RESEARCH ARTICLE Agricultural Science Digest, Volume 46 Issue 2: 314-318 (April 2026)

# The Effect of Napier Grass+Cowpea Intercropping and Different Fertilizer Levels on Soil Characteristics and Economics

Manisha Chaudhary[1], Rajeev[1], Ramandeep Singh[1], Kritika[1], Hina Upadhyay[1]

10.18805/ag.D-5894


## 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:** Three replications of factorial RBD design 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. 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).

**Result:** The results showed that in the interaction effect of intercropping and fertilizer levels the the highest value of pH and EC was found to be in $I_1F_2$- Sole Napier + 75% RDF (8.04 and 0.42 mhos $cm^{-1}$, respectively). Higher OC was found in $I_4F_3$- Napier+cowpea (1:3) + 125% RDF (18.23%) as compared to sole napier. However, sole cowpea plots recorded highest OC (18.60 %) in $I_2F_3$- Sole Cowpea + 125% RDF but lowest pH and EC. The lowest N, P and K in soil were seen in $I_1F_2$- Napier grass+75% RDF (90.00, 10.93 and 124.4 kg $ha^{-1}$, respectively) in interaction of intercropping and fertilizer levels among treatment combinations of napier grass. $I_2F_3$- Sole cowpea + 125% RDF recorded (225, 20.68 and 214.93 kg $ha^{-1}$) N, P and K, respectively, which was highest among all the treatment combinations. Highest net returns and B: C ratio of 3.37 was recorded from intercropping ratio 1:3 and 125% RDF which was followed by 100% RDF (3.13) and 75% RDF (2.77).


**Key words:** Cowpea, Intercropping, Napier grass, NPK.

## 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). With excellent agronomic and management methods, Napier is a tall, mostly vegetatively propagated perennial native to Sub-Saharan Africa that may generate biomass of 20-30 tonnes of dry matter $ha^{-1}$ $year^{-1}$. However, using traditional methods, the productivity of Napier grass begins to decline after a few years, especially if correct care is not applied. Napier grass stem cuttings or root splits are planted 15-20 cm deep in well-prepared soil, using organic or inorganic fertilizers, at 60 cm × 60 cm, 90 cm × 60 cm, or 90 cm × 90 cm spacing, depending on the quantity of rainfall received. The closer the gap, the heavier the rainfall (Orodho, 2006). 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). 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). Cowpea is the ideal intercrop to support the green fodder output as well as the economics of hybrid Napier cultivation during the winter months (Verma *et al.,* 2011).

[1]School of Agriculture, Lovely Professional University, Phagwara-144 401, Punjab, India.

**Corresponding Author:** Rajeev, School of Agriculture, Lovely Professional University, Phagwara-144 401, Punjab, India.
Email: rajeev.26421@lpu.co.in

**How to cite this article:** Chaudhary, M., Rajeev, Singh, R., Kritika and Upadhyay, H. (2026). The Effect of Napier Grass+Cowpea Intercropping and Different Fertilizer Levels on Soil Characteristics and Economics. *Agricultural Science Digest.* **46(2):** 314-318. doi: 10.18805/ag.D-5894.

**Submitted:** 05-10-2023 **Accepted:** 10-04-2024 **Online:** 24-07-2024

Including a legume in the production of fodder grasses would not only give a nitrogen supply to stimulate grass growth, but it would also improve the feed quality. Legumes help grasses by fixing nitrogen in the air, decaying dead root nodules and mineralizing shed leaves. The major reason for intercropping is yield advantage because environmental resources like water, light and nutrients may be used more efficiently in intercropping than in sole cropping systems (Jinghui *et al.,* 2006). As a result, using grass-legume forage intercropping helps to boost land and livestock feed productivity. According to Iannetta *et al.* (2016), legumes improve soil nitrogen by fixing between 32 and 115 kg $ha^{-1}$ of nitrogen in symbiosis with rhizobium bacteria. This can reduce the need for fertilizer in the crops that are produced afterward, resulting in a nitrogen reduction of between 23 and 31 kg $ha^{-1}$ (Preissel *et al*., 2015).

The cereal-legume intercropping method helped in soil conservation, enhanced the properties of the soil and improved nutrient and moisture uptake (Akman *et al.,* 2013). He found that adding legume crops to a system over a sole crop improved the amount of soil organic carbon and the amount of N, P and K that was readily available. So, crop combinations of grains and legumes can be considered a more profitable endeavor to increase the fertility of the soil. Therefore, compared to monocropping systems, legume intercropping with grasses allows lower inputs through reduced fertilizer and pesticide requirements and it contributes to a greater uptake of water and nutrients, increased soil conservation, increased efficiency of land use, improving the capture and use of light, controlling weeds, high productivity and profitability (Coll *et al*., 2012).

## MATERIALS AND METHODS

The field experiment was conducted in *kharif* season at Agriculture Research Farm of Lovely Professional University, Phagwara, Punjab (India) in 2022. The farm is located at 5423 m above sea level at a geographical altitude of 31.2690°N at 75.702°E longitude. It has a tropical climate of monsoon with an average rainfall of 600 mm and a climate with severely cold winters and hot summers. The annual average temperature in Punjab ranges from 10°C to 46°C, with temperatures reaching 49°C in the summer and falling to 1°C in the winter. Analyses of the site's soil revealed that it was sandy loam with a pH of 7.72, EC of 0.279 mhos $cm^{-1}$, an organic carbon content of 0.310% and soil nutrients of N-215, P-21 and K-200 (kg $ha^{-1}$).

The two crops used as the primary components of the treatments were Napier grass (*Pennisetum purpureum*) and cowpea (*Vigna unguiculata*), both of which intercropped and planted as pure stands as well. The experiment was carried out in Factorial RBD in three replications comprised of twelve treatment combinations in *kharif,* 2022. 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. Plots were 7.2 m×5 m in size, with 1 m between each replication. 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;

**Table 1:** Soil chemical properties (pH, EC, OC) as affected by different treatments.

| Symbol | Treatments | pH | EC (mhos $cm^{-1}$) | OC (%) |
|---|---|---|---|---|
| **Intercropping** | | | | |
| $I_1$ | Sole Napier | 8.02 | 0.41 | 17.37 |
| $I_2$ | Sole Cowpea | 7.65 | 0.34 | 18.44 |
| $I_3$ | Napier+cowpea (1:2) | 7.94 | 0.38 | 17.82 |
| $I_4$ | Napier+cowpea (1:3) | 7.85 | 0.36 | 18.13 |
| SE.m± | | 0.05 | 0.00 | 0.06 |
| CD(P<0.05) | | 0.14 | 0.01 | 0.18 |
| Fertilizer levels | | | | |
| $F_1$ | 100% RDF | 7.84 | 0.36 | 18.00 |
| $F_2$ | 75% RDF | 7.87 | 0.37 | 17.95 |
| $F_3$ | 125% RDF | 7.84 | 0.36 | 18.06 |
| SE.m± | | 0.04 | 0.00 | 0.05 |
| CD(P<0.05) | | NS | 0.01 | 0.16 |
| **Interaction** | | | | |
| $I_1F_1$ | Sole Napier+100% RDF | 8.02 | 0.41 | 17.37 |
| $I_1F_2$ | Sole Napier+75% RDF | 8.04 | 0.42 | 17.23 |
| $I_1F_3$ | Sole Napier+125% RDF | 8.00 | 0.39 | 17.50 |
| $I_2F_1$ | Sole Cowpea+100% RDF | 7.66 | 0.34 | 18.47 |
| $I_2F_2$ | Sole Cowpea+75% RDF | 7.68 | 0.34 | 18.27 |
| $I_2F_3$ | Sole Cowpea+125% RDF | 7.61 | 0.33 | 18.60 |
| $I_3F_1$ | Napier+cowpea (1:2)+100% RDF | 7.95 | 0.38 | 17.87 |
| $I_3F_2$ | Napier+cowpea (1:2)+75% RDF | 7.97 | 0.39 | 17.70 |
| $I_3F_3$ | Napier+cowpea (1:2)+125% RDF | 7.91 | 0.37 | 17.90 |
| $I_4F_1$ | Napier+cowpea (1:3)+100% RDF | 7.85 | 0.36 | 18.10 |
| $I_4F_2$ | Napier+cowpea (1:3)+75% RDF | 7.88 | 0.36 | 18.07 |
| $I_4F_3$ | Napier+cowpea (1:3)+125% RDF | 7.83 | 0.35 | 18.23 |
| SE.m± | | 0.08 | 0.01 | 0.11 |
| CD(P<0.05) | | NS | NS | NS |

$I_4F_2$- Napier and Cowpea Intercropping (1:3)+75% RDF; $I_4F_3$- Napier and Cowpea Intercropping (1:3)+125% RDF.

## RESULTS AND DISCUSSION

### Soil chemical properties (pH, EC, OC) as affected by different treatments after harvest

The data represented in Table 1 revealed that the effect of intercropping in treatment $I_4$- Napier+cowpea (1:3), showed a significantly lower pH and EC (7.85 and 0.36 mhos $cm^{-1}$, respectively) as compared to $I_1$-sole Napier grass (8.02 and 0.41 mhos $cm^{-1}$, respectively). However, plots of sole cowpea showed significantly lowest pH and EC (7.65 and 0.34 mhos $cm^{-1}$) among all treatments. The OC% of $I_2$- sole cowpea (18.44 %) was highest and lowest OC was seen in $I_1$- sole napier (17.37%). The application of $F_3$- 125% RDF decreases the pH (7.84) of soil which was having a non-significant effect and highest pH was observed at $F_2$- 75% RDF (7.87). The EC decreased with every increase in fertilizer dose with higher EC at $F_2$- 75% RDF (0.37 mhos $cm^{-1}$). Whereas the OC increased significantly with every increase in fertilizer level having highest value at F3-125% RDF (18.06%). In the interaction effect of intercropping and fertilizer levels the lowest pH and EC was observed in $I_4F_3$- Napier + cowpea (1:3)+125% RDF (7.83 and 0.33 mhos $cm^{-1}$, respectively) both of which had a non-significant effect. The highest value of pH and EC was found to be in $I_1F_2$- Sole Napier+75% RDF (8.04 and 0.42 mhos $cm^{-1}$, respectively). Higher OC was found in $I_4F_3$- Napier+cowpea (1:3)+125% RDF (18.23%) as compared to sole napier. However, sole cowpea plots recorded highest OC (18.60%) in $I_2F_3$- Sole Cowpea+125% RDF but lowest pH and EC.

This may be because legumes initially added more nitrogen, which caused the soil to become somewhat acidic and reduce the pH. Legumes may also enhance soil structure and water-holding capacity, which can reduce soil salinity and, in turn, soil EC. Additionally, the presence of numerous crops in an intercropping system result in a more effective utilization of soil nutrients, which may decrease soil EC and salt concentration. The results are in line with Rashpinder *et al.* (2018). According to Triveni *et al.* (2022), hybrid plants respond rapidly to inorganic fertilizers, which also improve the soil's physical properties and increase the activity of beneficial microorganisms in soil.

**Table 2:** Soil available N, P and K as influenced by various treatments.

| Symbol | Treatments | Available N (kg $ha^{-1}$) | Available P (kg $ha^{-1}$) | Available K (kg $ha^{-1}$) |
|---|---|---|---|---|
| **Intercropping** | | | | |
| $I_1$ | Sole napier | 94.22 | 12.31 | 197.84 |
| $I_2$ | Sole cowpea | 200.67 | 20.31 | 134.87 |
| $I_3$ | Napier+cowpea (1:2) | 112.33 | 18.68 | 174.96 |
| $I_4$ | Napier+cowpea (1:3) | 130.05 | 16.31 | 151.20 |
| SE.m± | | 1.14 | 0.16 | 1.27 |
| CD(P<0.05) | | 3.36 | 0.46 | 3.75 |
| **Fertilizer levels** | | | | |
| $F_1$ | 100% RDF | 145.83 | 16.15 | 159.18 |
| $F_2$ | 75% RDF | 133.83 | 17.06 | 164.23 |
| $F_3$ | 125% RDF | 147.00 | 15.91 | 155.78 |
| SE.m± | | 0.98 | 0.135 | 1.10 |
| CD(P<0.05) | | 2.91 | 0.40 | 3.24 |
| **Interaction** | | | | |
| $I_1F_1$ | Sole napier+100% RDF | 93.00 | 12.44 | 138.33 |
| $I_1F_2$ | Sole napier+75% RDF | 90.00 | 10.93 | 124.4 |
| $I_1F_3$ | Sole napier+125% RDF | 99.67 | 13.56 | 141.87 |
| $I_2F_1$ | Sole cowpea+100% RDF | 201.00 | 20.31 | 193.8 |
| $I_2F_2$ | Sole cowpea+75% RDF | 176.00 | 19.94 | 184.8 |
| $I_2F_3$ | Sole cowpea+125% RDF | 225.00 | 20.68 | 214.93 |
| $I_3F_1$ | Napier+cowpea (1:2)+100% RDF | 116.33 | 16.5 | 149.33 |
| $I_3F_2$ | Napier+cowpea (1:2)+75% RDF | 104.33 | 15.19 | 145.6 |
| $I_3F_3$ | Napier+cowpea (1:2)+125% RDF | 116.33 | 17.25 | 158.67 |
| $I_4F_1$ | Napier+cowpea (1:3)+100% RDF | 125.00 | 18.99 | 175.47 |
| $I_4F_2$ | Napier+cowpea (1:3)+75% RDF | 122.81 | 17.57 | 168.33 |
| $I_4F_3$ | Napier+cowpea (1:3)+125% RDF | 142.33 | 19.49 | 181.07 |
| SE.m± | | 1.97 | 0.27 | 2.20 |
| CD (P<0.05) | | 5.81 | NS | 6.49 |

**Table 3:** Green fodder yield, cost of cultivation, gross returns, net returns and benefit cost ratio.

| Treatment | Yield | | Gross returns (₹ ha$^{-1}$) | Total cost of cultivation (₹ ha$^{-1}$) | Net returns (₹ ha$^{-1}$) | B:C ratio |
|---|---|---|---|---|---|---|
| | GFY 1st cut (t ha$^{-1}$) | GFY 2nd cut (mixture) (t ha$^{-1}$) | | | | |
| $I_1F_1$ | 29.41 | 45.60 | 112515 | 41878.50 | 70636.50 | 1.68 |
| $I_1F_2$ | 24.90 | 42.03 | 100395 | 40777.53 | 59617.47 | 1.46 |
| $I_1F_3$ | 34.21 | 49.56 | 125655 | 42978.96 | 82676.04 | 1.92 |
| $I_2F_1$ | 28.17 | 20.23 | 90345 | 43905.44 | 46439.56 | 1.05 |
| $I_2F_2$ | 27.83 | 19.35 | 87525 | 43188.08 | 44336.92 | 1.02 |
| $I_2F_3$ | 32.50 | 24.05 | 93075 | 44622.80 | 48452.20 | 1.08 |
| $I_3F_1$ | 41.57 | 56.93 | 147750 | 45628.50 | 102121.50 | 2.23 |
| $I_3F_2$ | 36.33 | 52.65 | 133470 | 44527.53 | 88942.47 | 1.99 |
| $I_3F_3$ | 47.00 | 59.18 | 159270 | 46728.96 | 112541.00 | 2.40 |
| $I_4F_1$ | 56.23 | 69.65 | 188820 | 45628.5 | 143191.50 | 3.13 |
| $I_4F_2$ | 49.63 | 62.33 | 167940 | 44527.53 | 123412.50 | 2.77 |
| $I_4F_3$ | 60.67 | 75.69 | 204540 | 46728.96 | 157811.00 | 3.37 |

Green fodder price ₹ 1500 t$^{-1}$.

**Soil fertility as influenced by different treatments after harvest**

The data in Table 2 revealed that after harvest, the N, P, K available in soil differs significantly in intercropping system. Highest N among the treatments was found to be in $I_4$- Napier + cowpea (1:3) (130.05 kg ha$^{-1}$) followed by $I_3$- Napier+ cowpea (1:2) (112.33 kg ha$^{-1}$) and $I_1$- Sole Napier (94.22 kg ha$^{-1}$). However, sole cowpea obtained the highest nitrogen (200.67 kg ha$^{-1}$) in soil among the treatments. The lowest P and K were recorded in $I_4$- Napier+cowpea (1:3) (16.31 and 151.20 kg ha$^{-1}$, respectively). It was seen that different fertilizer levels on N, P and K of soil had a significant effect. N increases with every dose of nitrogenous fertilizer, whereas P and K decrease with extra addition of fertilizers. The highest N (147 kg ha$^{-1}$) and lowest P and K (15.91 and 155.78 kg ha$^{-1}$) were recorded in F3-125% RDF. The interaction effect of intercropping and fertilizer levels showed that available N and K differ significantly, but P showed a non-significant effect. The lowest N, P and K in soil were seen in $I_1F_2$- Napier grass+75% RDF (90.00, 10.93 and 124.4 kg ha$^{-1}$, respectively) in interaction of intercropping and fertilizer levels among treatment combinations of napier grass. $I_2F_3$- Sole cowpea+125% RDF recorded (225, 20.68 and 214.93 kg ha$^{-1}$) N, P and K, respectively, which was highest among all the treatment combinations.

By enhancing the microbial activity and soil health, intercropping can promote the mineralization of organic matter and the availability of nutrients, particularly nitrogen. With higher quantities of N application, there was more NPK readily available in the soil (Damane *et al.,* 2017). The diversity of soil microorganisms may grow because of intercropping, which may enhance nutrient cycling and increase nutrient availability in the soil. Through the release of organic acids, legumes could fix atmospheric nitrogen and improve soil P availability. According to Shekara *et al.* (2009), soil organic carbon content as well as available N and P have increased. The cereal-legume intercropping method increased soil properties, improved soil nutrient and moisture uptake and helped conserve soil. These findings were consistent with that of Kumar (2016).

**Economics as affected by different treatments**

The data presented in Table 3 showed that the maximum cost of cultivation was observed in plots intercropping with 125% RDF (₹ 46728.96) followed by 100% RDF (₹ 46728.96) and the lowest in sole napier plots with 75% RDF (₹ 40777.53). The highest cost of cultivation in intercropped treatments and more RDF must be due to additional cost of intercrops and additional fertilizer doses. The data showed the highest gross returns in intercropping with 1:3 ratio and 125% RDF (₹ 204540) followed by 100% RDF (₹ 188820). The least returns were obtained from sole cowpea with 75% RDF (₹ 87525). The higher gross return in intercropping might be due to more fodder yield on the system.Higher net returns were found in intercropping with 1:3 ratio and 125% RDF (₹ 157811) followed by 100% RDF (₹ 143191.5). The lowest returns were obtained from sole cowpea with 75% RDF (₹ 44336.92) followed by 100% RDF (₹ 46439.56). Maximum B: C ratio of 3.37 was recorded from intercropping ratio 1:3 and 125% RDF which was followed by 100% RDF (3.13) and 75% RDF (2.77). The higher green fodder yield in these treatments increased the B: C ratio. The lowest B: C ratio of 1.02 was recorded from sole cowpea plots and 75% RDF.

According to Rashpinder *et al.* (2018), all mixtures of Napier Bajra hybrid+cowpea and Napier Bajra+maize/Bajra (25 and 50% of recommended seed rate) had greater Benefit Cost Ratios. Similar results were found by Anita and Lakshmi (2017).

## CONCLUSION

This study demonstrated that intercropping and higher quantities of nutrients enhanced the soil fertility, increased the nutrient availability in soil and helps in conservation of soil. The soil properties were improved by adopting cereal-legume intercropping. Legumes may also enhance soil structure and water-holding capacity, which can reduce soil salinity. Additionally, the presence of numerous crops in an intercropping system result in a more effective utilization of soil nutrients. Net return, gross return and B: C ratio was also improved in intercropping with cowpea.

### Conflict of interest

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

## REFERENCES


Akman, H., Tamkoc, A. and Topal, A. (2013). Effects on yield, yellow berry and black point disease of fertilization applications in Hungarian vetch and durum wheat intercropping system. Digital Proceeding of the ICOEST' 2013, 18-21, June 2013, Turkey pp 839-847.

Anita, M.R. and Lakshmi, S. (2017). Relative performance of grass, cowpea varieties and row ratios on growth, productivity and economics of fodder crops. *International Journal of Forestry and Crop Improvement*. **8(1):** 1-7.

Coll, L., Cerrudo, R., Rizzalli, J., Monzon, P. and Rade, F.H. (2012). Capture and use of water and radiation in summer intercrops in the southeast Pampas of Argentina. *Field Crops Research*. **134:** 105-113.

Damame, S.V., Gore, S.B., Sinare. B.T., Gavit, M.G. and Pardeshi, H.P. (2017). Forage quality of bajra×napier hybrid cv. phule jaywant as affected by growing environments and nitrogen levels. *Indian Journal of Animal Nutrition*. **34:** 310-315.

Hanna, W.W., Chaparro, C.J., Mathews, B.W., Burns, J.C., Sollenberger, L.E. and Carpenter, J.R. (2004). Perennial *Pennisetums*. In: Warm-Season (C4) Grasses. [Moser, L.E., Burson, B.L., Sollenberger, L.E. (eds.)], American Society of Agronomy Monograph Series No. 45. Madison, WI, USA. p. 503-535.

Iannetta, P., Young, M., Bachinger, J., Bergkvist, G., Doltra, J. and LopezBellido, R. (2016). A comparative nitrogen balance and productivity analysis of legume and non-legume supported cropping systems: The potential role of biological nitrogen fixation. *Plant Science*. **7:** 1700.

Jinghui, L., Zhaohai, Z., Lixin, J., Yuegao, H., Ying, W. and Hai, L. (2006). Intercropping of different silage maize cultivars and alfalfa. *Zuowuxuebao*. **32(1):** 125-130.

Kebede, G., Feyissa, F., Assefa, G., Alemayehu, M.,Mengistu, A., Kehaliew, A. and Abera, M. (2016). Chemical composition and *in vitro* organic matter digestibility of Napier Grass [*Pennisetum purpureum* (L.) *Schumach*] accessions in the mid and highland areas of Ethiopia. *Int. J. Livest. Res*. **6:** 41-59.

Kumar, N. (2016). Sowing methods and varying seed rates of cowpea on production potential of sorghum, sudan grass hybrid and cowpea: A review. *Agricultural Reviews*. **37(4):** 290-299. doi: 10.18805/ag.v37i4.6459.

Nyambati, E.M., Muyekho, F.N., Onginjo, E. and Lusweti, C.M. (2010). Production, characterization and nutritional quality of Napier grass (*Pennisetum purpureum (Schum.*) cultivars in Western Kenya. *African Journal of Plant Science*. **4(12):** 496-502.

Orodho, A.B. (2006). The role and importance of Napier grass in the smallholder dairy industry in Kenya. http://www.fao.org/ag/agp/agpc/doc/Newpub/napier/napier_kenya.htm.

Preissel, S., Reckling, M., Schläfke, N. and Zander, P. (2015). Magnitude and farm economic value of grain legume pre-crop benefits in Europe: A review. *Field Crops Research*. **175:** 64-79.

Rashpinder, S., Tiwana, U.S. and Meenakshi, G. (2018). Fodder productivity and quality of Napier Bajra hybrid (*Pennisetum purpureum*× *Pennisetum glaucum*) and summer fodder intercrops with different seed rates. *Forage Research*. **43(4):** 299-303.

Shekara, B.G., Lohithaswa, H.C. and Pavan, R. (2009). Influence of forage legumes on green fodder yield and quality hybrid napier (*Pennisetum* purpureum). *Forage Research*. **35:** 107-109.

Triveni, B., Rao, K.A., Teja, A., Kumar, M.R. and Singh, V. (2022). Hybrid napier grass a potential asset for livestock production. *The Pharma Innovation Journal.* **11(12):** 4081-4083.

Verma, K.C., Devi, K.S., Reddy, A.P.K. and Sree, G.J. (2011). Economics of intercropping in bajra napier hybrid as influenced by cutting intervals. *J. Res. ANGRAU*. **39(4):** 79-82.