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Effect of Seeding Ratios of Alfalfa (*Medicago sativa*) and Rhodes Grass (*Chloris gayana*) Mixtures on Dry Matter Yield and Nutritive Quality of the Fodder

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Abstract

The study was conducted at Adami Tulu on-station and Shashemene (FTC) sites for two (2019-2020) consecutive years with the objective to determine the appropriate proportions of seeding ratio that could optimize the dry matter yield and quality of Alfalfa and Rhodes grass mixture. The treatment was laid out in a randomized complete block design (RCBD) with three replications. Different seeding ratios of Alfalfa and Rhodes grass were arranged according to the following treatments: T1; 100% Alfalfa $^{+}$0 % Rhodes, T2; 0% Alfalfa $^{+}$100% Rhodes, T3; 50% Alfalfa $^{+}$50% Rhodes, T4; 75% Alfalfa $^{+}$25% Rhodes and T5; 25% Alfalfa $^{+}$75% Rhodes. The results showed that number of tillers per plant of Rhodes grass and leaf to stem ratio of alfalfa, CP% content, NDF% and ADF% were showed a significance ($p<0.05$) difference among the seeding ratios. The result indicated that seeding ratio has significant ($p<0.05$) effect on the total dry matter yield of the mixture of alfalfa and Rhodes at both sites. The highest dry matter yield (8.47 t ha^{-1}) was obtained from seeding ratio of 25:75, followed by seeding ratio of 50:50 (7.84 tha^{-1}). The land equivalent ratios for the mixture were more than one showing that mixture of alfalfa with Rhodes is more advantageous than pure stand of forage. The highest CP% content (21.2%) was recorded from pure stand of alfalfa followed by seeding ratio 75:25 (18.5%), 50:50 (16.8%) and 25:75 (14.6%) while pure stand of Rhodes grass produced the least (11.1%) CP% value. The highest values of NDF% (34.48%) and ADF% (21.25%) were obtained from pure stands of Rhodes grass while the least values were recorded from pure Alfalfa. Thus, it can be concluded that seeding ratio combination of 50:50 could be recommended for use in the study areas and similar agro-ecologies due to its high dry matter yield, good quality and more balanced mixture of forage.

Keywords: Seeding Ratio, Rhodes, Alfalfa, Mixture.

INTRODUCTION

Livestock production is an integral part of the agriculture in Ethiopia. It serves as sources of food, traction, manure, raw materials, investment, cash income, security, foreign exchange earnings and social and cultural identity. Despite enormous contribution of livestock to the livelihood of farmers, they are faced with multifaceted problems in the production system, among which the major one is the quantitative and qualitative inadequacy of feed supply [1].

In most areas of the country, livestock feed is normally in short supply and is also of poor quality mainly during the latter part of the dry season. Seasonal feed shortage and inefficient utilization practices have been identified as the major problems affecting livestock production and productivity [2,3]. Nowadays the available feed from natural pasture is very low due to overgrazing, erosion and overall land degradation. Moreover, in most areas there is an ever-increasing human population with subsequent increase in land area put under crop production resulting in reduction of existing grazing areas [4]. This suggests the need for improving the quantity and quality of the feed resource. Accordingly, many grass and legume species have been tested and recommended for different agro-ecological zones in the country. To bring further improvement in yield and quality of forage species and land use efficiency, identifying appropriate forage production strategies are very crucial especially at smallholder farmers' level where land for forage production is very scarce.

Grass legume mixture forage production has many advantages including maximize yield, improve growth, produce palatability, supply the soil with nitrogen by legumes, make a better soil coverage and keep it

from erosion, compete weeds, attained a balanced and highly nutritive feeding to animals and decrease animals' bloats [5,6]. The acceptance of these forage mixtures is based on the apparent advantages offered by the association of different species that influence the performance temporal stability of yield and forage quality. Species that have different physiological and/or morphological characters may complement better and make better use of the nutritional resources. Among the grass species, Rhodes grass (*Chloris gayana*) recommended for low to high elevations. Similarly, Alfalfa is one of the recommended forage legumes with high potential as fodder crop. Alfalfa can grow in mixture with most of the grasses, but a balance of the alfalfa with the grass is best maintained if only an appropriate agronomic management is practiced. It also indicated that the establishment of Rhodes-Alfalfa mixture showed positive effect and compatible on their growth characters with each other's [7].

However, management practices such as proportions of seeding rate influences the yield and quality of these species and their compatibility when grown in mixtures [7]. The benefits from mixed forage species can be efficiently exploited only if proper management strategies such as optimum proportions of seed rates are used. However, there is limited information on the proportions of seeding rates that influence yield and quality of most of the grass-legume mixture including Rhodes grass and Alfalfa under rift valley condition of Oromia. Hence, this study was intended to determine the appropriate proportions of seeding rates of Rhodes and Alfalfa that could optimize dry matter yield and quality of the mixtures.

MATERIALS AND METHODS

Description of the Study Sites

The study was conducted at Adamantly Agricultural Research Center (on-station) and Shawsheen (FTC) under rain fed conditions. Adami Tulu Agricultural Research Center is found in Adami Tulu Judo Kombucha district that located in the middle rift valley of Ethiopia, at 167 kilometers from the capital city of the country, in south eastern part of Oromia between 38°20' and 38.5°5' E and 7°35'and 8°05' N. It lies at altitudinal range from 1500 to 2000 mask. It has an average annual rain fall of 760mm. It has a bimodal rain fall from March to April (short rain) and July to September (long rains) with a dry period in May to June which separates short rains from long rains. The average annual minimum and maximum temperature of the area at the study year were 11.8℃ and 28.3℃ (metrology station of Adami Tulu Agricultural Research Center). The soil is loam with sand, silt and clay in proportion of 44%, 34% and 22% respectively and the PH of the soil is 7.88 [8]. Shashikant district is found in West Aris Zone, Oromia Region at about 240km south of Addis Ababa lying on the main way road to Hawassa. Shashikant town is the capital town and administrative center of west Aris zone. Geographically, the area is located at 7° 11' 33" N altitudes and 38° 35' 33" E longitudes. The area has an annual average temperature ranging from 12℃ to 28℃. The rainfall ranges from 1500-2000ml [9].

Treatments and Experimental Design

Adapted cultivars of Rhodes grass (*Chloris gayana*) and Alfalfa (*Medicago sativa*) were used. The experiment was undertaken in a randomized complete block design with three replications. Different seeding ratios were arranged according to the following treatments: T1; 100% Alfalfa $^{+}$0% Rhodes, T2; 0% Alfalfa $^{+}$100% Rhodes, T3; 50% Alfalfa $^{+}$50% Rhodes, T4; 75% Alfalfa $^{+}$25% Rhodes and T5; 25% Alfalfa $^{+}$75% Rhodes. The seed proportions were calculated based on the recommended sole seed rates of 15 and 10 kg per hectare for Rhodes and Alfalfa, respectively. The plot size was 2.5 m x 2 m (5 m^2). A total of 10 rows per plot with row spacing of 25 cm apart from each other was used [7]. The spacing between replications and plots were 1.5 and 1.0 m, respectively. Germination test was done for both forages before sowing in order to adjust the seeding rates. The seeds were established in rows on a well-prepared seedbed and covered with soil. All other cultural practices including weeding was kept normal and uniform for all treatments.

Data Collection

Data on yield and yield related traits such as: plot cover (%), plant height (cm), leaf to stem ratio, number of tillers per plant and biomass yield were collected from each treatment. The forage was harvested for biomass yield determination at 10-50% flowering stage. Then consecutive cuts were conducted after the re-growth while it reaches an appropriate harvesting stage. Land equivalent ratio (LER) was used to assess the advantage of forage production in mixture. LER was defined as the relative area of mono-crop plant required for the same yield obtained from its mixture. The LER was calculated using the formula given below[10].

$$LER = \frac{\text{Yield of alfalfa in mixture}}{\text{Yield of alfalfa alone}} + \frac{\text{Yield of grass in mixture}}{\text{Yield of grass alone}}$$

When LER is greater than 1, the mixed growing favors the growth and yield of the mixture species. In contrast when LER is lower than 1, the mixed growing negatively affects the growth and yield of plants grown in mixture [11,12].

The feed sample was taken from each treatment and dried in an oven at 60°C for 72 hours to a constant weight and ground in a Willey mill to pass through a 1mm sieve. The ground samples were kept in airtight plastic bags prior to analysis for chemical composition. Crude protein (CP) was determined according to [13]. methods. The dry matter (DM) was determined by an oven drying at 105° overnight and ash content was determined by igniting the dry samples in a muffle furnace at 550°C for 6 hours to burn off all the organic material. The inorganic material which does not volatilized at that temperature is ash. The difference between sample DM and ash gives the organic matter (OM). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed [14]. For nitrogen (N) analysis, the Kjeldhal method was used and crude protein (CP) content was estimated from the N content by use of a multiplier of 6.25. Collected data was organized, summarized and analyzed by using SAS. LSD test at 0.05 probability levels was used to compare the treatment means [15].

RESULTS AND DISCUSSION

Analysis of variance showed that different seeding ratio of alfalfa and Rhodes grasses were significantly ($p<0.0016$) affected the total dry matter of the mixture (Table 1). Experimental sites were also significantly ($p<0.0001$) influencing the total biomass yield of the mixed alfalfa and Rhodes biomass production. On the other hands, the result showed that interaction effect of site and the treatments were didn't significantly ($p>0.1298$) affected the total dry matter production of the mixture.

Table 1: Mean squares of ANOVA for total dry matter yield of Alfalfa and Rhodes mixture under different seeding ratios

Source of Variation	DF	Mean squares	F-value	p-value
Replication	2	1.771	0.97	0.3868
Treatment	3	9.391	5.14	0.0016
Site	1	48.533	26.56	0.0001
Treatment*Site	3	3.429	1.88	0.1298
Error	38			
Total	47			

Where: DF= degree of freedom,

Agronomic Parameters

The combined analysis result for plot cover, plant height, number of tillers per plant and leaf to stem ratio were indicated in table 2. The results showed that non-significant ($p>0.05$) effect was observed on plot cover and plant heights for both fodder among the tested seeding ratios. However, numerically the maximum plot cover (87.5%) was recorded from 50:50 seeding ratio followed by sole Rhodes (85.2%) treatment. In this trial the plant height of alfalfa grown alone was statistically similar ($p>0.05$) to those alfalfa grown in a mixture. Similarly, plant height of Rhodes grass was not significantly differed among sole and mixture treatments. The non-significance ($p>0.05$) differences observed for alfalfa and Rhodes plant height illustrate the mutual benefits of the forage crops from mixed establishment.

The analysis also showed non-significant ($p>0.05$) difference on number of tillers pre plant of alfalfa in the tested seeding ratios. On the other hands, the number of tillers per plant of Rhodes grass was showed a significance ($p<0.05$) difference among the seeding ratios. Accordingly, the highest number of tillers per plant of Rhodes grass was recorded for sole Rhodes grass (22.44) followed by 25:75 (19.15) seeding ratio. As seeding ratio of alfalfa increases in the mixture, number of tiller of Rhodes grass were significantly decreases. This might be due to the slight competition of alfalfa and Rhodes for light and nutrients. The result can be relatively supported by other authors [16]. The result also showed the values of leaf to stem ratio (LSR) of alfalfa was significantly ($p<0.05$) differ among the tested seeding ratios. The highest LSR value (2.49) was recorded for sole alfalfa treatment followed by 50:50 (2.23) and 75:25 (2.23) seeding ratios. The highest value obtained for sole alfalfa could be due to the better vegetative growth as it had free from competition with other companion crops. The leaf to stem ratio values were higher than one shows that the leaf component was higher in proportion than the stem, which is should be taken as reference for the quality of alfalfa as fodder crops [17]. On the other hands, the leaf to stem ratio for Rhodes grass was not significantly ($p>0.05$) differ among the treatments.

Table 2: Agronomic performance of Rhodes and Alfalfa produced from different seeding rate proportions (combined)

Seeding ratio Alfalfa: Rhodes	Plot cover (%)	Plant height (cm)		No of tiller/plant		Leaf to stem ratio	
		Alfalfa	Rhodes	Alfalfa	Rhodes	Alfalfa	Rhodes
100:0	83.9	68.16	-	15.36	-	2.49[a]	-
0:100	85.2	-	103.75	-	22.44[a]	-	2.51
50:50	87.5	66.18	103.0	14.44	17.49[b]	2.23[ab]	2.33
75:25	83.8	65.13	100.22	14.88	17.58[b]	2.23[ab]	2.22
25:75	84.1	63.78	105.88	13.94	19.15[ab]	2.06[b]	2.42
Mean	84.9	65.82	103.2	14.66	19.2	2.25	2.37
CV (%)	10.7	15.76	24.3	13.82	24.8	19.0	20.67
LSD (0.05)	NS	NS	NS	NS	3.91	0.35	NS
p-value	0.8457	0.767	0.9575	0.260	0.049	0.0462	0.523

[1]CV=Coefficient of variation, LSD=Least significant difference, NS= Non significant,

[2] Figure having the same letters with in column are not significantly differ, while values followed by different letter (s) are significantly differ

Dry Matter Yield

The analysis result of Rhodes grass and Alfalfa biomass yield grown in pure stand and in mixture with different seeding ratios are indicated in table 3. The result shown that seeding ratio has significant ($p<0.05$) effect on the total dry matter yield of pure stand and the mixture of alfalfa and Rhodes at both sites. The highest total forage biomass yield (10.2 t/ha) was recorded from seeding ratio of 25:75 at Adami Tulu site where as 50:50 seeding ratio gives the highest biomass yield (6.85t/ha) at Shawsheen site. The lowest dry matter yield was recorded from sole alfalfa treatment at all sites. The combined analysis result also showed that significantly ($p<0.05$) the highest dry matter yield (8.47t/ha) was obtained from seeding ratio of 25:75 and followed by seeding ratio of 50:50 (7.84t/ha). The higher biomass yield obtained from these seeding ratios could be due to the fact that the proportion of Rhodes grass produced much more forage yield through increased number of tillers production than the other mixtures.

The total dry matter yield of sole alfalfa treatment (36.17 t/ha) was significantly lower than the total biomass yield production from seeding ratio of 50:50 (7.84 t/ha) and 25:75 (8.47 t/ha). As the result shown, the biomass of the mixtures was superior and advantageous compared to their pure stands. In line with this study, scholars emphasized on the advantages of grass legume mixture [18,19]. It also reported that total dry matter yield of mixed grass and legume pasture was greater than grass-based pasture, and overall feed value was better maintained throughout the grazing season when pastures include legumes [20].

On the other hands, the lowest performances (6.87 t/ha) of seeding ratio of 75:25 (alfalfa: Rhodes) as compared to the other mixtures could be due to the fact that alfalfa dominate and suppressed the growth of Rhodes grass in terms of light and nutrients utilization. These findings were supported by [7]. who reported seeding ratio of 50:50 for alfalfa and Rhodes produced the highest biomass yield? Moreover, the beneficial effects of mixing alfalfa and Rhodes may result from differences in their growth pattern in which Alfalfa is erected, whereas Rhodes grass is semi erected/ prostrate growth characters. This can lead to more efficient use of resources such as light when grown together than when grown separately [21]. Other findings also indicated that mixtures gave higher green forage yields than the pure stands [5]. This finding is in line with other scholars who reported that higher mean biomass yield was obtained from the mixture as compared to their components grown in monoculture [22]. Generally, the result shows that seeding ratio of 50:50 and 25:75 for alfalfa and Rhodes grass were showed the highest total biomass yields for the Rhodes grass and alfalfa in the intercropping system.

As indicated in the table 3, all alfalfa and Rhodes grass mixtures produced LER values greater than 1.0, indicating that these mixtures produced more DM yield as mixture compared to the yield of pure stands. The higher LER (1.21) was recorded for seeding ratio of 25:75 alfalfa to Rhodes grass followed by 50:50 (1.14). Reasons of the higher LER values for seeding ratio of 25:75 could be due to the better benefiting of the grasses from the fixed nitrogen through the alfalfa. Other studies also reported that nitrogen transfer from the fixed nitrogen by legumes to the grasses in the legume-grass mixtures [23].

On the other hands, the lower LER (1.01) for 75:25 seeding ratio could be due to the fact that alfalfa created competition effect on Rhodes grass and thus influence the growth and yield than the other combinations. Intercropping systems that constantly give LERs greater than one is considered to be more efficient systems from a land use point of view than mono-crops. In addition, legume-grass mixtures generally provide

more consistent and greater forage yields across a range of environments than grass or legume monocultures [24]. Hence, the value of LER for seeding ratios showing that mixture of the alfalfa and Rhodes are more advantageous than sole cropping.

Table 3: Biomass yield (t/ha) and land equivalent ratio of Alfalfa and Rhodes mixture under different seeding ratios

Seeding ratio Alfalfa: Rhodes	Adami Tulu			Shawsheen			Combined			LER
	Alfalfa	Rhodes	Total	Alfalfa	Rhodes	Total	Alfalfa	Rhodes	Total	
100:0	6.46^{a}	-	6.46^{c}	5.88^{a}	-	5.88^{b}	6.17^{a}	-	6.17^{c}	-
0:100	-	8.4^{a}	8.4^{abc}	-	6.5^{a}	6.50^{ab}	-	7.45a^{a}	7.45^{abc}	-
50:50	3.26^{b}	5.57^{bc}	8.84^{ab}	2.43^{c}	4.4^{b}	6.85^{a}	2.85^{bc}	4.99^{b}	7.84^{ab}	1.14
75:25	3.56^{b}	3.87^{c}	7.44^{bc}	3.1^{b}	3.2^{c}	6.31^{ab}	3.32^{b}	3.55^{c}	6.87^{bc}	1.01
25:75	2.95^{b}	7.22^{ab}	10.2^{a}	2.2^{c}	4.55^{b}	6.77^{a}	2.58^{c}	5.88^{b}	8.47^{a}	1.21
Mean	4.06	6.26	8.26	3.41	4.67	6.46	3.73	5.47	7.36	-
CV (%)	17.9	26.39	21.7	14.83	10.0	9.97	18.52	27.1	22.66	-
LSD (0.05)	0.87	2.0	2.13	0.61	0.56	0.77	0.56	1.21	1.36	
p-value	0.0001	0.0007	0.0172	0.0001	0.0001	0.0214	0.0001	0.0001	0.0156	

[1]LER=Land equivalent ratio, CV=Coefficient of variation, LSD=Least significant difference,

[2] Figure having the same letters with in column are not significantly differ, while values followed by different letter (s) are significantly differ

Chemical Composition

The analysis result of nutrient contents of Alfalfa and Rhodes with different seeding ratios combinations are indicated in table 4. The result indicated that the combinations of different seeding ratios didn't significantly ($p>0.05$) influenced the percent of dry matter and ash content of the feeds. The DM content of sole Rhodes grass found in the present study was lower than the findings of [25]. who reported DM percent of 92.3%? On the other hand, the different seeding ratios of Alfalfa and Rhodes mixture had showed a significant ($p<0.05$) variation among the values of CP%, NDF% and ADF%. The highest CP content (21.2%) was recorded from pure stand of alfalfa followed by seeding ratio 75:25 (18.5%), 50:50 (16.8%) and 25:75 (14.6%) while pure stand of Rhodes grass produced the least (11.1%) CP value. The average values of CP content were directly related to the Alfalfa seeding ratios in the mixture. The CP content of the Rhodes-Alfalfa produced in mixture is much improved due to alfalfa component in the mixture. Studies also indicated that production of grass- legumes mixture increased fresh fodder yield and protein contents as well as enhanced fodder palatability [5,16]. Even though the value of CP content in 75:25 seeding ratio was higher than other seeding ratios in the mixtures, the high proportion of alfalfa in this ratio is undesirable since these normally have a low dry matter yield.

Of the tested seeding ratios, pure stand of Rhodes grass had the highest NDF (34.48%) and ADF (21.25%) content followed by the seeding ratios of 25:75 which produced 34.28% and 17.24% of NDF and ADF, respectively. The lowest value of NDF (23.8%) and ADF (13.2%) content were recorded from pure stand of alfalfa. NDF and ADF concentrations in forage were directly proportional to the grass percentage in the mixture. As the seeding ratios of the Rhodes grass increased in the mixture, the content of NDF and ADF were increased. Other study also showed significant positive correlations between legume inclusion in pastures and forage quality traits like crude protein and negative correlations with NDF and ADF [26].

Table 4: Chemical composition of Alfalfa and Rhodes grass feeds under different seeding ratios

Seeding ratio Alfalfa: Rhodes	DM%	Ash%	CP%	NDF%	ADF%
100:0	88.98	14.76	21.2a	23.8b	13.2c
0:100	89.9	14.23	11.1d	34.48a	21.25a
50:50	89.6	14.47	16.8b	32.93a	16.6b
75:25	89.3	14.83	18.5b	28.59a	14.55bc
25:75	89.78	14.50	14.6c	34.28a	17.24b
Mean	89.5	14.56	16.4	30.88	16.57
CV (%)	0.38	3.81	10.3	21.3	15.86
LSD (0.05)	NS	NS	2.0	7.82	3.12
p-value	0.0864	0.3578	0.0001	0.0387	0.0002

[1]CV=Coefficient of variation, LSD=Least significant difference, NS= Non significant,

[2] Figure having the same letters with in column are not significantly differ, while values followed by different letter (s) are significantly differ

CONCLUSION

The study indicated seeding ratios significantly influenced the biomass yield of alfalfa and Rhodes mixture. The land equivalent ratio for the mixture were more than 1 showing that mixture of alfalfa with Rhodes is more advantageous than pure stand of the forage. Seeding ratio of 50:50 and 25:75 for alfalfa and Rhodes grass had produced better total biomass yields of the mixture. The highest CP content was recorded from pure stand of alfalfa followed by seeding ratio of 75:25, 50:50 and 25:75 for alfalfa and Rhodes. Even though the association of 25:75 seeding ratio accounted for the highest dry matter yield, it produced lower CP and high NDF and ADF contents as compared to the other mixture. On the other hands, the treatments with sole alfalfa and seeding ratios of 75:25 were showed the highest CP contents which are undesirable due to low total dry matter yields the treatments. Among the seeding ratios, 50:50 combination produced the maximum dry matter yield with optimum nutritive quality of alfalfa-Rhodes mixture. Thus, it can be concluded that seeding ratio combination of 50:50 could be recommended for use in the study areas and similar ago-ecologies due to its high dry matter yield, good quality and more balanced mixture of forage.

Conflict of Interest

None declared.

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None declared.

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