# 4. Effect of Ridging and Tie-Ridging Time on Yield and Yield Component of Sorghum in Wag- Lasta Area

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**Abstract**

*A field experiment was carried out at Lasta and Sekota districts of the Eastern Amhara Region in Ethiopia to evaluate the effects of Ridging and tie-ridging time on the yield performance of sorghum (Sorghum bicolor). The experiment consisted of eight treatments of ridging time and time of tie (Tie-ridging at planting, ridge at planting tying 2 weeks after planting, ridge at planting tying 4 weeks after planting, tie-ridging 3 weeks after planting, ridging 2 weeks after planting and tying 4 weeks after planting, ridge 3 weeks after planting and tying 6 weeks after planting, tie-ridging 6 weeks after planting), while Shilshalo as a control farmer practice which was arranged in a randomized complete block design (RCBD) with three replication. The experiment revealed that ridging and tie-ridging time has a significant effect on the yield of sorghum. Based on the result tie- ridging at planting increased the yield of sorghum by about 37.9 % at Sekota (Aybira) relative to the control (farmer practice). On the other*

*21.58% respectively at Lalibela as compared to the control (farmers practice) respectively. The highest yield of 3642 Kgha$^{-1}$ and 1903Kgha$^{-1}$ and 1696 Kgha$^{-1}$ was obtained from tie ridge at planting for Sekota (Aybira) and tie ridging 3 weeks after plant and ridge 2 weeks and tie 4 weeks after planting with recommendation NP fertilizer at Lalibela. Therefore, tie and ridge at planting could be appropriate for sorghum production at Sekota (Aybira) and sorghum growing similar areas. However, tie-ridge 3 weeks after planting and ridge 2 weeks and tie 4 weeks after planting could be appropriate for sorghum production at Lalibela (Kechinabeba).*

**Keywords:** Sorghum, Tie ridge, time, yield, water deficit

## Introduction

The dry land regions of Ethiopia account for greater than 66.6% of the overall landmass and are characterized by low annual rainfall (Georgis, K., *et al*., 2004). The common annual rainfall varies from 400mm to 600mm inside the semi-arid sector and levels among two hundred and 1000 mm from the dry semi-arid to the dry sub-humid sector (Kidane *et al*., 2001). In this semi-arid region, the quantity of rainfall is typically inadequate, erratic in distribution, short, and variability in quantity in the course of the crop developing season. The maximum crucial constraint of sorghum production in East Africa is water stress. Particularly in Ethiopia, soil water deficits in the course of crop status quo and grain fill have been identified as essential constraints (Wortman *et al*, 2009; Tesfahunegn *et al*., 2009).

Sorghum (S. bicolor) is the 5$^{th}$ maximum crucial global cereal crop after maize, rice, wheat, and barley (FAOSTAT, 2013). It is the second essential cereal crop after tef (Eragrostistef) in consumption. Sorghum is likewise a primary and one of the main conventional meal's cereals in Ethiopia with about 297,000 ha production vicinity insurance in keeping with annum and in northern Ethiopia (FAOSTAT, 2013). It accounted for 255,000 $hayr^{-1}$ (Wortmann *et al*., 2006) which contains 15-20% of the overall cereal production inside the country and its common yield in keeping with unit vicinity in Wag-Himra is 1.52 $tha^{-1}$ (CSA, 2016/2017). It is the dominant crop inside the semi-arid vicinity of the country and is restrained via way of means of a one-of-a-kind factor. Two essential elements that symbolize agriculture in Ethiopia include (i) The erratic climatic situations with common durations of water shortage (Stroosnijder and Van Rheenen, 2001; Tewodros, Mesfin, *et al.*, 2009) and (ii) The presence of huge regions of low fertile and crust inclined soils (Morin, 1993; Breman *et al.*, 2001). Sorghum production is specifically restrained by soil water and nutrient deficits in northern Ethiopia.

Water required for plant increase and improvement is taken from the soil via way of means of the roots. Leaves and stems do now no longer soak up considerable portions of water. Limited rainwater in dryland regions needs to consequently be made to go into the soil in any such way as to be simply to be had as soil moisture to the roots on the crucial durations of plant increase. All the land and crop control practices, which enhance rainwater garages inside the soil profile, include water conservation (Rana, 2007). In-situ water harvesting method as though tie ridging is one of the practices in sorghum production regions of drylands to enhance sorghum production. The investigation discovered that tie ridging will increase sorghum yield by as much as 46% compared to the farmer's exercise inside the dry regions of Ethiopia (Abebe *et al.*, 2009). The useful results of tillage include tied-ridging on crop yield range because of variations in quantity and distribution of rainfall, soil type, slope, panorama position, crop type, time of ridging, and the circumstance in which rainfall occasions bring about vast runoff. In addition, different studies discovered that tied-ridging improved sorghum grain yield via way of means of greater than 40% and soil water via way of means of greater than 25% in comparison to the conventional tillage exercise in northern Ethiopia (Gebreyesus *et al.*, 2006).

Ridging and tied ridging includes making ridges and furrows, tying or damming furrows with small mounds to grow the flow water and keep away from a runoff. The tie acts as a barrier for the rainwater motion and will increase touch time to be had for infiltration for this reason improving the provision of soil moisture to the vegetation (Rana, 2007). Tie-ridging includes developing ridges that might be 20-30 cm excessive and typically spaced 75 cm apart, both before, in the course of, or after planting. Row vegetation, including sorghum or corn, is perhaps sown at the ridge or inside the furrow. The furrows are tied at durations of 2 or more meters, depending on field conditions, to prevent runoff in the furrows. Tie-ridging effects on water storage and subsequent crop yield vary considerably from year to year and between locations (Brhane *et al.*, 2005).

The effectiveness of tie-ridging construction depends on weather conditions, soil properties, slope, crops, and other factors (Gebreyesus, *et al.*, 2005). Research has found that the main constraint to sorghum production in East Africa is water scarcity. Especially in Ethiopia, lack of soil moisture during crop cultivation and cereal filling is considered to be the main obstacle (Wortman *et al.*, 2009; Tesfahunegn *et al.*, 2009).

(Demlie G. and Shawel A. (2010) suggested that tied ridges at 75 cm intervals yielded significant yield improvements over other water protection practices and those of dry land farmers in Wag Himra area. Effective water protection practices are therefore of paramount importance in areas where soil moisture availability is generally the most limiting factor for crop production. They had significantly improved yields over water conservation practice, especially farmer practices is one of the biggest limiting factors (Tekur *et al.*, 2015). On the other hand, in many areas of Ethiopia, including the study area, the type of rainfall is irregular, leading to water stress during the crop growth stage. As the rainfall usually stops early, particularly at the flowering and graining filling stages of major crops, the availability of low soil moisture content at this stage and the low soil fertility status of most agricultural lands are the major limiting factors for crop production in the study areas. All of this requires sufficient time for water management techniques such as furrows and furrows for dryland crop production. This study then evaluates the appropriate timing of tie ridging constraction and improving sorghum productivity in cropland areas under different climatic and soil type conditions, along with adaptive mechanisms to enhance rainfall tethering. This was done to recommend the appropriate timing of tie-ridging for agricultural production in the study area and other similar agro-ecological areas.

*Study Area Description:* The field experiment was conducted in Wag-Himra and north Wollo administrative zone, namely at Kechinabeba and Aybra found in Lasta woreda and Sekota woreda Amhara regional state. The study sites were located at 11° 58’ 20.442’’ N latitude 039° 03’ 00.804’’ longitude E and 12° 437.482’’N latitude 39° 01’09.594’’E longitude and an altitude of 2159 m and 1928 meters above sea level (masl) respectively show in (Figure1). The experimental sites are characterized by gentle slopes (less than 5%) with soils suitable for agriculture.

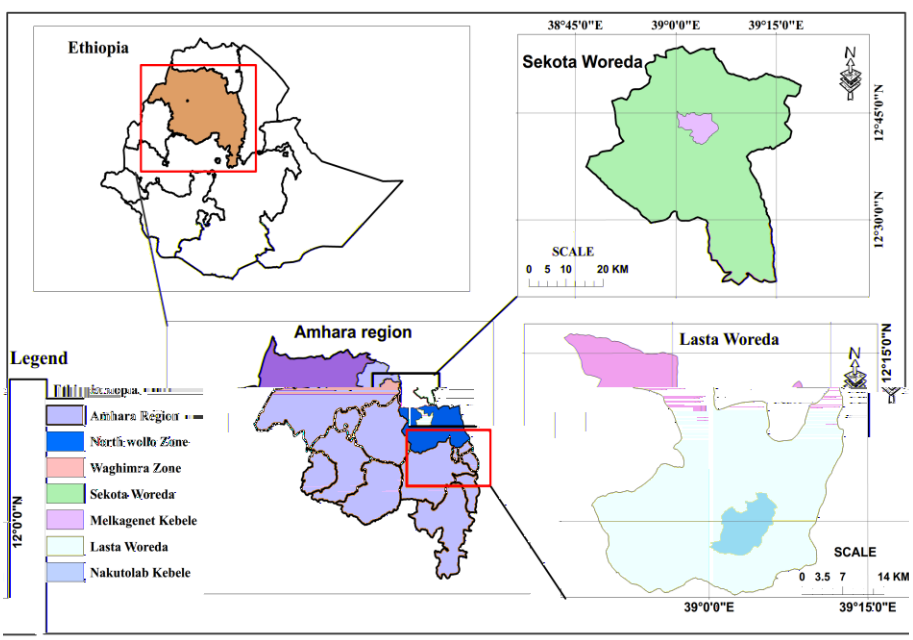



Figure 1: Location map of the study area

The rainfall pattern of the study areas is unimodal and usually occurs between July and August. The rainfall distribution is characterized by short, erratic, and variable across the growing seasons. Based on the 10-year meteorological data collected from the nearby stations, the annual average rainfall and maximum and minimum temperature of Sekota are 660.8mm,26.55ºC and14.97ºc. Similarly, for Lalibela with average annual rainfall and maximum and minimum temperatures are 737mm, 25ºC, and 13.6ºC respectively. The rainfall in the study area usually starts around mid of July extending to the end of August. The growing period annual rainfall and maximum and minimum temperature for Sekota and Lalibela are show in below (Table 1). The growing period of major crops grown in these areas are (sorghum, wheat, Fabian and tef) mostly from the beginning of July to the end of October shown in (Figures 2 and 3). According to *(*Dejene, A. (2003) the climatic zone classifications of Ethiopia based on altitude, rainfall, average annual temperature, and length of the growing season, Sekota (Melkagenet kebele) belongs to low land and midland for lalibela (Nakutolab kebele).

**Table 1. Annual rainfall and maximum and minimum temperature of the study areas in the 2017/2018 cropping season**

| | Rainfall (mm) | | Temperature(ºC) | | | |
|---|---|---|---|---|---|---|
| Location | 2017 | 2018 | 2017 | | 2018 | |
| | | | Max | Min | Max | Min |
| Lalibela | 818.8 | 886.6 | 24.7 | 13.4 | 23.6 | 13.08 |
| Sekota | 673.7 | 713.6 | 24.2 | 10.02 | 27.2 | 12.6 |

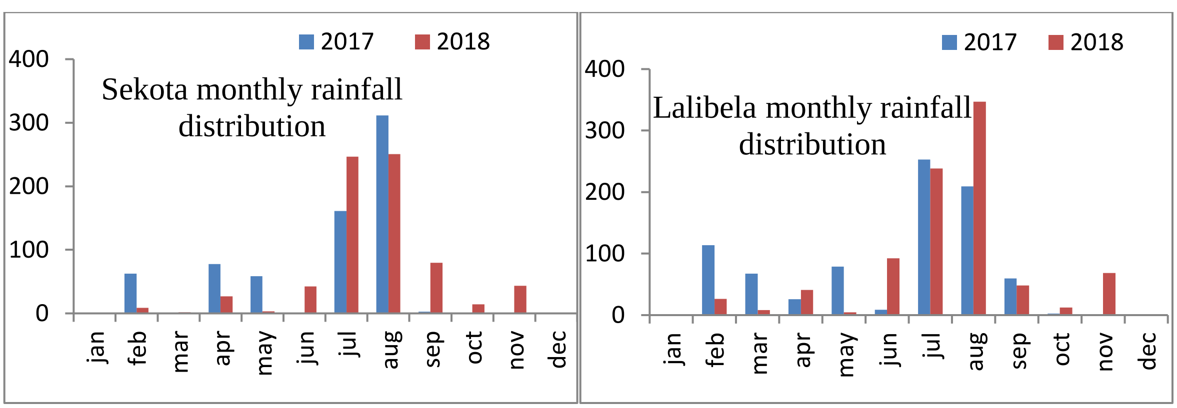
a)  b)


Figure 2: monthly rainfall 2017 and 2018 cropping season (a) Sekota and (b) lalibela

*Experimental Design and Treatments:* Field experiments were conducted during the summer season of 2017 and 2018 to investigate the effects of ride and tie-riding time on the yield and performance of sorghum under different agroecological conditions. Throughout the study periods, each experiment was laid down in a randomized complete block design with three replications.

The treatments considered were; (1) tie riding at planting; (2) riding at planting and tie 2 week s after planting; (3) riding at planting and tie 4 weeks after planting (4) tied ridge 3 weeks after planting ; (5) riding 2 weeks after planting and tie 4 weeks after planting; (6) riding 3 weeks after planting and 6 weeks after planting ; (7) tie riding 6 weeks after planting (8)control (farmers practice Shilshalo 6 weeks after planting for sekota and 8 weeks after planting for Lalibela ). The plot size of the treatment areas was 5m length by 4.5m width and the distance between plots and blocks was 1 and 1.5 m, respectively.

Diversion ditches were constructed to divert the inflow of runoff. An improved sorghum variety Misker was used as a test crop. The fields were primarily plowed three times and sowing was done in the first week of July. The crop was planted on a plot size of 5 m × 4.5 m in rows with a spacing of 75 by 15 cm. Tie-ridging is developing ridges with 20-30 cm depth and commonly spaced 75 cm apart, ridge and tie-ridge were constructed along with the couture the space between tie was 2m and 1m with staggered zigzag line. The recommended rate of 50 $Kgha^{-1}$ Urea and 100 $Kgha^{-1}$ NPS for Sekota and 50 $Kgha^{-1}$ Urea and 50 $Kgha^{-1}$ NPS for Lalibela were used as a source of Nitrogen and Phosphorus fertilizers respectively for each treatment for sorghum production (Sebnie W and Mengesha M. (2018). Nitrogen fertilizer was applied by split; application method in the form of urea half at planting and the remaining 45 days after planting. Phosphorus was applied once in the form of NPS at the time of planting. Agronomic practices such as weeding, cultivation, and fertilizer were done uniformly for all treatments as per need. Monitoring of weed infestation was regularly carried out, and hand-weeding techniques were applied and done three times to remove weeding

*Data Collection*

*Soil Data:* Composite soil samples were taken using an auger at a depth of 0- 20 cm from representative points in the trial sites and analyzed in the laboratory for major physiochemical properties and soil moisture characteristics. The USDA textural classification triangle was used to define the textural class for each composite soil sample taken. Besides, additional soil samples were taken from each treatment every 2-week intervals by a core sampler for monitoring the soil moisture content during the growing season.

A gravimetric field technique was used to determine the soil moisture content in this experiment.

*Agronomic Data:* Agronomic data including average plant height, length of sorghum head, the average weight of sorghum head, grain yield, and above-ground biomass of sorghum data ***were*** taken in all rows except borders in each plot. Data on plant height and head length were also taken on five randomly selected sorghum plants excluding border rows.

*Data Analysis***:** The agronomic data obtained were subjected to analysis of variance using SAS version 9.0 software and treatment effects were compared using the Fisher's Least Significant Differences (LSD) test at a 5% level of significance.

*Soil analysis*: The soil was air-dried and sieved through a 2 mm sieve. Soil pH was determined from the filtered suspension of 1:2.5 soil-to-water ratio using a glass electrode attached to a digital pH meter. The organic carbon of the soils was determined following the wet digestion method as described by Walkley and Black (1934) while the percentage of organic matter in the soils was determined by multiplying the percent organic carbon value by 1.724. Total Nitrogen was determined by the micro-Kjeldahl digestion, distillation, and titration method. Available phosphor was determined by the Olsen method (Olsen *et al.*, 1954).

## Results and Discussion

*Soil Physio-Chemical Characteristics of the Experimental Sites:* The major physiochemical characteristics of the soils in the experimental sites are summarized in Table 1. As shown in the table, the soil textural classes were found to be Sandy clay loam and sandy loam for Aybira and sandy loam and sandy clay loam for Lalibela experimental sites. Many agronomic practices require knowledge of the relation between the physical properties of the soil and the amount of soil water contained in a particular soil volume.

**Table 2: Physio-chemical properties of soil in the experimental site**

| Parameter | | PH | EC | %OM | %TN | av. P (ppm) | Texture class |
|---|---|---|---|---|---|---|---|
| Location | Year | | | | | | |
| Aybira | 1st | 6.1 | 0.14 | 0.538 | 0.025 | 16.1 | sand clay loam |
| | 2nd | 5.2 | 0.13 | 1.076 | 0.028 | 3.78 | sandy loam |
| Lalibela | 1st | 7.6 | 0.04 | 0.666 | 0.045 | 15.95 | sandy loam |
| | 2nd | 6.8 | 0.11 | 0.37 | 0.032 | 4.13 | sand clay loam |

compared to plots with the Farmer's practice (Shilshalo 6week Sekota 8week Lalibela after planting respectively). Which had the minimum soil moisture content and grain yield throughout the growing season except for the plot with tie-ridging 6 weeks after planting. Plots treated with ridging at planting tie 2 weeks after planting had on average the second-highest level of moisture content accumulated in the soil followed by plots treated with ridging at planting and tie 4 weeks after planting. Plots treated with farmers' practice (Shilshalo) had the minimum soil moisture content next to the plot treated with tie ridging 6 weeks after planting.

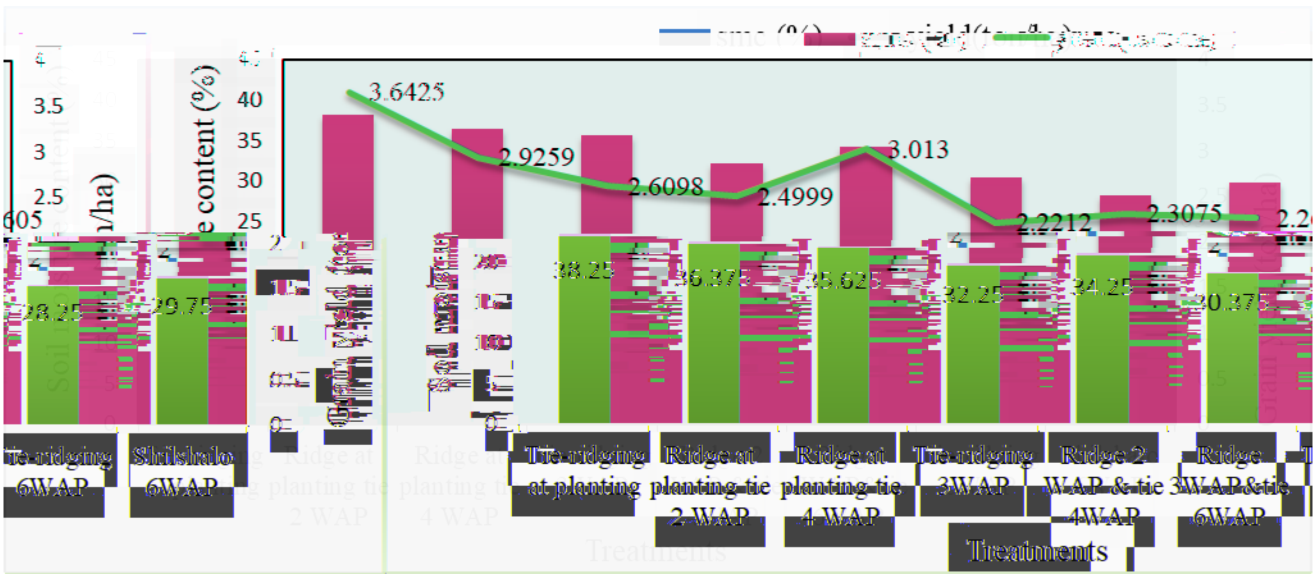



Figure 3. Effect of tie ridging time on soil moisture content and grain yield of sorghum in Sekota (Aybira) site

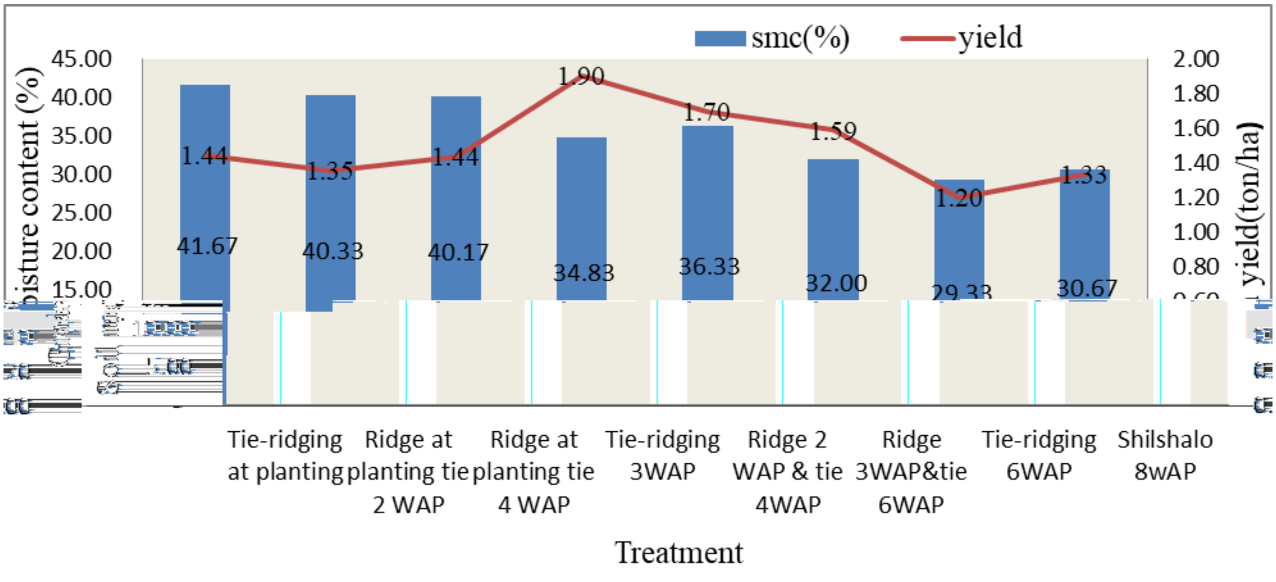



Figure 4: Effect of tie ridging on soil moisture content and grain yield of sorghum in Lalibela (Kechinabeba) site

*Effect of Riding and Tie Riding Time on Growth and Yield of Sorghum at Sekota*

*Plant Height and Head Length:* The riding and Tie riding time significantly ($P \leq 0.05$) affected the plant height of sorghum (Table 3). The higher Mean plant height of sorghum (175.17cm) at a tie and riding at planting was significantly higher than farmers' practice, The height was increased by 11.6%, compared with farmers' practice and the lower mean plant height (153.4cm) was recorded at the tie and riding 6 weeks after planting. Riding and Tie riding time was not significantly ($P \leq 0.05$) affecting the head length of sorghum as shown above in (Table 3). However, the highest mean plant head length (21.6 cm) was recorded at the tie and riding at planting. The current result agrees with the finding of (Legesse and Gobeze, 2015) who report Nitrogen and Phosphorus at a rate of 18 Nitrogen and 46 Phosphorus with tie-ridge had a significant effect on plant growth in areas of southern Ethiopia. Similarly (Brhane, 2012) observed that Nitrogen and Phosphorus at a rate of 18 and 46 $Kgha^{-1}$ with in-situ-moisture conservation had higher plant height.

**Table 3: Combined mean square value for the effect of riding and tie riding time on the plant height, sorghum head length at Ayibra**

| Treatment | Plant height (cm) | | | Head length (cm) | | |
|---|---|---|---|---|---|---|
| | 1st year | 2nd year | combined | 1st year | 2nd year | Combined |
| Tie-ridging at planting | 186.47a | 163.87a | 175.17a | 22.4a | 20.8a | 21.60a |
| Ridge at planting tie 2 WAP* | 179.33ab | 154.07ab | 166.7ab | 22.73a | 16.88bc | 19.81a |
| Ridge at planting tie 4 WAP | 172.6abc | 149.87ab | 161.23ab | 21.8a | 16.31bc | 19.05a |
| Tie-ridging 3WAP | 171.07abc | 145.8ab | 158.43ab | 22.46a | 16.19bc | 19.33a |
| Ridge 2 WAP & tie 4WAP | 179.2ab | 145.27b | 162.23ab | 21.86a | 14.24c | 18.05a |
| Ridge 3WAP&tie 6WAP | 169.2bc | 148.13ab | 158.67ab | 21.86a | 16.43bc | 19.15a |
| Tie-ridging 6WAP | 158.33cd | 148.47ab | 153.4b | 21.33a | 17.53b | 19.43a |
| Shilshalo 6WAP | 151.13d | 158.47ab | 154.8b | 20.26a | 17.86b | 19.06a |
| CV (%) | 5.61 | 6.87 | 9.94 | 7.9 | 9.44 | 16.7 |
| LSD (0.05) | 16.78 | 18.248 | 18.73 | 3.02 | 2.81 | Ns |

** The same letter is not significantly different at* p *= 0.05 (5 % level of significance) WAP= week after planting*

*Grain Yield and Biomass:* The grain yield was significantly affected by the ridge and tie-ridge time at ($P \leq 0.05$) shown in (Table 5). The grain yield of sorghum is influenced by the different times of tie and ridge time. Decreasing the time of ridge and tie ridge time increased the yield of the crop from 22.60Qha$^{-1}$ to 36.42 Qha$^{-1}$. Thus, compared to the farmer's practice, using the recommended rate of N and $P_2O_5$ (23/46 Kgha$^{-1}$) with tie-ridge at planting increased sorghum grain yield by 37.9%. This implies that proper management of tie-ridge time can gain the additional grain yield of sorghum. The result of the current study agrees with the finding of, (Gebrekidan, 2003) who observed that fertilizer application 46 $P_2O_5$ and 18 N with tie-ridge increases the grain yield of sorghum by 15-38% in the moisture stress areas of Eastern Ethiopia.

The biomass yield of sorghum was significantly affected by ridge and tie-ridge time at ($P \leq 0.05$). Biomass yield was increased with proper management of ridge and tie-ridging time. The highest biomass yield (155.15 Qha$^{-1}$) was recorded at ridge and tie-ridge at planting and the lowest biomass yield (84.53 Qha$^{-1}$) was recorded at ridging 3 weeks after planting and tied 6 weeks after planting treatment. The result indicates that tie riding at planting with the recommended rate of Nitrogen and Phosphorus (23/46Kgha$^{-1}$) fertilizer increases the biomass yield by 32.38% over farmers' practice. Biomass yield is very important because the leaves and stems are used for cattle feed during the long dry season.

**Table 4: Combined mean square value for the effect of riding and tie riding time on grain yield and biomass of sorghum at Ayibra**

| Treatment | Total biomass (Q ha$^{-1}$) | | | Grain yield (Q ha$^{-1}$) | | |
|---|---|---|---|---|---|---|
| | 1$^{st}$ year | 2$^{nd}$ year | Combined | 1$^{st}$ year | 2$^{nd}$ year | Combined |
| Tie-ridging at planting | 162.28$^{a}$ | 148.02$^{a}$ | 155.15$^{a}$ | 35.94$^{a}$ | 36.91$^{a}$ | 36.43$^{a}$ |
| Ridge at planting tie 2 WAP* | 121.10$^{bc}$ | 113.86$^{bc}$ | 117.48$^{bc}$ | 29.97$^{bc}$ | 28.55$^{bc}$ | 29.26$^{b}$ |
| Ridge at planting tie 4 WAP | 103.78$^{d}$ | 98.17$^{cde}$ | 100.98$^{de}$ | 24.69$^{cde}$ | 27.50$^{c}$ | 26.09$^{bc}$ |
| Tie-ridging 3WAP | 119.32$^{bcd}$ | 105.05$^{bcd}$ | 112.18$^{bcd}$ | 28.76$^{cd}$ | 21.23$^{d}$ | 24.99$^{cd}$ |
| Ridge 2 WAP & tie 4WAP | 126.61$^{b}$ | 114.77$^{b}$ | 120.69$^{b}$ | 32.82$^{ab}$ | 27.44$^{b}$ | 30.13$^{b}$ |
| Ridge 3WAP&tie 6WAP | 84.08$^{e}$ | 84.98$^{e}$ | 84.53$^{f}$ | 23.38$^{e}$ | 21.04$^{d}$ | 22.21$^{d}$ |
| Tie-ridging 6WAP | 106.92$^{cd}$ | 89.25$^{de}$ | 98.09$^{ef}$ | 25.04$^{cde}$ | 21.11$^{d}$ | 23.07$^{cd}$ |
| Shilshalo 6WAP | 111.43$^{bcd}$ | 98.40$^{cde}$ | 104.91$^{cde}$ | 24.52$^{de}$ | 20.69$^{d}$ | 22.61$^{cd}$ |
| CV (%) | 8.31 | 8.56 | 10.75 | 10.73 | 8.9 | 11.79 |
| LSD (0.05) | 17.016 | 15.97 | 14.04 | 4.79 | 4.075 | 3.75 |

** The same letter is not significantly different at* p *= 0.05 (5 % level of significance) WAP= week after planting*

*Effect of Riding and Tie Riding Time on Growth and Yield of Sorghum at Lalibela:*

*Plant Height and Head Length:* Riding and Tie riding time did not significantly (P≤0.05) affect the plant height of sorghum. The higher Mean plant height of sorghum (130.63cm) at tie-riding3week after planting was significantly higher than farmers' practice, and the lower mean plant height (119.3cm) was recorded at riding 3 weeks after planting and tied 6 weeks after planting. Riding and Tie riding time significantly (P≤0.05) affected the head length of sorghum as shown the above table8. But the highest mean plant head length (16.06 cm) was recorded at riding two weeks after planting and tie 4 weeks after planting.

**Table 5. Combined mean square value for the effect of riding and tie riding time on the plant height and the head length of sorghum at Lalibela**

| Treatment | Plant height | | | Head length | | |
|---|---|---|---|---|---|---|
| | 1st year | 2nd year | Combined | 1st year | 2nd year | Combined |
| Tie-ridging at planting | 110.07 | 130.60 | 120.33 | 15.46 | 14.2ab | 14.83 |
| Ridge at planting tie 2 WAP* | 114.4 | 143.07 | 128.73 | 15.53 | 14.8ab | 15.17 |
| Ridge at planting tie 4 WAP | 116.13 | 144.93 | 130.53 | 15.40 | 15.733a | 15.57 |
| Tie-ridging 3WAP | 116.00 | 145.27 | 130.63 | 16.00 | 15.80a | 15.90 |
| Ridge 2 WAP & tie 4WAP | 120.67 | 135.67 | 128.17 | 17.20 | 14.93ab | 16.07 |
| Ridge 3WAP&tie 6WAP | 114.13 | 124.47 | 119.30 | 15.45 | 14.37ab | 14.91 |
| Tie-ridging 6WAP | 114.67 | 136.33 | 125.50 | 15.33 | 13.86ab | 14.60 |
| Shilshalo 8WAP | 117.73 | 133.60 | 125.6 | 16.067 | 13.13b | 14.60 |
| CV (%) | 8.41 | 10.76 | 13.55 | 9.84 | 9.1 | 10.05 |
| LSD (0.05) | Ns | Ns | Ns | Ns | 2.32 | NS |

**Tthe same letter is not significantly different at* p *= 0.05 (5 % level of significance) WAP= week after planting*

*Grain Yield and Biomass:* The grain yield was significantly affected by the ridge and tie-ridge time at ($P \leq 0.05$) shown in (Table 9). The grain yield of sorghum is influenced by the different times of tie and ridge time. Decreasing the time of ridge and tie ridge time increased the yield of the crop from (13.309 $Qtha^{-1}$ to 19.03 $Qtha^{-1}$ and 16.96 $Qtha^{-1}$). Thus, compared to the farmer's practice, using a recommended rate of N and $P_2O_5$ (23/23 $Kgha^{-1}$) with tie-ridge 3week after planting and ridge 2 weeks and tie 3weeks after planting increased sorghum grain yield by 30.11%, 21.58% respectively. This implies that proper management of tie-ridge time can gain the additional grain yield of sorghum. The result of the current study agrees with the finding of, (Gebrekidan, 2003) who observed that fertilizer application 46 $P_2O_5$ and 18 N with tie-ridge increases the grain yield of sorghum by 15-38% in the moisture stress areas of Eastern Ethiopia.

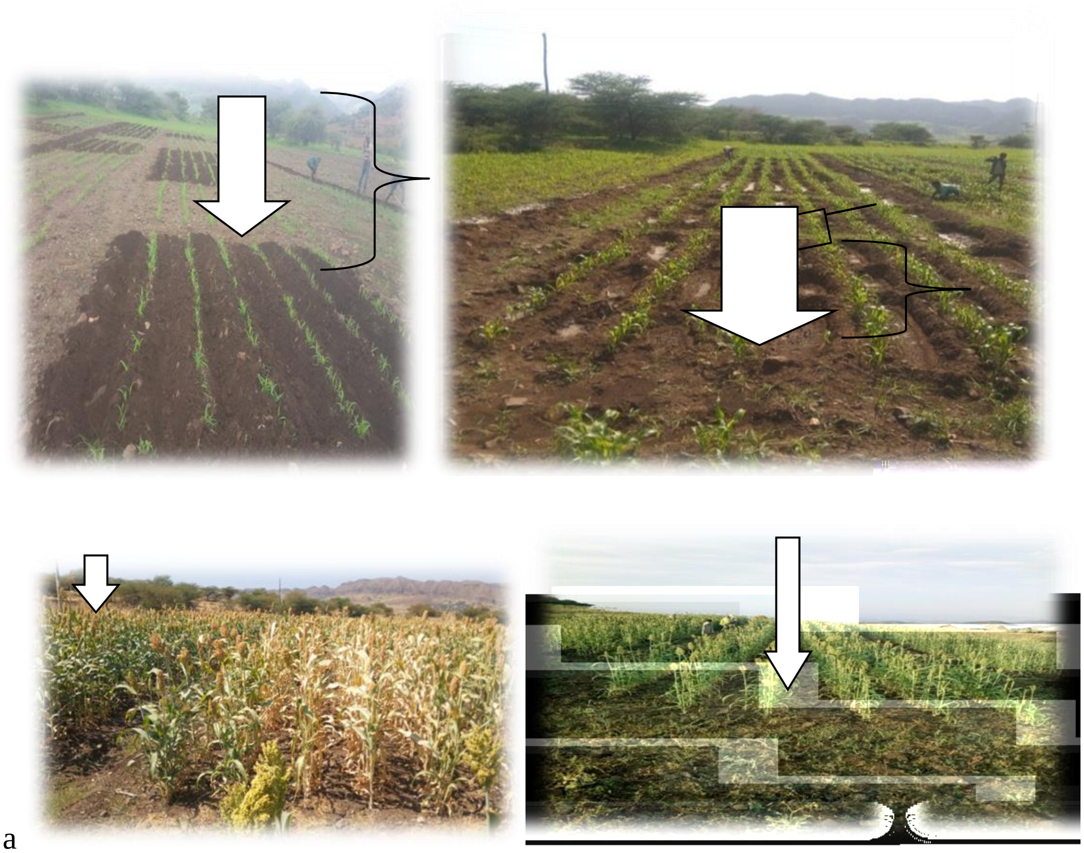
The biomass yield of sorghum was significantly affected by ridge and tie-ridge time at ($P< 0.05$). Biomass yield was increased with proper management of ridge and tie-ridging time. The highest biomass yield (142.99 $Qtha^{-1}$) was recorded at ridge and tie-ridge 3 weeks after planting and the lowest biomass yield (97.75 $Qtha^{-1}$) was recorded at tie-ridge 6 weeks after planting treatment.

The result indicates that tie-riding 3weeks after planting and with the recommended rate of Nitrogen and Phosphorus (23/23Kgha$^{-1}$) fertilizer increases the biomass yield by 31.6% and 18.07% over tie-ridging 6week after planting and farmers practice (shilshalo) respectively. Biomass yield is very important because the leaves and stems are used for cattle feed during the long dry season.

**Table 6. Combined mean square value for the effect of riding and tie riding time on grain yield and biomass of sorghum at Lalibela**

| Treatment | Total biomass (Qt/ha) | | | Grain yield (Qt/ha) | | |
|---|---|---|---|---|---|---|
| | 1st year | 2nd year | Combined | 1st year | 2nd year | Combined |
| Tie-ridging at planting | 104.81$^{cd}$ | 117.31$^{bc}$ | 109.14$^{cd}$ | 15.747$^{bc}$ | 13.09$^{c}$ | 14.42$^{cd}$ |
| Ridge at planting tie 2 WAP* | 122.31$^{b}$ | 122.66$^{b}$ | 122.52$^{b}$ | 13.277$^{cd}$ | 13.75$^{bc}$ | 13.52$^{de}$ |
| Ridge at planting tie 4 WAP | 125.06$^{ab}$ | 125.38$^{b}$ | 125.22$^{b}$ | 14.633$^{bcd}$ | 14.12$^{bc}$ | 14.37$^{cd}$ |
| Tie-ridging 3WAP | 121.28$^{bc}$ | 129.53$^{ab}$ | 125.41$^{b}$ | 20.323$^{a}$ | 17.74$^{a}$ | 19.03$^{a}$ |
| Ridge 2 WAP & tie 4WAP | 141.27$^{a}$ | 144.72$^{a}$ | 142.99$^{a}$ | 17.947$^{ab}$ | 15.98$^{ab}$ | 16.96$^{ab}$ |
| Ridge 3WAP&tie 6WAP | 122.57$^{b}$ | 119.75$^{b}$ | 121.16$^{bc}$ | 14.746$^{bcd}$ | 17.01$^{a}$ | 15.88$^{bc}$ |
| Tie-ridging 6WAP | 95.1$^{d}$ | 100.4$^{c}$ | 97.75$^{d}$ | 11.681$^{d}$ | 12.36$^{c}$ | 12.02$^{e}$ |
| Shilshalo 8WAP | 113.82$^{bc}$ | 120.48$^{b}$ | 117.15$^{bc}$ | 14.612$^{bcd}$ | 12.01$^{c}$ | 13.31$^{de}$ |
| CV (%) | 8.06 | 8.3 | 9.01 | 13.11 | 9.16 | 12.87 |
| LSD (0.05) | 16.7 | 17.8 | 12.65 | 3.53 | 2.33 | 2.25 |

**The same letter is not significantly different at* p *= 0.05 (5 % level of significance) WAP= week after planting*



a b

Figure 5: Field performance of sorghum at (a) Sekota and (b) Lalibela

**Conclusion and Recommendation**

Overall, it is found that the efficiency of in situ moisture conservation practices for sorghum production in dry-land areas like in Wag-lasta areas has varied based on climatic and soil conditions. The result shows that appropriate timing of ridge and tie-ridge with recommended rate of Nitrogen and Phosphorous fertilizer for sorghum production could make an important contribution to soil moisture improvement and increase production and productivity in the areas. Further research should be carried out on soil moisture content and fertilizer to put the recommendation on a strong basis and also to come up with increased yield and improved sorghum production in the area.

The mean grain yield of sorghum was significantly affected by the treatment of ridge and tie ridge time. Tie ridging at planting with the recommended rate of N and $P_2O_5$ (23/46Kgha$^{-1}$) fertilizer is found to be the appropriate timing for optimum productivity of sorghum in sekota (Aybira). Tie ridging at planting is recommended for Sekota (Aybira) and similar agroecology areas. Whereas tie ridging 3 weeks after planting with the recommended rate of N and $P_2O_5$ (23/23Kgha$^{-1}$) fertilizer is found to be the appropriate timing for optimum productivity of sorghum in lalibela (Kechinabeba) and ridge 2 weeks and tie 4 weeks after planting recommended as the second option in Lalibella (*Kechinabeba*) and the similar agro ecology areas.

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