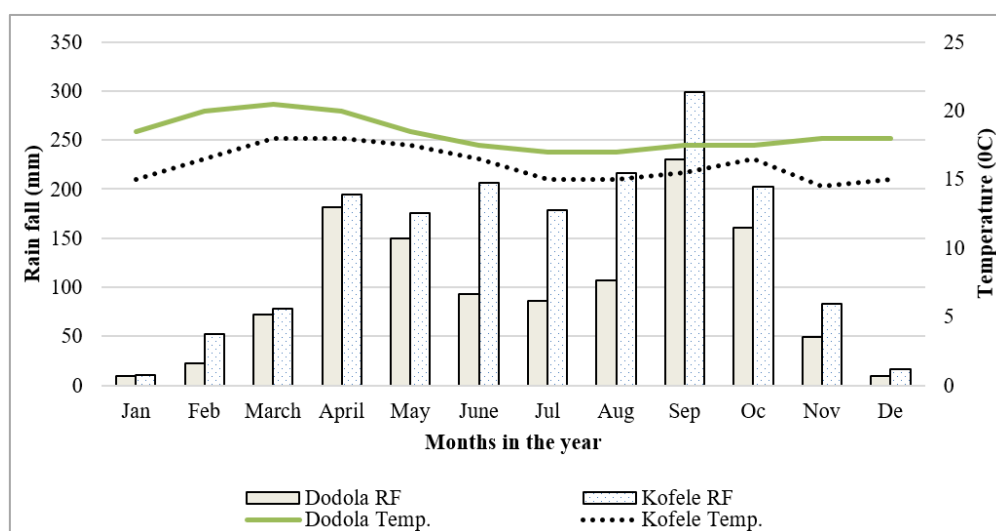
Moreover, lodging limits yield potential, affects the quality of fodder oats, and makes harvest more difficult and expensive. Lodging is influenced by crop management and many other factors including wind, rain, soil type, and disease [7, 8]. Hence it is important to identify management strategies that can either increase yield while maintaining acceptable lodging risk or reduce lodging while having no impact on yield. Adjustment in sowing time also can help in the regulation of green fodder and minimize the effect of lodging. Identifying

the proper time of sowing time is critical for the production of high biomass and quality fodder oats. On the other hand, studies have not yet been conducted and sufficient information is not available on the appropriate sowing times for the production of maximum biomass yield and quality fodder oats in west Arsi and similar highland agro-ecologies. Hence, this study was conducted to identify the appropriate sowing time for optimum biomass and quality of fodder oats production for the study areas.

## 2. Material and Methods

### 2.1. Study Site

The experiment was conducted at the selected sites in Dodola and Kofele districts of west Arsi Zone of Oromia for two consecutive years (2021-2022). Dodola site is located at 06°59' 21.372" N latitudes and 39°13'01.776" E longitudes while Kofele site is at latitude and longitude of 07° 04'39.558" N and 038° 47'08.945"E. The altitudes of the study sites are 2645 and 2690 m. a. s. l. respectively for Dodola and Kofele sites. The mean annual rainfall and temperature of the study sites are indicated in Figure 1. The areas are characterized by bimodal rainfall, where a relatively short rainy season occurs between February and May, and the main rainy season is between June and October. During the experimental period, the higher mean monthly rainfall data was recorded for Kofele site as compared to Dodola site. On the other hands, the temperature data indicated that higher monthly mean temperature was recorded for Dodola as compared to the Kofele area.



**Figure 1.** Mean monthly rainfall and temperature data of the study area.

## 2.2. Experimental Materials

An adapted variety of fodder oat (Bonsa) was used. The variety was released in 2011 for high and midland agro-ecologies of Bale and similar areas. The dry matter and seed yield performances of Bonsa variety at the time of release were 10.3 t/ha and 28.7 qt/ha respectively.

## 2.3. Experimental Treatments, Design, and Field Management

The treatments consist of five times of sowing; mid-June (at the start of wheat planting), late June to early July, mid-July, late July to early August, and mid-August). The treatment was arranged in a randomized completed block design with three replications. Plot size with 3 m \* 2 m and spacing of 0.2 m, 1 m, and 1.5 m, respectively between rows, plots, and blocks were used. A seed rate of 80 kg/ha was used for oat while fertilizer (NPS and Urea) at the rate of 100 kg/ha was used. The trial was managed and closely examined from the establishment until all important data collection was finalized. Forage biomass yield was estimated by harvesting the forage at 50% dough stage at a height of 5 cm near the ground. Plants in the middle row of the plots were harvested and weighed immediately to obtain fresh yield.

## 2.4. Data Collected

All relevant agronomic and yield data including plant height, days to 50% dough stage, tillers per plant, leaf to stem ratio, biomass yield, and seed yield were collected. Three plants were randomly selected from each plot and plant height was measured from the base of the plant to the flag leaf. The mean plant height was then calculated. The number of tillers per plant was determined by direct counting of the tillers from three plants that were randomly selected and the average was taken. The harvested forage samples were manually chopped into small pieces using a sickle and a sub-sample of 300 gm fresh weight was taken and oven-dried for determination of herbage dry matter yield. Forage DM yield was obtained by using the following [9] James *et al.* (2008) formula which is:

$$\text{DM yield (t/ha)} = (10 \times \text{TFW} \times \text{SSDW}) / (\text{HA} \times \text{SSFW})$$

Where; 10 = constant for conversion of yields in kg/m<sup>2</sup> to tone/ ha, TFW = total fresh weight from harvesting area (kg), SSDW = sub-sample dry weight (g), SSFW= sub-sample fresh weight (g).

Laboratory chemical analyses for major parameters were done at Batu Soil Laboratory. The feed sample was taken from each treatment and dried in an oven at 60 °C for 72 hours

to a constant weight and ground in a Willey mill to pass through a 1mm sieve. The ground samples were kept in air-tight plastic bags prior to analysis for chemical composition. The dry matter (DM) was determined by an oven drying at 105 ° overnight and ash content was determined by igniting the dry samples in a muffle furnace at 550 °C for 6 hours to burn off all the organic material. The inorganic material which does not volatilized at that temperature is ash. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed according to [10]. Crude protein (CP) was determined according to [11] methods. The Kjeldhal method was used and crude protein (CP) content was estimated from the N content by use of a multiplier of 6.25.

## 2.5. Data Analysis

Collected data was organized, summarized, and analyzed by using SAS 9.0 software. Means were separated using least significant difference (LSD) at 5% significant level [12].

## 3. Results and Discussion

### 3.1. Analysis of Variance (ANOVA)

Analysis of variance of the mean square shows a highly significant effect of sowing time on plant height ( $p < 0.01$ ), days to dough stage ( $p < 0.001$ ), tillers per plant ( $p < 0.05$ ), leaf to stem ratio ( $p < 0.01$ ) dry matter yield ( $p < 0.01$ ), and seed yield oat ( $p < 0.001$ ). Effect of year also had a significant effect on all parameters except dry matter yield while the experimental site effect was observed only on days to dough stage parameters. Sowing time-by-year interaction had a significant effect only on tillers per plant ( $p < 0.01$ ) and seed yield ( $p < 0.05$ ). A significant effect was observed on days to dough stage and leaf-to-stem ratio due to the interaction of sowing time and experimental site while the other parameters weren't significantly influenced ( $p > 0.05$ ) at this junction. Sowing time by site and year interaction had a significant ( $p < 0.01$ ) effect on DM yield, whereas, other parameters have shown non-significant ( $p > 0.05$ ) effects (Table 1). In line with this finding, [13] also reported that sowing time was significantly affected dry matter and seed yield of fodder oat. The large value of mean squares for sowing time indicated that the effect of sowing times were causing most of the variation in DM, seed yield, and other parameters. The significant variation observed due to year and site effect in some parameters could be related to the variations of climatic conditions and soil factors of the experimental sites.

**Table 1.** Mean squares of ANOVA for agronomic and yield parameters of oats in response to different sowing time.

Source of Variation	DF	PH	DDS	Tillers Per Plant	LSR	DM Yield	Seed Yield
Sowing time	4	5301.8**	6.69***	59.5*	0.94**	13.38**	680.1***

Source of Variation	DF	PH	DDS	Tillers Per Plant	LSR	DM Yield	Seed Yield
Year	1	1874.2*	150.4***	62.6*	15.8**	3.7NS	31.1*
Location	1	358.5NS	1782.1***	8.1NS	0.6NS	3.8NS	8.6NS
Sowing time *Year	4	57.3NS	6.8NS	35.8**	0.4NS	4.13NS	16.9*
Sowing time *location	4	466.5NS	7.25**	1.73NS	2.3*	2.77NS	9.29NS
Sowing time *location* Year	5	218.3NS	53.2NS	2.78NS	0.21NS	14.56**	4.56NS
Error		192.9	0.66	1.62	0.54	1.99	3.57

Where, \*, \*\* and \*\*\* shows significance at 0.05, 0.01, and 0.001%, respectively. DF: Degree of freedom

### 3.2. Plant Height and Tillers per Plant

Analysis result for plant height and number of tillers per plant of oat is presented in (Table 2). The result indicated that the values of plant height was significantly ( $p < 0.05$ ) differ among the sowing times. The higher plant height was recorded for early sowing times as compared to other times of sowing. The highest plant height (140.7 cm) was recorded from oat sown in mid-June followed by oat sown in late June to early July (139.6 cm) while the lowest plant height (90.5 cm) was recorded from oat sown in mid-August. The higher plant height recorded at early sowing times as compared to other sowing times may have been attributed to favorable weather conditions, while delayed sowing time resulted in lower plant height, which may have been caused by delayed germination and slower growth due to lower temperature during this time.

Number of tillers per plant was also significantly ( $p < 0.05$ ) differ among the sowing times with the highest (17.7) tillers per plant recorded for oat sown in mid-June followed by oat

sown in late June to early July (16.8) and mid-July (16.5). The lowest (12.5) value was obtained from oat established in the late planting time (mid-August). The lower tillers per plant recorded in late planting is attributed to the delayed germination and slower growth due to low temperature at the time of sowing. [14, 15] also reported that earlier sowing recorded higher plant height and tillers per plant in oats compared to delay sowing. Delays in sowing were associated with a gradual decline in both plant height and the number of tillers per plant. The decreased performances in plant height and tillers number in late sowing may be attributed to slow germination and poor growth caused by environmental stresses, particularly low soil moisture, which in turn causes a slow rate of vegetative growth due to poor root system development compared to early sowing. Similar findings were noticed by [16], who reported that low temperature decreased growth rate and delayed germination. [15] found that early sowing produced significantly taller plants in barley over late sowing. [17] Shou-Chen *et al.* (2018) also reported that delayed sowing significantly reduced the plant height and tillers per plant in oats compared to timely sowing.

**Table 2.** Effect of sowing time on plant height and tillers per plant of oat.

Sowing times	Plant height (cm)	Tillers per plant
Mid-June	140.7a	17.7a
Late June to early July	139.6 <sup>a</sup>	16.8 <sup>a</sup>
Mid-July	126.5 <sup>b</sup>	16.5 <sup>a</sup>
Late July to early August	112.3 <sup>c</sup>	13.7 <sup>b</sup>
Mid-August	90.5 <sup>d</sup>	12.5 <sup>b</sup>
Mean	121.9	15.46
CV (%)	12.7	15.1
LSD (0.05)	12.64	1.91

<sup>1</sup>CV=Coefficient of variation, LSD=Least significant difference, <sup>2</sup>Figures having the same letters within a column do not significantly differ, while values followed by different letter (s) significantly differ

### 3.3. Days to Dough Stage and Leaf to Stem Ratio

Analysis results of days to dough stage and leaf to stem ratio of oat tested at Dodola and Kofele sites are presented in (Table 3). The result indicated that days to dough stage was not significantly ( $p>0.05$ ) affected by sowing times at both sites. The mean values recorded were 101.0 and 111.9 respectively, for Dodola and Kofele sites. The longest days to reach the dough stage were recorded for oat established in mid-July (102.8) at Dodola and mid-June (113.3) at Kofele sites. The shortest (100) days to dough stage was also recorded at Dodola for oat sown in late June to early July and oat sown in late July to early August. At Kofele the shortest days required for the dough stage were recorded for oat estab-

lished in late June to early July and mid-July.

Leaf to stem ratio was significantly ( $p<0.05$ ) different among the tested sowing times at Kofele while it did not show significant ( $p>0.05$ ) differences at Dodola site. The maximum (0.93) value of leaf to stem ratio was obtained at Kofele from oat sown during mid-July followed by oat sown in mid-June (0.90) while the least value (0.88) was recorded from oat sown in mid-August. Relatively the higher values of leaf to stem ratio recorded at early sowing might be due to higher green leaf weight than green stem weight in early sowing. Looking at the mean value, the leaf to stem ratio recorded at Dodola (0.86) and Kofele (0.89) sites was comparable to the value reported by [18].

**Table 3.** Effect of sowing time on days to dough stage and leaf to stem ratio of oat tested at Dodola and Kofele sites.

Sowing times	Days to dough stage		Leaf to stem ratio	
	Dodola	Kofele	Dodola	Kofele
Mid-June	101.2	113.3	0.91	0.90 <sup>ab</sup>
Late June to early July	100.0	111.0	0.87	0.89 <sup>b</sup>
Mid-July	102.8	111.0	0.83	0.93 <sup>a</sup>
Late July to early August	100.0	111.7	0.85	0.89 <sup>b</sup>
Mid-August	101.0	112.5	0.84	0.88 <sup>b</sup>
Mean	101.0	111.9	0.86	0.89
CV (%)	4.0	2.6	9.16	2.4
LSD (0.05)	NS	NS	NS	0.04

<sup>1</sup>CV=Coefficient of variation, LSD=Least significant difference, NS= Non-significant, <sup>2</sup>Figures having the same letters within a column are not significantly differed, while values followed by different letter (s) are significantly differed

### 3.4. Dry Matter Yield

The result revealed that dry matter yield was significantly ( $p<0.05$ ) different among sowing times in both sites and years (Table 4). However, the yield was not-significantly ( $p>0.05$ ) different among sowing times of mid-June and oat sown in late June to early July in both years. At, Dodola, the 1<sup>st</sup> year data indicated that the maximum (13.9 t/ha) dry matter yield was recorded from oat sown in mid-June followed by oat sown in late June to early July (10.8 t/ha). In the 2<sup>nd</sup> year, the highest DM yield (8.0 t/ha) was obtained from oat sown in late June to early July followed by oat sown in mid-June (7.5 t/ha). The least dry matter yield (1.13 t/ha and 2.6 t/ha) was recorded from oat sown in mid-August in the years 2021/22 and 2022/23, respectively.

Similar trends of dry matter yield were obtained from the

two years of data at Kofele sites. In 2021/22, the maximum (9.2 t/ha) biomass yield was recorded from oat sown in late June to early July followed by oat established in mid-June (8.5 t/ha) while in 2022/23, the highest dry matter yield was recorded from oat sown in mid-June (11.2 t/ha) followed by oat sown in late June to early July (9.58 t/ha). The lowest DM yield was recorded from oat established in mid-August in both years. At both sites and years, the data indicated a significant reduction in forage yield with successive delays in sowing. When sowing times were delayed beyond early July the oat biomass yield declined mainly due to slower development and maturation rate of the forage. In line with this finding, different scholars also indicated that higher biomass yield in early sown oat crops compared to delayed sowing [19-21]. The higher biomass yield with earlier sowing may be ascribed to better growth and development of the crop as indicated by a corresponding increase in plant height and number of tillers



per plant. Favorable climatic conditions in this period might resulted in better growth contributing characters. The higher temperatures available to the early sown crop resulted in better growth of the crop in terms of plant height and tillers production thereby producing more biomass yield. [14] also

indicated that the higher biomass yield in the case of early sowing time may be ascribed to its superiority over delayed sowing concerning various yield attributes such as plant height, and number of tillers per plant which all were enhanced due to higher temperature at early growth stage.

**Table 4.** Effect of sowing time on dry matter yield (t/ha) performances of oat tested at Dodola and Kofele sites.

Sowing time	Dodola		Kofele	
	2021/22	2022/23	2021/22	2022/23
Mid-June	13.9 <sup>a</sup>	7.5 <sup>ab</sup>	8.5 <sup>a</sup>	11.2 <sup>a</sup>
Late June to early July	10.8 <sup>a</sup>	8.0 <sup>a</sup>	9.2 <sup>a</sup>	9.5 <sup>ab</sup>
Mid-July	7.3 <sup>b</sup>	6.2 <sup>b</sup>	7.4 <sup>ab</sup>	8.3 <sup>b</sup>
Late July to early August	3.9 <sup>bc</sup>	3.3 <sup>c</sup>	5.3 <sup>b</sup>	4.9 <sup>c</sup>
Mid-August	1.13 <sup>c</sup>	2.6 <sup>c</sup>	2.4 <sup>c</sup>	3.3 <sup>c</sup>
Mean	7.42	5.54	6.55	7.4
CV (%)	25.4	17.3	22.9	14.8
LSD (0.05)	3.43	1.74	2.73	2.0

<sup>1</sup>CV=Coefficient of variation, LSD=Least significant difference

<sup>2</sup>Figures having the same letters within a column do not significantly differ, while values followed by different letter (s) significantly differ

### 3.5. Seed Yield

The results of the analysis showed that in both years, sowing times had a significant ( $p < 0.05$ ) effect on seed yield (Table 5). In 2021-22, oats sown in mid-June and late June-early July yielded the highest seed yields (22.8 q/ha and 21.8 q/ha), respectively, while late planting (mid-August) produced the lowest seed yield (4.1 q/ha). Similarly, in 2022-2023 early planting of oats produced significantly ( $p < 0.05$ ) higher seed yield than late planting. Accordingly, the maximum seed yields of 20.1 q/ha and 18.9 q/ha were recorded for oat sown in mid-June and late June to early July, respectively. The lowest (4.8 q/ha) seed yield value was ob-

tained from oat sown in mid-June. [22-24] also reported that early-sown oats produced higher seed yields than late-sown oats. The higher seed yield with earlier sowing may be ascribed to better growth and development of the crop as indicated by the corresponding increase in plant height and number of tillers to the ultimate effect of seed production. Early sowing may be attributed to sufficient time available for the successful competition of both vegetative as well as reproductive phases of the crop. Studies have also proven that oats are very sensitive to high temperatures and the stages of their growth are affected by the delay in planting, especially the phase of filling the grain, which negatively affects its yield of grains [5].

**Table 5.** Effect of sowing time on seed yield (qt/ha) performances of oat tested at Dodola and Kofele sites in the years 2021/22 and 2022/23.

Sowing time	2021/22	2022/23
Mid-June	22.8 <sup>a</sup>	20.1 <sup>a</sup>
Late June to early July	21.8 <sup>a</sup>	18.9 <sup>a</sup>
Mid-July	16.6 <sup>b</sup>	12.8 <sup>b</sup>
Late July to early August	7.0 <sup>c</sup>	8.6 <sup>c</sup>
Mid-August	4.1 <sup>d</sup>	4.8 <sup>d</sup>

Sowing time	2021/22	2022/23
Mean	14.5	13.0
CV (%)	15.2	14.5
LSD (0.05)	2.62	2.25

<sup>1</sup>CV=Coefficient of variation, LSD=Least significant difference

<sup>2</sup>Figures having the same letters within a column do not significantly differ, while values followed by different letter (s) are significantly differ

### 3.6. Lodging

It was observed that lodging was a very serious problem for oats at the study sites and it is an important factor limiting the yield potential of oats. As sowing time elapsed, oat lodging declined and there was no lodging observed from oat sown in late June to early August and mid-August (Table 6). Although yield was not affected significantly, about 16.8, 7.2, and 1.3 % lodging was recorded for mid-June, late June to early July, and mid-July sowing times, respectively at Dodola site. A similar trend of lodging was recorded at Kofele with the highest (19.2%) value recorded for oat sown in mid-June followed by

late June to early July (10.3%) and mid-July (2.2%). The mean value of the two sites also indicated that about 18.0%, 8.75%, and 1.75% lodging was recorded for oat sown in mid-June, late June to early July, and mid-July, respectively. This indicated that up to 1.86 t/ha DM yield and up to 3.86 q/ha of seed yield can be reduced due to lodging problems. Studies also indicated that lodging can reduce the yield and quality of oats [7, 25] pointed out that depending on the timing and severity of lodging, it can reduce oat yields by 10 to 40 percent. In extreme cases, yield losses can be as much as 80 percent. [26] also demonstrated that lodging is an important factor in reducing yield up to 38% in wheat crops.

**Table 6.** Lodging (%) and its effect on biomass and yield of oat.

Sowing times	Lodging (%)			Actual yield (t/ha)		Yield loss due to lodging (t/ha)	
	Dodola	Kofele	Mean	DM yield	Seed yield	DM yield	Seed yield
Mid-June	16.8	19.2	18	10.31	21.46	1.86	3.86
Late June to early July	7.2	10.3	8.75	9.37	20.38	0.82	1.78
Mid-July	1.3	2.2	1.75	7.29	14.72	0.13	0.26
Late July to early August	0	0	0	4.34	7.8		
Mid-August	0	0	0	2.35	4.43		

### 3.7. Chemical Composition

The effect of sowing times on the chemical composition of oats is illustrated in (Table 7). The data revealed ADF and CP contents were significantly ( $p < 0.05$ ) affected by sowing time while DM, Ash, and NDF contents were not significantly ( $p > 0.05$ ) influenced by sowing time. The highest value (22.8%) of ADF was obtained from oat sown in mid-August while the minimum (19.4%) was recorded from oat sown in mid-June. The higher ADF concentration observed in late planting might be related to moisture conditions at the planting date. In delayed sowing time, the moisture availability in the soil decreases, which in turn decreases the nutrient uptake

capacity of crops and increases fiber content [27, 28]. Significantly the highest (10.9%) CP content was recorded from oat sown in late June to early July, followed by oat sown in mid-June (10.8%) while the least value (9.8%) was recorded from oat sown in late July to early August. In line with this study, improvement in CP content [29] and a decrease in ash content were observed with delay sowing [30] whereas, [31] indicated that CP was decreased NDF and ADF were increases as sowing date delayed. The inconsistency of the results reported by different scholars might be due to the variations in soil factors, climatic conditions, and agronomic practices applied. Generally, scholars also indicated that fodder quality was not mostly affected by the time of sowing [32, 33].

**Table 7.** Effect of sowing times on chemical composition of oat tested at Dodola and Kofele sites.

Sowing time	DM (%)	ASH (%)	NDF (%)	ADF (%)	CP (%)
Mid-June	93.4	12.0	47.4	19.4 <sup>c</sup>	10.8 <sup>a</sup>
Late June to early July	93.2	12.5	46.8	22.3 <sup>ab</sup>	10.9 <sup>a</sup>
Mid-July	93.5	12.3	46.7	21.1 <sup>abc</sup>	10.0 <sup>ab</sup>
Late July to early August	93.6	12.5	47.4	20.3 <sup>bc</sup>	9.8 <sup>b</sup>
Mid-August	93.0	11.8	47.2	22.8 <sup>a</sup>	10.1 <sup>ab</sup>
Mean	93.4	12.2	47.1	21.2	10.4
CV (%)	3.2	16.1	6.2	8.7	9.0
LSD (0.05)	NS	NS	NS	2.2	0.96

<sup>1</sup>CV=Coefficient of variation, LSD=Least significant difference, NS= Non-significant, <sup>2</sup>Figures having the same letters within a column are not significantly differed, while values followed by different letter (s) are significantly differ

### 3.8. Conclusions and Recommendations

Evaluation of different sowing times was conducted to identify appropriate sowing time for optimum biomass, seed, and quality of fodder oats production at Dodola and Kofele sites. The result revealed that early sowing produced significantly taller plants, more tillers per plant, higher dry matter yield, and seed yield than late sowing. All growth parameters and yield showed a consistent decrease with delay in sowing. Sowing oat in mid-June and in late June to early July recorded maximum dry matter and seed yields as compared to other sowing times. Higher biomass and seed yield may be attributed to better growth contributing characteristics such as plant height and number of tillers per plant under this treatment. Significant depressions of DM yield and seed yield were observed under delayed sowing time beyond the late June to early July. Except for ADF and CP contents, most of the chemical composition of oat were not significantly influenced by sowing times. On the other hands, a higher lodging effect was recorded for early planting times while as sowing time elapsed, lodging declined and there was no lodging observed from oat sown in late June to early August and mid-August. By considering agronomic, yield, and nutritional quality, the results of this study show that sowing oat from mid-June to early July is recommended to maximize both the yield and nutritive value of oats in the study area. To minimize the risks of lodging while sustaining high yield performance, it is important to use appropriate management practices and suitable oat varieties. Hence, further study is required on agronomic management practices to minimize the effect of lodging and identify the best yielder and lodging tolerant oat varieties.

### Abbreviations

ADF	Acid Detergent Fiber
ANOVA	Analysis of Variance
DM	Dry Matter
CP	Crude Protein
CV	Coefficient Variation
LSD	Least Significant Difference
NDF	Neutral Detergent Fiber

### Conflicts of Interest

The authors declare no conflicts of interest.

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