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Effect of Ridging and Tie-Ridging Time on Yield and Performance of Sorghum in Wag- Lasta Area

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Abstract

Objective: A field experiment was carried out in Lasta and Sekota woreda 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).

Methodology: The experiment consisted of eight treatments of ridging time & 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 & tying 4 Weeks After Planting, Ridge 3 Weeks After Planting & tying 6 Weeks After Planting, Tie-ridging 6 Weeks After Planting); including Shilshalo as a control farmer practice which was arranged in a randomized complete block design (RCBD) with three replication.

Result: 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 hand 'Tie ridging 3 weeks after planting' and 'ridging 2 weeks & tying 4 weeks after planting' increased sorghum yield by 30.11% and 21.58% respectively at Lalibela as compared to the control (farmers practice)respectively. The highest yield of 3642kg/h and 1903kg/ha and 1696kg/ha was obtained from tie ridge at planting for Sekota (Aybira) and tie ridging 3 weeks after plant and ridge2 weeks and tie 4 weeks after planting with recommendation NP fertilizer at Lalibela.

Conclusion: Therefore, tie and ridge at planting could be appropriate for sorghum production at Sekota (Aybira) and sorghum growing 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) and sorghum growing areas.

Keywords: Sorghum; Tie ridge; Yield; Water deficit

Introduction

The dry land areas of Ethiopia account for more than 66.6% of the total land mass and are characterized by low annual rainfall. The average annual rainfall varies from 400mm to 600mm in the semi-arid zone and ranges between 200 and1000 mm from the dry semi-arid to the dry sub-humid zone [1].In this semi-arid region, the amount of rainfall is usually adequate, erratic in distribution, short in duration, and varied in amount during crop growing season. The most important constraint of sorghum poduction in east Africa is water stress. Particularly in Ethiopia, soil water deficits during crop establishment and grain fill were recognized as major constraints [2].

Sorghum (sorghum b.) is the fifth most important world cereal crop after maize, rice wheat, and barley FAO STAT 2013. It is the second major cereal crop next to teff (Eragrostis tef) in consumption. Sorghum is also a major and one of the leading traditional food crops in Ethiopia with approximately 297,000 ha production area coverage per annum in northern Ethiopia (Table 2). It accounted for 255,000 ha y-1 [3] which comprises 15-20% of the total cereal production in the country and its average yield per unit area in wag himra is 15.2qt/ha [4] It is the dominant crop in the semi-arid area of the country and is constrained by a different factors. Two major factors that characterize agriculture in Ethiopia include (i) erratic climatic conditions with frequent periods of water shortage [5] and (ii) The presence of large areas of low fertile and crust prone soils [11]. Sorghum (Sorghum bicolor L. Moench) production is mainly constrained by soil water and nutrient deficits in northern Ethiopia.

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

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

Water required for plant growth and development is taken from the soil by the roots. Leaves and stems do not absorb appreciable quantities of water. Limited rainwater in dry land areas must therefore be made to enter the soil in such a manner as to be readily available as soil moisture to the roots at the critical periods of plant growth. All the land and crop management practices, which improve rainwater storage in the soil profile, comprise water conservation [5]. In-situ water harvesting technique as if tie ridging is one of the practices in sorghum production areas of dry lands to improve sorghum production [2-6]. Investigation revealed that tie ridging increases sorghum yield by up to 46% as compared to the farmer's practice in the dry areas of Ethiopia [1]. The beneficial effects of tillage such as tied-ridging on crop yield vary due to differences in the amount and distribution of rainfall, soil type, slope, landscape position, crop type, time of ridging, and the condition where rainfall events result in significant runoff (Table 4). In addition, other research revealed that Tied-ridging increased sorghum grain yield by

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Table 2: Physio-chemical property of soil in the experimental site.

Parameter		PH	EC	%OM	%TN	avi. 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

Table 3: First year (2017) mean square value for the effect of riding and tie riding time on the plant height, sorghum head length, grain yield, and biomass at Aybra.

Treatment	Plant	Head	Total	Grain
	Height(cm)	Length(cm)	Biomass(Qt/ha)	Yield(Qt/ha)
Tie-ridging at planting	186.47^{a}	22.4^{a}	162.28^{a}	**35.94^{a}**
Ridge at planting tie 2 WAP	179.33^{ab}	22.73^{a}	121.10^{bc}	29.97^{bc}
Ridge at planting tie 4 WAP	172.6^{abc}	21.8^{a}	103.78^{d}	24.69^{cde}
Tie-ridging 3WAP	171.07^{abc}	22.46^{a}	119.32^{bcd}	28.76^{cd}
Ridge 2 WAP & tie 4WAP	179.2^{ab}	21.86^{a}	126.61^{b}	32.82^{ab}
Ridge 3WAP&tie 6WAP	169.2^{bc}	21.86^{a}	84.08^{e}	23.38^{e}
Tie-ridging 6WAP	158.33 ^{cd}	21.33^{a}	106.92^{cd}	25.04^{cde}
Shilshalo 6wAP	151.13^{d}	20.26^{a}	111.43^{bcd}	24.52^{de}
Cv	5.61	7.9	8.31	10.73
LSD(0.05)	16.78	Ns	17.016	4.79

Table 4: Second year (2018) mean square value for the effect of riding and tie riding time on the plant height, sorghum head length, grain yield, and biomass at Aybra.

Treatment	Plant	Head	Total	Grain
	height (cm)	Length (cm)	Biomass (Qt/ha)	Yield (Qt/ha)
Tie-ridging at planting	163.87^{a}	20.80^{a}	148.02^{a}	36.90^{a}
Ridge at planting tie 2 WAP	154.07^{ab}	16.88^{bc}	113.86^{bc}	28.54^{bc}
Ridge at planting tie 4 WAP	149.87^{ab}	16.31^{bc}	98.17^{cde}	27.50^{c}
Tie-ridging 3WAP	145.8^{ab}	16.19^{bc}	105.05^{bcd}	21.23^{d}
Ridge 2 WAP & tie 4WAP	145.27^{b}	14.24^{c}	114.77^{b}	32.24^{b}
Ridge 3WAP&tie 6WAP	148.13^{ab}	16.43^{bc}	84.98^{e}	21.03^{d}
Tie-ridging 6WAP	148.47^{ab}	17.53^{b}	89.25^{de}	21.10^{d}
Shilshalo 6WAP	158.47^{ab}	17.86^{b}	98.40^{cde}	20.68^{d}
Cv	6.87	9.44	8.56	8.9
LSD(0.05)	18.248	2.81	15.97	4.075

Table 5: 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	186.47^{a}	163.87^{a}	**175.17^{a}**	22.4^{a}	20.8^{a}	**21.60^{a}**
Ridge at planting tie 2 WAP	179.33^{ab}	154.07^{ab}	166.7^{ab}	22.73^{a}	16.88^{bc}	19.81^{a}
Ridge at planting tie 4 WAP	172.6^{abc}	149.87^{ab}	161.23^{ab}	21.8^{a}	16.31^{bc}	19.05^{a}
Tie-ridging 3WAP	171.07^{abc}	145.8^{ab}	158.43^{ab}	22.46^{a}	16.19^{bc}	19.33^{a}
Ridge 2 WAP & tie 4WAP	179.2^{ab}	145.27^{b}	162.23^{ab}	21.86^{a}	14.24^{c}	18.05^{a}
Ridge 3WAP&tie 6WAP	169.2^{bc}	148.13^{ab}	158.67^{ab}	21.86^{a}	16.43^{bc}	19.15^{a}
Tie-ridging 6WAP	158.33^{cd}	148.47^{ab}	153.4^{b}	21.33^{a}	17.53^{b}	19.43^{a}
Shilshalo 6WAP	151.13^{d}	158.47^{ab}	154.8^{b}	20.26^{a}	17.86^{b}	19.06^{a}
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

more than 40% and soil water by more than 25% compared to the traditional tillage practice in northern Ethiopia [7].

Ridging and tied ridging involves making ridges and furrows, tying or damming furrows with small mounds to increase surface water storage and avoid a runoff. The tie acts as a barrier for rainwater movement and increases the contact time available for infiltration thus enhancing the availability of soil moisture to the crops [8-11]. Tie-ridging involves creating ridges that are 20-30 cm high and commonly spaced 75 cm apart, either before, during, or after planting. Row crops, such as sorghum or corn, may be sown on the ridge or in the furrow. The furrows are tied at intervals of 2 or more meters, depending on field conditions, to prevent runoff in the furrows (Table 6). Tie-ridging effects on water storage and subsequent crop yield vary considerably from year to year and between locations. The effectiveness of tied ridging depends on weather conditions, soil characteristics, slope, crop, and other factors [8]. Investigation revealed that the most important

Table 6: 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(Qt/ha)			Grain yield(Qt/ha)		
	1st year	2nd year	Combined	1st year	2nd year	Combined
Tie-ridging at planting	**162.28a**	**148.02a**	**155.15a**	**35.94a**	**36.908a**	**36.425a**
Ridge at planting tie 2 WAP	121.10bc	113.86bc	117.48bc	29.97bc	28.545bc	29.259b
Ridge at planting tie 4 WAP	103.78d	98.17cde	100.98de	24.69cde	27.502c	26.098bc
Tie-ridging 3WAP	119.32bcd	105.05bcd	112.18bcd	28.76cd	21.234d	24.999cd
Ridge 2 WAP & tie 4WAP	126.61b	114.77b	120.69b	32.82ab	27.44b	30.13b
Ridge 3WAP&tie 6WAP	84.08e	84.98e	84.53f	23.38e	21.035d	22.212d
Tie-ridging 6WAP	106.92cd	89.25de	98.09ef	25.04cde	21.105d	23.075cd
Shilshalo 6wAP	111.43bcd	98.40cde	104.91cde	24.52de	20.687d	22.605cd
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

Table 7: First year (2017) mean square value for the effect of riding and tie riding time on the plant height, head length, grain yield, and biomass of sorghum at Lalibela.

Treatment	Plant height(cm)	Head Length(cm)	Total Biomass (Qt/ha)	Grain Yield (Qt/ha)
Tie-ridging at planting	110.07	15.467	104.81cd	15.747bc
Ridge at planting tie 2 WAP	114.4	15.53	122.31b	13.277cd
Ridge at planting tie 4 WAP	116.13	15.40	125.06ab	14.633bcd
Tie-ridging 3WAP	116.00	16.00	121.28bc	20.323a
Ridge 2 WAP & tie 4WAP	120.67	17.20	141.27a	17.947ab
Ridge 3WAP&tie 6WAP	114.13	15.45	122.57b	14.746bcd
Tie-ridging 6WAP	114.67	15.33	95.1d	11.681d
Shilshalo 8wAP	117.73	16.06	113.82bc	14.612bcd
Cv(%)	8.41	9.84	8.06	13.11
LSD(0.05)	NS	NS	16.7	3.529

constraint of sorghum production in east Africa is water stress. Particularly in Ethiopia, soil water deficits during crop establishment and grain fill are recognized as major constraints [12-15].

[6] Suggested that Tied ridges with a spacing of 75 cm had brought a significant yield improvement over the other moisture conservation practices and the farmer's practice in the dry land area of Wag Himra. Therefore, the Use of effective moisture conservation practices is the most important issue in areas where the availability of soil moisture is the most limiting factor for crop production in general. Tied ridges had brought a significant yield improvement over the other moisture conservation practices in general and the farmer's practice in particular. Generally, it is obvious that in the wag-lasta area of northern Ethiopia, where the rainfall is low in amount, erratic in nature, and uneven distribution during the cropping season is one of the most limiting factors for crop production [16]. On the other hand, in many parts of Ethiopia including the study area (Table 7), the nature of rainfall is erratic which results, in water stress at the crop development stage. ; All these need appropriate time of water management techniques including, ridging and tie ridging for dry land crop production. This research was then conducted to evaluate the appropriate time of ridging and ties ridging on the productivity of sorghum in wag-lasta areas under different climatic and soil-type conditions and for recommending appropriate time of tie riding together with their adaptation mechanisms for enhancing rain-fed agricultural production in the study area and other similar agro-ecological areas.

Material and Methods

Study Area Description

The field experiment was conducted in wag-himra and north wollo administrative zone, namely at kechin abeba and Aybra found in Lasta woreda and Sekota woreda Amhara regional state. The study sites were located at 11o 58' 20.442'' N latitude 039o 03' 00.804''E Longitude and 12º 437.482''N latitude 39º 01'09.594''Elongitude an altitude of 2159 m and 1928 meter above sea level (asl) respectively. The experimental sites are characterized by a gentle slope (less than 5%) with soils suitable for agriculture.

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 temperature are 737mm, 25ºc, and 13.6ºc respectively. The rainfall in the study area usually starts around mid of July extends to the end of August. The growing period of major crops grown in these areas is, however, mostly from the beginning of July to the end of October. 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 low soil fertility status of most agricultural lands are the major limiting factors for crop production in the study areas.

Experimental design and treatments

Field experiments were conducted during the summer season (Kirmet) of 2016/2017 and 2017/2018 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 tie2week after planting; (3) riding at planting and tie 4 weeks after planting (4) tied ridge3week after planting ; (5) riding

2week after planting and tie 4week after planting; (6) riding 3 weeks after planting and 6 week after planting ; (7) tie riding 6 week after planting (8) control (farmers' practice shilshalo 6 weeks and 8 weeks after planting moisture harvesting techniques for sekota and Lalibela respectively). The plot size of the treatment areas was 4.5 by 5m 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 the couture the space between tie was 2m and 1m with staggered zigzag line. Urea and NPS were used as a source of nitrogen and phosphorus fertilizers respectively. 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.

Treatment arrangement

Tie-riding at planting.

Ridging at planting and tied 2 weeks after planting.

Ridging at planting and tied 4 weeks after planting

Flat at the time of planting, tie-ridging 3 weeks after planting

Flat at the time of planting, ridging 2 weeks after planting, and tied 4 weeks after planting.

Flat land at the time of planting, ridging 3 weeks after planting and tied 6 weeks after planting.

Flat at the time of planting, tie, and ridging 6 weeks after planting.

Control, farmers' practice (6-8week after planting shilshalo)

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 [17-19]. 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 2–3-week intervals after heavy rainfall by 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, gain 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 statistix 10 software and treatment effects were compared using the Fisher's Least Significant Differences 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 soils to water ratio using a glass electrode attached to a digital pH meter. Organic carbon of the soils was determined following the wet digestion method as described by [18] while the percentage of organic matter of 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 [13].

Result 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. The soil pH of the trial sites according to [15] ranged from moderately alkaline and neutral for Lalibela and strongly acidic and slightly acidic for sekota experimental site. Based on the results obtained from soil analysis as shown above in Table 1, the average total nitrogen (%TN) ranges from 0.025-0.045, according to [15]; was categorized under very low and low, and it needs N fertilizer sources for optimal crop production and productivity. Available phosphorus (Av. P) ranged from3.78 -16.1 PPM, according to [5]; which is grouped under low, medium, and high classes, which need phosphorous fertilizer sources for optimum crop production and productivity. Soil organic matter (%OM) status of the trial site was ranging of riding and tie riding time on the grain yield from 0.37-1.076, according to [15], it was very low and low for both locations (Table 10).

Effect of ridging and tie ridging time on soil moisture content and grain yield of Sorghum

The results indicated the comparative advantage of the conservation practices in increasing the moisture availability of the soil as compared to the control plot with farmers' practices (Shilshalo). As is seen in **[Figures 1 and 2]** below the amount of soil moisture content stored in plots with tie ridging was considerably higher than the farmer's practice (Shilshalo) throughout the growing seasons in both locations, except for plots treated with tie ridging for 6 weeks after planting. It is also clearly seen in the figures that tied ridge practice had the highest soil moisture accumulations on average in both cropping seasons and soil-type conditions. The gravimetric soil moisture content on plots with the tied ridge at planting was on average 22.22% higher in sandy clay loam soil (at Sekota) and 26.39% higher in sandy loam (at Lalibela) as compared to plots with the Farmer's practice (Shilshalo 6-8week after planting respectively). Which had the minimum soil moisture content and grain yield throughout the growing season except for the plot with tie-ridging 6week after planting. Plots treated with ridging at planting tie2week 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

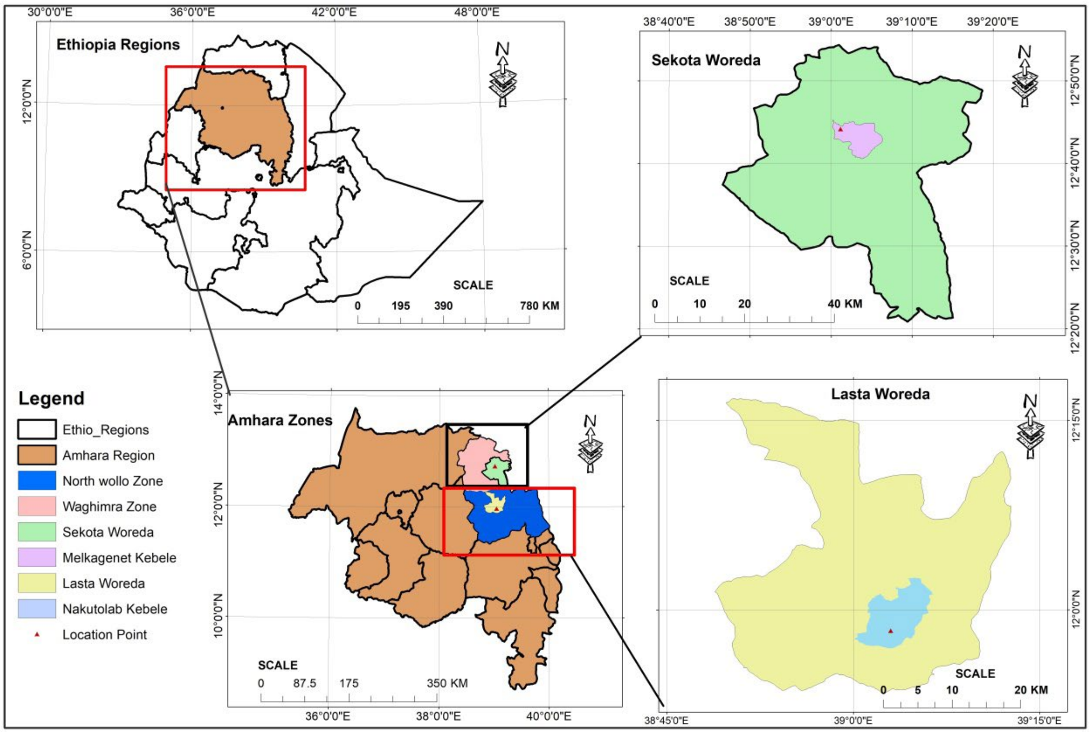

Figure 1: Location map of the study area.

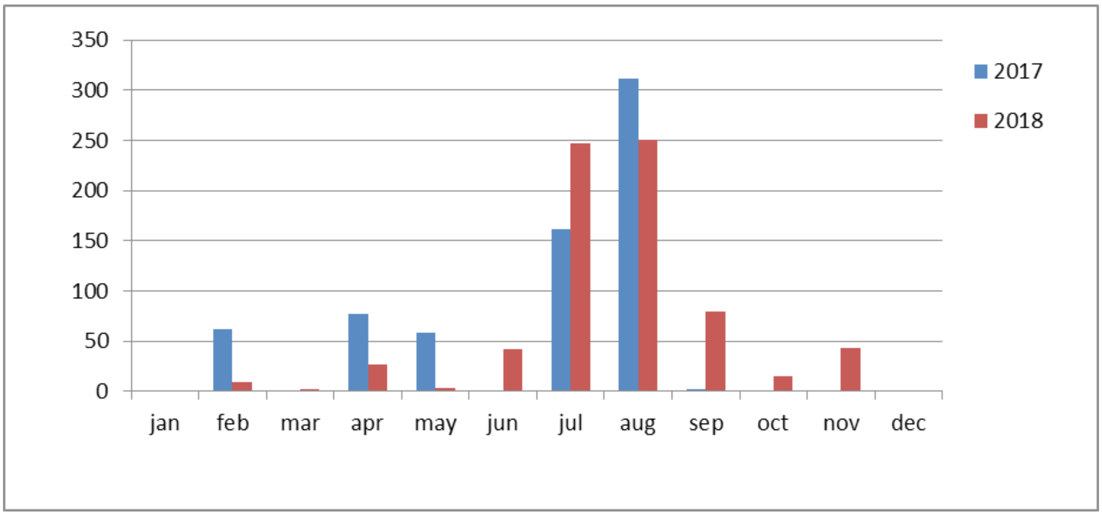

Figure 2: Sekota mean annual rainfall 2017 and 2018 cropping season.

farmers' practice (Shilshalo) had the minimum soil moisture content next to the plot treated with tie ridging 6week after planting.

Effect of riding and tie riding time on growth and yield of Sorghum at Aybira

The effect of ridge and tie ridge time was found significant effect (P≤0.05) on plant height, biomass, and yield parameters of sorghum, but there was no significant effect (P≤0.05) on the head length of sorghum at Aybira.

Plant height and head length

Riding and Tie riding time significantly (P≤0.05) affected the plant height of sorghum (Table 3). The higher Mean plant height of sorghum (175.17cm) at the 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≤0.05) affected the head length of sorghum as shown in the above (Table 5). 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 [10] who report nitrogen and phosphorus at the rate of 18 nitrogen and 46 phosphorus with tie-ridge had a significant effect on plant growth in areas of southern Ethiopia. Similarly [8] observed that nitrogen and phosphorus at the rate of 18 and 46 kg/ha with in-situ-moisture conservation had higher plant height.

Grain yield and biomass

The grain yield was significantly affected by the ridge and tie-ridge time at (P≤0.05). 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 from22.60Qt/ha to 36.42Qt/ha. Thus, compared to the farmer's practice, using the recommended rate of N and P2o5 (23/46 kg ha^{-1}) with tie- ridge at planting increased sorghum grain yield by37.9percentage. This implies that proper management of tie-ridge time can gain the additional grain yield of sorghum. The result of the current study agree with the finding of, [8] observed that fertilizer application of 46 P2O5 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 (155.15 Qt/ha) was recorded at ridge and tie- ridge at planting and the lowest biomass yield (84.53Qt/ha) was recorded at ridging3 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 (23/46kg/ha) fertilizer increases the biomass yield by 32.38% over farmers' practice **(Figure 3-5)**. Biomass yield is very important because the leaves and stems are used for cattle feed during the long dry season.

Effect of riding and tie riding time on growth and yield of sorghum at Lalibela

The effect of riding and tie riding time was found significant effect (P≤0.05) on plant height, biomass, and yield parameters of sorghum.

Plant height and head length

Riding and Tie riding time did not significantly (P≤0.05) affect the plant height of sorghum (Table 9). The higher Mean plant height of sorghum (130.63 cm) at tie- riding3week after planting was significantly higher than farmers' practice, and the lower mean plant height (119.3 cm) 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 in the above (Table 8). But the highest mean plant head length (16.06 cm) was recorded at riding two weeks after planting and tie 4 weeks after planting.

Grain yield and biomass

The grain yield was significantly affected by the ridge and tie-ridge time at (P≤ 0.05). 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 (13.309Qt/ha to 19.03Qt/ha P2O5 and16.96Qt/ha). Thus, compared to the farmer's practice, using the recommended rate of N and (23/23 kg ha^{-1}) with tie-ridge3week after planting and ridge 2 weeks and tie3 week after planting increased sorghum grain yield by30.11% and 21.58% respectively.

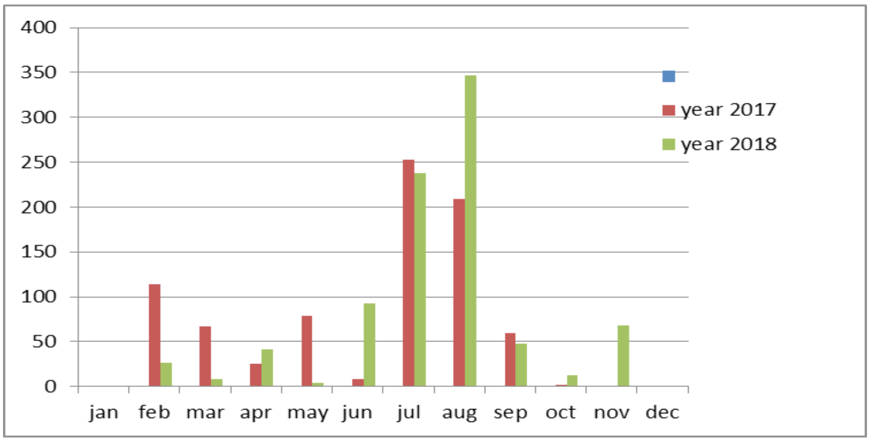

Figure 3: Lalibela mean annual rainfall for the 2017 and 2018 cropping season.

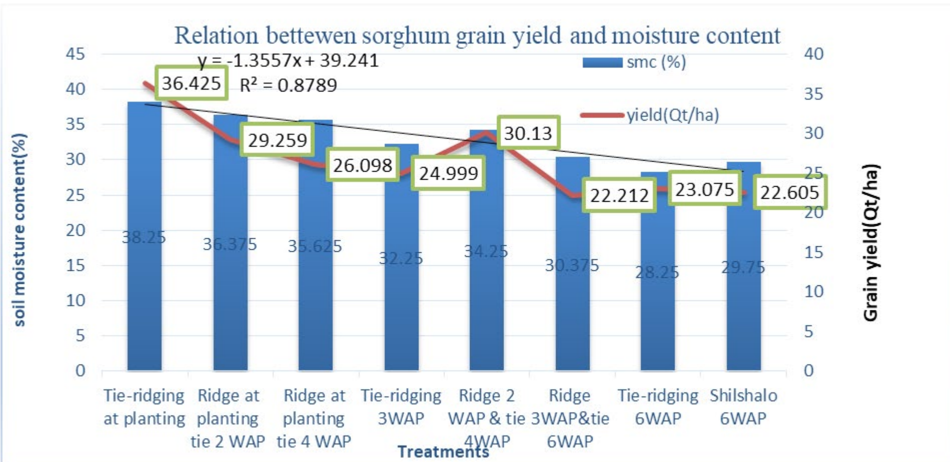

Figure 4: Effect of tie ridging time on soil moisture content and grain yield of sorghum in sekota (aybira) site.

Table 8: Second year (2018) mean square value for the effect of riding and tie riding time on the plant height, head length, grain yield, and biomass of sorghum at Lalibela.

Treatment	Plant height(cm)	Head Length(cm)	Total Biomass(Qt/ha)	Grain Yield(Qt/ha)
Tie-ridging at planting	130.60	14.2ab	117.31bc	13.097c
Ridge at planting tie 2 WAP	143.07	14.8ab	122.66b	13.754bc
Ridge at planting tie 4 WAP	144.93	15.733a	125.38b	14.115bc
Tie-ridging 3WAP	145.27	15.8a	129.53ab	17.742a
Ridge 2 WAP & tie 4WAP	135.67	14.933ab	144.72a	15.978ab
Ridge 3WAP&tie 6WAP	124.47	14.37ab	119.75b	17.007a
Tie-ridging 6WAP	136.33	13.867ab	100.4c	12.357c
Shilshalo 8wAP	133.60	13.133b	120.48b	12.007c
Cv(%)	10.76	9.1	8.3	9.16
lsd(0.05)	NS	2.32	17.8	2.328

Table 9: 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	14.833
Ridge at planting tie 2 WAP	114.4	143.07	128.73	15.53	14.8ab	15.167
Ridge at planting tie 4 WAP	116.13	144.93	130.53	15.40	15.733a	15.567
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	**16.067**
Ridge 3WAP&tie 6WAP	114.13	124.47	119.30	15.45	14.37ab	14.912
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	Ns	Ns	Ns	Ns	2.32	NS

Table 10: Combined mean square value for the effect of riding and tie riding time on the 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	104.81cd	117.31bc	109.14cd	15.747bc	13.097c	14.422cd
Ridge at planting tie 2 WAP	122.31b	122.66b	122.52b	13.277cd	13.754bc	13.515de
Ridge at planting tie 4 WAP	125.06ab	125.38b	125.22b	14.633bcd	14.115bc	14.374cd
Tie-ridging 3WAP	121.28bc	129.53ab	125.41b	20.323a	17.742a	**19.033a**
Ridge 2 WAP & tie 4WAP	141.27a	144.72a	**142.99a**	17.947ab	15.978ab	**16.962ab**
Ridge 3WAP&tie 6WAP	122.57b	119.75b	121.16bc	14.746bcd	17.007a	15.877bc
Tie-ridging 6WAP	95.1d	100.4c	97.75d	11.681d	12.357c	12.019e
Shilshalo 8wAP	113.82bc	120.48b	117.15bc	14.612bcd	12.007c	13.309de
Cv(%)	8.06	8.3	9.01	13.11	9.16	12.87
Lsd(0.05)	16.7	17.8	12.651	3.529	2.328	2.247

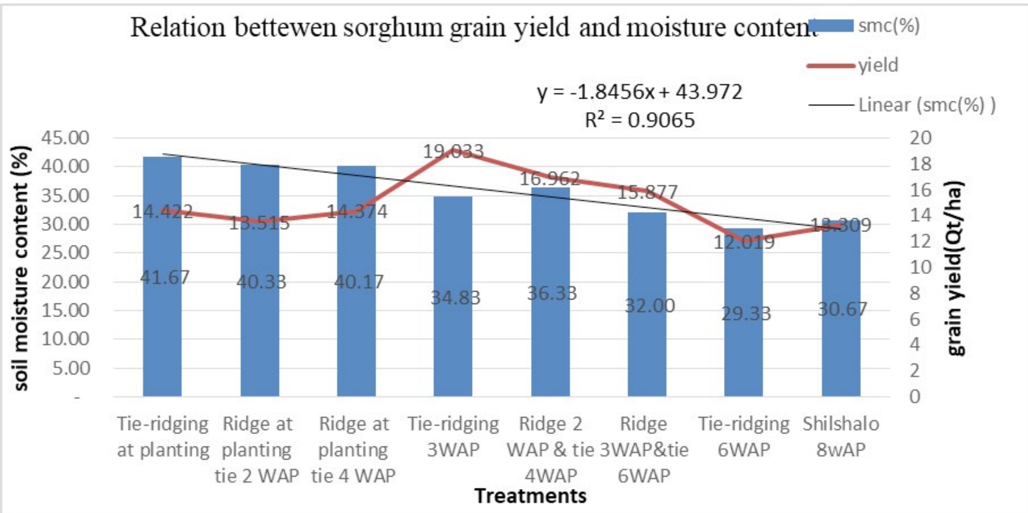

Figure 5: Effect of tie ridging on soil moisture content and grain yield of sorghum in Lalibela (kechinabeba) site.

This implies that proper management of tie-ridge time can gain the additional grain yield of sorghum. The result of the current study agree with the finding of [8] observed that fertilizer application of 46 P2O5 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 Qt/ha) was recorded at ridge and tie- ridge 3 weeks after planting and the lowest biomass yield (97.75Qt/ha) was recorded at tie - ridge 6 weeks after planting treatment **(Figure 6)**. The result indicates that tie-riding 3week after planting and with the recommended rate of nitrogen and phosphorus (23/23kg/ha) fertilizer increases the biomass yield by 31.6% and 18.07% over tie-ridging 6 week 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.

Fieldp erformance at Sekota (Aybira) Fieldp erformance at Lalibela

Figure 6: Field performance of sorghum at Lalibela and sekota.

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 the 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 treatment of ridge and tie ridge time. Tie ridging at planting with the recommended rate of N and P2O5 (23/46kg/ha) 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 P2O5 (23/23kg/ha) fertilizer is found to be the appropriate timing for optimum productivity of sorghum in Lalibela (kechin abeba) and ridge 2 weeks and tie 4 weeks after planting recommended as the second option in Lalibella (kechin abeba) and the similar agro ecology areas.

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Authors' contributions

YA designed the study and wrote the manuscript; HL field data collection and edited the manuscript; YR provided technical guidance and reviewed the manuscript; TE guidance for analysed data and edited the manuscript; All authors read and approved the fnal manuscript.

Conflict of Interest

The authors declare that they have no competing interests

Availability of data and materials

Data that were used to generate these results are available upon request from the corresponding author.

Consent for publication

Not applicable

Ethics approval and consent to participate

Not applicable.

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