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Research Article

Effects of Seed Proportion on Forage Yield of Greenleaf Desmodium (*Desmodium intortum)* and Guinea Grass (*Panicum maximum)* Mixture at Adami Tulu Agricultural Research Center

Meseret Tilahun* , **Nabi Husein** , **Dawit Abate**

Animal Feed Resources and Rangeland Management, Oromia Agricultural Research Institute, Adami Tulu Agricultural Research Center, Batu, Ethiopia

Abstract

Establishing of grass-legume pastures is one of the recognized strategies for enhancing both quantity and quality of feed resources. Therefore, determining the impact of seed proportion on the nutritional qualities and forage yield of combinations of guinea grass and green leaf desmodium is the goal of this study. A Randomized Complete Block Design (RCBD) with three replications was used to arrange five seed proportions of desmodium and guinea grass. Analysis of variance revealed that variations in treatments have significant differences (p<0.05) on panicum heights, desmodium tillers, and Desmodium height. In addition, the effects of years showed significant (p<0.05) effects on panicum tiller, desmodium height, and percentage of coverages. Interaction of treatments with years showed a significant effect on tiller per plant and plant heights while the other parameters weren't influenced. The combined mean of dry matter and percentage of coverage have showed significant differences (p<0.05) between the treatments. This result reveals that the seed proportion have effect on the dry matter and percentage of plant coverages. The aggressivity index also has significant mean differences (P<0.05) between the treatments. Legumes with the lowest proportion (25%) performed less competently than those with the highest proportions (75%) and 50% D. intortum. The crowding coefficient of P. maximum and D. intortum mixed forage showed significance differences (P<0.05). However, the value of seed proportion on crowding coefficient of panicum maximum and desmodium intortium were more than one. The LER has significant differences (P<0.05) due to ratio of P.maximum and D.intortium mixture and its value at T2, T3, and T4 showed as to be (LER>1) that revealed the yield advantages. Cobined mean results showed that there is significance difference (P<0.05) of CP, Ash, ADF, NDF and ADL due to different seed proportion mixture. In addition the CP of panicum incurred from 8.24% to 18.55% by mixing different seed proportion of D.intortium. An integration of legume forage with grasses improves the feed quality and quantity. Thus, based on the dry matter, yield advantage and nutritive values the integration of 75% and 50% desmodium is recommended for use in the study areas and similar agro-ecologies.

Keywords

Animal Feeds, Biomass, Dry Matter, Legumes, Nutritive Value

*Corresponding author: mesereta28@gmail.com (Meseret Tilahun)

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1. Introduction

Livestock are an important pillar in the Ethiopian economy and contribute considerably to the national economy and the livelihood of the citizens [17, 12]. However, inadequate feed was one of the livestock industry's main obstacles [18]. Feed availability and quality are two of the major factors limiting livestock productivity in Ethiopia [1, 4]. Both under nutrition and malnutrition are major problems for the bigger part of the country and for most of the time. The amount and quality of the natural pastures and crop leftovers that Ethiopian livestock graze on are insufficient to maintain adequate levels of animal output [18].

Reduced grazing and pasturelands, overstocking, seasonal variations in roughage feed availability, low nutritional quality of fodder, utilization of crop residues for other purposes, restricted availability and high cost of concentrate feeds, low adoption of improved fodder, low adoption of silage and hay production, and low adoption of urea treatment of crop residues at smallholder farmer level are some of the general feed-related constraints that need to be addressed in order to increase livestock productivity and output [3, 1].

To enhance the animal feed availability and developing different forage strategy, improving low feed quality and using industrial by product were the major opportunity due to the shortage of grazing land. However, most tropical grass have low nutritive values [12]. Therefore, one of the acknowledged methods in other nations for improving the quantity and quality of feed resources is the creation of grass-legume pastures [18]. The grass-legumes mixture play great role in improvement of soil fertility besides to improving animal feed nutrition [2]. Therefore, the *Panicum maximum* and *Desmodium intortum* mixtures were one of the legumes and grass mixtures integration that were sown to improve the quality of grasses with different seed proportions.

Pancium grass is a very adaptable plant that can grow in a wide range of tropical altitudes (from sea level to 2500 meters above sea level), with some resistance to drought and acidic soils. It is also an excellent erosion control tool and is well-suited for cutting and grazing [11]. The tufted perennial grass thrives on well-drained, fertile soils in areas with heavy rainfall, but it can withstand extended droughts thanks to its deep, dense, and fibrous root system. Guinea grass grows better under rotational grazing and may tolerate prolonged periods of intense grazing with stocking rates of 2.5 cattle/ha and high yearly rainfall [16]. It responds well to manuring and yields large amounts of tasty feed, although it quickly decreases in nutritive value with age. The crude protein of guine grass was 6.77% and with legume s mixture 9.8-15.5% [16]. Although, its dry matter is not high as elephant grass, its protein yield and dry matter intake are higher than elephant grass [16, 14].

The *Desmodium intortium is* widely distributed throughout the tropical and sub-tropical regions. It grows on a wide range of soils from light to clay loams with neutral to moderately acidic in reaction and is well adapted to poorly drained or water logged conditions. Green forage yield and nutritive values are around 19t/ha and 13.1% C.P respectively, while average dry matter yield ranges from 5.8 to 12.5 t/ha depending upon the stage of the crop. It contributes large quantity of N to soil too [6]. It increases the fertility and moisture-holding capacity of sandy soils in addition to providing feed value by forming a healthy surface layer of organic matter. Forage with higher CP and lower fiber contents was produced by pure legume stands and grass-legume combinations compared to pure grass stands [18]. Because legumes are more nutrient-dense than grass and may be more affordable than grass, their introduction into guinea grass pastures shows promise [16]. The primary causes of the low grass-legume productivity are improper guinea grass-legume proportion and poor cutting management. The crude protein of guinea grass was 6.77% and with legume mixture 9.8-15.5% [16] but not with desmodium. Therefore, acquiring the appropriate optimum seed proportion for panicum maximum and desmodium mixtures improves main feed quality and quantity. Therefore, the study was conducted to evaluate the effect of seeding proportion of panucum and desmodium mixtures on biomass and nutritive value.

2. Materials and Methods

2.1. Description of the Study Area

The study was done at Adami Tulu Agricultural Research Center (ATARC) and Dodola district of west Arsi zone of Oromia regional state, which represent lowland and midland agro-ecology respectively. ATARC is found in east Shewa zone of Oromia region and far 167 km from the capital city of the country ‘Finfinnee’. It was located at 7o 45’N 38o 40’E longitude and latitude with an elevation ranging from 1500-2300 masl. It has an average annual rainfall of 760 mm and minimum and maximum temperatures of 12.8 and 27.3 ℃, respectively. The agro-ecological zone of the area is semi-arid and sub-humid with acacia woodland vegetation type. The soil type is fine, sandy loam with sand: silt: clay in the ratio of 34: 38: 18, respectively. The average pH is7.88 (ATARC, 1998).

2.2. Treatments and Experimental Design

Five seed proportion of panicum and desmodium grass (sole desmodium, 25% panicum: 75% desmodium, 50% panicum: 50% desmodium.

The experiment was conducted in RCBD with three replications. A plots of 3 m * 4 m were used to plant the treatments. The mixed seeds proportion of the two species were row planted on given plots area with 30 cm spaces. The seed were mixed according to their respective seed proportion treatment combination as the following arrangements.

Seeding Proportion
T1=Sole Desmodium 100%
T2=25% Panicum: 75% Desmodium
T3=50% Panicum: 50% Desmodium
T4=75% Panicum: 25% Desmodium
T5=sole panicum100%

2.3. Experimental Procedures and Field Management

The land was cultivated/ploughed two times before the onset of rain. Before planting, additional cultivation was done to prepare a fine seedbed to kill off weeds and sown the seed onto the soil surface [19]. In addition, the hand weeding was done as necessary based on close follow up. The pure stands of each component were also included for comparison.

2.4. Data Collected

The data collected were, plant height, tiller, percentage of coverage and fresh biomass to determine dry matter, compatibility and other nutritive values.

2.4.1. Measurements for Compatibility Indices of the Mixed Pasture

(i). Land Equivalents Ratio (LER)

Biological yield advantages and species compatibility of the different binary was assessed using land equivalent ratio (LER) calculated by the following equation:

$$LER=LG+LL \quad (1)$$

Whereas, the values of LG and LL were estimated based on the [15] equation as follows:

$$LG=YG/SG \text{ and } LL=YL/SL \quad (2)$$

Where LG and LL are the partial LER values of grass and legumes, YG and YL are their yields in mixtures and SG and SL are their respective yields in the pure stands. If $LER_{LG}>1$. There is yield advantage.

(ii). Relatives Yield (RY)

The relative yield RY for grass and legumes was assessed using the equation of [8].

$$RY_G=DMY_{GL}/DMY_{GG} \text{ and } RY_L=DMY_{LG}/DMY_{LL} \quad (3)$$

Where: DMY_{GG} is dry matter yield of GG *Panicum maximum* (G) as a sole crop, DMY_{LL} is dry matter yield of *Desmodium intortum* (L) as a sole crop, DMY_{GL} is the dry matter yields of any annual grass component (G) grown in mixture with any annual legume (L) and DMY_{LG} is dry matter yield of any annual legume component (L) grown in mixture with any annual grass (G). Relative yield total and land equivalent ratio (LER) was calculated according the formula of [8].

Relative total yield (RTY) was calculated according to the formula of [9].

$$RTY_{GL} = (DMY_{GL}/DMY_{GG}) + (DMY_{LG}/DMY_{LL})$$

(iii). Relative Crowding Coefficient (RCC)

This parameter was calculated to determine the competitive ability of grass and legume in the mixture to measure the component that has produced more or less DMY than expected in annual grass-legume mixture according to [8].

$$RCC_{GL} = DMY_{GL}/ (DMY_{GG}–DMY_{GL})$$

$$RCC_{LG} = DMY_{LG}/ (DMY_{LL} – DMY_{LG})$$

Where, LG = the sown proportion of legume in combination with grass, GL = the sown proportion of grass in combination with legume, RCC = Relative GL crowding coefficient of grass / legume mixture and RCCLG = Relative crowding coefficient of legume/ grass mixture.

(iv). Aggressivity Index (AI)

The dominance or aggressive ability of grass against the annual legume in a mixture were described by calculating aggressivity index (AI) as indicated by [13].

$$AIGL = DMY_{GL}/ (DMY_{GG} \times 0.5) – DMY_{LG}/ (DMY_{LL} \times 0.5)$$

2.4.2. Agronomical and Chemical Composition Analysis

In order to estimate biomass, the two center rows were collected and divided into the grass and legume components after the grass component reached 50% blooming stage. A subsample of each forage biomass species was dried in an oven at 65 ℃ for 72 hours in order to determine the dry matter yield (DM yield). The fresh weight of each component was weighed and recorded immediately following partition. DM and ash were calculated using the method described in [5]. The Khjedal method was used to determine the samples' N content, and N x 6.25 was the formula for CP. The following standard techniques were followed in order to determine the amounts of acid detergent lignin (ADL), neutral detergent fiber (NDF), and Acid detergent fiber (ADF) [21].

2.5. Data Analysis

The organized data were interred into Microsoft excel and imported to SAS software version 9.1 to analysis statistically. The ANOVA procedure was computed to analysis the data and the Tukey's Honestly Significant Difference (HSD) test was used for mean separation. The significance difference was assigned at P<0.05.

3. Results and Discussion

3.1. Analysis of Variance

Analysis of variance revealed that variations in treatments had statistically significant (p<0.05) impact on panicum heights, desmodium tillers, Desmodium height, and plot coverages. In addition, the effects of years showed significant (p<0.05) effects on panicum tiller, desmodium height, and percentage of plot coverage. Interaction of treatments with years showed a significant effect on tiller per plant and plant heights while the other parameters weren't influenced (Table 1).

Table 1. *Mean squares of ANOVA for plant tiller, height, and percentage of coverages as influenced by different seed proportions of Green-leaf desmodium and Guinea grass mixture.*

No	Variation sources	DF	Mean square				
			Panicum Tiller	**Panicum height**	**Desmodium Tiller**	**Desmodium height of**	**Coverage**
1	Treatments	4	188.76NS	3619.11*	65.30*	10.43**	844.56***
2	Years	1	0.009**	250.39NS	10.05NS	174.87***	187.50*
3	Yrs*trt	4	0.0003***	9449.59***	204.76***	10.71**	68.75
	Error	20	95.03	21.93	999.27	1.74	6.60
	Residual		0.72	0.71	0.55	0.88	0.87

*trt=treatment, yrs=years, DF=degree of freedom

3.2. Effects of Years on Desmodium and Panicum Mixture Seed Proportion on the Physical Parameter

Table 2. *Effects of years and seed proportion treatments on the plant tillers and height.*

No	Treatments	Excremental year							
		2021				**2022**			
		Panicum		**Desmodium**		**Panicum**		**Desmodium**	
		Tiller	**Height**	**Tiller**	**Height**	**Tiller**	**Height**	**Tiller**	**Height**
1	Sole Desmodium	0.00	0.00	13.27^{a}	94.44	0.00	0.00	26.44^{a}	119.00^{a}
2	25% Pan:75% Desm	24.45	120.67^{a}	8.61^{ab}	74.55	16.67^{ab}	104.11^{ab}	10.67^{b}	88.55^{ab}
3	50%Pan:50%Desm	24.50	115.72^{ab}	11.28^{ab}	61.11	22.34^{a}	122.89^{a}	14.78^{ab}	58.55^{b}
4	75%Pan:25%Desm	27.72	89.61^{b}	10.78^{ab}	75.89	16.45^{ab}	71.33^{bc}	13.22^{ab}	97.78^{ab}
5	sole Panicum	24.89	89.06^{b}	0.00	0.00	17.33^{ab}	42.77^{c}	0.00	0.00
CV		22.45	14.38	18.21	18.91	26.83	8.44	22.51	12.78
LSD		16.84	24.08	8.09	54.61	7.43	24.86	3.57	56.38
P-Value		ns	0.0282	0.0442	ns	0.0039	<.0001	0.0004	0.0018

*Means with the same letter are not significantly different. CV=coefficient variation

There is significance differences (P<0.05) of panicum height and desmodium tillers between the treatments in 2021 and 2022. The T2 (25% Pan: 75% Desm) has higher plant height following T3 (50%Pan: 50%Desm) and T4 (75%Pan: 25%Desm). This indicates, the panicum grass height decrease as the seed proportion increased as stated on the above table 2. The tiller also have significance differences at P<0.05 as indicated on the above Table 2 with the seed proportion of forage grasses and legumes. However, the highest tiller of plant was showed at sole cropping for Panicum and Desmodium. This might be due to absence of competition between the species. The plant height of Panicum have high mean value at the treatment of 25% Pan: 75% Desm following the 50%Pan: 50%Desm and 75%Pan: 25%Desm. In addition, the highest tiller number of Desmodium was observed at the sole desmodium followed the others treatments in 2021. The panicum tiller and height also have significance difference at (P<0.05) between the treatments in 2022.

The 50% Pan: 50% Desm treatments have high number of tiller than the others. But the sole desmodium treatments have showed higher tiller number and height followed by the others. This might be due to absence of competition with different proportion of panicum seeds.

Table 3. *Combined mean of dry matter per ton and percentage of coverages.*

No	Treatments	Parameters	
		DM ton ha^{-1}	**Coverage (%)**
1	Sole Desmodium	5.07±0.6	90.67+5.8
2	25% Pan:75% Desm	8.71±0.3	87.50+3.5
3	50%Pan:50%Desm	6.67±3.7	73.75+7.5
4	75%Pan:25%Desm	5.13±2.1	56.67+7.6
5	100%sole Panicum	4.35±1.2	91.67+2.9
CV		16.93	7.78
P-value		<.0001	0.0002

DMtha^{-1}= dry matter yield tone per hectare, CV=coefficient variation

The combined mean of dry matter and percentage of coverage have showed significance difference (P<0.05) between the treatments due to seed proportion effects of intercropping. This result reveals that the seed proportion have effect on the dry matter and percentage of plant coverages. Hence, the 25% Pan: 75% Desm has higher dry matter followed by 50%Pan: 50% Desm treatments. The similar result was reported by [7, 12] as dry matter increasing with rate of legumes seed proportion and improves the quantity and quality of forages.

3.3. Compatibility Indices of *P.maximum and D.intortum* Mixtures

Table 2 shows the effects of different P. maximum and D. intortum seed proportions on the mixed pasture's aggressivity index (AI). The analysis of variance results showed that there were significant mean differences (P<0.05) between the AI Panicum maximum and Desmodium total. 25% of the legumes had lower levels of competence compared to 75% of the legumes with the highest proportion and 50% D. intortum. A similar outcome was documented by [12].

Table 4. *Effects of different seed proportions of Panicum maximum and D. intortum on Aggressive index (AI) of the mixed pasture Mean +SE.*

No	Seed proportion	*D. intortum*	*P. maximum*	K-total
1	Sole Desmodium	-	-	-
2	25% Pan:75% Desm	0.44+0.10	1.99+0.01	2.43+0.11
3	50%Pan:50%Desm	0.04+0.02	1.96+0.04	0.54+0.09
4	75%Pan:25%Desm	0.01+0.01	1.56+0.10	1.57+0.11
5	100%sole Panicum	-	-	-
CV		29.1	4.20	21.14
P-value		0.0002	0.0002	<.0001

Means with the same letter are not significantly different, SE =standard error, CV=coefficient variation, AI=Aggressive index

Table 5. *Effects of different seed proportions of P. maximum and D. intortum mixed pasture on crowding coefficient (K) of the component species.*

No	Seed proportion	K-P. maximum	K-D. intortum
1	Sole Desmodium	-	-
2	25% Pan:75% Desm	1.01+0.00	-6.67+0.60
3	50%Pan:50%Desm	1.05+0.02	-10.00+1.5
4	75%Pan:25%Desm	1.87+.0.29	-4.04+0.70
5	100%sole Panicum	-	-
Overall mean		1.19	-5.75
CV		18.77	23.62
P-value		0.0025	0.0012

Means with the same letter are not significantly different, CV=coefficient

Significant differences (P<0.05) were seen in the crowding coefficient of P. maximum and D. intortum mixed fodder when varied seed quantities were used.

However, the value seed proportion on crowding coefficient of *panicum maximum* and *desmodium intortium* more than one (1). This indicates that intercropping has more favor to legumes than when land is used for mono-cropping. Thus, the importance of legumes integration with grass play great role with ecosystem, economic and environmental benefits [20]. Furthermore, it enhances the quantity and quality of animal feed deficiencies; in addition, [10] found that total dry matter production was higher in grass-legume combination plots than in grass-only plots.

The value of K-*desmodium intortium* at 75%Pan: 25% Desm was better than the other. But it is decreasing with seed proportion of desmodium that indicates the seed proportion affects the density of plant. However, [12] stated similar result at 50% of seed proportion.

The LER for *Panicum maximum* and *Desmodium intortum* mixed pasture at different seed proportions was indicated in Table 4. Analysis of variance showed that the significant differences (P<0.05) of the land equivalent ratio of *P.maximum* and *D.intortum* mixture with different seed proportions. The value of land equivalent ratio of mixed forage at T2, T3, and T4 showed as to be (LER>1) revealed the yield advantages of the forage mixtures.

Table 6. *Effects of different seed proportions of Panicum maximum and D. intortum on Land equivalent (LER) of ratio of the mixed pasture.*

No	Seed proportion	LER-Total	Yield advantages (%)
1	Sole Desmodium	-	
2	25% Pan:75% Desm	1.59+0.21	8
3	50%Pan:50%Desm	1.36+0.10	5
4	75%Pan:25%Desm	1.33+0.10	3
5	100%sole Panicum	-	
Overall mean		1.07	
CV		22.42	
P-value		0.0004	

Means with the same letter are not significantly different, CV=coefficient LER=land equivalent ration, CV=Coefficient variation

The land equivalents ratio (LER), which is one method of assessing a particular land's productivity when crops are planted in mixtures, can influence the biomass yield of various forage crops depending on the value of the land at different planting techniques. Conversely, the Land Required for Monoculture (LER) refers to the area of land needed to produce the same quantity of dry matter yield as the intercrop. As a result, the value of LER for seeding ratios demonstrates that a combination of panicum and desmodium is preferable to a single crop.

Table 7. *Combined mean of chemical composition of the grass P. maximum, grown with D. intortum as affected by seed proportion of the components species.*

No	Seed proportion	Nutritional parameters					
		DM%	Ash%	CP%	NDF%	ADF%	ADL%
1	Sole Desmodium	92.50	14.00^{a}	23.18^{a}	73.59^{a}	26.76a	9.42d
2	25% Pan:75% Desm	91.73	11.57^{b}	22.54^{ab}	67.29^{c}	16.03e	17.73c
3	50%Pan:50%Desm	91.57	12.07^{ab}	22.50^{ab}	67.18^{d}	18.62d	29.28a

No	Seed proportion	Nutritional parameters					
		DM%	Ash%	CP%	NDF%	ADF%	ADL%
4	75%Pan:25%Desm	91.83	12.70ab	16.31b	66.41e	1973b	13.79e
5	100%sole Panicum	91.53	10.63b	8.24c	69.10b	18.93c	23.50b
Overall mean		91.833	12.19	18.55	68.71	20.02	18.74
CV		0.60	7.20	12.61	0.00	3.99	0.00
P-value		0.2701	0.0096	<.0001	<.0001	<.0001	<.0001

*DM%=dry matter percentage, CP=crude protein, ADF=Acid detergent fiber, ADL=Acid detergent lignin, NDF=Nitrogen detergent fiber, CV=Coefficient variation

Combined mean results showed that there is significance difference (P<0.05) of CP, Ash, ADF, NDF and ADL percentage due to different seed proportion of Desmodium and Panicum mixture. The integration of improved forage play great role to incur the quality of grasses. The CP of panicum incurred from 8.24% to 18.55% by mixing different seed proportion *D.intortium*. The study agree with the results of (Lemoufouet J. et al., 2021) that undertaken at the University of Dschang as possible to significantly increase the CP contents (from 8.88% to 15.19% and DM (from 92.51% to 94.33% with the addition of *D. intortum.*

4. Conclusion and Recommendation

The total dry matter yield of mixed grass-legumes (panicum M-desmodium) were highest for the dominant seed proportion of the *Desmodium intortum.* However, the integration of legumes uses to improve low quality of grasses. The combined mean of dry matter and percentage of coverage have showed significance difference (P<0.05) between the treatments. This result reveals that the seed proportion have effect on the dry matter and percentage of plant coverages. The *Panicum maximum* and Desmodium intercropping has more favors to the legumes than when the land is used for mono-cropping. The biomass production of various forage crops can be influenced by the value of the land at different planting techniques. One method of assessing the productivity of a given plot of land when crops are planted in mixtures is to use the land equivalents ratio (LER). Therefore, different seed proportion forage mixture have yield advantages and improves the quantity and quality of animal feed. The compatibility indices showed high aggressivity index at seed proportion of 25% Pan: 75% Desm and higher CP than the other seed proportion of treatments. The highest CP content was recorded from pure stand of Desmodium followed by seeding ratio of 75:25, 50:50 and 25:75 for Desmodium and panicum respectively. In addition, the CP of panicum incurred from 8.24% to 18.55% by mixing different seed proportion. Therefore, the due to land equivalent ration, high crude protein and optimum dry matter, the mixture of 75% and 50% desmodium recommended for use in the study areas and similar agro-ecologies.

Abbreviations

ADF	Acid Detergent Fiber
ADL	Acid Detergent Lignin
AI	Aggressivity Index
NDF	Nitrogen Detergent Fiber
CP	Crude Protein
DM	Dry Matter
LER	Land Equivalent Ration
RY	Relative Yield

Author Contributions

Meseret Tilahun: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Supervision, Writing – original draft Writing – review & editing

Nabi Husein: Conceptualization, Data curation, Supervision, Writing – review & editing

Dawit Abate: Data curation, Methodology, Supervision, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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