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The effect of Cowpea intercropping and different fertilizer levels on Nutritional quality of Napier grass

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ABSTRACT

The field experiment was conducted to check the optimization of fertilizer requirement for napier grass and cowpea intercropping system at the farm of Lovely Professional University, Phagwara, Punjab during kharif season 2022. Study was conducted on total twelve treatment combinations, I_1 (Sole Napier with 100, 75, and 125% RDF), I_2 (Sole Cowpea with 100, 75, and 125% RDF), I_3 (Napier grass + cowpea intercropping in 1:2 ratio with 100, 75, and 125% RDF), and I_4 (Napier grass + cowpea intercropping in 1:3 ratio with 100, 75, and 125% RDF) replicated thrice in Factorial RBD design. The results showed that the overall best quality fodder was obtained from I_4F_3- Napier and Cowpea Intercropping (1:3) + 125 % RDF in which more crude protein, ash content, fat was recorded which is considered good source of feed for livestock and which was at par with I_4F_1- Napier and Cowpea Intercropping (1:3) + 100% RDF. Moreover, this treatment recorded less fibre, ADF and NDF which is difficult to digest by livestock. Hence, it is considered best for feed intake and also increase performance of dairy animals. The lowest crude protein was found in I_1F_2- Sole Napier + 75% RDF. Intercropping increased the nutrient levels in soil and hence improved the uptake. Therefore, we can say that intercropping with legumes and 25% increase in fertilizer dose can improve the overall fodder quality of Napier grass which makes it beneficial for feeding to cattle.

Key words: *Fodder, Quality, Intercropping, Fertilizers, Protein and nutrition quality*

Introduction

Pennisetum purpureum Schumach. (2n=28), commonly known as Napier grass, is a vigorous perennial grass that has been widely used as a tropical feed, yielding more dry matter (DM) than other tropical grasses (Hanna *et al.,* 2004). 8.90 lakh hectares (5.38 lakh hectares in kharif) of land in Punjab is used for growing fodder crops, and 679 lakh tonnes of green fodder are produced per year against a demand of 911 lakh hectares (Rashpinder *et al.,* 2018). If supplemented with legumes and protein concentrates, it can provide an acceptable fodder supply for dairy cows despite its low protein content (Nyambati *et al.,* 2003). The outcrossing species Napier grass has a low self-fertilization rate. Due to its limited seed set and seed viability, it is only reproduced vegetatively. The introduction of high-yielding Napier fodder types is one of the most promising approaches for increasing forage availability in mixed crop-livestock production systems in high-rainfall locations (Orodho, 2006; Nyambati *et al.,* 2010). However, a variety of factors, including meteorological conditions, edaphic environments, agronomic practices, and genotypes, have been demonstrated to influence Napier grass yields and nutritional qualities

(Rengsirikul *et al.,* 2013; Kebede *et al.*, 2016; Negawo *et al.,* 2017). In general, Napier grass accessions have distinct growth, days to maturity, plant height, DM yield, morphological fractions, and climatic adaptability features. These genetic differences are the basis for nutritive value variation, as well as the production, utilization, and various management practices (Kebede *et al.,* 2016). The nutritional value and other nutritional features of Napier grass have been recorded in many research, with substantial differences in dry matter production (DM), crude protein (CP), neutral detergent fibre (NDF), and acid detergent fibre (ADF). In samples taken from 10–15 week old plants, however, Napier grass has 9 percent CP, 20 percent DM, 70 percent NDF, 50 percent ADF, 9 percent ash, and 6 percent lignin on average (Gwayumba *et al.,* 2002).

Intercropping Napier grass with appropriate legumes to improve the nutritional content of cow feed is necessary to assure nutritional security without losing herbage productivity. The adaptability of these plants to row spacing allows for the inclusion of intercrop, which makes them compatible by lowering competition. When the component crops have distinct growth patterns, there is less competition for the system's resources, including the usage of local resources, which results in the maximum yield advantage and complementing effects (Mahapatra, 2011). With the addition of an additional crop to a system, the profit in terms of gross returns, net returns, and B: C ratio rose over the lone stand of crop. As a result, crop combinations can be considered a more profitable endeavor than sole farming (Kumar, 2016).

Materials and Methods

To study the impact of cowpea intercropping on the growth, yield, and quality of napier grass, a field experiment was conducted in the Kharif season of 2022 at the agricultural fields of Lovely Professional University, Phagwara, Punjab. The farm is located at latitude and longitude of 31.2690 ° north and 75.7021 ° east, respectively, at an elevation of 5423 meters above sea level. It has severely chilly winters and summers as well as a tropical monsoon climate with an average annual rainfall of 600 mm. Punjab experiences annual temperatures that range from 10 °C to 46 °C on average, with summer highs of 49 °C and winter lows of 1 °C. Analyses of the site's soil revealed that it was sandy loam with a pH of 8.72, an organic carbon content of 0.310%, and soil nutrients of N-235, P-24, and K-221 (kg ha^{-1}).

Treatment and design

The two crops used as the primary components of the treatments were cowpea (*Vigna unguiculata*) and Napier grass (*Pennisetum purpureum*), both of which intercropped and planted as pure stands as well. The experiment was set up with a factorial arrangement and three replications using a randomized block design. Plots were 7.2 m x 5 m in size, with 1 m between each replication. There were 12 different treatment combinations altogether. The treatment combinations included were, I_1F_1- Sole Napier + 100% RDF; I_1F_2-Sole Napier + 75% RDF; I_1F_3-Sole Napier + 125% RDF; I_2F_1-Sole Cowpea + 100% RDF; I_2F_2- Sole Cowpea + 75 % RDF; I_2F_3- Sole Cowpea + 125 % RDF; I_3F_1- Napier and Cowpea Intercropping (1:2) + 100% RDF; I_3F_2- Napier and Cowpea Intercropping (1:2) + 75 % RDF; I_3F_3- Napier and Cowpea Intercropping (1:2) + 125 % RDF; I_4F_1- Napier and Cowpea Intercropping (1:3) + 100% RDF; I_4F_2-Napier and Cowpea Intercropping (1:3) + 75 % RDF; I_4F_3-Napier and Cowpea Intercropping (1:3) + 125 % RDF.

Harvesting procedure and sample collection

After Napier grass and cowpea were sowed in the second week of June (14 June 2022) and two fodder cuttings were collected in the months of August (last week) and October (last week). It was advised to use 50, 40, and 40 kg ha^{-1} of N, P_2O_5, and K_2O, respectively. Fertilisers with N, P_2O_5, and K_2O were administered as urea, diammonium phosphate, and murate of potash, respectively. Phosphorus and potassium were treated uniformly to all plots as basal dressings, whereas nitrogen was applied to the plots in split (2 equal) dosages at each cutting according to the treatment. Two cuts in total were taken at various time intervals.

The yields of cowpea, Napier grass, and mixture were measured in accordance with the protocol. From each plot, samples of fodder were collected. Plant samples were dried in a hot-air oven at 60°C for 48 hours prior to processing for analysis. Dry matter yield was observed once constant weight was achieved. The benefit: cost ratio was calculated by subtracting the cultivation costs of each treatment from the corresponding gross returns of the two crops cultivated under the various treatments.

Experimental design and data analysis

Three replications of a 4×3 factorial experiment with 4 cropping patterns (I_1, I_2, I_3, and I_4) and 3 fertilizer levels (F_1, F_2, and F_3) were set up. With intercropping as the treatment, responses to biomass production, performances, fodder quality, and nutrient yield and contents were examined in a two-way analysis of variance (ANOVA) of a Factorial Randomized Block Design (FRBD) using statistical analysis software (OPSTAT).

Observations recorded

At each cutting of the trial, numerous observations of the crop's parameters of quality were made. In both cuttings, estimates of the quality traits such crude protein, crude fat, crude fibre, NDF, ADF, and nutritional content were made. A mixture of both the crops were taken at the crop's final harvest (135 DAS), however just sole napier was taken at the crop's initial cut (70 DAS) for analysis. Before being analyzed for the quality contents, the samples were crushed and oven dried.

Results and Discussion

Quality parameters

As shown in Table 1, the ash content and crude fat of napier differ significantly in intercropping with cowpea and under different fertilizer levels it showed a significant effect at 2nd cut but a non significant effect was seen at 1st cut. Maximum ash content was seen in I_3- Napier+ cowpea (1:2) (12.03 and 12.91 % at 1st and 2nd cut respectively) and minimum was seen in sole napier (10.67 and 11.07 % at 1st and 2nd cut respectively) in intercropping system. Under different fertilizer levels F_3- 125% RDF (12.46 and

Table 1. Quality parameters (Ash, Crude protein, Crude fat) of napier grass as affected by cowpea intercropping and different fertilizer levels and their interaction.

	Ash %		Crude protein %		Crude fat %	
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
Intercropping						
I_1	10.67	11.07	10.34	9.44	1.51	1.12
I_2	-	9.55	-	19.00	-	7.81
I_3	13.05	16.00	13.26	11.87	2.89	7.19
I_4	12.03	12.91	14.52	14.02	2.36	6.74
SE.m+	0.11	0.12	0.14	0.18	0.02	0.07
CD(P<0.05)	0.39	0.37	0.51	0.52	0.08	0.19
Fertilizer levels						
F_1	11.91	12.43	12.77	14.72	2.24	5.67
F_2	11.37	13.14	11.86	13.82	1.96	5.63
F_3	12.46	13.25	13.50	14.80	2.55	5.96
SE.m+	0.11	0.11	0.14	0.15	0.02	0.06
CD(P<0.05)	NS	0.32	0.51	0.45	NS	0.17
Interaction						
I_1F_1	10.74	11.24	10.50	9.67	1.47	1.17
I_1F_2	9.91	10.53	8.70	8.33	1.10	0.90
I_1F_3	11.35	11.44	11.83	10.33	1.97	1.30
I_2F_1	-	9.77	-	20.00	-	7.67
I_2F_2	-	8.86	-	16.00	-	7.63
I_2F_3	-	10.01	-	21.00	-	8.13
I_3F_1	12.92	16.03	13.20	12.00	2.90	7.10
I_3F_2	12.59	14.01	12.97	10.77	2.76	7.00
I_3F_3	13.64	17.96	13.60	12.83	3.00	7.47
I_4F_1	12.07	12.70	14.60	13.60	2.37	6.73
I_4F_2	11.61	12.44	13.90	13.43	2.03	6.57
I_4F_3	12.39	13.57	15.06	15.02	2.68	6.93
SE.m+	0.18	0.22	0.24	0.31	0.04	0.11
CD(P<0.05)	NS	0.64	0.89	0.91	NS	NS
CV	2.66	3.01	3.29	3.91	3.06	3.40

13.25%) showed maximum ash and minimum was found in F_2- 75% RDF (11.37 and 13.14%) at both the cuttings. Similarly, crude fat content was also maximum at I_3- Napier+ cowpea (1:2) (2.89 and 7.17% at 1st and 2nd cut, respectively) and minimum in sole napier (1.51 and 1.12 %) in intercropping system. Under different fertilizer levels, crude fat was higher in F_3-125% RDF (2.55 and 5.96 %) and lower in F_2-75% RDF (1.96 and 5.63%). Crude protein of napier grass as affected by intercropping with cowpea and different fertilizer levels and their interaction differ significantly. Highest protein was found in I_4- napier+ cowpea (1:3) (14.52 and 14.02% at 1st and 2nd cut respectively) which was at par with I_3- napier + cowpea (1:2) and the lowest protein content was found in I_1-sole napier (10.34 and 9.44%) in intercropping system. Fertilizer level F_3- 125% RDF (13.50 and 14.80 %) recorded maximum protein content followed by F_1- 100% RDF and minimum was found in F_2-75% RDF (11.86 and 13.82%) at both the cuttings.

Table 2 revealed that intercropping with cowpea had a significant effect on NDF, ADF and crude fibre of napier grass. However, different fertilizer levels had a non significant effect at 1st cut and significant effect at 2nd cut on the NDF, ADF and crude fibre content of napier grass. The interaction effect showed a non significant effect on NDF, ADF and crude fibre except in 2nd cut of NDF which differ significantly. The lowest NDF (51.63 and 49.74%), ADF (32.54 and 40.70%), and crude fibre (28.18 and 26.66%) were recorded in I_4- napier + cowpea (1:3), which was at par with I_3- napier + cowpea (1:2). The highest NDF (69.37 and 66.89%), ADF (38.43 and 43.26%) and fibre (30.06 and 28.64 %) were seen in I_1- sole napier at 1st and 2nd cut respectively. Maximum NDF (72.33 and 70.33 %), ADF (39.21 and 45.30%) and fibre (30.57 and 29.33%) in interaction

Table 2. Quality parameters (NDF, ADF, Crude fibre) of napier grass as affected by cowpea intercropping and different fertilizer levels and their interaction.

	NDF %		ADF %		Crude fibre %	
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
Intercropping						
I_1	69.37	66.89	38.43	43.26	30.06	28.64
I_2	-	42.67	-	38.84	-	16.36
I_3	53.71	51.34	36.83	41.47	29.30	27.52
I_4	51.63	49.74	32.54	40.70	28.18	26.66
SE.m+	0.56	0.39	0.31	0.29	0.28	0.22
CD(P<0.05)	2.07	1.16	1.15	0.85	1.03	0.65
Fertilizer levels						
F_1	58.45	52.81	35.99	42.09	29.23	24.81
F_2	56.42	55.10	35.05	40.80	28.75	24.63
F_3	59.84	53.93	36.75	42.46	29.57	25.24
SE.m+	0.56	0.34	0.31	0.25	0.28	0.19
CD(P<0.05)	NS	1.00	NS	0.73	NS	0.57
Interaction						
I_1F_1	70.11	67.33	38.40	42.44	29.97	28.58
I_1F_2	65.67	63.00	37.68	42.02	29.65	28.02
I_1F_3	72.33	70.33	39.21	45.30	30.57	29.33
I_2F_1	-	42.90	-	38.71	-	16.48
I_2F_2	-	41.97	-	37.57	-	15.81
I_2F_3	-	43.15	-	40.24	-	16.78
I_3F_1	53.59	51.35	36.96	41.44	29.34	27.51
I_3F_2	53.28	50.85	36.37	41.14	29.09	27.27
I_3F_3	54.27	51.82	37.16	41.85	29.49	27.77
I_4F_1	51.65	49.67	32.62	40.62	28.38	26.67
I_4F_2	50.32	49.14	31.10	40.50	27.50	26.23
I_4F_3	52.90	50.41	33.89	40.99	28.65	27.07
SE.m+	0.98	0.68	0.54	0.50	0.49	0.38
CD(P<0.05)	NS	2.01	NS	NS	NS	NS
CV	2.91	2.24	2.61	2.10	2.88	2.67

were recorded in I_1F_3- sole napier + 125% RDF which were at par with I_1F_1 and I_1F_2 and lowest were seen in I_4F_2- napier +cowpea (1:3) + 75% RDF at both the cuttings.

Nutrient content after harvest

The data shown in Table 3 revealed that N, P and K differ significantly in intercropping system and fertilizer levels of napier grass as an individual factor. The interaction effect of intercropping and fertilizer level showed a significant effect on plant N whereas; a non significant effect was seen in P and K. In intercropping, maximum N (2.32 and 2.24%) was seen in I_4- napier +cowpea (1:3) and lowest was seen in I_1- sole napier (1.64 and 1.50%). However, P (0.30 and 0.28%) and K (1.82 and 2.01%) recorded highest value in I_3- napier + cowpea (1:2) at both the cuttings, respectively and lowest P (0.22 and 0.22%) and K (1.39 and 1.59%) in sole napier. Among different fertilizer levels F_3- 125% RDF recorded maximum N (2.16 and 2.34%), P (0.28 and 0.27%) and K (1.70 and 1.96%) at 1st and 2nd cuttings followed by F_1- 100% RDF and lowest in F_2-75% RDF. In interaction effect of intercropping and fertilizer levels maximum N (2.41 and 2.40 %) was seen in I_4F_3- napier +cowpea (1:3) + 125% RDF which was at par with I_4F_1- napier +cowpea (1:3) + 100% RDF (2.34 and 2.22%). The lowest N was recorded in I_1F_2- sole napier+ 75% RDF (1.45 and 1.29%) at 1st and 2nd cutting, respectively. On the other hand P (0.32 and 0.28%) and K (1.97 and 2.06%) content in napier grass was highest in I_3F_3- napier +cowpea (1:3) + 125% RDF and lowest P (0.21 and 0.20%) and K (1.32 and 1.53%) was recorded in I_1F_2- sole napier+ 75% RDF.

Table 3. Nutrient content (N, P, and K) in napier grass as affected by cowpea intercropping & different fertilizer levels and their interaction.

	N %		P %		K %	
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
Intercropping						
I_1	1.64	1.50	0.22	0.22	1.39	1.59
I_2	-	3.03	-	0.30	-	2.19
I_3	2.14	1.88	0.30	0.28	1.82	2.01
I_4	2.32	2.24	0.26	0.25	1.60	1.81
SE.m+	0.03	0.02	0.00	0.003	0.02	0.02
CD(P<0.05)	0.10	0.63	0.01	0.01	0.08	0.06
Fertilizer levels						
F_1	2.03	2.21	0.26	0.26	1.61	1.92
F_2	1.92	2.32	0.24	0.27	1.50	1.99
F_3	2.16	2.34	0.28	0.27	1.70	1.96
SE.m+	0.03	0.02	0.00	0.003	0.02	0.02
CD(P<0.05)	0.10	0.55	0.01	0.01	0.08	0.05
Interaction						
I_1F_1	1.61	1.57	0.22	0.23	1.41	1.61
I_1F_2	1.45	1.29	0.21	0.20	1.32	1.53
I_1F_3	1.86	1.65	0.23	0.23	1.43	1.63
I_2F_1	-	3.15	-	0.30	-	2.20
I_2F_2	-	2.57	-	0.29	-	2.10
I_2F_3	-	3.37	-	0.31	-	2.27
I_3F_1	2.14	1.92	0.30	0.28	1.79	2.03
I_3F_2	2.07	1.76	0.28	0.28	1.70	1.95
I_3F_3	2.20	1.95	0.32	0.28	1.97	2.06
I_4F_1	2.34	2.22	0.26	0.25	1.64	1.83
I_4F_2	2.22	2.09	0.24	0.24	1.46	1.73
I_4F_3	2.41	2.40	0.27	0.26	1.70	1.88
SE.m+	0.05	0.04	0.01	0.005	0.04	0.03
CD(P<0.05)	0.17	0.11	NS	NS	NS	NS
CV	3.99	2.97	3.99	3.56	3.93	3.13

Discussion

When the legume was included in the intercrop, it was shown that the crude protein of Napier grass was greatly increased compared to sole Napier grass (Njoka-Njiru *et al.,* 2006). The leaf fraction had a greater quantity of CP than the stem fraction. The results of Tang *et al.* (2008) and Ansah *et al.* (2010), who all showed more CP in grass leaves than the stem, are in agreement with this. Damame *et al.* (2017) demonstrated similar outcomes. In addition, Ahamed *et al.* (2021) discovered that intercropping had higher CP than sole napier hybrid. Additionally, the % CP dramatically reduced as the cutting period increased. The quantity of fibrous material grows and the proportion of protein falls as the plant ages, which was the cause. Khaled *et al.* (2005) and Peiretti *et al.* (2015) reported comparable findings about the drop in CP with progressing phonological stages and an increase in CP content in intercropping of legumes with napier grass. The explanation could be that intercropping systems can benefit Napier grass in a number of ways, including enhanced nitrogen availability, synergistic effects, less competition, and improved soil fertility, all of which can help the grass have higher protein and ash contents. Protein, ether extract, and total ash yields were higher in NBH intercropped with cowpea, according to Hindoriya *et al.* (2019). According to Semman *et al.* (2018), adding more nitrogen increased the ash content of napier grass. As a result, ash content is shown to increase to various degrees with every increase in fertilizer level.

The EE or fat content were observed to increase as the nitrogen fertilizer level increased by Ayub *et al.* (2002); the least concentration was recorded with no fertilizer, which was consistent with the findings of Walie *et al.* (2022). The cause is that fertilizing with nitrogen can make more nitrogen available to plants, which can promote plant growth and lead to an increase in the accumulation of organic materials, including lipids. According to Manoj *et al.* (2020), intercropping rather than sole napier produced less fibre. The intercropping system's use of legumes may have improved the Napier grass's ability to be digested as an outcome. The complex carbohydrates in grass are broken down by legumes, making them simpler for animals to digest. According to Tilahun *et al.* (2017), intercropping systems had lower NDF and ADF levels than sole napier. As a result, it was discovered that providing adequate legumes in addition to napier grass was better for animals because they were more easily digestible. The same outcomes were also reported by Tenakwa *et al.* (2019). Applying more fertilizers (N, P and K) can improve a plant's metabolic processes, resulting in greater leaf growth and nutrient uptake. Additionally, the amount of nutrients in the leaves may rise as a result. Moreover, application of fertilizer with a 25% increase in RDF can boost a plant's photosynthetic rate, resulting in increased leaf growth and nutrient uptake. This may also result in a rise in the nutritional value of the leaves.

Conclusion

This study demonstrated the advantages of napier grass as a fodder crop when cultivated with fodder cowpea as an intercrop in 1:3 ratio. A moderate quality of fodder napier alone can be obtained during the first and second cuttings by planting according to standard procedure. In comparison to the sole Napier grass, Crude protein, fat, ash, fibre, ADF and NDF were appreciated in the legume intercrop. Legumes and napier grass can be intercropped to improve a variety of growth characteristics, including soil fertility, weed pressure, pest and disease resistance, and yield.

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