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Research Article

Evaluation of Herbage Yield and Nutritive Value of Desho Grass Integrated with Alfalfa at Different Seeding Rates in Shashemene District, Ethiopia

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Abstract

The experiment was conducted in Shashsssamene district with the objective to evaluate the optimal seeding rates of Alfalfa integrated with Desho grass for better biomass yield and quality forage production. The study conducted by randomized complete block design with three replications and six treatments with four integration levels of Alfalfa seed rates (100%, 75%, 50%, and 25%) and two sole (Desho and Alfalfa). Alfalfa FG-10-09 cultivar and Desho grass Areka-DZF #590 variety were used for the experiment. Alfalfa was sown between rows of Desho grass established via root splits. Important agronomic data collected included dry matter yield, plant height, tiller number and leaf-to-stem ratio. Integration of Alfalfa and Desho grass significantly ($P < 0.005$) affect Desho grass plant height, number of tillers per plant, leaf number per plant, leaf-to-stem ratio, and total dry matter yield. Integrating Desho with Alfalfa at 50% and 75% seed rates resulted in significantly taller Desho plants (88-94.81 cm), higher tiller numbers (29.57-31.60), and greater dry matter yield compared to the sole Desho. Forage quality was significantly influenced by integrating ($P < 0.001$). Crude protein content increased in integrated treatments and the highest value (21.10%) was observed in sole Alfalfa, and intermediate values (15.5-15.38%) in 75% and 50% Desho grass integrated with Alfalfa. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) contents were lower in integrated plots, indicating improved digestibility and palatability of the forage. Overall, the 50% and 75% Alfalfa seed rates provided optimal balance between yield and nutritional quality. This finding indicates the integration these forage considered as a sustainable strategy for improving both productivity and feed quality in forage-based livestock systems. Further demonstrations of Desho grass integrated with alfalfa at 50 and 75% seed rates are recommended to maximize both biomass yield and forage quality in the study area and similar agroecology

Keywords

Alfalfa, Desho Grass, Integration, Biomass Yield, Nutritive Value

1. Introduction

Livestock production in the study area is constrained mainly by chronic shortages of quality feed resources resulting from population growth and expansion of cultivated land, which have led to continuous reduction of grazing areas. During the dry season, crop residues constitute approximately 80% of available livestock feed; however, their low nutritional

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value is inadequate to meet even the maintenance requirements of animals, particularly during prolonged dry periods. This situation highlights the need for developing and promoting improved forage species that are well adapted to local agro-ecological conditions and capable of producing high biomass and quality forage [1].

Alfalfa (*Medicago sativa* L.) is a globally important forage legume due to its wide climatic adaptability, high crude protein content, and superior digestibility compared to grasses [13, 24]. Despite its nutritional importance, alfalfa production remains limited in the study area. Desho grass (*Pennisetum pedicellatum*) is a multipurpose perennial grass adapted to a wide range of altitudes and soil conditions, with high biomass production potential and additional benefits for soil conservation and cut-and-carry feeding systems [4, 23]. Previous evaluations identified Desho grass variety Areka-DZF #590 as high yielding under local conditions (23.71 t ha^{-1}) [14], while several alfalfa cultivars showed promising dry matter yields in Ethiopia [2].

Legume-grass mixtures enhance forage yield stability, nutritive value, and resource use efficiency compared with sole cropping systems, while reducing dependence on costly protein supplements [7, 10]. Integration of legumes with grasses also contributes to soil fertility improvement, weed suppression, and sustainable forage production [5]. Integration effect of Desho grass with alfalfa is not documented yet in the study area. So it is necessary to evaluate different options to maximize yield and quality of Desho grass with alfalfa without affecting agronomic practices of Desho grass and announce the best technology to the end users. Therefore, the current study aimed to determine the appropriate seeding rates of Alfalfa integrated with Desho grass for high biomass yield and quality forage production.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted in Watara Tworufe Kebele, Shashamane district of Oromia Regional State, Ethiopia, during the three cropping seasons (2015, 2016 and 2017 EC). The area is situated at an altitude of 1925 meters above sea level, with latitude and longitude coordinates of 7 °12' N and 38 °36' E, respectively. It is located at approximately 240 km south of the capital city, Finfinne. The mean annual temperature ranges from 11 ℃ to 27 ℃ and the mean annual rainfall is 850 to 900 mm, with the main rainy season occurring between belg/kiremt. The soil type predominant in the area is Nitisols, which is suitable for the cultivation of (main crops likes, Maize, Wheat, Barley and Teff). The local farming system is predominantly smallholder mixed farming, involving both crop production and livestock rearing.

2.2. Experimental Design and Treatments

In this study, Areka-DZF # 590 and alfalfa cultivar FG-10-09) were utilized. The experimental set up included row spacing of 80 cm, a plot size of 3 m ×4 m, with 1 m and 75 cm as the distances between blocks and plots, respectively [8]. Alfalfa was sown by drilling, with its rows aligned between the rows of Desho grass. A seed rate of 6 kg was applied for alfalfa, while Desho grass was established through root splitting. The experiment was arranged in a Randomized Complete Block Design (RCBD), consisting of six treatments: 100, 75, 50 and 25% of the recommended seed rates of alfalfa integrated with Desho graas, alongside sole Desho, and sole alfalfa. Each treatment was replicated three times.

Table 1. *Description of Experimental Treatments.*

Treatments	Description	Treatments	Description
T1	Desho grass established with 100% Alfalfa seed rate	T4	Desho grass established with 25% Alfalfa seed rate
T2	Desho grass established with 75% Alfalfa seed rate	T5	Desho grass established sole
T3	Desho grass established with 50% Alfalfa seed rate	T6	Alfalfa established sole

2.3. Land Equivalent Ratio (LER)

LER is the widely used to measure the biological efficiency and yield per unit area of mixed cropping system compared to mono-cropping. When LER is greater than 1, intercropping improves the productivity of the combined species. In contrast; when LER is lower than 1, it suggests that intercropping negatively affects the plant growth and yield performance [3]. LER was calculated as: LER = (YID/YSD) + (YIA/YSA),

Where YID and YSD are the yields of intercropped and sole Desho grass, YIA and YSA are the yield intercropped and sole Alfalfa, respectively.

2.4. Data Collected

Dry matter yield, plant height, leaf to stem ratio (both forages), number of tillers per plant and number of leaves per

plant (Desho grass) were collected.

2.5. Forage Sampling Procedures

Forage samples were collected by harvesting from the two middle rows per plot at 50% flowering for Alfalfa and Desho grass were also harvested simultaneously once in a year. They were cut at a height of 5 cm from the ground. The total fresh biomass yields were recorded separately from each plot in the field using a sensitive balance.

2.6. Total Dry Matter (DM) Yield Determination

DM yield was determined by drying a representative subsample in an oven at 60 °C for 72 hours to measure the partial DM content. These measurements were performed at the Animal feed laboratory of Adami Tulu Research Center. The final DM yield was calculated and expressed in tons per hectare using the formula: DM yield = 10 × TotFW × (DWss / (HA × FWss)) [17].

Where, TotFW = Total fresh weight, DWss = reweight subsample, FWss = Fresh weight subsamples and HA = Harvesting area.

2.7. Chemical Analyses

The dried samples were then ground to pass through a 1 mm sieve. Representative subsamples of both forage were collected separately from the harvested biomass for each replication of each treatment (plot) and oven-dried at 105 C° overnight for chemical analysis. The dried samples were ground to pass through a 1mm sieve for chemical analyses. Chemical analyses were performed in duplicate for each sample to enhance result precision. Ash content was determined by igniting the samples in a muffle furnace at 550 C° for 3 hours at ATARC. Crude protein (CP) was calculated as nitrogen (N) × 6.25 using the Kjeldahl methods at the Ziway soil Research Center. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to [21] at the ATARC Animal feed laboratory.

2.8. Data Analysis

To test the differences in recorded data were analyzed using a Generalized Linear Model in SAS Software [16]. Significant differences between means were employed with Tukey's HSD at $P \leq 0.05$.

3. Results and Discussion

3.1. Analysis of Variance

Analysis of variance revealed that integrating of alfalfa with Desho grass at different seeding ratios significantly ($P < 0.005$) influenced major growth and yield parameters of Desho grass, including plant height, number of tillers per plant, number of leaves per plant, and total dry biomass yield. This indicates that the performance of Desho grass is strongly affected by interspecific interactions arising from legume and grass integration [15]. In terms of treatment and year interaction effect; number of tillers per plant and total dry biomass yield showed significance differences among the collected parameters. The significant main and interaction effects observed in this study confirm that integrating Desho grass with alfalfa at appropriate seeding ratios can enhance growth characteristics and biomass yield, while also improving system resilience across season [18].

Table 2. *Mean Squares of ANOVA for Desho Grass and Alfalfa Herbage Yields and Agronomic Performance as influenced by Alfalfa Seeding Ratios.*

Source variation	DF	PHd	PHa	NTPPd	DMY	LSRd	LSRa	NLPP
Rep	2	4.39ns	5.44ns	2.06ns	4.390***	0.0509ns	0.03ns	0.136ns
Trt	5	11.0**	5.36ns	323.5**	167.4***	0.6006**	0.33ns	60.161*
Year	2	3.61ns	6.32ns	2.12*	7.34*	3.54ns	0.76ns	4.02ns
Trt * year	5	3.48ns	23.12ns	17.76ns	3.65ns	11.71*	5.31ns	21.11ns
Error	38	5.34	1.09	1.78	0.98	0.10	0.27	0.59

Rep- Replication, Trt-Treatment, DF-Degree Freedom, PHd-Plant height of desho grass, PHa- Plant height of alfalfa, NTPPd-Number of tiller per plant of Desho grass, DMY-Dry Matter yield, LSRd-Leaf to Stem Ration, LSRa- Leaf to Stem Ration and NLPP-Number of leaf per plant.

3.2. Agronomic Performances of Integrated Desho Grass with Different Seed Rates of Alfalfa

The effect of integrating Desho grass with different seed rates of alfalfa on agronomic parameters is presented in Table 3. The results showed that the integration of Desho grass with alfalfa at varying seed rates resulted in significant difference ($p<0.05$) in the number of tillers per plant and dry matter yields of both forages, as well as plant height and leaf to steam ratio for Desho grass. In contrast, plant height and leaf to steam ratio of alfalfa did not show significant variation among treatments ($p>0.05$).

The number of leaves per plant in Desho grass also showed significance among treatments. The highest plant height in Desho grass (88- 94.81cm) was recorded under integrated planting systems, whereas the lowest plant height (71.56 cm) was recorded in sole Desho grass plots. Integrated treatments produced significantly taller Desho grass plant height compared to sole cropping, which is consistent with report of [19]. This improvement in plant height might be due to N fixation by Alfalfa, which likely enhanced soil nitrogen availability and promoted faster growth of Desho grass under integrated conditions.

The highest number of tillers per plant of Desho grass (29.57-31.60) was recorded in the integrated treatments, while the lowest value (23. 85) was observed in the sole established Desho grass stand. The number of tillers per plant of Desho grass increased with higher Alfalfa seed rates. The highest total dry matter yield of Desho grass was achieved with the 75% alfalfa seed rate integration, followed by the 50% seed rate treatment. In contrast, the lowest yields were recorded in the 100% alfalfa seed rate and sole Desho grass treatments. The current results align with [6], who reported that integrating forage legumes with grasses produces better yields than sole forage grass stands.

The increased dry matter yield in integrated plots may be attributed to the higher number of tillers compared to pure stands. The highest leaf to steam ratio of Desho grass was recorded in treatments integrating 75% and 25% of alfalfa seed rates, whereas the lowest values recorded in the sole Desho grass and 25% of alfalfa seed rate treatments. Similarly, the highest number of Desho grass leaves was recorded under 100%, 75% and 50% of alfalfa seed rate, while the shortest leaves observed in the sole Desho grass and 25% alfalfa seed rate treatments.

Table 3. *Agronomic Performance of Desho Grass Integrated with Different alfalfa Seed Rates.*

Treatments	PH (cm)		NTP	DM (t/ha)			LSR		NLPP
	Desho	Alfalf	Desho	Desho	Alfal	TDM	Desh	Alfal	Desho
Desho+100% Alfalfa	92.74^{a}	65.22	31.60^{a}	20.68^{b}	1.28^{c}	21.96^{b}	3.40^{ab}	2.06	10.31^{a}
Desho+75% Alfalfa	94.81^{a}	65.26	30.91^{a}	24.9^{a}	3.39^{b}	28.37^{a}	3.62^{a}	1.91	10.54^{a}
Desho+50% Alfalfa	90.33^{a}	65.07	30.11^{a}	21.1^{ab}	3.10^{b}	24.2^{ab}	3.61^{a}	1.82	10.04^{a}
Desho+25% Alfalfa	88.70^{a}	66.9	29.57^{a}	20.4^{b}	1.28^{c}	21.65^{b}	3.12^{b}	1.70	9.87^{b}
Desho sole	71.6b	-	23.8b	20.5b	-	20.5^{b}	3.06b	-	7.95b
Alfalfa sole	-	63.93	-	-	6.46^{a}	6.46^{c}	-	1.85	-
Mean	87.63	65.28	29.21	21.54	3.07	20.53	3.36	1.87	9.74
CV%	12.9	3.6	12.9	13.6	27.8	20.7	8.9	30.5	12.9
LSD (0.05)	10.81	2.210	3.602	0.38	0.81	0.56	0.29	0.54	1.56
P-Value	<.001	NS	<.001	0.009	<.001	<.005	<.001	NS	<.001

3.3. Land Equivalent Ratio (LER)

All integrated treatments exhibited LER greater than 1, indicating that intercropping was more productive than sole cropping of either Desho grass or Alfalfa. The highest LER of 1.74 was achieved by the Desho grass+ 75% alfalfa seed rate treatment, demonstrating the most efficient land use. This was followed by Desho grass + 50% Alfalfa seed rate treatment, which also performed well with LER of 1.51. Although the Desho grass + 100% Alfalfa seed rate combination exceeded sole cropping with LER of 1.21, its efficiency was lower than the 75% and 50% combinations. This indicated that moderate Alfalfa seed rates are more beneficial in integrated systems. The Desho grass + 25% alfalfa seed rate treatment had the lowest LER among intercrops (1.19), yet it still outperformed the sole cropping systems.

Table 4. *Land Equivalent Ratio of Desho grass integrated with different seed rate of Alfalfa.*

Treatments	Yields of intercropped Desho grass	Yields of intercropped Alfalfa	Total LER (combined)
Desho+100% Alfalfa	1.01	0.20	1.21
Desho+75% Alfalfa	1.21	0.52	1.74
Desho+50% Alfalfa	1.03	0.48	1.51
Desho+25% Alfalfa	1.00	0.20	1.19
Desho sole	-	-	-
Alfalfa sole	-	-	-

3.4. Chemical Composition

The chemical composition of Desho grass integrated with varying seed rates of alfalfa is presented in Table 5. The results revealed significant ($p < 0.001$) differences among treatments for DM, ash, CP, NDF, and ADF.

All integrated treatments exhibited high dry matter content (>88%). The highest average DM content (89.73%) was recorded in Desho + 50% alfalfa treatment, while the lowest (88.14%) was found in sole Desho grass. The inclusion of alfalfa slightly improved DM content compared to sole stands. These results align with [11], who noted typical forage DM contents between 85-92%, and [22], who reported values between 87-89% for similar forage mixtures.

Ash content, reflecting mineral composition, was significantly influenced by treatment ($p < 0.001$). Sole alfalfa had the highest ash content (13.78%), whereas sole Desho grass had the lowest (10.52%). Integrated treatments showed intermediate values ranging from 11.10% to 12.15%. This corresponds with findings of [12], who reported ash contents of 9-11% in Desho grass and 11-14%, in alfalfa [9].

CP content was also significantly affected by treatments ($p < 0.001$). Sole alfalfa had the highest CP (21.10%), followed by the 75% and 50% alfalfa integration treatments (15.5% and 15.38%, respectively). This value is might be due to harvested early vegetative stage of Desho grass and N fixation of Alfalfa. The lowest CP content was recorded in sole Desho grass (10.06%). These results clearly indicate the role of alfalfa integration improving the protein content of forage grass, Consistent with [22], who observed a 3-6% increase in CP when legumes were integrated with grass.

NDF and ADF values were significantly reduced in integrated plots, particularly in the 75% alfalfa treatment, which had one of the lowest NDF values (32.82%) compared to sole Desho grass (41.00%). ADL, an indicator of forage indigestibility, was also significantly lower in integrated treatments, with the lowest value (4.51%) recorded in sole alfalfa. The highest ADL (7.67%) was found in sole Desho grass. These reductions in fiber content reflect improved forage quality and potential palatability, consistent with [20, 21], who emphasized the importance of legume integration in reducing cell wall contents. Overall, integration at 75% and 50% alfalfa seed rates provided the most balanced improvement in chemical composition, enhancing protein content while reducing fiber levels.

Table 5. *Chemical Composition of Desho Grass as Influenced by Alfalfa Seed Rate.*

Treatments	Chemical compositions					
	DM%	Ash%	CP%	NDF%	ADF%	ADL%
Desho+100% Alfalfa	89.20^{ab}	11.10^{bc}	13.83^{c}	36.41^{ab}	28.07^{b}	6.07^{ab}
Desho +75% Alfalfa	89.43^{ab}	12.15^{b}	15.5^{b}	32.82^{bc}	26.20^{b}	4.55^{b}
Desho + 50% Alfalfa	89.73^{a}	11.97^{b}	15.38^{bc}	36.92^{ab}	27.02^{b}	5.37^{ab}
Desho +25% Alfalfa	89.08^{b}	11.25^{bc}	13.97^{bc}	37.86^{ab}	27.76^{b}	5.43^{ab}
Desho sole	88.14^{c}	10.52^{c}	10.06^{d}	41.00^{a}	35.34^{a}	7.67^{a}
Alfalfa sole	89.30^{ab}	13.78^{a}	21.10^{a}	30.12^{c}	26.15^{b}	4.51^{b}

Treatments	Chemical compositions					
	DM%	Ash%	CP%	NDF%	ADF%	ADL%
Mean	89.15	11.80	14.97	35.86	28.42	5.60
CV%	3.9	4.1	4	5.2	4.2	9.2
LSD (0.05)	0.38	0.86	1.065	3.29	2.10	1.90
P-value	<.001	<.001	<.001	<.001	<.001	0.031

4. Conclusions and Recommendations

The integration of Desho grass with different seed rates of Alfalfa significantly affects agronomic performance and chemical composition of the forage. Integrating Desho grass with Alfalfa at 75% and 50% seed rate resulted in superior agronomic performance such as increased plant height, number of tillers per plant, leaf-to-stem ratio, and total dry matter yield for Desho grass as compared with sole cultivated. All integrating treatments recorded LER greater than one showing that integration was more productive than establishing Desho grass or Alfalfa alone.

In terms of nutritional quality, the integration of Alfalfa and Desho grass also had a positive impact. All integrated treatments showed higher dry matter content compared to sole Desho grass, with significant improvements in CP content. The highest CP was recorded from sole Alfalfa (21.10%), while the 75% Alfalfa seed rate with Desho grass yielded the highest CP (15.5%) among the integrated treatments, indicating the nutritional advantage of integrating legumes with grasses. Ash content was also higher in integrated treatments than in sole Desho grass, reflecting improved mineral composition. Integration lowered fiber fractions (NDF, ADF, and ADL), showing enhanced forage quality and digestibility. Overall, integrating Desho grass with Alfalfa, at 75% and 50% seed rate, is a promising strategy for optimizing both biomasses yield and forage quality.

Abbreviations

ADF Acid Detergent Fiber
ADL Acid Detergent Lignin
CP Crude Protein
DM Dry Matter
LER Land Equivalent Ratio
NDF Neutral Detergent Fiber

Author Contributions

Nebi Husein: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Supervision, Validation Visualization, Writing – original draft, Writing – review & editing

Meseret Tilahun: Supervision

Conflicts of Interest

The authors declare no conflicts of interest.

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