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The Effect of Cowpea Intercropping and Different Fertilizer Levels on Growth and Yield of Napier Grass

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ABSTRACT

Background: 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.

Methods: Study was conduct on total twelve treatment combinations, I1 (Sole napier with 100, 75 and 125% RDF), I2 (Sole Cowpea with 100, 75 and 125% RDF), I3 (Napier grass + cowpea intercropping in 1:2 ratio with 100, 75 and 125% RDF) and I4 (Napier grass + cowpea intercropping in 1:3 ratio with 100, 75 and 125% RDF) replicated thrice in Factorial RBD design.

Result: All the growth parameters and yield in intercropping with cowpea were found significantly superior over sole napier grass. Maximum plant height (253.6 cm) and number of leaves (16.13) of napier were seen in intercropping with cowpea I4F3 (1:3 ratio + 125% RDF) which were at par with I3F1 (1:3 ratio + 100% RDF) and I3F2 (intercropping in 1:2 ratio + 125% RDF). There was a significant main effect of intercropping on green fodder yield of Napier grass with a higher yield in (75.69 t ha^{-1} in mixture and 60.65 t ha^{-1} sole) recorded in the intercropping ratio of 1:3 with 125% RDF (I4F3). The minimum yield of 24.41 t ha^{-1} was found in I1F2 (sole napier with 75% RDF) followed by 29.41 t ha^{-1} in I1F1 (Sole napier + 100% RDF) in 1st cutting. Intercropping napier with cowpea enhanced the overall growth and green fodder yield as compared to sole napier.

Key words: Cowpea, Green fodder yield, Growth, Intercropping.

INTRODUCTION

The perennial grass known as elephant grass or Napier grass (*Pennisetum purpureum*) is commonly cultivated in tropical and subtropical areas of Asia, Africa, southern Europe and America. It can thrive in a wide range of agro ecological circumstances due to its robust vegetative growth, high biomass production and deep-rooted root structure. For three to four years on the same field, the hybrid napier grass can be maintained as a fruitful fodder crop (Triveni *et al*., 2022). Due to its high yields and nutritional content, it has been a major feed crop in the tropics. For cattle to remain healthy and productive, access to green forage is crucial. This is particularly important in the dairy industry, where a steady supply of green forage is required to maintain milk output. In addition to providing energy, green plants also include vitamins and minerals with improved dry matter digestion (Surve *et al*., 2012). Napier grass is best suited to intense small-scale farming systems and can provide a year-round source of green fodder with the right management techniques. Napier grass is a preferred feed due to numerous advantageous qualities, which include a high yield per unit area, resilience to periodic drought and a high-water usage efficiency (Kabirizi *et al*., 2015). It is resilient to repeated cutting and regenerates quickly, giving forth tasty green branches. Considering this, improving knowledge-based utilisation and conservation of the available Napier grass resources holds the possibility of having a significant positive impact on cattle value chains (Negawo *et al*., 2017).

Intercropping napier grass with the right legumes is crucial for ensuring nutritional security without reducing herbage productivity and improving the quality of cattle feed (Sushma *et al*., 2021). In Kenya, the value of herbaceous forage legumes in boosting grass productivity and feed quality has been recognized (Mwangi and Wambugu, 2002). Legumes would improve the quality of feed in addition to being an important source of nitrogen for the growing of fodder grasses. Legumes support grasses by adding nitrogen to the soil through air fixation, the decomposition of dead root nodules, or the mineralization of shed leaves (Tenakwa *et al*., 2019). When the component crops have diverse growth patterns, there is less competition for the system's resources, including the utilization of the local environment and the yield advantage and complimentary effects are highest (Mahapatra, 2011). Anantawiroon *et al.* (2006) discovered that intercropping grass with legumes at a ratio of 1:1 produced more fodder than growing sole grass. According to a study by Sushma *et al*. (2021), hybrid napier produces more fodder when grown in paired rows with fodder cowpea as an intercrop. The goal of this study was to

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determine how intercropping cowpea might affect the yield and quality of napier grass.

MATERIALS AND METHODS

A field experiment was performed in the *Kharif* season, 2022 at the agricultural fields of Lovely Professional University, Phagwara, Punjab to study the effect of cowpea intercropping on growth, yield and quality of napier grass. The farm is situated at a latitude and longitude of 31.2690° north and 75.7021° east, respectively. It possesses a tropical monsoon environment with 600 mm of annual rainfall on average as well as extremely cold winters and summers. In Punjab, the yearly average temperature ranges from 10°C to 46°C, with summer peaks of 49°C and winter recessions of 1°C. The site's soil was determined by analysis and found to be sandy loam with a pH of 8.72, organic carbon content of 0.310% and soil nutrients of N-235, P-24 and K-221 (kg ha^{-1}).

Treatment and design

Treatments consisted of Napier grass (*Pennisetum purpureum*) and cowpea (*Vigna unguiculata*) planted as pure stand and their intercropping under different levels of fertilizers. The design of the experiment was a randomized complete block design in a factorial arrangement with 3 replications. Plots sizes were 7.2 m × 5 m with 1 m between replications. Total number of treatment combinations was 12. The treatment combinations included were, I1F1- Sole Napier + 100% RDF; I1F2-Sole Napier + 75% RDF; I1F3-Sole Napier + 125% RDF; I2F1-Sole Cowpea + 100% RDF; I2F2- Sole Cowpea + 75% RDF; I2F3- Sole Cowpea + 125% RDF; I3F1- Napier and Cowpea Intercropping (1:2) + 100% RDF; I3F2- Napier and Cowpea Intercropping (1:2) + 75% RDF; I3F3- Napier and Cowpea Intercropping (1:2) + 125% RDF; I4F1- Napier and Cowpea Intercropping (1:3) + 100% RDF; I4F2-Napier and Cowpea Intercropping (1:3) + 75% RDF; I4F3-Napier and Cowpea Intercropping (1:3) + 125% RDF.

Harvesting procedure and sample collection

Two fodder cuttings were collected in the months of August (last week) and October (last week) after Napier grass and cowpea were sown in second week of June (14 June, 2022). N, P_2O_5 and K_2O dosages of 50, 40 and 40 kg ha^{-1} each were recommended. Fertilizers containing N, P_2O_5 and K_2O were applied as urea, diammonium phosphate and murate of potash, respectively. While nitrogen was applied to the plots according to the treatment in split (2 equal) dosages at each cutting, phosphorus and potassium were applied evenly to all plots as basal dressings. Total two cuts were taken, at 70 and 135 DAS.

According to procedure, yields of Napier grass, cowpea and mixture were recorded. Samples of fodder were taken from every plot. Before being processed for analysis, plant samples were dried in a hot-air oven at 60°C for 48 hours. With the achievement of constant weight, dry matter yield was noted. The benefit: cost ratio was computed after calculating the net return of both crops grown under the various treatments by deducting the cultivation costs of each treatment from their respective gross returns.

Experimental design and data analysis

A 4 × 3 factorial experiment (4 cropping patterns I1, I2, I3 and I4 × 3 fertilizer levels F1, F2 and F3) in a randomized block design was laid out in 3 replications. Considering the intercropping as treatment, their responses to biomass production, performances and nutrient yield and contents were analyzed in an ANOVA of a factorial randomized block design (FRBD) using statistical analysis software (OPSTAT), two-way analysis of variance (ANOVA) was performed on all the recorded data.

Observations recorded

During the experiment, various observations of growth and yield of the crop were taken from the five randomly selected plants from each plot. The randomly selected plants were tagged for recording the growth parameters like plant height, leaf length, leaf width, leaf area, leaf area index and chlorophyll index at different growth stages (30, 60, 90, 120 and 135 DAS). The green fodder yield of Napier grass and cowpea (1st and 2nd cutting) was estimated from each plot with the help of 1 m^2 quadrate and then the values were converted into tonne per hectare by multiplying them with an appropriate factor. The mixture yield of both the crops was taken at final harvest of the crop. Similarly, Dry fodder yield was calculated by multiplying percent dry matter content with green fodder yield.

RESULTS AND DISCUSSION

Growth characteristics

A significant result was found in intercropping unlike fertilizer levels which was found to be non-significant (Table 1 and 2). There was a non significant effect on the interaction in plant height in both the cuttings whereas a significant result was found in intercropping alone. The maximum Plant height in interaction (253.60 and 253.33 cm in 1st and 2nd cutting, respectively) was recorded in I4F3 in both the cuttings followed by I4F1 (242 and 243.33cm), I4F2 (237.67 and 239.67 cm) and I3F3 (235.67 and 238.33 cm) and the minimum height observed in I1F2 (sole Napier) (220.40 and 218.67 cm). Maximum height was observed in intercropping factor alone i.e. 244.42 cm in I4 (1:3) which was at par with 230.0 cm in I3 (1:2) and 223.20 in I1 (sole napier) at first cutting. Similarly, in 2nd cutting I4 showed maximum height of 245.44 cm followed by 234.33 cm in I3 and 225.89 cm in I1. A natural phenomenon of growth that supports the autotrophic nature of plants is the growth and increase in the number of leaves together with height. Due to its spreading growth behavior, which fills all gaps, cowpea eventually competes with main crops for resources such as sunlight and soil moisture, which also causes napier to grow taller.

The maximum number of leaves, in interaction (15.67 and 16.13 in 1st and 2nd cutting, respectively) was recorded in I4F3 in both the cuttings which were at par with I4F1 (14.33 and 15.33), I4F2 (13.47 and 14) and I3F3 (13.03 and 13.87) and the minimum number of leaves were found in I1F2 (10.13 and 10.27) (Table 1). The number of leaves in intercropping and fertilizer levels alone were significant but their interaction was found to be non significant. Leaf length and leaf width and leaf area in both the cuttings in intercropping showed significant difference whereas non significant variation was seen in fertilizer levels. Their interaction was not significant. Leaf length (97.20 and 92.20 cm) and width (4.22 and 3.85 cm) were found to be highest in I4F3 combination and lowest in I1F2 (74.33 and 73 cm leaf length) (3.23 and 2.88 cm width) at both the cutting intervals. This finding was in line with that of Gelayanew *et al*. (2020) and Tenakwa *et al*. (2019).

Similarly, leaf area was maximum in I4F3 (652.67 and 617 cm^2) which were at par with I4F1 (617.67 and 601 cm^2) and I3F3 (576.67 and 578.33 cm^2) (Table 2). Lowest leaf area was recorded in I1F2 (543.67 and 536.67 cm^2). LAI showed a non significant effect in interaction but significantly differs in intercropping. Leaf area index at both the cuttings were maximum in I4F3 (1.29 and 1.31) followed by I4F1 (1.24 and 1.27) and I4F2 (1.22 and 1.23) and minimum LAI was found in I1F2 (0.38 and 0.38). Chlorophyll index of interaction were not significant whereas a significant variation was observed in intercropping. Highest value of chlorophyll was recorded in I4F3 (45.47 and 35.97) which were at par with I4F1 (44.91 and 31.37) and I4F2 (43.78 and 31.03), in first and second cuttings. Lowest chlorophyll index was found in sole napier grass I1F2 (35.30 and 26.59).

The findings of this study support those of Nilanthi *et al.* (2004) regarding hybrid napier. Similar results were shown by Gelayanew *et al*. (2020) and Tenakwa *et al.* (2019). They showed the increased growth of Napier grass in intercropping with legumes as compared to sole napier grass. Sima *et al.* (2010) concluded that, the utilization of symbiotically fixed nitrogen, improved light absorption and other benefits made the triple rows of cowpea preferable to the double or single row. Similar findings were made by Lakshmi and Anita (2020). When grown together, cowpea may have a synergistic impact that increases growth and yield of napier grass. The napier grass may benefit more from the combination of crops with a 1:3 ratio than with a 1:2 ratio. Similar outcomes were demonstrated by Dinsa and Yalew (2022) who recommended a planting density of 24 plants m^{-2} as a better choice for good forage quantity and quality in intercropping of napier with cowpea. The reason being different crops exchange resources including

Table 1: Growth characteristics of Napier grass as affected by intercropping and different fertilizer levels in two cutting intervals.

	Plant height (cm)		No. of leaves		Leaf length (cm)		Leaf width (cm)	
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
Intercropping								
I1	223.20	225.89	10.69	11.29	78.09	76.11	3.27	3.19
I3	230.00	234.33	12.38	13.24	83.87	81.58	3.56	3.45
I4	244.42	245.44	14.49	15.16	91.22	86.24	4.02	3.75
SE.m±	5.47	4.99	0.40	0.40	2.42	1.93	0.13	0.09
CD (P<0.05)	20.07	18.33	1.47	1.47	8.89	7.09	0.48	0.34
Fertilizer levels								
F1	231.29	235.22	12.46	13.38	84.09	80.36	3.59	3.53
F2	228.02	229.78	11.77	12.24	81.02	78.87	3.53	3.30
F3	238.31	240.67	13.32	14.07	88.07	84.71	3.74	3.57
SE.m±	5.47	4.99	0.40	0.40	2.42	1.93	0.13	0.09
CD (P<0.05)	NS	NS	1.47	1.47	NS	NS	NS	NS
Interaction								
I1F1	223.53	228.67	10.67	11.40	78.47	76.00	3.26	3.33
I1F2	220.40	218.67	10.13	10.27	74.33	73.00	3.23	2.88
I1F3	225.67	230.33	11.27	12.20	81.47	79.33	3.33	3.37
I3F1	228.33	233.67	12.40	13.40	83.80	81.33	3.57	3.45
I3F2	226.00	231.00	11.70	12.47	82.27	80.80	3.47	3.41
I3F3	235.67	238.33	13.03	13.87	85.53	82.60	3.65	3.48
I4F1	242.00	243.33	14.33	15.33	90.00	83.73	3.95	3.80
I4F2	237.67	239.67	13.47	14.00	86.47	82.80	3.91	3.60
I4F3	253.60	253.33	15.67	16.13	97.20	92.20	4.22	3.85
SE.m±	9.47	8.65	0.70	0.69	4.20	3.35	0.23	0.16
CD (P<0.05)	NS	NS	NS	NS	NS	NS	NS	NS
CV	7.05	6.37	9.62	9.05	8.61	7.13	10.83	7.95

water, nutrients and sunlight in an intercropping system. Napier grass may be less competitive for these resources with a ratio of 1:3, enabling it to grow more effectively and provide higher yields. Moreover, cowpea is considered a valuable source of farming system due to its ability to increase soil fertility and reduce disease and pest population. Similarly, the nutrient use efficiency of napier grass can be raised by applying additional fertilizer, which allows the plant to utilize the applied fertilizer more effectively to create biomass and yield. Higher yields and more cost-effective fertilizer use may result from this. Therefore, 125% RDF resulted in maximum growth and yield.

Yield characteristics

There were significant results found in effects of legume intercropping and different fertilizer level individually, but their interaction was not significant (Table 3). There was a significant main effect of intercropping on green fodder yield of Napier grass with a higher yield 60.67 t ha^{-1} in 1st cut taken sole and 75.69 t ha^{-1} in 2nd cut taken in mixture with cowpea, which was recorded in the intercropping ratio of 3:1 (I4F3) followed by I4F1 (56.23 t ha^{-1} in sole and 69.65 t ha^{-1} in mixture with cowpea) and I4F2 (49.63 t ha^{-1} in sole and 62.33 t ha^{-1} in mixture with cowpea). The least green fodder yield was found in sole Napier grass, I1F2 in both the cuttings (24.90 and 42.03 t ha^{-1} respectively). The overall yield was found maximum (75.69 t ha^{-1}) in 2nd cut in which mixture of napier and cowpea were taken as compared to 1st cut (60.67 t ha^{-1}) in which only napier was harvested. Therefore, adding legumes with napier grass results in higher overall production with equal number of inputs. The Napier grass in the intercrop may have benefited from the available nitrogen fixed by the legumes.

There was a significant effect of interaction on dry fodder yield in the first cutting, but a non-significant result was seen in second cut. The maximum DFY was found in I4F3 in both the cuttings *i.e.*, 25.37 and 24.97 t ha^{-1} respectively, in 1st and 2nd cut which were at par with I4F1 (22.27 and 24.19 t ha^{-1}) and I4F2 (20.50 and 23.65 t ha^{-1}). The least DFY (8.63 and 14.42 t ha^{-1}) were found in I1F2 (8.63 and 14.42 t ha^{-1} in sole cut and mixture with cowpea, respectively).

These findings were found similar with Anantawiroon *et al.* (2006), who found significant effect of legume intercrop on the yield of Napier grass. Njoka-Njiru *et al.* (2006) reported that Napier grass benefited from the legumes by producing high herbage yield. Rahman *et al.* (2015) also reported a significant ($p<0.05$) difference in total biomass yield between the intercropped group. This was similar with findings of Hindoriya *et al.* (2019). This study demonstrated the advantages of hybrid napier's fodder output when

Table 2: Growth characteristics of Napier grass as affected by intercropping and different fertilizer levels in two cutting intervals.

	Leaf area (cm^2)		Leaf area index		Chlorophyll (SPAD reading)	
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
Intercropping						
I1	552.33	549.11	0.42	0.40	37.78	27.45
I3	569.33	571.67	1.01	1.13	41.08	29.56
I4	617.89	599.78	1.25	1.27	44.72	32.79
SE.m±	11.67	11.66	0.03	0.05	1.03	0.85
CD (P<0.05)	42.84	42.80	0.13	0.17	3.79	3.12
Fertilizer levels						
F1	580.11	574.67	0.89	0.95	41.45	29.54
F2	563.56	560.89	0.83	0.87	39.82	28.83
F3	595.89	585.00	0.96	0.98	42.31	31.43
SE.m±	11.67	11.66	0.03	0.05	1.03	0.85
CD (P<0.05)	NS	NS	0.13	NS	NS	NS
Interaction						
I1F1	555.00	551.00	0.40	0.41	38.48	27.78
I1F2	543.67	536.67	0.38	0.38	35.30	26.59
I1F3	558.33	559.67	0.48	0.42	39.57	27.99
I3F1	567.67	572.00	1.04	1.17	40.96	29.47
I3F2	563.67	564.67	0.88	1.01	40.39	28.88
I3F3	576.67	578.33	1.10	1.21	41.88	30.33
I4F1	617.67	601.00	1.24	1.27	44.91	31.37
I4F2	583.33	581.33	1.22	1.23	43.78	31.03
I4F3	652.67	617.00	1.29	1.31	45.47	35.97
SE.m±	20.21	20.19	0.06	0.08	1.79	1.47
CD (P<0.05)	NS	NS	NS	NS	NS	NS
CV	6.04	6.10	11.73	15.31	7.51	8.51

Table 3: Green fodder yield and Dry fodder yield of Napier grass as affected by intercropping and different fertilizer levels in two cutting intervals.

	Green fodder yield (t ha^{-1})		Dry fodder yield (t ha^{-1})	
	1st cut	2nd cut (NG +cowpea)	1st cut	2nd cut (NG+cowpea)
Intercropping				
I1	29.51	45.73	9.41	15.64
I2	-	21.21	-	3.83
I3	41.63	56.26	13.02	18.96
I4	55.51	69.22	22.71	24.27
SE.m±	1.63	1.50	0.77	0.44
CD (P<0.05)	5.99	4.41	2.84	1.29
Fertilizer levels				
F1	42.40	48.10	14.73	15.51
F2	36.96	44.26	13.35	14.07
F3	47.29	52.12	17.05	16.80
SE.m±	1.63	1.30	0.77	0.38
CD (P<0.05)	5.99	3.82	2.84	1.11
Interaction				
I1F1	29.41	45.60	9.45	15.38
I1F2	24.90	42.03	8.63	14.42
I1F3	34.21	49.56	10.13	17.13
I2F1	-	20.23	-	3.75
I2F2	-	19.35	-	3.12
I2F3	-	24.05	-	4.63
I3F1	41.57	56.93	12.48	18.70
I3F2	36.33	52.65	10.92	17.72
I3F3	47.00	59.18	15.67	20.45
I4F1	56.23	69.65	22.27	24.19
I4F2	49.63	62.33	20.50	23.65
I4F3	60.67	75.69	25.37	24.97
SE.m±	2.82	2.59	1.34	0.75
CD (P<0.05)	10.37	NS	4.92	NS
CV	11.58	9.32	15.44	8.33

cultivated with an intercrop like fodder cowpea. A moderate yield of hybrid napier and cowpea alone can be obtained by planting according to standard procedure. This finding was similar with (Sushma *et al.,* 2021). Utilizing resources like water and sunlight more effectively can be achieved by intercropping cowpea and napier grass. Because cowpea grows more quickly than napier grass, it can be harvested early, allowing the napier grass to receive a greater amount of sunlight. Cowpea also has a shallow root system compared to napier grass's deeper root system. Due to the complementary nature of the two crops' water and fertilizer requirements, there will be less competition and a consequent increase in yields. Therefore, intercropping is found to be more beneficial as compared to sole napier.

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 yield of napier alone can be obtained during the first and second cuttings by planting according to standard procedure. In comparison to the sole Napier grass, plant height and leaf area and yield 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.

Conflict of interest

There is no conflict of interest in manuscript and manuscript had not submitted to other journal.

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