Research on World Agricultural Economy
https://ojs.nassg.org/index.php/rwae

RESEARCH ARTICLE

Production and Commercialization Status of Improved Panicum Grass Cultivation in the Lowland Livestock Production System of South Omo South-Western Ethiopia

Denbela Hidosa[1*] Asmera Adicha[2] Muhaba Sultan[3]

1. Livestock Research Directorate, Jinka Agricultural Research Center, Ethiopia
2. Socio Economic and Gender Research Directorate, Jinka Agricultural Research Center, Ethiopia
3. Natural Resource Research Directorate, Jinka Agricultural Research Center, Ethiopia

Abstract: Lack of information on the production and commercialization status of improved Panicum grass is one of the major livestock production impediments in South Omo. The improved Panicum grass is a perennial grass species used throughout the tropics for livestock feeding. Therefore, the present study was conducted to understand the seed and hay production status and the economic visibility of improved Panicum grass cultivation. The face-to-face interviews were conducted with improved Panicum grass producers. The quantitative data, such as the amount of bales and seed produced, and the qualitative data, such as agro-pastoralists' perceptions, were analyzed using simple descriptive statistics and the Likert scale. The results revealed that the seed yield and herbage productivity after seed harvest were 2.5 quintals and 788 bales per hectare per cut, respectively. The average income generated from the sale of herbage and seed of Panicum grass was 325,350 ETB and 442,500 ETB per hectare per year, respectively. Based on the results, the authors concluded that joint efforts are needed to step the agro-pastoralists out of the poverty vicious cycle through promoting wide-scale improved Panicum grass production by linking products to market sources in addition to legume-Panicum grass-based cattle and goat fattening intervention.

Keywords: Agro-pastoralists perception; Economic visibility; Herbage Panicum grass; Seed

*Corresponding Author:
Denbela Hidosa,
Livestock Research Directorate, Jinka Agricultural Research Center, Ethiopia,
Email: denbelahidosa@gmail.com

Received: 31 August 2022; **Received in revised form:** 21 October 2022; **Accepted:** 28 October 2022; **Published:** 31 October 2022

Citation: Hidosa, D., Adicha, A., Sultan, M., 2022. Production and Commercialization Status of Improved Panicum Grass Cultivation in the Lowland Livestock Production System of South Omo South-Western Ethiopia. *Research on World Agricultural Economy*. 3(4), 694. http://dx.doi.org/10.36956/rwae.v3i4.694

DOI: http://dx.doi.org/10.36956/rwae.v3i4.694

1. Introduction

Ethiopia has about 70 million cattle, 42.9 million sheep, 52.5 million goats, 8.1 million camels, 2.15 million horses, 10.8 million donkeys, 0.38 million mules, and 57 million chickens [1]. Livestock herds have provided food, power for crop production, transportation, organic fertilizer, a source of biofuel, security in times of crop failure, and a means of wealth accumulation to 3.85 million rural households in the highland and 7.15 million rural households in the lowland [2,3]. Similarly, in South Omo's lowland areas, livestock production has played an important role in providing quality foods (milk, meat and egg), sources of cash income, social insurance, and esteem [4-7]. However, the livestock production system is characterized by a low-input/low-output system and the productivity, which refers to the ability of the animals grown to produce economic outputs such as livestock products and by-products, is generally very low [6]. This is due to poor livestock feed quality and quantity, a lack of improved forage production practices, and as a result, herders rely entirely on natural pasture, which is unable to meet the nutrient requirements of livestock to obtain required production from the livestock. Moreover, in the study area, improved forage seed production and supply systems are found to be critical for livestock production due to prevailing of high improved forage seed prices, that makes inaccessible to livestock keepers and, as a result, improved forage production is poorly adapted by livestock keepers. Cognizant of this state of affairs, during the last several years, Jinka Agricultural Research Center (JARC) has been carrying out an adaptability study on different improved forage species by using irrigation and an array of potential grass, legume, and browse trees of improved forage species were recommended for South Omo agro-ecologies. The selected improved forage species have shown better herbage yield and quality than those in the naturally occurring rage-forage grasses. The improved Panicum grass is among the adapted and recommended improved forages for South Omo agro-ecologies and is used throughout the tropics for livestock feeding inform of pasture, cut-and-carry, silage, and hay making [8]. Panicum grass has a global average dry matter yield of 2,000 bales per hectare per year [9], which can vary depending on the species and variety, fertilizer application, and farm management practices. Thus, the studies reported from the research station of South Omo [10,11] have shown that the Panicum grass yields about 1,000 bales per hectare per cut without fertilizer in rain-fed conditions and 1200 bales per hectare per cut in irrigated conditions, respectively. However, its dry matter yield was reported at up to 2,800 bales per hectare in nitrogen-fertilized conditions [12]. Moreover, grass is generally preferable to supplement with sources of protein to improve animal performance due to the fact that it is well eaten by all classes of grazing livestock, particularly high intakes of young leafy plants stages. It is reported that the cows grazing on improved Panicum grass yield 10 kg to 12 kg of milk per day. The other feeding trial conducted on goats showed that goats supplemented with improved Panicum grass give better results when it is complemented with a legume-based or concentrate diet. Also, improved Panicum grass is a fast-growing and bulky grass that helps prevent soil erosion since it provides rapid ground cover when it is well managed. However, with this notable potential, the improved Panicum grass seed and hay production and commercialization status, and agro-pastoralists' perception level are not well documented in the study area due to the scarcity of surplus viable seed, the limited knowledge and capability of agro-pastoralists, and the poor extension services delivered by the government in the study area [13]. In recent years, a few NGOs in the Dasenech district have been trying to multiply and produce small-scale seeds by mobilizing agro-pastoral communities in groups, but they have not able to satisfy the voracious demand for improved Panicum grass seed and hay, which has continued forward at country level. It is hoped that by understanding how agro-pastoralists perceive the Panicum grass seed and hay production and commercialization approaches and linking products (seed and hay) to market sources will transform poor agro-pastoralists into productive and prosperous livelihoods. Therefore, the present study was initiated (1) to understand the production and commercialization status and agro-pastoralists' perception on improved Panicum grass seed and hay production and (2) to understand the economic visibility of improved Panicum grass seed and hay production under agro-pastoralists managed system.

2. Materials and Methods

2.1 Descriptions of the Trial Location

The study was conducted in Alkatakech Kebele (Administrative-subunit) of the Dasenech district of South Omo. It is located in the Omo River basin, south of the Omo River, not more than 500 meters from the Omo Rate, the capital city of Dasenech district, and 200 kilometers from Jinka, the capital city of South Omo. The site is situated at 5°14' N latitude, 36°44' E longitude, and has a temperature range of 25 °C ~ 40 °C. The altitude of the study site is 350 m and rainfall ranges from 350 mm to 600 mm with a bimodal rainfall type in an erratic distribution [14]. The majority of economic activity that has pre-

vailed in the study area is low-input/low-output livestock and small-scale sorghum, maize, and banana production using small-scale irrigation from the Omo River. The major indigenous livestock species that have been kept in the study area are cattle, sheep, and goats [13].

2.2 Agro-pastoral Selection

Based on irrigation facility and agro-pastoralist interest in producing Panicum grass seed and hay for livestock feeding and commercialization purpose, JARC established one improved Panicum grass seed and hay producing pastoral and agro-pastoral research and extension group (PAREG), which consisted of about 41 agro-pastoralist members from Alketekech Kebele in collaboration with the Dasenech district of Livestock and Fisher Development Office.

2.3 Site Selection and Planting

Each household (HH) in a group received 0.25 ha of communal land, and a total of 10.25 ha of land per group was plowed, disked, harrowed, and ridged using tractors and corrected by laborers donated by PAPREGs members. Panicum grass seed was purchased from the local market and sown by drilling with a seeding rate of 15 kg/ha at a 30 cm interval between rows [18].

2.4 Trial Site Management

Appropriate site management activities such as weeding, irrigating, hoeing, and monitoring were conducted. The trial farm was kept nearly weed-free by using PAPREG. Family members and trial agro-pastoralists kept the trial site free of animals and rodents. The regular monitoring of the trial site was held at different times by researchers and experts.

2.5 Seed and Hay Harvesting

The hand-harvesting method was used, and grass seed heads were mowed with sickles, bound and stoked in the field, then collected for threshing after drying in the shade. Then the heads of grass were beaten with sticks and hands, roughly sieved, and then sun-dried. The inert matter and damaged seed from harvested seed threshed and dried materials were cleaned by hand to ensure good seed quality. Finally, at the end of processing, the threshed seed was packed and sealed in locally available containers (jars) and stored in ventilated rooms until sold to the local market. Regarding haymaking, after seed harvest for those interested in hay production, the grass was cut and laid out in the sun under shade, raked a few times, and turned regularly to hasten its drying and then dried grass was raked and baled.

2.6 Technology Promotion

At mid-term grass production, a field day was organized for agro-pastoralists, administrative bodies, experts, and other stakeholders and participants to compare the introduced technological options with existing practices. The posters, banners, and other promotional materials were displayed to participants during the field day program. The discussion was held among the stakeholders on the way forward, and some additional roles might be identified, and roles and responsibilities were shared for the next contributions along the value chain of grass hay production and commercialization.

2.7 Data Collection

Data on agro-pastorals' perceptions of improved Panicum grass production, amount of bale and seed produced, harvesting frequency, the selling price of a bale, and the economic visibility of Panicum grass production were collected by using face-to-face interviews from the total of were 41 respondents (16 males and 25 females).

2.8 Method of Data Analysis

Quantitative data such as the amount of bales and seed produced and qualitative data such as agro-pastoralists' perceptions were analyzed using simple descriptive statistics (percentage and mean) and the Likert scale. A benefit and cost ratio was used to analyze the cost of production and net income from Panicum grass production.

3. Results and Discussion

3.1 Socioeconomic Characteristics of Trial Agro-pastoralists

The demographic and socioeconomic characteristics of trial agro-pastoralists in the study area are presented in Table 1. The result on demographic characteristics revealed that the majority (60.97%) of interviewed Panicum grass growers were female-headed, while about 39.02% were male-headed. It is obvious that in pastoral areas of Ethiopia, the females are more involved in agricultural activities like planting, weeding, harvesting, and threshing than the males, aside from household routine activities such as preparing dishes, clearing the house and barn, caring for children, and fetching water and firewood. This is because, culturally, males were paid more dowries during marriage time for females' families, and thus, they were considered slaves, allowing females to be more involved in agricultural activities than males. They reported that most of the time, males were involved in preparing land

and herding cattle rather than planting, weeding, and harvesting. Similarly, the studies reported by Hidosa and Ayele [15] and Zelalem *et al.* [6] from the pastoral and agro-pastoral areas of Hamer and Bena-Tsemay districts have shown that most of the time, females were involved in agricultural activities like planting, weeding, and harvesting, in addition to house routine activities, while males herded cattle. Meanwhile, the study reported by Worku and Lisanework [16] elucidated that young males are involved in herding cattle to distant places, especially to an island (Desset) in the Dasenech district of South Omo, while females are involved in crop farming activities using small irrigation systems adjacent to residential areas in addition to household routine activities. The minimum family size of agro-pastoralists who were involved in Panicum grass production was 3, and the maximum was 9, and the average was 6. The overall average family size from the present study was lower than the reported value of 9.65 persons by Demerew *et al.* [4] for the Malle district of South Omo and 10 persons for Borana pastoralists by Zekarias [17], but it was similar to the reported value of 6.19 persons for agro-pastoralists of the Bena-Tsemay district of South Omo by Zelalem *et al.* [6]. Regarding experience in Panicum grass production, the findings of this study indicated that the minimum year of experience for agro-pastorals who have been involved in Panicum grass production was one year, while the maximum was seven years, and on average about three years. The finding on Panicum grass production experience from this study implies that agro-pastoralists are not new to improve Panicum grass production, but that successful production and getting benefit from the production might depend on the provision of training. Less experienced agro-pastoralists are expected to have less access to Panicum grass seed and hay production and marketing information. Similarly, the study reported by Gebreegziabher and Tsegay [18] indicated that more experienced farmers adopted forage production practices more quickly than less experienced ones. The maximum number of family members involved in Panicum grass production in the study area was 5 people, while the minimum was 2 people, and the average was 3.22 people. The involvement of family members in Panicum production is important to implement different farm management operations like irrigating, weeding, and harvesting to share among them. The involvement of family members in Panicum grass production is also important to create more job opportunities for jobless household members and thus generate income and reduce jobless family members, thereby improving their means of livelihood.

As indicated in Figure 1, the majority of the agro-pastoralists who were involved in Panicum grass production were illiterate (61.1%), about 16.1% had acquired primary education, and very few (11.1%) had learned grade 5-8 and above grade 8 (11.1%). The studies reported by Zelalem et al. [6] and Demerew et al. [4] have shown that about 66% and 12% of agro-pastoralists of Bena-Tsemay, and 68.3% and 11% of agro-pastoralists of Malle districts who are involved in cattle production were illiterate and acquired primary school (Grade 1-4th), respectively, which was relatively in agreement with the results from our study. However, the results from this study were not in line with the previously reported values of 41.7% by Tollossa et al. [19] for Borana pastoralists who had attended formal education (1-4th grade) and 83.88% by Hidosa and Ayele [15] for Hamer pastoralists who were illiterate, i.e., unable to read and write.

3.2 Reason for Improved Panicum Grass Production

The important attribute factors that have motivated agro-pastoralists to improve Panicum grass production in the study area are presented in Table 2. According to agro-pastoralists, livestock feed shortages are an important factor that has motivated them to get involved in improving Panicum grass production. Accordingly, about 51.23% of agro-pastoralists replied that for the last 10 years they have faced a livestock feed shortage, but cur-

Table 1. Demographic and Socioeconomic characteristics of sample respondents

Characteristics of respondents		Frequency	Percent	
Sex	Male	16	39.02	
	Female	25	60.97	
	Minimum	Maximum	Mean	Std. Dev
Age of household	25	50	35.72	7.98
Family size	3	9	6.22	1.96
Experience in Panicum grass production (year)	1	7	3.44	1.82
Family number engaged in Panicum grass production	2	5	3.22	1.06

Source: Own survey, 2022

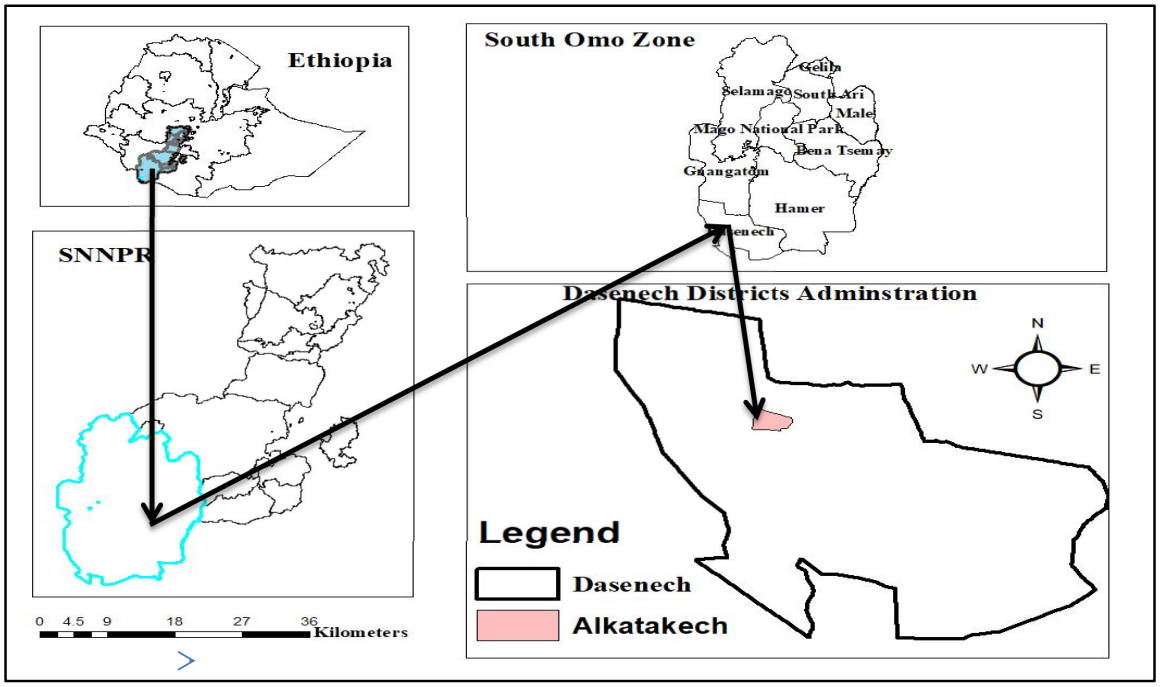

Figure 1. Map of study Area

rently they have solved this by starting the production of improved Panicum grass in their backyard and feeding it by cut and carry system. In addition, they were reported that agro-pastoralists involved in Panicum grass production because they were trained by researchers from the JARC and experts from the Dasenech district of Livestock and Fisher Development Office (DDLFDO) and obtained improved Panicum grass seed freely from these organizations. During the focus group discussion with them, they mentioned that there were a lot of cattle that died this year in nearby Kebeles who were not involved in Panicum grass planting as we did due to the lack of rainfall in the last three consecutive years as result of climate change. On the other hand, about 36.58% of respondents reported that they did not observe livestock feed shortages because they were recently solved by planting Panicum grass, and very few agro-pastoralists (12.19%) replied that livestock feed shortages occurred sometimes. Similarly, the study reported by Getaneh *et al.* [13] indicated that livestock feed shortages in the Dasenech district were severe problems, especially between January and March due to a lack of awareness of improved forage species except that very few agro-pastoralists were involved in Panicum grass production. As it is indicated in Table 2, all respondents (100%) have replied that they have participated in the growing of improved Panicum grass due to an improvement in awareness of the importance of improved Panicum grass. They mentioned that the improved Panicum grass production is important because they sell seed and hay on the local market and buy grains like maize and sorghum to fulfill the food requirements of their family members, besides feeding their cattle, sheep, and goats by the cut and carry system. Similarly, the study reported by Mengistu *et al.* [20] indicated that farmers of the Damota Gale district of Wolaita Zone have produced improved forages as a source of cash, for use as feed, for soil erosion control, or two or more of these functions. Regarding the benefits of growing Panicum grass, the majority (92.68%) of respondents reported that the benefits of growing improved Panicum grass were highly improving; while very few (7.32%) reported that benefits obtained were slowly improving. This implies that the majority of respondents realized the importance of growing Panicum grass as their main livelihood improvement activity in the study areas. The high improvement in the growth of Panicum grass is due to growers' having received training on planting methods, irrigating schemes, harvesting time, conservation methods, hay-making practices, and ways of utilization. The studies reported by Gebreegziabher and Tsegay [18] and Dejene *et al.* [21] have indicated that about 74.5% and 66.7% of farmers participated in improved forage production in highland areas of Ethiopia due to an improvement in awareness of the importance of improved forage production, respectively.

Table 2. The attribute factors that have motivated agro-pastoralists in improved Panicum grass production

Attributes	Respondents response	Freq	Percent
Feed shortage	• Yes it occurs often but not now	21	51.23
	• Yes it occurs sometimes	5	12.19
	• No, recently solved	15	36.58
Awareness improvement in improved forage production	• Yes	41	100
	• No	0	0
The benefit of growing panicum	• Highly improving	38	92.68
	• Slowly improving	3	7.32

Source: own survey, 2022

As indicated in Figure 2, the majority (66.67%) of respondents of Panicum grass growers reported that they were trained by researchers from JARC, whereas very few (5.55%) of respondents were trained by experts from DLFRDO, and the remaining were trained by JARC in collaboration with LLRL (11.11%) and JARC in collaboration with DLFRDO and LLRP (16.67%). The result from the present study implies that in the study area, Panicum grass growers were well trained on the improved panicum grass production package by the different organizations. As mentioned by DLFRDO experts during household surveys in the study area, the different improved forage species like Elephant grass, Sesbania, Luecunea, Lablab, Cowpea, Rhodes, and Panicum grass were demonstrated to agro-pastoralists by different organizations, but of these, Panicum grass was highly adopted by agro-pastoralists. The reasons for the high adoption rates of Panicum grass by agro-pastoralists were that grass is highly preferred by their animals; it is easy to establish; it has high herbage and seed yielding potential; it is resistant to water and moisture stress; and there is a high demand for herbage and seed at the local market.

3.3 Herbage and Seed Productivity

The total amount of herbage (bales) and seed (quintals) produced in the study area is presented in Table 3. According to agro-pastoralists, the seed yield and herbage productivity after seed harvest of Panicum grass were 2.5 quintals per hectare per cut and 788 bales (11.82 tones) per hectare per cut, respectively. Of the total herbage produced, about 964 bales were fed to their cattle by a cut and carry system, while about 650 bales of green herbage were gifted to their relatives who were not involved in Panicum grass cultivation to save their cattle, goats, and sheep during a severe drought in the study area. Moreover, agro-pastoralists reported that about 760 bales of green herbage were exchanged with 65 goats in a bartering system, and about 1,566 bales of green herbage were sold both at the farm gate and local market and purchased grains and covered the food requirements of family members. The results obtained from the present study were lower than the reported values of 1000 and 1200 bales by Denbela [10] and Hidosa *et al.* [11] for improved Panicum grass cultivated in rain-fed and irrigated conditions, respectively. The result of seed yield from the present study was lower than the reported values of 3.1 quintals per hectare by Hassen [22] and 4.71 quintals per hectare by Zeleke *et al.* [23] for *Panicum antidotale* grass from the Afambo and Amibara districts of the Afar region, respectively.

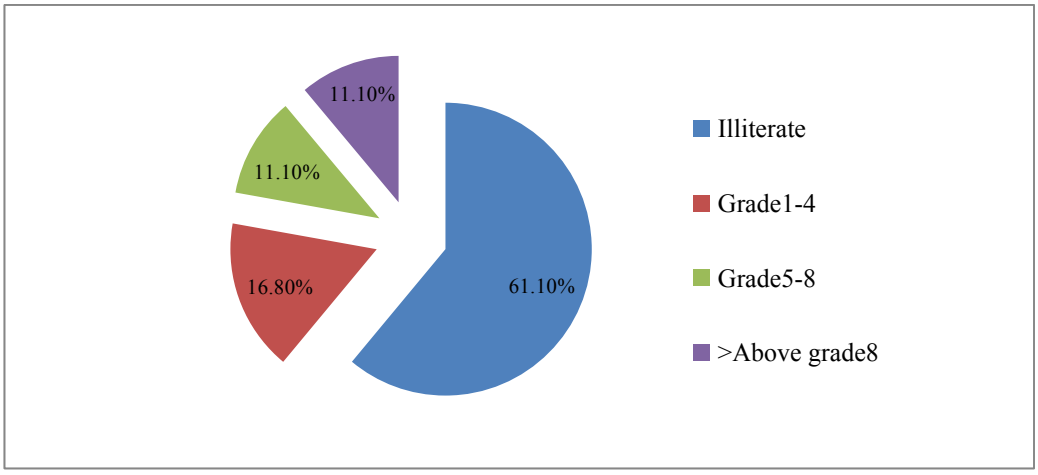

Figure 2. Education status of improved Panicum grass producer house hold

Table 3. Amount of improved Panicum herbage and seed produced and utilized by agro-pastoralists in irrigated lowland of Dasenech district under agro-pastoral management system

Seed(Quintal)/ha/cut	2.5
Herbage (Bale)/ha/cut	788
Amount of herbage consumed/HH/year	
• Own cattle(Bale)	964
• Gifted (Bale)	650
• Bartering(Bale)	760
• Sold at the farm gate(Bale)	1,566

Source: own survey, 2022

3.4 Herbage Utilization Way

The Panicum grass herbage utilization practices after seed harvest are indicated in Figure 3. As indicated in Figure 3, the majority (49.3%) of respondents replied that they fed their cattle, goats, and sheep and sold green herbage at the farm gate, while about 20.90% of respondents fed their cattle, sheep, and goats by cut and carry system. On the other hand, about 23% of respondents replied that they used herbage as a direct feed to cattle, sheep, and goats by cut & carry system, haymaking for their cattle, and selling green herbage in the farm market, while very few agro-pastoralists (6.8%) reported that they sold fresh herbage on the farm. Similar to the current study's findings, Zereu and Lijalem [24] found that approximately 98.4% and 75.6% of farmers in the Wolaita zone's midland and lowland agro-ecologies used improved forage by cut and carry systems, respectively. Moreover, the study reported by Tolera [25] stated that cultivated forages are mainly important as cut-and-carry sources of feed and as a supplement to crop residues and natural pastures, which was concurrent with the result of this study.

3.5 Seed and Herbage Harvesting Frequency

According to agro-pastoralists, the average improved Panicum grass seed harvesting day in the study area was between 50 and 60 days. They mentioned that if their farm was irrigated with enough water every week, the seed was harvested 50 days after planting, while if the farm was not irrigated with enough water every week, the seed harvesting days were extended up to 60 days. Similarly, the seed harvesting frequency was dependent on irrigation water access, and as the agro-pastoralists, the minimum Panicum grass harvesting frequency was 4 times, the maximum was 6 times, and the average was 5 times per year for seed production. Similarly, the study reported by Zeleke *et al.* [23] indicated that the improved *Panicum antidotale* grass was harvested 61 days after planting for seed. The result of this study was lower than that reported 7 times per year by Zeleke *et al.* [23] from the Amibara district of the Afar region, Ethiopia. Concerning the harvesting frequency of improved Panicum grass for herbage production, agro-pastoralists reported that at 45 days, improved Panicum grass bloomed up to 50% and it was ready to feed animals by cut and carry system. The study reported by Denbela [10] indicated that improved Panicum grass bloomed up to 50% at 78 days after planting under rain-fed conditions, which was longer than what agro-pastoralists reported in the present study. This study's inconsistent results on seed harvesting date and frequency when compared to previous studies are due to soil variability, weather conditions, species difference, or management practices. Forage yield and yield-related agronomic parameters may vary due to

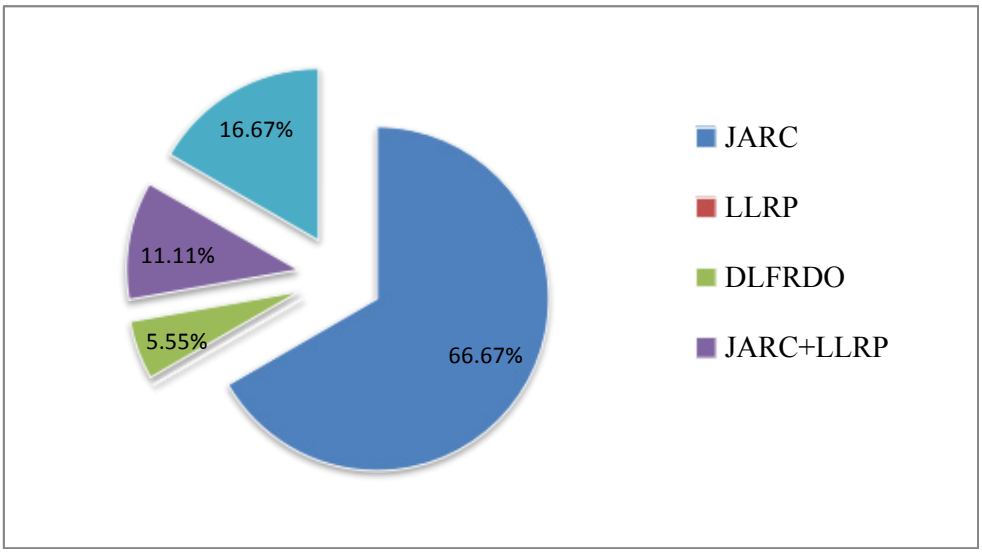

Figure 3. Training delivery organizations on improved Panicum grass production packages

differences in soil parameters, harvesting age, irrigation effect, management, and agro-ecological differences [5,26,27].

3.6 Income from Panicum Grass Production

The income generated from improved Panicum grass production (seed and herbage) is presented in Table 4. According to agro-pastoralists, the average price of herbage (bale) was 90 ETB, whereas the minimum and maximum prices of bale were 80 ETB and 100 ETB, respectively. The mean price of improved Panicum seed per kg was 300 ETB, whereas the minimum and maximum prices per kg were 250 ETB and 350 ETB. Based on the result, the minimum and maximum bales produced per cut per hectare were 650 and 926 bales, respectively with average 788 bales (Table 4). The average income generated by households per year per hectare from the sale of fresh herbage and seed was 325,350 ETB and 442,500 ETB, respectively, and the mean total income of 767,850 ETB. The high incomes were a major driver of the development of forage production for sale and animal feeding in the study area. For instance, by cultivating improved Panicum grass for sale in local markets, small-scale irrigated Panicum grass production is viable as a cash crop. It has been determined that irrigated Panicum grass production is economically competitive with other crops based on frequent harvesting with promising herbage yield, quality, and on-farm gate prices. Other advantages include increasing and improving the productivity of farm animals in terms of milk and meat production, meaning the amount of profitability derived from the improved Panicum grass may be greater and clear. Previous research from Vietnam, Cambodia, and China found that improving animal feeding increased the financial benefits of smallholder cattle production systems [28-31]. The study reported by Getnet [32] indicated that the initiatives aimed at fodder agronomy, value chain development, and business viability over the long term can increase stabilized farm revenue.

3.7 Cost of Panicum Grass Production

The total cost for the production of improved Panicum grass is described in Table 5. The Panicum grass production cost was calculated from a face-to-face semi-structured interview of beneficiary agro-pastorals by the price norms approved by the Jinka Agricultural Research Center for wage employees in 2021, which have been taken into consideration during the total cost calculation. Based on the approved wage norm of JARC, the average cost of production for improved Panicum grass production per hectare per year was 114,000 ETB. Regarding the price of land, it is not considered in the cost price calculation because the land is a free resource/value or communal in the agro-pastoral and pastoral areas.

3.8 Net Income from Panicum Grass Production

The net income from improved Panicum grass seed and hay production in the study area is presented in Table 6. The mean net income per hectare per year from the sale of green herbage and seed was 767,850 ETB by considering five harvesting frequencies per year and the required production cost for improved Panicum grass production was 114,000 ETB. This means that agro-pastoralists that participated in improved Panicum grass production would get a net income of 653,850 ETB/year. Moreover, the benefit-to-cost ratio of Panicum grass production was 5.73:1, which indicated that each household gets a benefit from Panicum grass production nearly six times the cost of production. This result would motivate new agro-pastoralists to tend to participate improved Panicum grass cultivation to realize benefits of this profitable enterprise.

Table 4. Income from improved Panicum grass herbage and seed/ha/cut/year

Attributes	Min	Max	Mean
Harvesting frequency per year	4	6	5
Herbage/ha/cut (bale)	650	926	788
Price per bale (ETB)	80	100	90
Seed produced/ha/cut (kg)	150	350	250
Price per kg (ETB)	250	350	300
Income from the sale of herbage/HH (ETB)	234,000	416,700	325,350
Income from the sale of seed/HH (ETB)	150,000	735,000	442,500
Total income (ETB)/ha/year	384,000	1,151,700	767,850

Source: own survey, 2022

Table 5. Cost of Panicum grass production per household per hectare per year

Items	Measurements	Amount	Price/ETB	Total cost	Remark
Panicum Seed	Kg	15	300	4,500	
Land clearing	Person/day	30	100	3,000	
Land preparation	Person/day	20	100	2,000	
Planting	Person/day	20	100	2,000	
Irrigating	Round	104	100 ETB*8person*104	83,200	Irrigation frequency per ha
1st wedding	Person/day	20	100	2,000	
2nd weeding	Person/day	20	100	2,000	
Herbage harvesting	Person/day	20	100	2,000	
Haymaking	Person/day	20	100	2,000	For tedding and baling
Seed harvesting	Person/day	20	100	2,000	
Seed threshing	Person/day	66	100	6,600	Drying and packing
Seed cleaning	Person/day	27	100	2,700	
Total				**114,000**	Per year

Source: own survey, 2022

Table 6. Net income from improved Panicum grass seed and hay production/ha/year

Income and cost of production	Mean (ETB)
Gross income (seed + herbage)	767,850
Cost of production (seed and herbage)	114,000
Calculated net income	653,850
Benefit: cost ratio	5.73:1

Source: own survey, 2022

3.9 Benefit of Establishing Improved Panicum Grass-producing Cooperative

The benefits of establishing improved Panicum grass-producing cooperative in the study area are indicated in Figure 4. As indicated in Figure 4, about 38.9% of respondents replied that producing Panicum grass and being in a cooperative enables them to earn a high income, while about 27.8% replied that being in a cooperative is imperative to share forage cultivation practice and other experiences. The remaining 33.3% of agro-pastoralists said that growing Panicum grass in cooperatives gives them access to irrigation and other new technological options. Several empirical studies have shown that agricultural cooperatives raise farm output by encouraging the use of productivity-enhancing technological options and thereby enhancing their collective bargaining power, which reduces the market risks they may face. Furthermore, they provide member farmers/pastoralists with financing options that raise productivity ceilings and are essential for the distribution of agricultural products like chemical fertilizers, seeds, and other inputs [33-36].

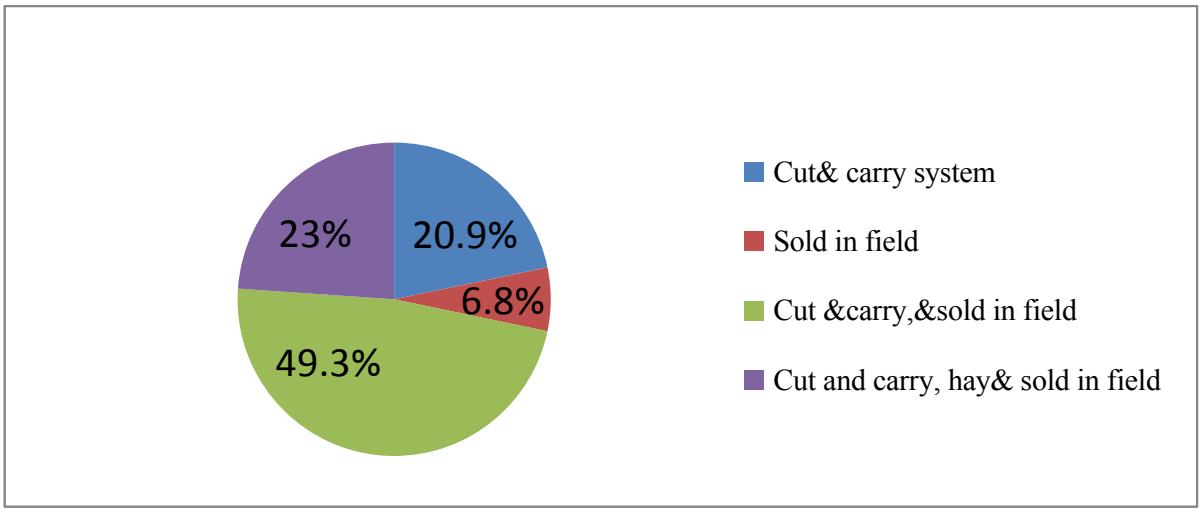

Figure 4. Utilization ways of herbage of Panicum grass after seed harvesting

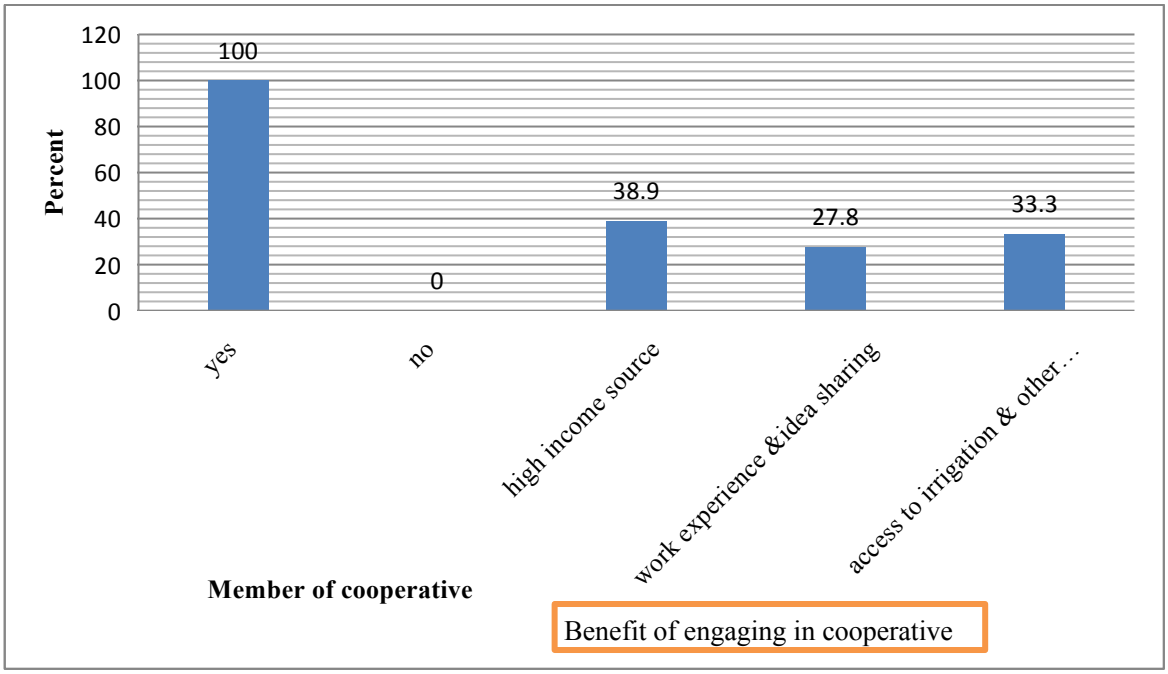

Figure 5. Benefit of engaging in cooperation during Panicum grass production

3.10 Agro-pastoral Perception on Panicum Grass Production

Table 7 shows agro-pastoralists' perceptions of improved Panicum grass production. About 87.8% of agro-pastoralists appraised the establishment potential of Panicum grass as very good, while about 12.5% appraised it as good compared to locally grown Panicum grass. They stated that improved Panicum grass was easily established within 4-5 days after planting, while their local Panicum takes a week and requires high soil moisture. Regarding early maturity, all agro-pastoralists reported that improved Panicum grass was early mature for seed production as compared to local grass, which took a long time to reach its maturity for seed production. They mentioned that improved Panicum grass had reached its maturity for seed harvesting within 50~60 days after planting, but lo-

Table 7. Summary of agro-pastoralists' perception of improved Panicum grass

Characteristics of variety	Rate of scale (0= poor, 0.5=good, 1= very good)					
	Very good		good		Poor	
	N	%	N	%	N	%
Ease of establishment	36	87.8	5	12.2	0	0
Early maturity	41	100	0	0	0	0
Resistance to stress	34	82.9	5	12.2	2	4.8
Biomass yield	41	100	0	0	0	0
Dual purpose	41	100	0	0	0	0
Repeated harvest	41	100	0	0	0	0
Leaf-to-stem ratio	41	100	0	0	0	0
Intake by animals	41	100	0	0	0	0
Seed yield	41	100	0	0	0	0
Marketability	41	100	0	0	0	0

Source: own survey, 2022

cal Panicum grass lasted for 3~4 months. Similarly, the study reported by Zeleke *et al.* [23] from Amibara district of Afar has elucidated that agro-pastoralists preferred the improved Panicum grass over Rhodes and *C. cilaria* grass due to higher establishment potential, the number of multiple harvests per year, and high seed yielding potential. About 82.9%, 12.2%, and 4.8% of agro-pastoralists reported that improved Panicum grass was very resistant, resistant, and poorly resistant to different stresses, respectively, as compared to the local one. They replied that the improved Panicum grass was resistant to water, nutrient, and disease/pest stresses by stating that Panicum grass stays alive for up to a year in soil with less moisture, while local Panicum grass easily vanishes after 2~3 months when exposed to moisture stress. Similarly, Hassen [22] reported that agro-pastoralists who were involved in improving forage production ranked *Panicum antidotale* grass first rather than Rhodes and *C. ciliaris* grasses because it stayed green and vigorously for a longer period without water. Moreover, all the agro-pastoralists (100%) perceive the improved Panicum grass as dual-purpose (seed and herbage) with repeated harvesting as compared to local Panicum grass species. They highly preferred improved Panicum grass over local ones because the former provided seed as well as quality herbage after seed harvest, which was used as a source of feed for cattle, sheep, and goats. In support of the results from the present study, the studies reported by Hassen [22] and Abdullah *et al.* [37] have shown that the cultivation of perennial forage crops like *Panicum antidotale* grass provides the farmers with available year-round feed sources for meeting the nutritional requirements of the animals. They also mentioned that high herbage production of improved grass with repeated harvest about five times per year is used as a source of income for agro-pastoralists. Similarly, all agro-pastoralists agreed that improved Panicum grass has a high leaf-to-stem ratio and is highly preferred by cattle, goats, and sheep as compared to local Panicum grass. They were raised to an astonishing idea by stating that the herbage of improved Panicum grass is very soft and highly preferred by their animals, while the local Panicum grass has high stems rather than leafy, which leads to blood in the mouth and lips of their animals. Correspondingly, a study reported by Hassen [22] indicated that agro-pastoralists preferred the *Panicum antidotale* grass over Rhodes and *C. ciliaris* grasses due to its high performance in terms of herbage yield and palatability by livestock species. Moreover, the results from the present study were in line with Amakirin *et al.* [38], who reported that high-value fodder crops like Panicum grass are vastly preferable by Nigerian farmers as dry season supplementary feeding.

Figure 6. Small-scale cluster based improved Panicum grass cultivation in Alketekech Kebele of Dasenech district

4. Conclusions

The results from this study revealed that improved Panicum grass production has highly improved agro-pastoralists' livelihoods through income generation by selling green herbage and seed. Each agro-pastoralist who has involved in improved Panicum grass production is now able to feed their cattle, sheep, and goats; gifted fresh biomass to their relatives; and exchange green herbage with goats by using a bartering system. The mean net income per household from the sale of green herbage and seed was 653,850 ETB per hectare per year. Based on the results, we concluded that joint efforts are needed to step-up the agro-pastoralists out of the poverty vicious circle through promoting wide-scale improved Panicum grass seed and herbage production and a commercialization approach by linking products to market sources to transform agro-pastoralists into productive and prosperous livelihoods. Moreover, we have concluded that agro-pastoralists should be involved in cattle and goat fattening practices by using a mixture of legume-improved Panicum grass-based feeding systems to enhance their income besides the sale of seed and green herbage.

Author Contributions

Mr. Denbela H. prepared the proposal, secured the funds, conducted research, collected data, and wrote and edited the whole paper. Mr. Asmera A. participated in data collection, analysis, drafting, and formatting the paper according to journal protocol. Mr. Muhaba S. participated in land securing, preparing, planting, and monitoring activities.

Funding

This research activity was conducted funds from the International Development Association (IDA) and the International Fund for Agricultural Development (IFAD) through the Lowland Livelihood Resilience Project (LLRP) to improve livestock feed and feeding systems in South Omo and to enhance resilience in pastoral areas of Ethiopia.

Availability of Data and Materials

All data are available in the main text or in the supporting materials, and raw data can be obtained from the corresponding author upon request.

Conflict of Interest

We declared that there are no competing interests between us for publication of this manuscript.

Acknowledgments

This study was conducted with funds from the International Development Association (IDA) and the International Fund for Agricultural Development (IFAD) through the Lowland Livelihood Resilience Project (LLRP) of the Regional Bureau of Pastorals in Southern Nation, Nationality and People Regional State for the enhancement of pastoral livelihoods in the South Omo. We are extremely thankful to the LLRP experts in Hawassa and the South Omo LLRP coordinating office for collaboration in on-time budget release and other logistic support. Finally, we are grateful to acknowledge Dassench Woreda Livestock and Fisheries and Water and irrigation Offices, developmental agents, and agro-pastoralists for their participation and collaboration during this study.

References

[1] Central Statistical Agency, 2021. Agricultural sample survey 2020/2021. Report on livestock and livestock characteristics (private peasant holdings). Statistical bulletin. Addis Ababa 1–199.

[2] Didanna, H.L., 2015. The contribution of livestock in meeting food production and nutrition in Ethiopia. Journal of Food Science and Technology. 21-45.

[3] Shapiro, B.I., Gebru, G., Desta, S., et al., 2017. Ethiopia livestock sector analysis: A 15 year livestock sector strategy. ILRI Project Report.

[4] Demerew, G., Sandip, B., Mestawet, T., 2019. Husbandry and breeding practices of Malle Cattle reared in Malle District South Omo Zone of Southwest Ethiopia. Journal of Animal and Veterinary Advances. 18(12), 323-338.

[5] Denbela, H., Shanachew, H., Joseph, O., 2020. Goat Feed Inventory and Feed Balance in Hamer and Bena-TsemayWoreda of South Omo Zone, South Western Ethiopia. Acta Scientific Veterinary Sciences. 2(6), 28-43.

[6] Adane, Z., Yemane, N., Hidosa, D., 2021. Reproductive and Productive Performance of Indigenous Cattle Breed in Bena-Tsemay District of South Omo, South-Western Ethiopia. Journal of Fisheries & Livestock Production. 9, 312.

[7] Adane, Z., Yemane, N., Hidosa, D., 2021. Cattle Production System and Breeding Practices in Bena-Tsemay District of South Omo, South-Western Ethiopia. International Journal of Agriculture and Biological Sciences.

[8] Heuzé, V., Tran, G., 2020. Grape pomace. Feedipedia, a Programme by INRAE, CIRAD, AFZ and FAO.

[9] Cook, B.G., Pengelly, B.C., Brown, S.D., et al., 2005. Tropical Forages: an interactive selection tool.

[10] Denbela, H., 2015. Adaptation and evaluation of Cenchrus ciliaris, Chloris gayana and Panicum coloratum grass species on station of Jinka Agricultural Research Center, Jinka, Ethiopia. International Journal of Agriculture and Biosciences. 4(6), 236-239.

[11] Hidosa, D., Hitiso, W., Guyo, M., 2018. Biomass production of different grass species available at irrigated lowland of Dassench Woreda in South Western Ethiopia. Bangladesh Journal of Animal Science. 46(3), 188-191.
DOI: https://doi.org/10.3329/bjas.v46i3.36313

[12] Phimmasan, H., 2005. Evaluation of tropical forages as feeds for growing rabbits (Doctoral dissertation, Swedish University of Agricultural Sciences).

[13] Getaneh, D., Mebrahtu, K., Berhane, A., 2020. Assessment of Livestock Production Constraints and Technology Need Identification in Dasenech District of South Omo Zone, Ethiopia. Journal of Life Sciences. 8(1), 28-39.

[14] South Omo Finance and Economic Development Bureau, 2014. South Omo Zone, Zonal Statistical Abstracts Jinka, Ethiopia.

[15] Hidosa, D., Ayele, B., 2015. Assessment on dairy production, post-harvest handling and marketing systems in hamer woreda of South omo zone. Assessment. 5(23).

[16] Worku, B., Lisanework, N., 2016. Pastoral perceptions towards livestock and rangeland management practices in Kuraz District of south Omo zone, South Western Ethiopia. Journal of Natural Sciences Re-

search. 6(1), 60-69.

[17] Zekarias, H., 2017. Factors Affecting Profitability Of Insurance Companies In Ethiopia (Doctoral dissertation, st. Mary's University).

[18] Gebreegziabher, Z., Tsegay, L., 2016. Production and reproduction performance of local chicken breeds and their marketing practices in Wolaita Zone, Southern Ethiopia. African Journal of Agricultural Research. 11(17), 1531-1537.

[19] Tolosa, E., Litvan, I., Höglinger, G.U., et al., 2014. A phase 2 trial of the GSK-3 inhibitor tideglusib in progressive supranuclear palsy. Movement Disorders. 29(4), 470-478.

[20] Mengistu, S., Nurfeta, A., Tolera, A., et al., 2021. Livestock production challenges and improved forage production efforts in the Damot Gale District of Wolaita Zone, Ethiopia. Advances in Agriculture.

[21] Dejene, M., Assefa, G., Kebede, G., et al., 2012. Forage seed production and Supply Systems in the Central Highlands of Ethiopia. Forage seed research and development in Ethiopia. pp. 59-70.

[22] Hassen, A.S., 2019. Participatory forage production for biomass and seed production through different sowing methods in Afar Regional State, Ethiopia: In the Case of Afambo District of Afar Ethiopia. International Journal of Agricultural Science and Food Technology. 5(1), 019-025.

[23] Zeleke, Z., Megersa, B., Teshome, P., et al., 2018. Participatory evaluation and demonstration of improved forage technologies under small scale irrigated condition in Amibara District of Afar Region. Global Journal of Science Frontier Research: D Agriculture and Veterinary. 18(2), 148-155.

[24] Zereu, G., Lijalem, T., 2016. Status of improved forage production, utilization and constraints for adoption in Wolaita Zone, Southern Ethiopia. Livestock Research for Rural Development. 28(78).

[25] Tolera, A., 2008. Feed resources and feeding management: A manual for feedlot operators and development workers. Ethiopia Sanitary and Phytosanitary Standards and Livestock & Meat Marketing Program (SPS-LMM), USAID, Addis Ababa, Ethiopia.

[26] Molla, E.A., Wondimagegn, B.A., Chekol, Y.M., 2018. Evaluation of biomass yield and nutritional quality of oats–vetch mixtures at different harvesting stage under residual moisture in Fogera District, Ethiopia. Agriculture & Food Security. 7(1), 1-10.

[27] Semman, U., Eba, B., Dinkale, T., 2018. Performance evaluation of improved oat varieties/accessions at the highland of Guji Zone, Bore, Ethiopia. Journal of Biology, Agriculture and Healthcare. 8(17).

[28] Khanh, H.L.P., Corfield, J., Ba, N.X., et al., 2015. The best-bet participatory approach and its impact on smallholder livelihoods. Sustainable and profitable crop and livestock systems in south-central coastal Vietnam', ed. by S. Mann, MC Webb and RW Bell. ACIAR Proceedings. (143), 208-218.

[29] Stür, W., Khanh, T.T., Duncan, A., 2013. Transformation of smallholder beef cattle production in Vietnam. International Journal of Agricultural Sustainability, 11(4), 363-381.

[30] Young, J.R., Rast, L., Suon, S., et al., 2013. The impact of best practice health and husbandry interventions on smallholder cattle productivity in southern Cambodia. Animal Production Science. 54(5), 629-637.

[31] MacLeod, N., Waldron, S., Wen, S.L., 2015. A comprehensive approach for assessing the economic contribution of forage and livestock improvement options to smallholder farming enterprises. Journal of Integrative Agriculture. 14(8), 1573-1580.

[32] Getnet, K., Haileslasseie, A., Dessalegne, Y., et al., 2016. On the profitability of irrigated fodder production: comparative evidence from smallholders in Koga irrigation scheme, Ethiopia. Animal Production Science. 57(9), 1962-1974.

[33] Woldu, T., Tadesse, F., 2015. Women's participation in agricultural cooperatives in Ethiopia.

[34] Abebaw, D., Haile, M.G., 2013. The impact of cooperatives on agricultural technology adoption: Empirical evidence from Ethiopia. Food Policy. 38, 82-91.

[35] Abate, G.T., Francesconi, G.N., Getnet, K., 2014. Impact of Agricultural Cooperatives on Smallholders'technical Efficiency: Empirical Evidence From Ethiopia. Annals of Public and Cooperative Economics. 85(2), 257-286.

[36] Tefera, D.A., Bijman, J., Slingerland, M.A., 2017. Agricultural co□operatives in Ethiopia: evolution functions and impact. Journal of International Development. 29(4), 431-453.

[37] Abdullahi, A.A., Aliero, B.L., Aliero, A.A., et al., 2013. Effects of irrigation regime, organic and inorganic mineral source on growth and yield components of switchgrass (Panicum virgatum L.) in upland and lowland conditions in Sokoto, Nigeria. Pakistan Journal of Biological Sciences: PJBS. 16(2), 51-58.

[38] Amakiri, A.O., Owen, O.J., Udenze, C.N., 2011. Comparative Study of nutritional value of two pasture grasses: Panicum Maximum (guinea grass) and Pennisetum purpureum (elephant grass) using weaner rabbits. New Clues in Sciences. 1, 88-91.