EVALUATION OF PROMISING HYBRID NAPIER CULTIVARS UNDER VARYING PLANT POPULATION

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THESIS
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2011

DECLARATION

I, hereby declare that this thesis entitled **“Evaluation of promising hybrid Napier cultivars under varying plant population”** is a bonafide record of research work done by me during the course of research and that it has not been previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara

Soumya P.

CERTIFICATE

Certified that this thesis, entitled "**Evaluation of promising hybrid Napier cultivars under varying plant population**" is a bonafide record of research work done independently by **Ms. Soumya P.** under my guidance and supervision and that it has not formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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Introduction

1. INTRODUCTION

India's cattle wealth is immense with one fifth of the world's bovine population. Bulks of the livestock are in holdings of small and marginal farmers having less than two hectares of land. In the case of small holder dairy, feed is the most important constraint and farm animals are forced to subsist on dry stalks and straw with low nutritive value during lean periods. It is estimated that, feed alone constitute about 60-65 per cent of the total cost of milk production which can be reduced to 30-40 per cent by providing cheap and quality roughages such as natural and cultivated grasses (Thomas, 2008).

The fodder resources of our country are hardly sufficient for feeding even half of the existing cattle population and the shortage of green fodder is well recognised. The land assigned for fodder crop under assured water supply is only 4 per cent of the total cultivated area and the fodder fed to the animals is of poor quality. This has resulted in poor animal health and low output per animal in terms of milk, meat and motive power.

Kerala state also has most of the cattle population in small holdings, of which 83.4 per cent are crossbreds. The main forage resources of the state are paddy straw, pine apple waste, cassava leaves and stem, coffee husk, seasonal weeds, banana waste, and road side grazing. The availability of grazing land is negligible in this state except in Wynad and Idukki districts located in the high ranges. It is also to be noted that in Kerala, exclusive allocation of forages to net cultivated area may not be feasible due to heavy pressure on land for food and commercial crops. Logically, then our attention should be sought in intensive cultivation methods to produce all our requirements of green fodder from the limited area available, through use of better forage crops and better technologies for their cultivation. Fortunately we now have several species of forage crops and their varieties with very high yielding potential.

Hybrid Napier, is an interspecific hybrid between Napier grass and bajra (pearl millet) which combines high quality and faster growth of bajra with the deep root system and multicient habit of Napier grass. It is widely distributed in sub-tropical regions in Asia, Africa, Southern Europe and America. Hybrid Napier is a triploid grass, so does not produce seeds. It produces large number of tillers and numerous leaves. Although it can grow on a variety of soils, light loams and sandy soils are preferred to heavy soils. The grass does not thrive well on waterlogged and flood prone lands. Hybrid Napier is superior in quality to Napier grass and contains about 10.2 per cent crude protein and 30.5per cent crude fibre. The grass once planted supplies fodder continuously and regularly for a period of three years. The cost of production is almost half that of single-cut crops and the production per unit area and time is approximately double than that of conventional fodders.

In India, majority of the area under cultivation of this grass is in the states of Tamil Nadu, Karnataka, Kerala, Andhra Pradesh, Odisha, Maharastra and Gujarat (Vijayakumar *et al*., 2009). The high yield, palatability and adaptability to varying soil and climatic conditions have made the grass popular among dairy farmers throughout the country. It is recommended for intensively managed small holder crop - livestock farming systems and is well suited for the “cut and carry” feeding system.

Several cultivars were released from different centres in India which are of superior quality and suitable for different regions. These include cultivars tolerant to low temperature in winter and high temperature in summer, high nutritional quality in terms of low oxalate and high crude protein content, suitability for inter cropping, suitability for growth on problem soil etc. Even though the package of practices of Kerala Agricultural University recommends the cultivars Pusa giant Napier, Gajraj, NB-5, NB-6, NB-21 and NB-35 for cultivation in Kerala, none of these cultivars are cultivated by farmers of the state. Instead, recently released cultivars namely CO3, CO(CN)4 and KKM-1 have gained wide popularity and acceptance among dairy farmers of the state. Similarly, with regard to spacing, the ad-hoc recommendation available for hybrid Napier cultivation is 60cm x 60cm (KAU, 2007). Higher tiller production, vegetative growth and spreading canopy of the new cultivars demand a wider spacing for maximum growth and fodder production as evidenced from farmer's feedback. This necessitates a scientific investigation to decide the suitable cultivar and optimum spacing of hybrid Napier for Kerala conditions.

The investigation was planned with the following objectives.

1. To identify superior cultivars of hybrid Napier in terms of growth, yield and quality.

2. To standardise optimum plant spacing for hybrid Napier.

Review of Literature

2. REVIEW OF LITERATURE

Among various fodder grasses recommended for the tropics, hybrid Napier is much popular among farmers because of its high yield potential and quality. Hybrid Napier, an interspecific hybrid between pearl millet and Napier grass shows the desirable characteristics of both parents in terms of yield and quality. Bajra or pearl millet (*Pennisetum glaucum* L., 2n=14), is a popular millet in the dry tropics grown widely in Asia and Africa. Although it is primarily grown for grain purpose, it is also grown as feed and forage for animals (Gupta and Mhere, 1997). Napier or elephant grass (*Pennisetum purpureum* Schum. 2n=28) is a robust perennial grass grown for forage mainly in tropical areas of Africa, Asia, and South and Central America. Gupta and Mhere (1997) reported that these two species readily cross and the interspeific hybrids are more vigorous than the parent species and highly sterile (2n=21). Being a clonally propagated crop, the hybrid vigour can be maintained permanently without any deterioration. The feasibility of multiplication extensively through vegetative method is a unique advantage of hybrid Napier over all other forage grass.

The possibility of growing hybrid Napier as a forage crop has been investigated in many countries and it has been shown that, it is able to produce more forage than Napier grass and pearl millet. In tropical countries, it behaves as a perennial with higher yields and better forage quality than either parents (Burton and Powell, 1966). According to Pritchard (1971) it is a high yielding perennial grass with high dry matter yield with high leaf percentage, high nitrogen percentage in the stem, high stem digestibility and wide adaptability.

2.1. Crop husbandry

2.1.1. Growth and fodder production

According to Watkins and Lewy-Van Severen (1951), the period of the lowest growth in grasses is from February to May, and the maximum growth is from June to November. This trend is very much similar for all the forage grasses. According to Ryle, (1970) and Selvi and Subramanian, (1993) the rate of fodder production is a function of tiller production and leaf growth. Plant height, tiller number and leaf number directly influences the yield of fodder. Barbbar (1985) reported that the green fodder yield per plant was positively correlated with number of tillers per plant, number of leaves per plant and stem weight per plant.

According to Shinde *et al*. (2007) green forage yield was significantly and positively associated with dry matter yield, crude protein yield, number of leaves, number of tillers and plant height. Stem girth at the second node, leaf length and leaf breadth were negatively associated with oxalic acid content, and thus were identified as important fodder quality traits. Sotomayour-Rois *et al*. (1972) observed that tillering ability and forage volume showed the highest correlation with yield. Stand density, soil moisture, and soil fertility are the other factors positively correlated with forage yield. According to Singh *et al*. (1995), measurement of leafiness is an indicator of yield and nutritive value. Leaf number and leaf area per plant were closely related with yield and digestibility.

Hybrid Napier requires hot moist season for growth and can be grown up to an altitude of 1500m. It is usually cultivated in irrigated areas and is propagated by stem or root cuttings (Pahuja and Joshi, 2007). With liberal dressings of fertilisers, hybrid Napier can be expected to yield 40 t of dry matter, 6000 kg of crude protein and about 2000 kg of extractable protein from one hectare in a year in India (Gore *et al.*, 1974). Under irrigated conditions, in the tropics, hybrid Napier can provide green fodder throughout the year and yields on an average 200-400 t/ha/year depending on the cultivar and region (Thomas, 2008). Pandey and Roy, (2011) have reported that hybrid Napier grows fast and produces high herbage but the stems are hard and the plants are less persistent. The grass once planted supplies fodder continuously and regularly for a period of three years and the cost of production is almost half that of single-cut crops. The fodder production per unit area and time is approximately double than conventional fodders.

2.1.2. Cutting interval

Singh and Joshi (2002) has reported that, in hybrid Napier, green forage and crude protein yield were highest with a six week cutting interval, while dry matter content and digestible dry matter yield increased with increase in cutting interval from 5 to 7 weeks. Green forage yield, dry matter yield, plant height, number of leaves per clump, leaf area index and dry matter accumulation in leaves and stems increased with increase in cutting interval from 5-7 week except number of tillers/clump which decreased with increase in cutting interval. Crude protein content, digestibility (%) and leaf: stem ratio were also decreased with increase in cutting interval. Increase in nitrogen application also increased herbage yield and yield attributes of Napier bajra hybrid.

Devi *et al.* (2007), from her study on the effect of cutting interval in hybrid Napier cultivar ABPN-1, reported that green and dry fodder yields significantly increased with increasing cutting interval from 30-60 days. According to Ibrahim *et al.* (2008), the crude protein content and dry matter percentage of the hybrid Napier is higher than Napier grass or pearl millet at 100 and 150 cm heights. As the plant height increased, the crude fibre percentage and acid detergent fibre percentage also increased in hybrid Napier but crude protein content decreased with increasing plant height, while the neutral detergent fibre percentage and acid detergent fibre percentage of pearl millet, Napier grass and its hybrids were nearly similar.

2.1.3. Inter cropping

Among annual legumes, cowpea was found to be the best intercrop for hybrid Napier with a green fodder yield of 136.94 t/ha and dry fodder yield of 50.10 t/ha. The B: C ratio of this combination was 2.5 (Lakshmi *et al.,* 2002). Hybrid Napier intercropped with cowpeas produced the highest mean green forage yield of 33.6 t/ha and crude protein yield of 916 kg/ha and the highest net returns (Reddy and Naik, 1999). Under shaded condition, as an intercrop in coconut garden, the cultivar PBN-16 recorded high tillering (29 per clump) with high total dry matter content of 23.4 per cent. When planted along with legumes, hybrid Napier PBN-16+Centro combination recorded significantly superior mean total forage yield per year (82.57 t/ha) and was followed by another hybrid Napier DHN-3 along with Centro combination. The pooled mean data of two years study on palatability showed that the mixture of DHN-3+Centro was more palatable to cows (87.4 per cent) followed by Guinea+Centro combination while the lowest palatability was recorded with DHN-1+Centro combination (Manjunath *et al*., 2002).

2.1.4. Effect of nutrients

In an experiment conducted by Patel *et al*. (2008), it was reported that farm yard manure applied at the rate of 30 t/ha every year was significantly superior in enhancing green forage and crude protein yields from 22 cuts. Similarly, successive increase in nitrogen application from 50 to 75 and 100 kg/ha after each cut significantly increased green forage, dry matter and crude protein yields in total of 22 cuts of bajra-Napier hybrid.

Forage and crude protein yields increased with increased rate of applied nitrogen (Sood *et al*., 1995). Gupta (1995) reported that plant height (155.8 cm), fresh fodder yield (102.73 t/ha) and dry matter yield (17.03 t) increased with increased nitrogen rate up to 90 kg/ha with high economic returns but tillering was unaffected by fertilizer. In an experiment conducted by Prasad and Kumar (1995) on three cultivars of *Pennisetum purpureum* NB-21, IGFRI-6 and HGN/BN-1 at different nitrogen levels, they recorded higher dry matter yields of 11.5 t, 12.8 t and 13.0 t respectively at 60 kg/ha nitrogen.

Soni and Singh (1991) reported that the plant height increased with increasing N rates up to 120 kg/ha. Leaf number per plant and shoot number per tussock also increased linearly with increasing nitrogen rate, but percentage crude protein content was not significantly affected by application of nitrogen at high rate. Wadi *et al.* (2003) has observed that the plant height, total dry matter weight, stem dry matter weight, root dry matter weight, mean tiller dry matter weight, crop growth rate and leaf area index increased with time and with the increase in the level of fertilization.

2.2. Cultivars of hybrid Napier

In India, a number of state level released cultivars are under cultivation in different agro climatic and production systems. The superior material or selections as well as state released varieties are popularly grown across the regions of the country.

The differences in green forage, dry matter, crude protein yield, and the variation in the yield and quality is mainly due to the variation in cultivars (Pathan and Bhilare, 2008). The cultivars recommended for Kerala are Pusa giant Napier, Gajraj, NB-5, NB-21, and NB-35 (KAU, 2007). Suguna and Supriya, the varieties released during 2006, were also recommended for cultivation. Hybrid Napier cultivars CO1 and CO2 are suitable for black soils under irrigated ecosystem (Das *et al*., 2000). CO2 is a cultivar developed at Tamil Nadu Agricultural University (TNAU), Coimbatore through inter specific cross between bajra-PT 8369 and Napier-FD 488 followed by clonal selection. It has been recommended for cultivation in south zone of the country and was highly adapted for black soil areas. It provides 350 t/ha of green fodder in a year (Pandey and Roy, 2011).

Hybrid Napier cv. CO3 was developed at TNAU, Coimbatore in 1996. It exhibited an average green fodder yield of 5-8 kg/plant/cut or 350 t/ha/year under local conditions. When harvested at correct stage, CO3 contained a dry matter per cent of 18-20 (Premartne and Premlal, 2006). CO3 was derived from the cross between cumbu PT1697 and Napier. It is suitable for red loamy soil areas and also for sheep and goat feeding in addition to cattle feeding. It is characterised by high leafiness, with long, broad, and soft leaves. The leaf-stem ratio is higher than that of CO2. CO3 gave an average green fodder yield of 393.6 t/ha/year during station trials conducted at Tamil Nadu during 1991-92 and a maximum yield of 514 t/ha at Pudupalayam in the Salem district as part of adaptive research trials. The average dry matter yield (65.1 t/ha/year) and crude protein yield (5.40 t ha/year) were also higher than the respective values for CO1 and CO2. According to Fazlullahkhan *et al*. (1996) CO3 was having superior qualities compared to Co-1 and CO2 in terms of leafiness, broader and softer leaves, high leaf: stem ratio and very high fodder yield.

Trial conducted by Vijayakumar *et al*. (2009) has revealed that CO3 is characterised by light green densely hairy leaves with white midrib. Leaf margins are serrated with an average leaf length of 80-95 cm and leaf width 3-4.2 cm. Number of leaves per clump vary from 300-400 with high leaf stem ratio of 0.60. It is having a plant height of 300-360 cm at flowering and stem girth of 5.0 cm. Number of tiller per clump vary from 25-30. Vijayakumar *et al.* (2009) obtained a fresh fodder and dry matter yield of 325.5 t/ha, 62.1 t/ha respectively in a year with dry matter percentage of 19.1.

In 2008, CO(CN)4, another high yielding and nutritious hybrid Napier was developed at the Department of Forage Crops, Centre for Plant Breeding and Genetics, TNAU, Coimbatore. It is an interspecific hybrid between fodder bajra CO8 and Napier grass FD-461. CO(CN)4 is well adapted to the soil and climatic conditions of Tamil Nadu and is highly palatable, with high biomass, high leaf: stem ratio, soft stem, and more protein. It is much preferred by milch animals, goat and sheep. It registered a mean green fodder yield of 382 t/ha/year, which was 33 per cent higher yield over CO3. It renders seven cuttings per year. It has erect plant habit with 4-5m plant height at flowering. It is characterised by non lodging, profuse tillers (30-40 tillers/clump), soft juicy stem with a brix value of 3.4 and stem girth of 5.6 cm, dark green leaves with bright white midrib, serrated leaf margins with an average leaf length of 110-115 cm and leaf width of 4-5 cm. A uniform and visible white powdery coating on the stem is a distinguishing feature of this cultivar. Green, conspicuous arial roots encircling each node provide quick regeneration quality. Number of leaves per clump varied from 400-450 with high leaf: stem ratio of 0.71. Under station trials conducted at TNAU, it gave fresh fodder yield of 396.75 t/ha and dry matter yield of 81.4 t/ha in a year with dry matter percentage of 21.3 (Vijayakumar *et al*., 2009).

Killikulam-1 (KKM-1) was another hybrid released from TNAU in 2000 is specially suited for red soil areas of southern parts of Tamil Nadu. It is highly leafy with long and broad soft leaves and with quick regeneration capacity compared to CO2 and CO3. It recorded an average green fodder yield of 288 t/ha/year in station trials conducted at Killikulam, during 1991/92-1996/97, with a dry matter production of 16.4 t/ha (Das *et al*., 2000).

Suguna and Supriya are two cultivars developed at College of Agriculture, Vellayani, under the AICRP on Forage Crops and released during 2006 by Kerala Agricultural University. Suguna is a cross between bajra Composite 9 and Napier line FD 431. It is having high yield potential of 283 t/ha/year with high quality fodder. It differed from other cultivars in having a pale green leaf sheath with purplish pigmentation (KAU, 2007). Supriya is a cross between bajra TNSC 4 and Napier line FD 471. It is having a yield potential of 272.7 t/ha/year with superior quality fodder. Supriya is characterised by pale green leaves with small hairs on both sides (KAU, 2007). These two cultivars are mainly recommended for cultivation in southern districts of Kerala (Pandey and Roy, 2011).

IGFRI-3 (Swetika) was a cultivar developed at Indian Grassland and Fodder Research Institute, Jhansi by hybridization of Napier grass and bajra (PSB-2). The variety was notified for cultivation in north and central zones of the country. It is a profuse tillering type, erect with narrow upright leaves with quick regeneration ability and have thin stems like guinea grass. It is tolerant to frost and low temperature and is suitable for low pH conditions. It has field resistance to *Helminthosporium* blight and gave an average yield of 70–80 t/ha green fodder and 18 t/ha dry fodder (Pandey and Roy, 2011). Faruqui *et al*. (2009) has reported a green fodder potential of 90-160 t/ha for IGFRI-3 found highly suitable for intercropping in central, north east and north hill regions due to its erect growth habit, high tillering and leafiness. Screening studies conducted at Indian Grassland and Fodder Reasearch Institute, Regional Research Station, Dharwad revealed that IGFRI-3 was a superior, shade tolerant variety exhibiting high green fodder yield, dry fodder yield, tillering potential and persistence even under 70 per cent shade (IGFRI, 2000).

DHN-6 (Sampoorna) is a cultivar developed by IGFRI Regional Research Station, Dharwad, through inter specific hybridization of IPM 14188 (Bajra line) × FD 184 (Napier line) followed by clonal selection. The variety is recommended for cultivation in Karnataka state under irrigated conditions. It has low oxalic acid content (1.9 per cent) and yields 120-150 t/ha green fodder in 6-8 cuts (Pandey and Roy, 2011). Sridhar *et al*. (2008), reported a green fodder yield of 182.4 t/ha and dry matter yield of 73.1 t/ha for DHN-6 with relatively high palatability (71.6 per cent). It also showed resistance to *Helminthosporium* leaf spot and rust disease.

2.3. Spacing

Optimum plant population per unit of land area is essential for increased production. The competition between plants and need for optimum plant population were described in detail by Donald (1963). Plants do not compete with each other so long as the water content, nutrient supply and light are in excess of the needs of the plants. When the immediate supply of a single necessary factor falls below the combined demands of the plants, competition begins. The relationship between plant population and yield had been studied in many crops by many workers. In hybrid Napier too, several studies on optimum spacing have been reported.

There are conflicting reports on the ideal spacing for hybrid Napier to realise the yield potential. For Kerala, the recommended spacing of hybrid Napier at present is 60cm x 60cm (KAU, 2007). Studies conducted by Munegowda *et al.* (1989) on fertilizer and spacing of hybrid Napier variety BH-18 has shown that the highest yield was realised in all fertilizer levels at closer spacing of 60cm x 30cm. They also observed a progressive decrease in yield with increase in spacing to 75cm x 45cm, 100cm x 60cm and 120cm x 90cm. In another study, Munegowda *et al.* (1991) also reported that averaged over 10 cuts, there were no effects of fertilizers or plant spacings on green fodder yield of hybrid Napier. Chhillar and Tomer (1970) observed that a spacing of 60cm x 30cm and combined application of 120 kg nitrogen and 60 kg phosphorus/ha produced higher yields in hybrid Napier. Tiwana *et al*. (1975) reported that hybrid Napier growing with a spacing of 60cm x 30cm gave higher yield than 90cm x 40 cm and 60cm x 60cm.

A study conducted by Velayudham *et al.* (2011) on the impact of spacing on the performance of bajra Napier hybrid revealed that adopting different spacing did not significantly influence the height of plants, leaf: stem ratio, and crude protein content. However, tillering ability of plant was influenced positively due to adoption of different spacing. Adoption of 60cm x 50cm and 75cm x 50cm had enhanced the number of tillers per clump in hybrid Napier. Similarly, higher number of leaves/stem was obtained at spacing of 75cm x 60cm which was on par with that of 60cm x 50cm and 75cm x 50cm. Green fodder yield as well as dry matter yield and hence net return was higher at 60cm x 50cm.

A field study conducted in barley varieties to see the effect of row spacing on the yield showed that a closer row spacing of 15 cm produced higher green fodder yield than wider row spacing of 22.5cm (Kaur *et al*., 2009). In a field experiment conducted with forage cowpea, with different level of phosphorus and spacing, the green forage yield was significantly superior (22.29 t/ha) with 30 cm spacing as compared to 45 cm spacing, while the number of branches per plant was higher with 45 cm spacing than that of 30 cm spacing (Patel *et al.,* 2009).

A spacing trial conducted by Bhatti *et al*. (1985) in Napier grass has shown that higher plant height was attained under closer spacing of 50cm x 50 cm compared to wider spacing of 60cm x 60cm and 70cm x 70cm and the maximum green forage and dry matter yield was also obtained under closer spacing of 50cm x 50 cm compared to wider spacing of 60cm x 60cm and 70cm x 70cm. At the same time, number of tillers per plant was non significant due varied spacing. Yao *et al*. (1990) has observed higher leaf area index (LAI) in rice when grown under high plant density compared to low plant density. According to Shrivastava *et al.* (1982) spacing leads to increased plant growth compared to lower spacing in cotton.

In an experiment involving *Lucaena leucocephala* cultivar Hawaiian giant K8, hybrid Napier cultivar NB-21 and *Panicum maximum* cultivar Hamil grown at different spacings, a spacing of 50cm x 50cm (4 plants/m^2) gave the highest fresh fodder, dry matter and crude protein yields than when grown at a spacing of 100cm, 50cm or 30cm in rows 100cm apart (1, 2 and 3 plants/m^2, respectively) (Gawali *et al*., 1989). Another study conducted in Punjab has shown that the highest average fresh yield and dry matter yields (100.8 and 28.0 t/ha) were achieved with a net return of Rs 12,047/ha/year when hybrid Napier was grown with 30 kg nitrogen and intercropped with legumes, at a row spacing of 1.0 m, (Bhagat *et al*., 1992). Shukla *et al.* (1970) observed that maximum nutrient accumulation occurs when hybrid Napier grown under 1.2m x 1.2m spacing with intercrop of guar and lucerne in winter between rows.

2.4. Nutritive value and quality

Quality of a forage grass is a vital parameter to ensure the fulfilment of all nutritional ingredients for animal. Proximate analysis devised long ago by the Weende Experimental Station in Germany is still made use of for assessing nutritive value of fodder crops (Thomas, 2008). Nutritional quality of fodder grass is evaluated in terms of five fractions - crude protein, crude fibre, ether extract, nitrogen free extract and total ash content and by the presence of some anti nutritional principle such as oxalate. Minerals like phosphorus, potassium, calcium and magnesium are also important in livestock nutrition. It has been established that nutrient contents of fodder species differ according to the crop, variety and growing conditions.

Crude protein gives an approximate value of protein content in the forage. According to Yeh (1988), nitrogen rate was positively correlated with crude protein content, leaf number and plant height and negatively correlated with dry matter content and had little or no effect on leaf: stem ratio, crude fibre content and stem diameter. The potassium rate was positively correlated with leaf number, plant height and stem diameter, and negatively correlated with dry matter and crude fibre content and had no effect on leaf: stem ratio and crude protein content. The crude protein yield decreased with delay in cutting and was found maximum when cut at 50 days interval in the case of Pusa giant Napier (Tomer *et al*., 1974) and 45 days in the case of NB-21 and BN-2 (Mani and Kothandaramanan, 1981).

Govindaswamy and Manickam (1989) reported that increasing nitrogen rates increased the average crude protein contents of hybrid Napier from 8.41 to 9.90 per cent and oxalic acid contents from 2.29 to 2.85 per cent in 8 cuts. Jeyaraman (1988) also reported that the increasing nitrogen rates increased dry matter yield of hybrid Napier from 24.96 - 27.59 tonnes to 50.48 - 53.45 tonnes and crude protein yield from 1.87 - 2.10 tonnes to 5.02 - 5.32 tonnes per hectare and crude protein contents from 7.49-7.61 to 9.96 per cent in two years of trials. Kakkar and Kochar (1973) have shown that the crude protein content of hybrid Napier decreased with each cut and it was found to decrease from 11.56 to 5.16 per cent from first to the third cut in NB-21 variety and from 9.38 to 4.84 per cent in a Pusa giant Napier variety.

According to Vijayakumar *et al*. (2009), hybrid Napier cultivar CO3 had an average crude protein yield of 6.52 t/ha in a year with crude protein percentage of 10.5. Where as CO(CN)4 had a crude protein yield of 8.71 t/ha/year with a crude protein percentage of 10.71. Sridhar *et al*. (2008), had reported that hybrid Napier cultivar DHN-6 was rich in crude protein content (13.2 per cent) with a relatively high crude protein yield of 4.53 t/ha. When harvested at the correct stage, CO3 contained a crude protein per cent of 15-16 (Premartne and Premlal, 2006). The cultivar CO3 with 21.4 per cent dry matter when analysed at green stage contained 10.38 per cent crude protein (Elanchezhian and Reddy, 2009). Pahuja and Joshi (2007) reported that KKM-1 in terms of nutritional quality had a crude protein content varied from 9.36 per cent to 10.28 per cent.

Rangil *et al*. (1973) had reported that in hybrid Napier, crude protein contents of leaves and stems and total mineral contents of stems decreased as age increased. When hybrid Napier grass, EB-4, was grown under irrigated condition with consideration to rainfall, crude protein, ether extract, fibre, ash, and oxalic acid content varied significantly with season and stages of growth but calcium content did not show any variation. According to Kaur and Choudhary (2010), in hybrid Napier, the maximum crude protein and ash were found when harvesting at 50 cm height and declined gradually to a minimum when cut at 200cm height. However crude fibre content increased gradually with advancing plant growth. A trial conducted at Rahuri, Maharashtra using different varieties of hybrid Napier on seasonal response showed that, in rainy season, hybrid Napier grass contains a higher crude protein content of 9.91 per cent. (Fernandes *et al.*, 2007). According to Mohammad *et al*. (1988), Napier grass contained a crude protein percent of 6.4, 8.1, 9.8 per cent when harvested at 60, 45, 30 days interval respectively. According to Muker and Paul (2007), hybrid Napier cultivar PBN-342 contain an average crude protein content of 8.31 per cent and PBN-233 contain 5.68 per cent.

Fibre content of forage is important for rumination. Grasses in general contain more crude fibre than legumes. According to Vijayakumar *et al*. (2009), the cultivar CO(CN)4 had a lower crude fibre (28.1%) and higher total ash content (17.52%) compared to that of CO3 (30.5% and 16.17% respectively). According to Premartne and Premlal (2006), hybrid Napier cultivar CO3 had a total ash and crude fibre per cent of 9.8-12.8 and 34-37, respectively, when harvested at the correct stage. The crude fibre content of guinea grass ranged from 28-36 per cent (Chatterjee and Das, 1989). Vicente-Chandler *et al*. (1959) noticed increased forage fibre content by increasing nitrogen doses in Guinea grass and Napier grass. Fernandes *et al.* (2007) had observed higher ash percent of 14.11 in hybrid Napier during rainy season. According to Mohammed *et al*. (1988), Napier grass contained a crude fibre per cent of 32.7, 30 and 25.1 and total ash per cent of 14.6, 15.3 and 13.4 when harvested at 60, 45, 30 days interval, respectively.

According to Elanchezhian and Reddy (2009) the hybrid Napier cultivar CO3 with 21.4 per cent dry matter contained crude fat, neutral detergent fibre, and acid detergent fibre per cent of 2.05, 64.38 and 39.57, respectively at green stage. Premartne and Premlal (2006) found that CO3 contains an average crude fat percent of 6.2 when harvested at correct stage. According to Fernandes *et al.* (2007), in rainy season, hybrid Napier grass contains a crude fat content of 2.68 per cent.

Phosphorus content of guinea grass, Napier grass and para grass was 0.15, 0.4, and 0.8 per cent, respectively according to Chatterjee and Das (1989). Rathore and Vijay (1977) noticed a decreasing trend in phosphorus content of the grass due to nitrogen application. Vicente-Chadler *et al*. (1959) observed that the phosphorus and potassium contents of three tropical grasses, Napier grass, guinea grass, and para grass decreased markedly with length of harvest interval. According to Premartne and Premlal (2006), the average potassium content of hybrid Napier cultivar was 0.42 per cent. Fernandes *et al.* (2007) has reported that the hybrid Napier grass contain higher phosphorus content of 0.26 per cent during rainy season.

Bosworth *et al.* (1980) analysed the potassium content of grasses and found that the contents were 3.1, 3.2, 2.7 and 2 per cent respectively in Texas panicum, crab grass, crow foot grass, and bermuda grass at flowering stage. According to Chatterjee and Das (1989) the calcium content of guinea grass herbage was ranged from 0.52 to 0.69 per cent. According to Bosworth *et al.* (1980), magnesium content of grasses like *Panicum texacum, Digitaria sanguinalis, Dactyloctenium aegyptium,* and C*ynodon dactylon* at flowering stage was 0.35, 0.33, 0.33, and 0.22 per cent, respectively. The calcium and magnesium content of three tropical grasses - Napier grass, guinea grass and para grass, decreased markedly with length of harvest interval (Vicente-Chadler *et al*., 1959). According to Elanchezhian and Reddy (2009) the hybrid Napier cultivar CO3 with 21.4 per cent dry matter contained a calcium per cent of 0.4. At correct stage of harvest, cultivar CO3 contained a calcium and magnesium per cent of 0.11 and 0.36 respectively (Premartne and Premlal, 2006). According to Fernandes *et al.* (2007), the average calcium content of hybrid Napier grass was 0.61 per cent during rainy season.

Oxalate is an important anti nutritional principle present in forages, particularly hybrid Napier. High oxalate content of forage is harmful to animal health. Several case of poisoning in cattle was reported due to feeding of hybrid Napier having high oxalate content. The oxalate content of some of the varieties may be high. It can be mitigated if harvested at longer intervals (45 to 60 days). Talapatra *et al.* (1948) reported that Napier grass contained an average oxalic acid content of 3.3 per cent and it reduced with age and height of plant. Kipnis and Dabush (1988) found that Napier grass accumulate more oxalate in stem than its F_1 hybrid however no differences was there in the leaf oxalate levels of the parent grass and its hybrid. Oxalate levels in the leaves were higher than in stems and decreased in both plant parts with advancing maturity.

Tiwana and Bains (1976) reported that intercropping lucerne with hybrid Napier reduced the oxalic acid content in hybrid Napier. A trial conducted by

Fernandes *et al*. (2007) at Rahuri, Maharashtra using different varieties of hybrid Napier on seasonal response of hybrid Napier showed that, the average oxalate content of hybrid Napier was 3.07 per cent during rainy season which was higher than that of summer and winter seasons. According to Sharma *et al*. (1968), oxalic acid content of leaves, stem and composite sample decreased with maturity and oxalic acid content was the highest during the rainy season and the lowest during the winter months. Tiwana *et al*. (1975) observed a reduction in oxalic acid content of Napier bajra hybrid with increase in plant height. From the study conducted at Punjab Agricultural University, regarding the oxalate content present in the leaf and stem of hybrid Napier, it was shown that the leaf exhibit significantly higher concentration of oxalate (3.8 per cent) compared to stem (1.95 per cent) (Kaur *et al*., 2009). According to Singh (2002), the mean oxalate content (%) of Napier bajra hybrid (PNB-233) at one metre height from April to August was 2.84 ± 0.50 and the highest concentration of oxalic acid was in the month of June. The relative proportion of soluble and insoluble oxalates remained constant during this period however at one meter and two meter height, the per cent proportion of soluble oxalate was 28.60 and 38.30, respectively.

According to Das *et al*., (2000) KKM-1 had a very low oxalate content compared to CO2 and CO3. The oxalic acid content is lower in cultivar CO3 than in Co-1 and CO2 (Fazlullahkhan *et al*., 1996). According to Vijayakumar *et al*. (2009) the hybrid Napier cultivar CO3, and CO(CN)4 recorded an average oxalic acid per cent of 2.51 and 2.48 respectively. Sridhar *et al*. (2008), reported that the cultivar DHN-6 has very low oxalic acid content (0.2%).

Materials and Methods

3. MATERIALS AND METHODS

The experiment was conducted during the year 2009-2010 to evaluate hybrid Napier (*Pennisetum glaucum* L. X *P. purpureum* Schum.) cultivars for fodder production and quality. Comparisons were made with eight different cultivars of hybrid Napier under three different plant densities. The details of the materials used and methods adopted for the study are described in this Chapter.

3.1 General details:

Experimental site

The experiment was conducted at the Research Farm of the Department of Agronomy, College of Horticulture, Kerala Agricultural University, Vellanikkara. Geographically, the area is situated at 10^{0}31'N latitude and 76^{0}13'E longitude and at an altitude of 40.3m above mean sea level.

Soil

The soil of the experimental site was sandy loam in texture (order: Ultisols). The physico - chemical properties of the soil are given in Table.1

Weather

The weather data recorded during the cropping period (December 2009 to December 2010) are given in Appendix I and graphically presented in Fig. 1 and Fig 2.

Field operations

The experimental site was ploughed, stubbles removed, levelled and laid out into major plots and minor plots as per the lay out plan given in Fig. 3.

Table 1. Physico - chemical properties of the soil

A. Physical properties		
Particulars	**Value**	**Method used**
Bulk density (g/cm^3)	1.73	Core sampler method (Piper, 1942)
Particle density (g/cm^3)	2.30	
Porosity (%)	24.78	
B. Mechanical composition		
Sand (%)	68.20	Robinson international pipette method (Piper, 1942)
Silt (%)	19.50	
Clay (%)	11.50	
C. Chemical properties		
Particulars	**Quantity**	**Method used**
pH (1 : 2.5)	5.82	pH meter
Organic C (%)	0.39	Walkley and Black method (Jackson, 1958)
Available N (kg/ha)	208.68	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P (kg/ha)	22.64	Ascorbic acid reduced molybdophosphoric blue colour method (Watnabe and Olsen, 1965)
Available K (kg/ha)	102.45	Neutral normal ammonium acetate extractant flame photometry (Jackson, 1958)

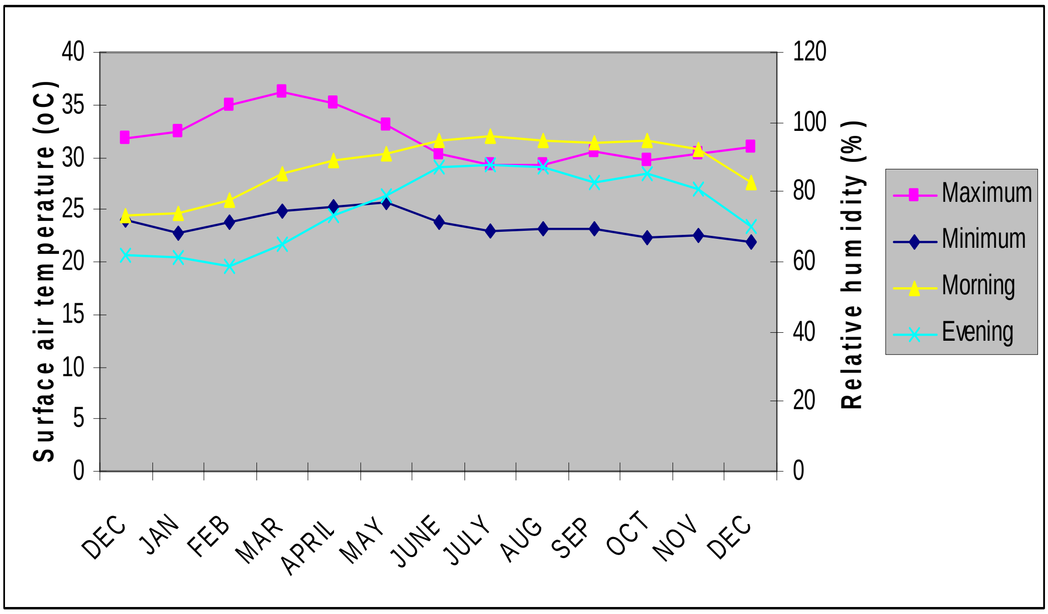


Fig. 1. Weather data during the crop period (December 2009 to December 2010) at Vellanikkara, Thrissur.

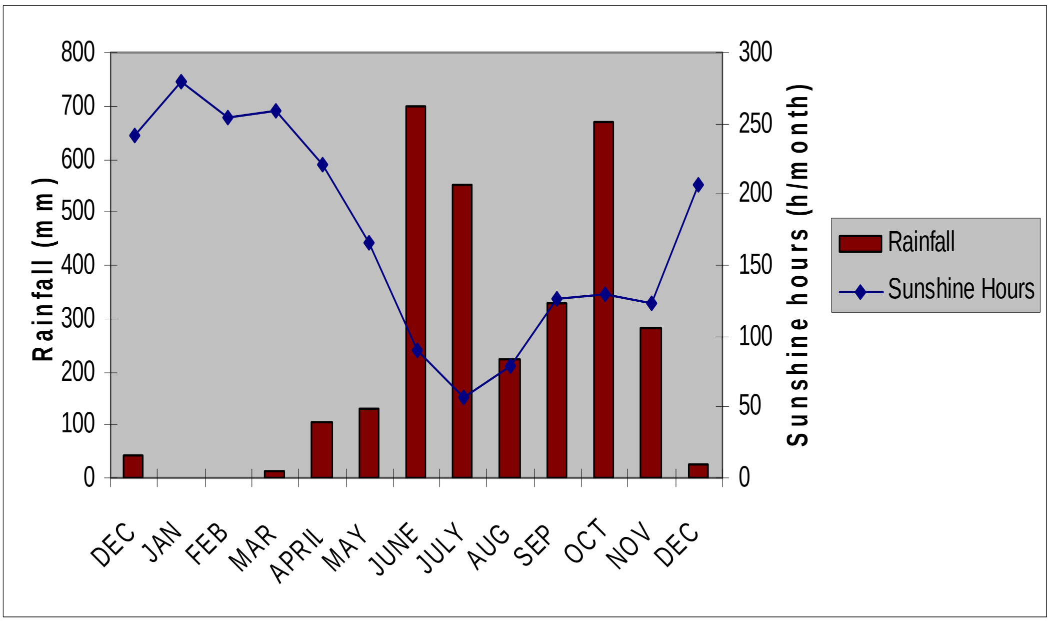


Fig. 2. Weather data during the crop period (December 2009 to December 2010) at Vellanikkara, Thrissur.

The size of the minor plots was 5.4 m x 5.4 m. Bunds were taken around each plot at 45 cm width. Farm yard manure was applied and incorporated to the field at the rate of 25t/ha at the time of land preparation.

Planting

Planting was done on 26.12.2009 by using two noded, uniform sized, three months old stem cuttings were used for planting. Basal dose of fertilizers were added and incorporated into the soil two days before planting. The fertilizers were added at the recommended dose of 200:50:50 kg N, P, K of which 40 kg N and full P and K as basal dose and the remaining N as top dress in equal splits after each harvest. Gap filling was done at 15 days and 20 days after planting, using pre-germinated setts. Hand weeding was done at 30 days after planting and also after each harvest of the crop.

3.2. Experimental details

Eight popular cultivars of hybrid Napier namely CO2, CO3, CO(CN)4, KKM-1, Suguna, Supriya, IGFRI-3 and DHN-6 were planted under three different spacing of 60x60 cm, 90x60 cm, and 90x90 cm, so that the plant population per plot will remain 81, 54 and 36 respectively at respective spacing. The recommended spacing for hybrid Napier under Kerala condition is 60cm x 60cm. In order to find out the effect of higher spacing on the performance of hybrid Napier cultivars, wider spacing of 90cm x 60cm and 90cm x 90cm were also tried in the experiment. Among the cultivars, CO2, CO3 and CO(CN)4 were released from Tamil Nadu Agricultural University, Coimbatore. KKM-1 is a cultivar released from Agricultural College and Research Institute (TNAU), Killikulam, Tamil Nadu. Suguna and Supriya are cultivars released from Kerala Agricultural University, Vellanikkara. IGFRI-3 was released from Indian Grassland and Fodder Research Institute (IGFRI), Jhansi and DHN-6 was released from IGFRI Regional Research Station, Dharwad, Karnataka.

Plate 1. Hybrid Napier cultivar - CO2

Plate 2. Hybrid Napier cultivar Suguna

Plate 3. Hybrid Napier cultivar - KKM-1

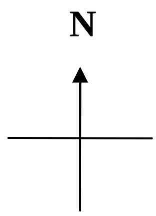
Plate 4. Hybrid Napier cultivar - DHN-6

Plate 5. Hybrid Napier cultivar - Supriya

Plate 6. Hybrid Napier cultivar – CO(CN)4

Plate 7. Hybrid Napier cultivar - CO3

Plate 8. Hybrid Napier cultivar - IGFRI-3



R1			R2			R3		
$S_2 C_1$	$S_3 C_5$	$S_1 C_6$	$S_3 C_5$	S_2C_8	$S_1 C_2$	$S_3 C_6$	$S_1 C_2$	$S_2 C_8$
$S_2 C_5$	$S_3 C_8$	$S_1 C_4$	$S_3 C_1$	$S_2 C_4$	$S_1 C_4$	$S_3 C_1$	$S_1 C_8$	$S_2 C_6$
$S_2 C_4$	$S_3 C_1$	$S_1 C_1$	$S_3 C_8$	$S_2 C_3$	$S_1 C_8$	$S_3 C_4$	$S_1 C_6$	$S_2 C_7$
$S_2 C_3$	$S_3 C_3$	S_1C_8	$S_3 C_6$	$S_2 C_7$	$S_1 C_6$	S_3C_7	$S_1 C_4$	$S_2 C_1$
$S_2 C_8$	$S_3 C_4$	$S_1 C_7$	$S_3 C_3$	$S_2 C_5$	$S_1 C_3$	$S_3 C_2$	$S_1 C_5$	$S_2 C_4$
$S_2 C_7$	$S_3 C_6$	$S_1 C_2$	$S_3 C_2$	$S_2 C_2$	$S_1 C_7$	$S_3 C_3$	$S_1 C_1$	$S_2 C_3$
$S_2 C_6$	$S_3 C_2$	$S_1 C_5$	$S_3 C_7$	$S_2 C_1$	$S_1 C_5$	$S_3 C_8$	$S_1 C_7$	$S_2 C_5$
$S_2 C_2$	$S_3 C_7$	$S_1 C_3$	$S_3 C_4$	$S_2 C_6$	$S_1 C_1$	$S_3 C_5$	$S_1 C_3$	$S_2 C_2$

Fig. 3. Layout of field experiment

Design : Split plot design

Replications : Three

Plot Size : 5.4m x 5.4m

Main plots

S_1- Spacing at 60cm x 60cm

S_2- Spacing at 90cm x 60cm

S_3- Spacing at 90cm x 90cm

Sub plots

C_1 – CO3

C_2 – CO(CN)4

C_3 – KKM-1

C_4 – SUGUNA

C_5 – SUPRIYA

C_6 – IGFRI-3

C_7 – DHN-6

C_8 – CO2

The experiment was laid out in split plot design with three spacing as major plots and eight cultivars as minor plots. The details of the observations made are given below.

Growth parameters:

Plant height
Number of tillers per clump
Number of leaves per tiller
Length of leaves
Width of leaves

Growth analysis:

Leaf Area Index
Leaf Area Ratio
Net Assimilation Rate
Relative Growth Rate
Leaf: Stem Ratio

Yield:

Green fodder yield
Dry matter yield

Plant analysis:

Nitrogen
Phosphorus
Potassium
Calcium
Magnesium
Crude protein
Crude fibre
Ether extract
Total ash
Nitrogen free extract
Oxalate

Observations on growth characters were taken at every harvest of the crop at 50-55 days interval. Plants were selected randomly from each plot. Based on the observations, derived variables such as Relative Growth Rate (RGR), Net

Assimilation Rate (NAR), Leaf Area Index (LAI), and Leaf Area Ratio (LAR) as detailed by Gardner *et al*., (1985) were calculated.

Table 2. Schedule of field experiment

Sl. No.	Event	Date
1	Planting	26.12.2009
2	First harvest	17.03.2010
3	Second harvest	08.05.2010
4	Third harvest	02.07.2010
5	Fourth harvest	25.08.2010
6	Fifth harvest	18.10.2010
7	Sixth harvest	10.12.2010

3.2.1. Biometric Observations

At each harvest, three plants were selected randomly from each plot and observations on the following growth characters were taken.

(i) Plant height

The plant height in cm was recorded from the base of the plant to the tip of the top most leaf during each observation.

(ii) Number of tillers per clump

Number of tillers per plant was counted at different stages of observation and the mean was worked out.

(iii) Number of leaves per tiller

Number of leaves per tiller was counted from three different plants randomly selected from a plot and the mean was worked out.

(iv) Leaf length

Length of leaves in cm was measured from the base of leaves to the leaf tip and recorded.

(v) Leaf width

Width of leaves in cm was measured from the middle portion of the leaf.

3.2.2 Growth Analysis

Different growth indices were worked out as below (Gardner *et al.*, 1985).

(i) Leaf Area Index

It refers to the ratio of leaf area to the ground area. The leaf area noted from the selected plants using leaf area meter were used to calculate LAI.

$$\text{Leaf Area Index (LAI)} = \frac{\text{Leaf Area}}{\text{Land Area}}$$

(ii) Leaf Area Ratio

$$\text{Leaf Area Ratio (LAR)} = \frac{(La_2 - La_1) \times (\ln W_2 - \ln W_1)}{(\ln La_2 - \ln La_1) \times (W_2 - W_1)} \ cm^2/g$$

Where La_1 and La_2 are total leaf area at time t_1 and t_2; W_1 and W_2 are total dry weights at time t_1 and t_2.

(iii) Net Assimilation Rate

$$\text{Net Assimilation Rate (NAR)} = \frac{(W_2 - W_1)(\ln La_2 - \ln La_1)}{(t_2 - t_1)(La_2 - La_1)} \text{ g/m}^2\text{/day}$$

Where La_1 and La_2 are total leaf area at time t_1 and t_2 and W_1 and W_2 are total dry weights during the same period.

(iv) Relative Growth Rate

$$\text{Relative Growth Rate (RGR)} = \frac{(\ln W_2 - \ln W_1)}{(t_2 - t_1)} \text{ g/g/day}$$

Where W_1 and W_2 are total dry weight at time t_1 and t_2 days

(v) Leaf: stem ratio

Stems and leaves were separated from the plant and recorded the fresh weights separately. From this, leaf: stem ratio was worked out.

$$\text{Leaf: stem ratio} = \frac{\text{Fresh weight of leaf}}{\text{Fresh weight of stem}}$$

3.2.3. Fodder production potential

(i) Green fodder yield

Green fodder yield from each plot was recorded immediately after cutting and the yield of green fodder in tonnes/ha was calculated for each plot.

(ii) Dry matter production

Five pants were selected randomly after each harvest and the plants from each plot were initially weighed, oven dried and dry weight was recorded. From this, yield of dry fodder in tonnes/ha was calculated.

3.2.4. Nutritive value and quality

Plant samples from all the treatments were collected at six months after planting and were used to find out the five fractions of proximate analysis – crude protein (CP), crude fibre (CF), ether extract (EE), total ash and nitrogen free extract (NFE).

(i) Crude protein

The nitrogen content in the plant was estimated by microkjeldahl digestion and distillation method (Jackson, 1958). The nitrogen content thus obtained was multiplied by 6.25 to obtain crude protein content of the sample.

(ii) Crude fibre

The crude fibre content was estimated by using the acid-alkali digestion method (Sadasivam and Manickam, 1996).

(iii) Ether extract

Ether extract which represents the he crude fat content, was estimated by extracting the plant fat using organic solvent, petroleum benzene, (A.O.A.C, 1975).

(iv) Total ash

Total ash which represents the total minerals present in the fodder sample was estimated by igniting a known quantity of plant sample at 500^0C for one hour.

(v) Nitrogen free extract (NFE)

Nitrogen free extract of the plant sample was obtained by subtracting the per cent crude protein, crude fibre, ether extract and ash content from hundred.

(vi) Phosphorus

Plant samples were digested using the diacid mixture (HNO_3: $HClO_4$ at 2:1 ratio) and the phosphorus content was determined by Vanedomolybdo phosphoric yellow colour method (Koenig and Johnson, 1942). The intensity of yellow colour was read using Spectrophotometer at 420 nm.

(vii) Potassium

The potassium content in the digested plant sample was estimated by using EEL Flame photometer (Jackson, 1958).

(viii) Calcium and Magnesium

By using diacid mixture, Ca and Mg present in the plant sample were read by Atomic Absorption Spectrophotometer (AAS) (Jackson, 1958).

(ix) Oxalate content

Oxalate content in the plant sample was analysed colorimetrically as suggested by Marderosian *et al*. (1979). The dried plant material was powdered and 0.5g of the sample was added to 10 ml of distilled water followed by 10 ml of citric acid reagent. The oxalates were extracted by shaking for 10 minutes at room temperature. The extract was filtered and the precipitate was dissolved in 50 ml of 0.4N hydrochloric acid by shaking for 10 minutes. The sample was filtered, and 2 ml of the filtrate was added to 2 ml of diluted ferron reagent and absorbance was read at 540 nm in a spectrophotometer. The oxalate content of dried sample was calculated from the standard graph and expressed on dry weight basis.

3.2.5. Nutrient uptake

The nutrient uptake was calculated during the third stage of harvest by taking it as a representative stage. The nutrient uptake was calculated as the product of dry matter yield and the plant nutrient content.

3.2.6. Benefit cost analysis

The economic analysis of the data was done by calculating the benefit cost ratio of the data. The cost was calculated based on the prevailing market price and wage rate. The cost of cultivation during the first year of hybrid Napier cultivation is given in Appendix II.

3.3. Data analysis

The data were analysed by using the statistical package, ‘MSTAT’ (Freed, 1986).

Results

4. RESULTS

Field trials were conducted at the research farm of the Department of Agronomy, College of Horticulture, Vellanikkara, during 2009-2010. Comparisons were made between eight different cultivars of hybrid Napier namely CO2, CO3, CO(CN)4, KKM-1, Suguna, Supriya, IGFRI-3 and DHN-6 were planted in three different spacing of 60cm x 60cm, 90cm x 60cm, and 90cm x 90cm.

Two noded, uniform sized, setts prepared from three months old stems were planted on 26.12.2009. Bud regeneration was observed within 7-10 days of planting. New leaves started emerging from 15-20 days of planting with proper establishment of the field. The plant growth was almost uniform and started tillering within a month. It took 75 days to reach maturity during the initial stage hence first cutting was done at 75 days maturity. Subsequent harvests were done at 50-55 days interval. The harvest was determined based on the overall plant vigour and stem hardiness. Observations on various aspects of growth, fodder production potential and nutrient composition of different cultivars of hybrid Napier grass were taken during the experimental period.

4.1. Biometric observations

4.1.1. Plant height

The plant height of hybrid Napier varieties at spacing of 60cm x 60cm, 90cm x 60cm and 90cm x 90cm for a period of one year over six harvests are presented in Table 3.

The height of the grass showed significant differences between cultivars. During the initial stage, growth was slow as evidenced by comparatively low plant height. The average plant height was the maximum during the fourth harvest and after that, the plant height decreased gradually.

During the first and second harvests, KKM-1 attained maximum plant height of 190.78 cm and 180.33 cm respectively and was on par with CO(CN)4, and the lowest height was recorded for IGFRI-3 (118.87 cm and 131.84 cm respectively). During the third harvest, the maximum plant height was observed for CO2 with a height of 242.43 cm which was on par with that of DHN-6 and minimum height was obtained for IGFRI-3 (183.77 cm). During the fourth harvest, although CO2 attained the maximum height (242.05 cm), it was on par with KKM-1, DHN-6, CO3, and CO(CN)4. The cultivar IGFRI-3 recorded the lowest height (173.33 cm). During the fifth harvest also, CO2 was the tallest with a height of 205 cm; and KKM-1, DHN-6 and Supriya were on par. IGFRI-3 was the shortest (143.44 cm). During the sixth cutting, plant height was maximum for CO2 with an average value of 131.66 cm, followed by KKM-1, CO(CN)4 and DHN-6, which were on par. IGFRI-3 had the least plant height (114.55 cm). The average height of plants over six harvests was found to be maximum for KKM-1 (185.38 cm), which was on par with CO2, CO(CN)4 and DHN-6. The lowest average height was recorded by IGFRI-3 (141.3 cm).

Variation in spacing did not affect height of hybrid Napier cultivars and interaction effect between spacing and variety was also not observed with regard to plant height.

4.1.2. Number of tillers per clump

The number of tillers produced by hybrid Napier cultivars under three different spacings of 60cm x 60cm, 90cm x 60cm and 90cm x 90cm are given in Table 4.

The number of tillers showed significant differences among cultivars. During the initial stage of the experiment, the tiller production was less, then increased and again decreased towards the end of the experiment. During the first harvest, KKM-1 produced the maximum number of tillers (38.44) and the tiller

Table 3. Effect of treatments on plant height (cm) of hybrid Napier at each harvest

Treatments	Stages of harvest						
	H1	**H2**	**H3**	**H4**	**H5**	**H6**	**Mean**
Spacing							
60cmx60cm	144.25	148.83	210.70	224.41	165.88	127.54	169.18
90cmx60cm	150.31	148.46	224.27	226.50	185.21	126.37	175.70
90cmx90cm	140.99	160.10	204.08	221.33	179.38	124.45	170.81
CD (0.05)	NS	NS	NS	NS	NS	NS	NS
Cultivars							
CO3	142.23	139.33	207.94	231.55	168.44	125.00	168.34
CO(CN)4	175.24	168.11	209.33	235.55	175.67	129.77	181.41
KKM-1	190.78	180.33	213.61	226.77	181.78	130.99	185.38
Suguna	129.22	153.33	199.61	217.44	165.00	123.22	163.95
Supriya	143.22	141.22	216.22	225.22	186.22	122.66	171.54
IGFRI-3	118.87	131.83	183.77	173.33	143.44	114.55	141.30
DHN-6	134.41	155.78	231.61	239.00	188.78	131.11	179.74
CO2	127.49	149.78	242.05	243.77	205.22	131.66	183.52
CD (0.05)	22.86	21.67	20.43	16.62	28.21	05.26	8.48
Interaction	NS	NS	NS	NS	NS	NS	NS

Table 4. Effect of treatments on number of tillers per clump of hybrid Napier at each harvest

Treatments	Stages of harvest						
	H1	**H2**	**H3**	**H4**	**H5**	**H6**	**Mean**
Spacing							
60cmx60cm	21.08	31.38	41.08	28.88	27.08	25.96	29.24
90cmx60cm	24.58	33.79	43.08	30.13	29.17	25.96	31.02
90cmx90cm	31.42	38.50	47.71	30.85	31.96	27.42	34.64
CD (0.05)	1.29	2.17	3.26	NS	NS	NS	4.11
Cultivars							
CO3	27.33	34.33	43.33	30.22	26.00	23.67	30.85
CO(CN)4	29.89	41.11	50.11	35.22	24.56	31.44	35.39
KKM-1	38.44	45.78	58.56	34.00	25.22	26.00	38.00
Suguna	28.33	33.56	42.11	30.33	31.67	25.11	31.85
Supriya	26.78	37.33	45.11	27.72	39.22	18.00	32.36
IGFRI-3	24.78	30.00	40.11	30.44	40.44	35.00	33.46
DHN-6	12.00	29.33	38.33	27.44	22.78	25.78	25.94
CO2	18.00	25.00	34.00	24.22	25.33	25.00	25.26
CD (0.05)	3.06	3.75	3.70	5.65	12.20	4.89	2.85
Interaction	5.30	6.48	6.42	NS	NS	NS	NS

production was minimum in DHN-6 (12). During the second and third harvest also, the highest number of tillers was observed in KKM-1 (45.78 and 58.56 respectively) while the lowest number of tillers was produced by CO2 (25 and 34 respectively). In fourth harvest, CO(CN)4 had the highest tiller production of 35.22 which was on par with IGFRI-3, KKM-1, Suguna and CO3. In fifth harvest, IGFRI-3 could produce the maximum number of tillers (40.44) which was on par with Suguna and Supriya and minimum was observed in DHN-6. During the sixth harvest also, the cultivar IGFRI-3 produced the highest number of tillers (35) which was on par with CO(CN)4.

During the initial stages, tillering was at a slow rate which reached maximum during the third harvest and again decreased. The average number of tillers under different spacing and stages of harvest was found to be the highest for KKM-1 (38).

There were significant differences between different spacings with regard to the number of tillers. During first, second and third harvest, number of tillers was found to be the maximum at the widest spacing of 90cm x 90cm. The lowest number of tillers was observed at the lowest spacing of 60cm x 60cm. During all other observations, even though there were no significant differences between different spacings, tiller production was higher at higher order spacing of 90cm x 90cm. The average number of tillers was found to be higher at widest spacing of 90cm x 90cm (34.64), which was on par with 90cm x 60cm.

The interaction effect between spacing and cultivars was significant during first, second and third harvests (Tables 5, 6, and 7). During all the three initial harvests, KKM-1 produced maximum number of tillers at 90cm x 90cm spacing. At 60cm x 60cm, KKM- produced the maximum number of tillers in first harvest. However, in the second harvest, CO(CN)4, KKM-1, Suguna, CO3, Supriya and IGFRI-3 were on par and superior in tiller count. In the third harvest, the cultivars Suguna, KKM-1, CO(CN)4 and Supriya produced significantly higher tiller

Table 5. Interaction effect of hybrid Napier cultivars and spacing on tiller production during first harvest

Cultivars	Spacing		
	S1	**S2**	**S3**
CO3	19.00	24.33	38.67
CO(CN)4	21.00	27.67	41.00
KKM-1	33.33	36.33	45.67
Suguna	24.67	29.33	31.00
Supriya	23.33	24.00	33.00
IGFRI-3	24.67	24.67	25.00
DHN-6	8.67	12.33	15.00
CO2	14.00	18.00	22.00

CD (0.05) 5.30

Table 6. Interaction effect of hybrid Napier cultivars and spacing on tiller production during second harvest

Cultivars	Spacing		
	S1	**S2**	**S3**
CO3	31.67	35.33	36.00
CO(CN)4	34.67	43.33	45.33
KKM-1	34.33	49.33	53.67
Suguna	31.67	32.33	36.67
Supriya	34.33	37.33	40.33
IGFRI-3	30.00	30.00	30.00
DHN-6	27.33	22.67	38.00
CO2	27.00	20.00	28.00

CD (0.05) 6.48

Table 7. Interaction effect of hybrid Napier cultivars and spacing on tiller production during third harvest

Cultivars	Spacing		
	S1	**S2**	**S3**
CO3	40.67	44.33	45.00
CO(CN)4	43.67	52.33	54.33
KKM-1	45.67	63.33	66.67
Suguna	47.33	36.67	42.33
Supriya	43.33	47.33	44.67
IGFRI-3	35.67	40.00	44.67
DHN-6	36.33	31.67	47.00
CO2	36.00	29.00	37.00

CD (0.05) 6.42

count, which were on par. During fourth, fifth, and sixth harvests, the interaction was not significant.

4.1.3. Number of leaves per tiller

The data of number of leaves of eight hybrid Napier cultivars under three spacings of 60cm x 60cm, 90cm x 60cm and 90cm x 90cm are given in Table 8. There were significant differences between the cultivars with regard to leaf production.

During the initial stage, the maximum number of leaves was observed in cultivar CO2. During the second harvest, although CO2 produced the maximum number of leaves, it was on par with KKM-1, DHN-6, Suguna and CO(CN)4. In the third harvest, there were no significant differences among the cultivars. During the fourth and fifth cuttings the average number of leaves was highest in CO2 which did not differ significantly from CO(CN)4. During the last harvest Suguna and IGFRI-3 had the maximum leaf production. The average number of leaves was found to be maximum for CO2 (11.5).

Number of leaves was not affected by spacing as evidenced by little variation all three different spacings of 60cm x 60cm, 90cm x 60cm and 90cm x 90cm.

4.1.4. Leaf length

The data pertaining to leaf length of hybrid Napier cultivars taken over six cuttings in a year are given in Table 9. There was significant variation in leaf length among the eight cultivars.

During the first and second harvests, KKM-1 had the lengthy leaves (88.2 cm and 92.42 cm respectively) which was on par with Suguna, Supriya, DHN-6 and CO3. Supriya was having the longest leaves (115.33 cm) during the third cutting which was on par with that of DHN-6, KKM-1, CO(CN)4 and Suguna. During the fourth cutting, Suguna had the highest leaf length of 128.33 cm which was on par with CO3, KKM-1 and Supriya. While in fifth harvest, Supriya was found to be having the highest leaf length with an average of 112.44 cm which was on par with KKM-1, Suguna, CO3 and DHN-6. During the sixth harvest, maximum leaf length was observed with Suguna. CO3 and KKM-1 were on par with Suguna. Among the cultivars, Suguna had the highest leaf length compared to other cultivars. The average leaf length was found to be highest in Suguna (101.02 cm) and was on par with KKM-1, CO3 and Supriya.

There was no variation in leaf length with respect to spacing and the interaction between varieties and spacing was also absent.

4.1.5. Leaf width

Leaf width of eight different cultivars of hybrid Napier grass under three different spacings are given in Table 10. There was significant variation between the cultivars with respect to leaf width.

During the first harvest, the maximum leaf width was observed with DHN-6 (4.47 cm) which was on par with CO(CN)4. During second cutting, average leaf width was found to be highest in CO2 (4.08 cm), followed by CO(CN)4 which was on par. During third and fourth harvest also CO2 had the maximum leaf width with an average value of 4.68 cm and 3.96 cm which was on par with DHN-6. CO2 had the maximum leaf width during fifth harvest also (2.85 cm), which was on par with DHN-6, CO(CN)4, and Supriya. During sixth cutting, maximum leaf width was observed with CO(CN)4 (2.77 cm) which was on par with DHN-6 and CO2. The cultivar CO2 attained the maximum leaf width (3.65 cm) during the entire experimental period.

Table 8. Effect of treatments on number of leaves per tiller of hybrid Napier at each harvest

Treatments	Stages of harvest						
	H1	H2	H3	H4	H5	H6	Mean
Spacing							
60cmx60cm	5.67	7.50	13.21	11.71	10.04	7.25	9.23
90cmx60cm	7.18	8.50	12.66	12.04	10.16	7.91	9.74
90cmx90cm	5.58	8.04	13.16	11.96	10.37	7.70	9.47
CD (0.05)	NS	NS	NS	NS	NS	NS	NS
Cultivars							
CO3	4.49	6.89	12.78	11.89	9.44	7.77	8.88
CO(CN)4	5.82	9.44	13.89	13.22	10.44	7.44	10.04
KKM-1	6.19	7.33	12.44	10.78	9.22	7.55	8.92
Suguna	5.07	8.11	12.78	11.00	8.88	8.00	8.97
Supriya	5.20	6.11	12.44	11.56	8.55	6.88	8.46
IGFRI-3	4.12	7.00	12.11	10.67	12.22	8.00	9.02
DHN-6	6.91	9.56	13.56	12.44	10.00	7.66	10.02
CO2	11.36	9.67	13.89	13.70	12.77	7.66	11.50
CD (0.05)	3.1	2.64	NS	1.05	2.50	NS	0.92
Interaction	NS	NS	NS	NS	NS	NS	NS

Table 9. Effect of treatments on leaf length (cm) of hybrid Napier at each harvest

Treatments	Stages of harvest						
	H1	H2	H3	H4	H5	H6	Mean
Spacing							
60cmx60cm	80.38	84.38	106.85	108.62	96.04	85.25	93.59
90cmx60cm	76.25	80.80	97.52	111.20	91.91	80.62	89.72
90cmx90cm	79.03	83.37	106.41	104.75	96.41	82.00	92.00
CD (0.05)	NS	NS	NS	NS	NS	NS	NS
Cultivars							
CO3	81.01	84.34	100.61	125.33	104.00	88.88	97.37
CO(CN)4	71.82	76.38	101.88	89.77	91.33	81.22	85.40
KKM-1	88.20	92.42	112.33	123.66	101.11	87.44	100.86
Suguna	87.33	91.44	103.66	128.33	101.22	94.11	101.02
Supriya	86.80	91.13	115.33	114.11	112.44	81.88	100.29
IGFRI-3	67.57	72.36	88.38	92.44	70.66	68.44	76.65
DHN-6	85.90	90.23	111.44	106.66	101.44	80.77	96.08
CO2	59.82	64.49	95.11	85.22	76.11	78.22	76.50
CD (0.05)	9.17	10.25	12.33	17.79	17.47	7.96	6.03
Interaction	NS	NS	NS	NS	NS	NS	NS

Spacing did not show any effect on leaf width of hybrid Napier. Interaction was also absent.

4.2. Growth analysis

4.2.1. Leaf area index

Leaf area index of hybrid Napier cultivars was worked out at six different stages of harvest. The data are presented in Table 11. Significant differences in leaf area index between the different cultivars were noticed.

During the first stage of harvest, CO(CN)4 and KKM-1 had the highest leaf area index on par with CO2 and IGFRI-3. KKM-1 had the highest leaf area index during the second stage of harvest and CO(CN)4 and CO2 were on par. During the fourth stage of harvest, DHN-6 had the highest leaf area index but Supriya, IGFRI-3 and CO2 were on par with DHN-6. During third, fifth and sixth harvests, there was no significant differences between the cultivars. On an average, Leaf area index was found to be the highest for KKM-1 (7.74) which was on par with Supriya, IGFRI-3, CO(CN)4, DHN-6 and CO2.

During all the stages of harvest, irrespective of the cultivars, the leaf are index was found to be highest at the lowest spacing of 60cm x 60cm followed by 90cm x 60cm and the lowest leaf area index was noticed at 90cm x 90cm.

4.2.2. Leaf area ratio

The data regarding the leaf area ratio (LAR) of hybrid Napier cultivars are presented in Table 12. LAR showed significant difference between different cultivars during most of the experimental stages.

Table 10. Effect of treatments on leaf width (cm) of hybrid Napier at each harvest

Treatments	Stages of harvest						
	H1	**H2**	**H3**	**H4**	**H5**	**H6**	**Mean**
Spacing							
60cmx60cm	3.55	3.33	3.49	3.02	2.30	2.21	2.99
90cmx60cm	3.57	3.24	3.34	3.28	2.39	2.14	3.00
90cmx90cm	3.50	3.18	3.77	3.36	2.41	2.10	3.07
CD (0.05)	NS	NS	NS	NS	NS	NS	NS
Cultivars							
CO3	3.17	2.67	3.27	3.20	2.00	1.88	2.70
CO(CN)4	4.04	3.51	3.54	3.45	2.55	2.77	3.31
KKM-1	3.44	2.77	3.42	2.86	2.33	2.08	2.82
Suguna	3.31	3.16	3.08	2.85	2.01	2.05	2.75
Supriya	3.32	3.04	3.46	2.93	2.38	1.75	2.86
IGFRI-3	2.94	3.28	3.46	2.79	2.11	1.61	2.70
DHN-6	4.47	3.48	3.35	3.73	2.71	2.47	3.37
CO2	3.65	4.08	4.68	3.96	2.85	2.61	3.65
CD (0.05)	0.47	0.59	0.78	0.42	0.48	0.54	0.26
Interaction	NS	NS	NS	NS	NS	NS	NS

Table 11. Effect of treatments on leaf area index of hybrid Napier at each harvest

Treatments	Stages of harvest						
	H1	**H2**	**H3**	**H4**	**H5**	**H6**	**Mean**
Spacing							
60cmx60cm	9.21	9.54	10.51	9.80	9.48	8.40	9.49
90cmx60cm	7.93	7.98	8.88	7.93	7.17	6.32	7.70
90cmx90cm	6.02	6.07	6.46	5.70	5.19	4.78	5.70
CD (0.05)	0.10	0.12	0.25	0.36	0.20	0.18	0.12
Cultivars							
CO3	7.65	7.86	8.60	7.62	6.99	6.41	7.52
CO(CN)4	7.85	7.93	8.56	7.75	7.40	6.67	7.70
KKM-1	7.85	8.04	8.76	7.67	7.45	6.70	7.74
Suguna	7.62	7.76	8.46	7.64	7.12	6.36	7.49
Supriya	7.62	7.81	8.78	7.86	7.33	6.49	7.65
IGFRI-3	7.77	7.86	8.47	7.98	7.36	6.53	7.66
DHN-6	7.66	7.78	8.59	8.07	7.32	6.39	7.64
CO2	7.73	7.87	8.73	7.87	7.28	6.44	7.65
CD (0.05)	0.18	0.17	NS	0.27	NS	NS	0.12
Interaction	NS	NS	NS	NS	NS	NS	NS

During the all the stages of harvest, except during third harvest, among the cultivars, IGFRI-3 had the highest leaf area ratio. During third harvest, LAR was not significant with respect to cultivars. Considering the average value of LAR during the entire experimental period, comprising of six harvests, leaf area ratio was the highest for IGFRI-3 (35.82) and lowest for CO3 (30.69).

There was significant difference between the three spacings with respect to LAR. Among the three spacings tried, LAR was found to be higher at highest spacing of 90cm x 90cm. During first and third harvests, the LAR at 90cm x90cm and 90cm x 60cm were on par.

4.2.3. Leaf: stem ratio

The data on leaf: stem ratio of hybrid Napier varieties are presented in Table 13. There were no significant differences between the three spacings during any of the stages. However, there existed significant differences in leaf: stem among the different cultivars. In all the stages of harvest, IGFRI-3 had the highest leaf: stem ratio with an average value of 0.92 compared to other cultivars. CO2 had the lowest leaf: stem ratio during all the observations with an average of 0.66. All other cultivars were observed with almost similar values of leaf stem ratio.

4.2.4. Relative growth rate

Relative growth rate (RGR) of hybrid Napier cultivars are presented in Table 14. A significant variation was observed among the different cultivars during most of the stages.

During the initial stage, among the cultivars, KKM-1 exhibited the highest relative growth rate (0.128 g/g/day) all other cultivars except IGFRI-3 were on par. During the second stage of observation, KKM-1 and CO(CN)4 had the highest RGR (0.135 g/g/day). In the third stage of harvest, CO3, Suguna,

Table 12. Effect of treatments on leaf area ratio (cm^2/g) of hybrid Napier at each harvest

Treatments	Stages of harvest					
	H1	H2	H3	H4	H5	H6	Mean
Spacing							
60cmx60cm	38.48	29.06	24.55	25.40	26.98	26.65	28.52
90cmx60cm	46.04	32.56	29.13	28.81	29.03	28.76	32.39
90cmx90cm	45.72	35.41	30.34	29.93	30.79	31.31	33.92
CD (0.05)	3.48	0.594	1.32	0.802	1.66	2.26	0.86
Cultivars							
CO3	43.42	32.17	27.80	26.60	27.15	27.00	30.69
CO(CN)4	42.99	31.90	27.86	26.94	28.21	28.35	31.04
KKM-1	42.20	32.05	28.44	26.61	28.04	28.00	30.89
Suguna	42.20	31.87	27.60	27.30	28.20	28.23	30.90
Supriya	41.95	31.98	28.28	28.62	28.71	28.54	31.35
IGFRI-3	50.60	34.68	28.83	31.73	34.35	34.72	35.82
DHN-6	41.87	32.09	27.44	28.80	28.32	28.39	31.15
CO2	42.07	32.02	27.81	27.79	28.51	28.01	31.03
CD (0.05)	2.27	0.84	NS	1.41	1.74	1.53	0.77
Interaction	NS	NS	NS	NS	NS	NS	NS

Table 13. Effect of treatments on leaf stem ratio of hybrid Napier at each harvest

Treatments	Stages of harvest					
	H1	H2	H3	H4	H5	H6	Mean
Spacing							
60cmx60cm	0.71	0.71	0.72	0.72	0.72	0.72	0.72
90cmx60cm	0.72	0.72	0.72	0.72	0.72	0.72	0.73
90cmx90cm	0.72	0.72	0.73	0.74	0.74	0.74	0.74
CD (0.05)	NS	NS	NS	NS	NS	NS	NS
Cultivars							
CO3	0.70	0.70	0.70	0.70	0.70	0.70	0.70
CO(CN)4	0.71	0.71	0.73	0.72	0.72	0.72	0.72
KKM-1	0.69	0.69	0.71	0.69	0.69	0.69	0.70
Suguna	0.69	0.69	0.69	0.70	0.70	0.70	0.69
Supriya	0.70	0.71	0.71	0.72	0.72	0.72	0.71
IGFRI-3	0.91	0.92	0.92	0.93	0.93	0.93	0.92
DHN-6	0.71	0.71	0.72	0.73	0.73	0.72	0.72
CO2	0.65	0.65	0.65	0.66	0.67	0.67	0.66
CD (0.05)	0.02	0.02	0.03	0.03	0.22	0.02	0.02
Interaction	NS	NS	NS	NS	NS	NS	NS

DHN-6 and CO2 exhibited the highest value of RGR (0.14 g/g/day). During the fourth stage CO2, CO3, CO(CN)4 and KKM-1 had the highest RGR (0.138 g/g/day). CO3, CO(CN)4 and KKM-1 had the highest RGR (0.136 g/g/day) during the fifth stage of harvest. CO3 and KKM-1 had the highest RGR (0.134 g/g/day) in sixth harvest and all other cultivars except IGFRI-3 were on par. During all the stages IGFRI-3 had the least RGR. The average value of RGR was found to be higher for KKM-1, CO(CN)4 and CO3 (0.135 g/g/day).

There were significant differences between the three spacings in most of the observations. During the initial four stages of harvest, RGR was higher at widest spacing of 90cm x 90cm. During the fifth and sixth harvest, RGR was not significant with respect to spacing.

4.2.5. Net assimilation rate

The data on net assimilation rate of hybrid Napier varieties are presented in Table 15. The varietal difference was significant in hybrid Napier with respect to NAR.

During the first stage of harvest, KKM-1 exhibited the highest net assimilation rate (4.06 g/m^2/day) while CO(CN)4, Suguna, DHN-6, CO2 and Supriya were on par. During the second, third and fifth stages of harvest, all the cultivars except IGFRI-3 were superior. During the fourth stage KKM-1 gave the highest value of net assimilation rate (6.83 g/m^2/day) followed by CO3, CO(CN)4, CO2 and Suguna which were on par with KKM-1. During the sixth stage, CO3 (5.78 g/m^2/day) had the highest net assimilation rate and the cultivars CO2, CO(CN)4 and KKM-1 were on par. On an average, higher NAR was found for the cultivar KKM-1 (5.94 g/m^2/day), and low for IGFRI-3 (5.02 g/m^2/day).

Table 14. Effect of treatments on relative growth rate (g/g/day) of hybrid Napier at each harvest

Treatments	Stages of harvest					
	H1	**H2**	**H3**	**H4**	**H5**	**H6**	**Mean**
Spacing							
60cmx60cm	0.1250	0.1320	0.1380	0.1360	0.1340	0.1320	0.1330
60cmx90cm	0.1260	0.1350	0.1390	0.1370	0.1350	0.1330	0.1340
90cmx90cm	0.1290	0.1350	0.1400	0.1380	0.1350	0.1330	0.1350
CD (0.05)	0.0011	0.0003	0.0007	0.0003	NS	NS	0.0003
Cultivars							
CO3	0.1270	0.1340	0.1400	0.1380	0.1360	0.1340	0.1350
CO(CN)4	0.1270	0.1350	0.1390	0.1380	0.1360	0.1330	0.1350
KKM-1	0.1280	0.1350	0.1390	0.1380	0.1360	0.1340	0.1350
Suguna	0.1270	0.1340	0.1400	0.1370	0.1350	0.1330	0.1340
Supriya	0.1270	0.1340	0.1390	0.1370	0.1350	0.1330	0.1340
IGFRI-3	0.1230	0.1330	0.1380	0.1350	0.1310	0.1280	0.1310
DHN-6	0.1270	0.1340	0.1400	0.1370	0.1350	0.1330	0.1340
CO2	0.1270	0.1340	0.1400	0.1380	0.1350	0.1330	0.1340
CD (0.05)	0.0014	0.0005	0.0002	0.0008	0.0008	0.0011	0.0005
Interaction	NS	NS	NS	NS	NS	NS	NS

Table 15. Effect of treatments on net assimilation rate (g/m^2/day) of hybrid Napier at each harvest

Treatments	Stages of harvest						
	H1	**H2**	**H3**	**H4**	**H5**	**H6**	**Mean**
Spacing							
60cmx60cm	3.75	5.38	7.12	6.50	5.88	5.33	5.66
90cmx60cm	3.76	5.67	6.97	6.52	6.00	5.46	5.73
90cmx90cm	4.19	5.64	7.06	6.59	5.98	5.50	5.83
CD (0.05)	0.18	0.01	NS	NS	NS	NS	NS
Cultivars							
CO3	3.86	5.59	7.10	6.82	6.20	5.78	5.89
CO(CN)4	3.98	5.69	7.07	6.81	6.19	5.65	5.90
KKM-1	4.06	5.71	7.02	6.83	6.26	5.74	5.94
Suguna	3.97	5.61	7.11	6.60	6.00	5.43	5.79
Supriya	4.00	5.60	7.06	6.40	5.99	5.49	5.76
IGFRI-3	3.28	5.14	6.70	5.73	4.87	4.38	5.02
DHN-6	4.02	5.58	7.19	6.49	6.08	5.44	5.80
CO2	4.02	5.62	7.15	6.62	6.02	5.55	5.83
CD (0.05)	0.17	0.15	0.23	0.32	0.31	0.27	0.13
Interaction	NS	NS	NS	NS	NS	NS	NS

There was no significant difference among the three spacings in most of the observations but in the first and second set of observations, net assimilation rate was found to be higher at the widest spacing of 90cm x 90cm and 90cm x 60cm respectively.

4.3. Fodder Production Potential

4.3.1. Green fodder yield

The data pertaining to green fodder yield of hybrid Napier cultivars are presented in Table 16. During the initial harvests, the yield was comparatively less. Highest yield was obtained during the third harvest and the lowest yield was recorded during the sixth harvest.

There was significant variation between the cultivars with respect to green fodder yield recorded at six harvests. During the initial harvest, the highest green fodder yield was obtained from CO3 (36.98 t/ha) and the cultivars CO(CN)4, DHN-6, KKM-1, and CO2 were on par with CO3. The lowest yield was obtained from IGFRI-3 (21.3 t/ha). During the second harvest, KKM-1 exhibited the highest green fodder yield (76.78 t/ha) and CO(CN)4, DHN-6 and CO2 were on par with KKM-1. The lowest yield was from the cultivar IGFRI-3. KKM-1 had the maximum yield during the third and fifth harvest (89.29 t/ha and 40.89 t/ha) which was on par with CO(CN)4. During the fourth harvest, CO(CN)4, CO3, Suguna, Supriya and KKM-1 were on par in which the highest green fodder yield being recorded by KKM-1 (61.26 t/ha) and the lowest yield was again observed for IGFRI-3 (44.09 t/ha). During the sixth harvest, yield was the maximum for CO2 (17.66 t/ha) and KKM-1, Suguna and Supriya were on par. IGFRI-3 (12.97 t/ha) exhibited the lowest yield. The total green fodder production was found to be higher for KKM-1 (316.04 t/ha/year) and CO(CN)4 (311.77 t/ha/year) and the minimum for IGFRI-3 (213.22 t/ha/year). With respect to total yield, the performance of CO2 and DHN-6 were on par and can be ranked second. Supriya, CO3 and Suguna came third and IGFRI-3, fourth.

There were significant differences in yield due to spacing during first, second, and third cutting. During the first harvest, the highest yield was observed at lowest spacing of 60cm x60cm followed by 90cm x 60cm and 90cm x 90cm. There was no interaction effect between spacing and varieties. The total green fodder yield was also higher at closer spacing of 60cm x 60cm.

4.3.2. Dry matter yield

The dry matter yield estimated from hybrid Napier cultivars at three spacing of 60cm x 60cm, 90cm x 60cm and 90cm x 90cm for a period of one year over six cuttings are presented in Table 17. During the initial stages, the yield was less. Then increased gradually and again showed decreasing trend. The highest dry matter production was recorded during the third harvest and the lowest yield was recorded during the sixth harvest. Dry yield, being a derivative of green fodder yield, also showed similar trend as in the case of green fodder yield.

Dry yield showed significant differences between the cultivars. During the first harvest, dry yield was maximum for CO3 (7.54 t/ha) and CO(CN)4, DHN-6, KKM-1, and CO2 were on par with CO3. The lowest yield was obtained for IGFRI-3 (4.4 t/ha). During the second harvest, KKM-1 exhibited the highest dry yield (16.12 t/ha) and CO(CN)4, DHN-6 and CO2 were on par with KKM-1. The lowest yield was obtained from IGFRI-3 with a yield of 10.82 t/ha. During the third harvest, maximum yield was observed for KKM-1 (17.88 t/ha) which was on par with CO2 and CO(CN)4. All the cultivars except IGFRI-3 had higher yield in fourth harvest in which KKM-1 had the maximum dry yield (12.23). During the fifth harvest also KKM-1 was superior with respect to dry matter production and CO(CN)4 was on par. During the sixth harvest, CO2, KKM-1, Suguna and Supriya were on par in which the highest yield was for CO2 (3.69 t/ha). The lowest yield was recorded by IGFRI-3 (2.67 t/ha). The total dry fodder production was found to be the highest for KKM-1 (64.24 t/ha/year) and CO(CN)4 (61.33 t/ha/year) and the lowest yield was observed for IGFRI- 3 (44.45 t/ha/year).

Table 16. Effect of treatments on green fodder yield (t/ha) of hybrid Napier at each harvest

Treatments	Stages of harvest						
	H1	H2	H3	H4	H5	H6	Total
Spacing							
60cmx60cm	38.84	77.60	78.37	57.11	33.99	15.25	301.16
90cmx60cm	31.30	66.30	76.05	52.76	33.61	14.07	274.10
90cmx90cm	21.80	57.71	73.32	55.82	34.00	15.48	258.13
CD (0.05)	6.51	7.42	2.41	NS	NS	NS	14.55
Cultivars							
CO3	36.98	57.99	64.09	60.52	35.68	14.76	270.04
CO(CN)4	35.38	73.03	87.89	60.70	40.49	14.27	311.77
KKM-1	32.31	76.78	89.29	61.26	40.89	15.51	316.04
Suguna	21.93	63.73	73.70	56.71	29.57	15.43	261.08
Supriya	29.21	68.75	71.63	55.07	30.66	15.65	270.97
IGFRI-3	21.30	51.53	63.14	44.09	20.19	12.97	213.22
DHN-6	35.97	73.58	72.50	52.41	35.66	13.18	283.31
CO2	32.07	72.25	85.05	51.09	37.79	17.66	295.93
CD (0.05)	7.33	5.68	2.59	7.99	2.74	2.7	13.20
Interaction	NS	NS	NS	NS	NS	NS	NS

Table 17. Effect of treatments on dry matter yield (t/ha) of hybrid Napier at each harvest

Treatments	Stages of harvest						
	H1	H2	H3	H4	H5	H6	Total
Spacing							
60cmx60cm	7.97	16.30	15.93	11.70	7.00	3.34	62.24
90cmx60cm	6.34	13.92	15.29	10.68	6.79	3.05	56.07
90cmx90cm	4.48	12.12	14.74	11.47	6.97	3.39	53.15
CD (0.05)	1.377	2.16	0.40	NS	NS	NS	3.25
Cultivars							
CO3	7.54	12.18	12.79	12.30	7.41	3.08	55.30
CO(CN)4	7.25	15.34	17.77	12.45	8.22	3.04	64.07
KKM-1	6.45	16.12	17.88	12.23	8.36	3.19	64.24
Suguna	4.44	13.38	14.72	11.56	5.95	3.55	53.60
Supriya	6.07	14.44	14.56	11.35	6.20	3.62	56.23
IGFRI-3	4.40	10.82	12.82	9.12	4.11	3.17	44.45
DHN-6	7.33	15.45	14.63	10.67	7.47	2.67	58.23
CO2	6.60	15.17	17.39	10.58	7.66	3.69	61.10
CD (0.05)	1.38	1.18	0.72	1.68	0.63	0.62	2.91
Interaction	NS	NS	NS	NS	NS	NS	NS

There were significant differences in dry matter yield under different spacings in first second and third harvest. During the first harvest, the highest yield was obtained at lowest spacing of 60cm x 60cm. During second harvest also, the highest yield was recorded at the lowest spacing of 60cm x 60cm. As the spacing between the plants increased, the dry fodder yield decreased and the lowest yield was obtained at the widest spacing of 90cm x 90cm. The total yield was also higher at 60cm x60cm spacing. The interactions between spacing and varieties were also nil.

4.4. Nutritive value and quality

4.4.1. Crude protein

The data on crude protein content of hybrid Napier cultivars are given in Tables 18 and 19. Crude protein content of leaves ranged from 11.23 per cent (CO2) to 13.83 per cent (CO(CN)4) and the crude protein content of stem varied from 6.14 per cent (CO2) to 8.4 per cent (CO(CN)4). There were significant differences between the cultivars with respect to crude protein content. All the cultivars except CO2 were high in crude protein. CO(CN)4 had the highest amount of crude protein and was on par with CO3, KKM-1, Suguna, Supriya, IGFRI-3 and DHN-6. Spacing did not affect the crude protein content. Interaction between cultivars and spacing also showed no significant differences.

4.4.2. Crude fibre

The data pertaining to crude fibre content of hybrid Napier grass is given in Tables 18 and 19. The crude fibre content of hybrid Napier leaves ranged from 27.56 per cent (CO(CN)4) to 32.73 per cent (CO2) and crude fibre content of stem varied from 32.53 per cent (CO(CN)4) to 37.68 per cent (CO2). No significant differences were noticed among different cultivars in crude fibre content. The spacing did not affect the crude fibre content. Interaction between cultivars and spacing also did not show any significant variation.

4.4.3. Crude fat

Crude fat content of hybrid Napier grass is given in Tables 18 and 19. The crude fat content of hybrid Napier leaves ranges from 2.66 per cent to 2.82 per cent and the fat content of stem varied from 1.79 per cent to 1.87 per cent. No significant difference was noticed among the different cultivars regarding crude fat content. Spacing also did not affect the crude fat content. Interaction between varieties and spacing also showed no significant differences.

4.4.4. Total ash

The data regarding the total ash content are given in Tables 18 and 19. The total ash content of hybrid Napier leaves ranged from 11.62 per cent to 13.07 per cent and that of stem varied from 12.30 per cent to 13.90 per cent. Total ash content showed no significant differences between different cultivars. Spacing also did not affect the ash content. Interaction between cultivars and spacing was also nil.

4.4.5. Nitrogen free extract

The nitrogen free extract of hybrid Napier grass is given in Tables 18 and 19. The NFE of hybrid Napier leaves ranged from 41.33 per cent to 44.82 per cent and that of stem varied from 42.14 per cent to 45.22 per cent. No significant differences were noticed among the cultivars regarding NFE. The NFE content of hybrid Napier did not get affected by spacing or due to interaction between spacing and cultivars.

4.5. Major nutrient elements

4.5.1. Nitrogen

Nitrogen content of hybrid Napier grass is given in Tables 20 and 21. The

Table 18. Proximate analysis of hybrid Napier leaves (%)

Treatments	Crude protein	Crude fibre	Ether extract	Nitrogen free extract	Total ash
Spacing					
60cmx60cm	13.15	28.58	2.708	43.91	12.70
90cmx60cm	13.23	28.96	2.785	43.38	12.68
90cmx90cm	13.27	29.40	2.828	43.18	12.36
CD (0.05)	NS	NS	NS	NS	NS
Cultivars					
CO3	13.60	28.16	2.80	44.82	11.62
CO(CN)4	13.83	27.56	2.80	43.74	13.07
KKM-1	13.51	30.54	2.78	41.57	12.80
Suguna	13.65	28.32	2.76	43.90	12.46
Supriya	13.44	28.35	2.82	43.97	12.41
IGFRI-3	13.15	28.33	2.79	44.15	12.58
DHN-6	13.30	27.85	2.78	44.42	12.64
CO2	11.23	32.73	2.66	41.33	13.05
CD (0.05)	0.73	NS	NS	NS	NS
Interaction	NS	NS	NS	NS	NS

Table 19. Proximate analysis of hybrid Napier stem (%)

Treatments	Crude protein	Crude fibre	Ether extract	Nitrogen free extract	Total ash
Spacing					
60cmx60cm	7.72	33.54	1.76	44.13	13.19
90cmx60cm	7.81	33.91	1.84	44.05	12.73
90cmx90cm	7.84	34.36	1.88	43.94	12.33
CD (0.05)	NS	NS	NS	NS	NS
Cultivars					
CO3	8.17	33.12	1.85	44.87	12.30
CO(CN)4	8.40	32.52	1.85	44.46	13.07
KKM-1	7.87	35.50	1.83	41.19	13.90
Suguna	8.14	33.28	1.81	44.62	12.46
Supriya	8.01	33.31	1.87	44.73	12.37
IGFRI-3	7.72	33.29	1.84	45.07	12.38
DHN-6	7.87	32.81	1.83	45.23	12.55
CO2	6.14	37.68	1.71	42.14	12.96
CD (0.05)	0.79	NS	NS	NS	NS
Interaction	NS	NS	NS	NS	NS

nitrogen content of hybrid Napier leaves ranged from 1.80 per cent to 2.21 per cent and that of stem ranged from 0.98 per cent to 1.34 per cent. There were significant differences between the cultivars with respect to nitrogen content. All the cultivars except CO2 were high in nitrogen. CO(CN)4 had the highest amount of crude protein and was on par with CO3, KKM-1, Suguna, Supriya, IGFRI-3 and DHN-6. Spacing did not affect the nitrogen content. Interaction between cultivars and spacing also showed no significant differences.

4.5.2. Phosphorus

Phosphorus content of hybrid Napier grass is given in Tables 20 and 21. The phosphorus content of hybrid Napier leaves ranged from 0.17 per cent to 0.20 per cent and that of stem ranged from 0.16 per cent to 0.20 per cent. The data on phosphorus content did not differ between the cultivars and spacing. The interaction between cultivars and spacing was also not significant.

4.5.3. Potassium

The data on potassium content are given in Tables 20 and 21. Potassium content of hybrid Napier leaves ranged from 1.64 per cent to 2.14 per cent and that of stem varied from 1.75 per cent to 2.03 per cent. Potassium content of hybrid Napier showed no significant differences between cultivars and spacing. The interaction between cultivars and spacing was also not significant.

4.5.4. Calcium

The data regarding calcium content of hybrid Napier grass are given in Tables 20 and 21. Calcium content of hybrid Napier leaves and stem ranged from 0.42 per cent to 0.43 per cent. No significant differences were observed in calcium content between cultivars and spacings. Interaction between varieties and spacing also showed no significant differences.

Table 20. Major nutrient elements of hybrid Napier leaves (%)

Treatments	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium
Spacing					
60cmx60cm	2.10	0.19	1.97	0.43	0.49
90cmx60cm	2.12	0.18	1.91	0.43	0.51
90cmx90cm	2.12	0.18	1.94	0.43	0.49
CD (0.05)	NS	NS	NS	NS	NS
Cultivars					
CO3	2.18	0.19	1.99	0.42	0.49
CO(CN)4	2.21	0.17	1.97	0.43	0.50
KKM-1	2.16	0.18	1.96	0.43	0.49
Suguna	2.18	0.19	2.14	0.43	0.48
Supriya	2.15	0.18	1.64	0.42	0.48
IGFRI-3	2.10	0.20	2.10	0.42	0.50
DHN-6	2.13	0.18	1.85	0.43	0.49
CO2	1.80	0.19	1.88	0.43	0.54
CD (0.05)	0.18	NS	NS	NS	NS
Interaction	NS	NS	NS	NS	NS

Table 21. Major nutrient elements of hybrid Napier stem (%)

Treatments	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium
Spacing					
60cmx60cm	1.24	0.18	1.84	0.42	0.49
90cmx60cm	1.25	0.18	2.02	0.42	0.49
90cmx90cm	1.25	0.17	1.89	0.42	0.49
CD (0.05)	NS	NS	NS	NS	NS
Cultivars					
CO3	1.31	0.17	2.02	0.42	0.48
CO(CN)4	1.34	0.16	2.03	0.42	0.49
KKM-1	1.26	0.18	1.75	0.42	0.48
Suguna	1.30	0.18	2.00	0.43	0.49
Supriya	1.28	0.17	1.79	0.42	0.48
IGFRI-3	1.23	0.20	1.84	0.42	0.48
DHN-6	1.26	0.17	1.96	0.42	0.49
CO2	0.98	0.18	1.97	0.42	0.48
CD (0.05)	0.13	NS	NS	NS	NS
Interaction	NS	NS	NS	NS	NS

4.5.5. Magnesium

The data on magnesium content are given in Tables 20 and 21. Magnesium content of hybrid Napier leaves varied from per cent 0.48 to 0.54 per cent and that of stem varied from 0.48 per cent 0.49 to per cent. Magnesium also did not differ significantly between cultivars, and spacings. Interaction between varieties and spacing also showed no significant differences.

4.6. Oxalate content

The data on oxalate content of hybrid Napier grass are given in Table 22. Oxalate content of hybrid Napier leaves ranged from 2.84 per cent to 4.19 per cent and stem varied from 1.19 per cent to 2.21 per cent. The cultivars differed significantly with regard to oxalate content. The highest oxalate content was observed in CO2 and IGFRI-3. The lowest oxalate content was observed in DHN-6. Spacing did not affect the oxalate content. Interaction between varieties and spacing also showed no significant differences.

4.7. Nutrient uptake

The nutrient uptake by plants was calculated during third harvest as a representative stage of harvest and presented in Table 23. Regarding the uptake of nitrogen, there were significant differences between cultivars and CO(CN)4 and KKM-1 had maximum uptake of nitrogen which were on par. Regarding phosphorus uptake, there was no variation among cultivars as well as among spacing. Potassium uptake varied between different cultivars. CO(CN)4 had maximum uptake of potassium while KKM-1 and CO2 were on par. Regarding calcium uptake, there was variation between cultivars and spacing. Calcium uptake was found to be higher at closer spacing of 60cm x 60cm. Among cultivars, KKM-1 had the highest uptake. However, CO(CN)4 and CO2 were on

Table 22. Effect of treatments on oxalate content (%) of hybrid Napier

Treatments	Oxalate content of leaves	Oxalate content of stem
Spacing		
60cmx60cm	3.64	1.75
90cmx60cm	3.61	1.72
90cmx90cm	3.67	1.78
CD (0.05)	NS	NS
Cultivars		
CO3	3.83	1.85
CO(CN)4	3.70	1.72
KKM-1	3.09	1.45
Suguna	3.67	1.69
Supriya	3.66	1.68
IGFRI-3	4.17	2.20
DHN-6	2.84	1.20
CO2	4.19	2.21
CD (0.05)	0.33	0.34
Interaction	NS	NS

Table 23. Nutrient uptake of hybrid Napier grass at third harvest (kg/ha)

Treatments	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium
Spacing					
60cmx60cm	254.07	29.54	302.30	67.38	78.05
90cmx60cm	245.90	27.68	301.91	64.52	76.21
90cmx90cm	238.03	25.88	280.79	62.42	72.36
CD (0.05)	NS	NS	NS	0.94	NS
Cultivars					
CO3	212.94	22.76	256.17	53.75	62.44
CO(CN)4	303.42	29.89	355.08	75.26	87.60
KKM-1	291.75	32.63	328.80	75.66	87.03
Suguna	244.71	26.87	302.84	62.83	71.86
Supriya	238.97	26.09	249.82	61.37	71.30
IGFRI-3	211.76	25.46	251.49	54.00	63.08
DHN-6	237.73	25.60	279.28	61.64	71.78
CO2	226.72	32.31	336.57	73.67	89.26
CD (0.05)	21.60	NS	37.90	3.33	5.32
Interaction	NS	NS	NS	NS	NS

par. Magnesium uptake was also found to be higher for CO2, whereas KKM-1 and CO(CN)4 were on par.

4.8. Benefit cost analysis

The cost of cultivation of hybrid Napier was calculated for the first year under experimental condition. The cost was calculated based on the prevailing wages and market rate and given in Appendix II. The returns were calculated at the rate of Rs.1.5/kg of green fodder. The benefit: cost ratio was worked out separately for each cultivar and spacing as presented in Table 24. Among the cultivars, KKM-1 showed the highest B: C ratio (2.93) and B: C ratio of 2.66 was obtained due to adoption of 60cm x 60cm spacing.

Table 24. Benefit cost analysis

Treatments	Cost (Rs./ha)	Gross returns (Rs./ha)	Net Returns (Rs./ha)	B:C Ratio
Spacing				
60cmx60cm	1,69,925	4,51,740	2,81,815	2.66
90cmx60cm	1,59,857	4,11,150	2,51,293	2.57
90cmx90cm	1,56,375	3,87,195	2,30,820	2.48
Cultivars				
CO3	1,62,052	4,05,060	2,43,008	2.50
CO(CN)4	1,62,052	4,67,655	3,05,603	2.89
KKM-1	1,62,052	4,74,060	3,12,008	2.93
Suguna	1,62,052	3,91,620	2,29,568	2.42
Supriya	1,62,052	4,06,455	2,44,403	2.51
IGFRI-3	1,62,052	3,19,830	1,57,778	1.97
DHN-6	1,62,052	4,24,965	2,62,913	2.62
CO2	1,62,052	4,43,895	2,81,843	2.74

Discussion

5. DISCUSSION

An experiments was conducted at Research farm, College of Horticulture, Vellanikkara during 2009-2010 to obtain information on growth, fodder production potential and nutritive value of some promising hybrid Napier cultivars under three different spacings. The results obtained from the experiment are discussed based on available literature.

5.1. Growth analysis

The experiment was laid out during December, 2009 and the planting was done on 26.12.2009. Plant growth increased with time and varied according to the environmental conditions. Initially, the plant growth was at a slow rate and later all the cultivars established well and started showing proportionate increase in growth.

Plant height in different hybrid Napier cultivars varied from 141.30 cm to 185.38 cm. Maximum plant height was attained during June to August period after the onset of monsoon. During the initial stages (January- April), the grasses exhibited slow growth due to difficulty in establishment and high atmospheric temperature.

Plant height is a varietal character which is genetic and may be modified by the environment. It is seen from the Table 3 that the cultivars differed significantly in height. During the initial stages, KKM-1 showed maximum plant height but later CO2 showed dominance in plant height. The average height was comparatively higher for cultivars KKM-1, CO(CN)4, CO2 and DHN-6. IGFRI-3 had minimum plant height. Since it is a varietal character, the varieties under investigation gave different values as depicted in Fig.4. In an experiment conducted at Tamil Nadu Agricultural University (TNAU), Coimbatore,

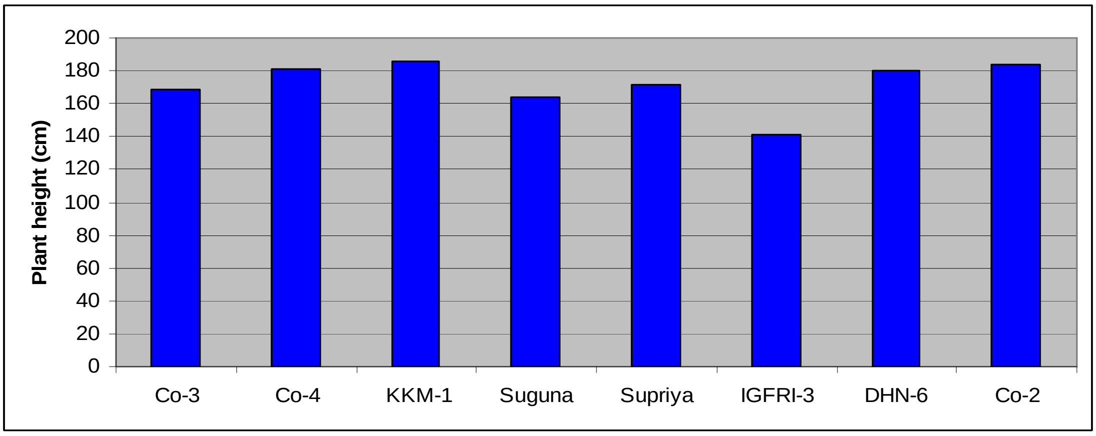


Fig. 4. Average plant height of hybrid Napier cultivars

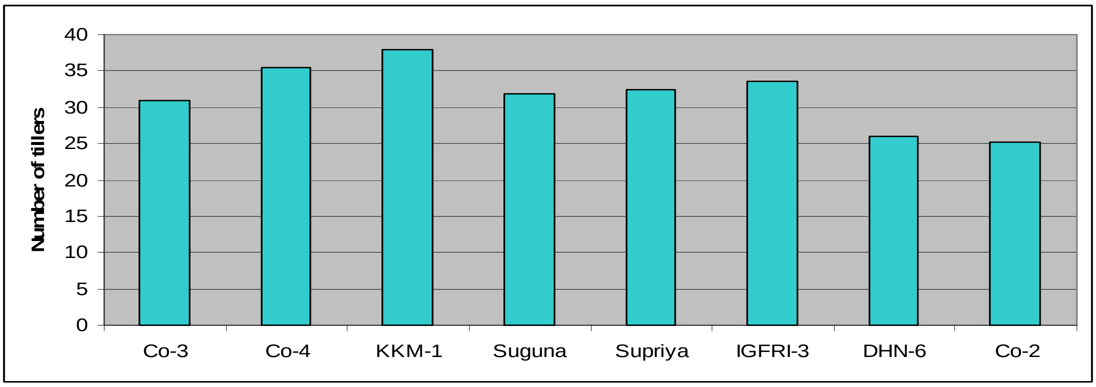


Fig. 5. Average number of tillers in hybrid Napier cultivars

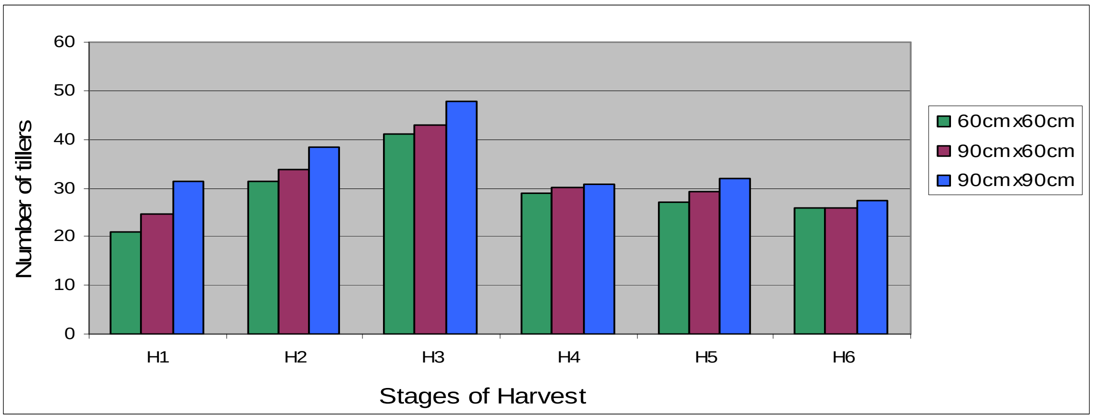


Fig. 6. Number tillers per clump of hybrid Napier cultivars under different spacing

Vijayakumar *et al*. (2009) observed that hybrid Napier cultivar CO(CN)4 can grow upto 4-5 m height at flowering stage.

Spacing did not have any significant influence on plant height. Results of the studies conducted at TNAU, Coimbatore by Velayudham *et al*. (2011) also revealed that spacing did not influence the plant height in hybrid Napier cultivar CO(CN)4.

Average number of tillers in hybrid Napier cultivars varied from 25.26 to 38. The results showed that maximum tillering was attained during the third harvest (June). Optimum temperature and enough sunlight during May with the receipt of rainfall during June might have favoured high tillering. According to Gardner *et al*. (1985), tillering is highly influenced by factors such as light, temperature, spacing, moisture and nitrogen supply. During the initial stages (January- April), the rate of tillering was less. This was probably due to the stress during establishment and high temperature that prevailed during this period. The results presented in Table 4 and Fig. 5 showed that KKM-1 produced maximum tillers followed by CO(CN)4 and IGFRI-3. Tiller production is also a varietal character. The genetic control of axillary branching was reported in cereals such as rice, wheat, and oats by Gardner *et al*. (1985). Vijayakumar *et al*. (2009) has reported that CO(CN)4 is a non lodging grass with profuse tillers (30-40 tillers/clump). Pandey and Roy (2011) has reported that IGFRI-3 is a profuse tillering type, erect with narrow upright leaves with quick regeneration ability and having thin stem similar to guinea grass. During the initial stages, KKM-1 produced higher number of tillers and later other cultivars started dominating KKM-1, which shows that KKM-1 is having capacity for early sprouting and easy establishment than other cultivars.

Production of tillers was higher at wider spacing of 90cm x 90cm compared to closer spacing of 90cm x 60cm and 60cm x 60cm as depicted in Fig. 6. During the initial stages, wider spacing reduced plant competition for space and hence plants could utilise the resources more effectively which resulted in higher tiller production. The wider feeding area provided by planting at 90cm x 90cm gave an opportunity for greater root growth, increased availability of nutrients and greater accessibility of nutrients to plant with reduced plant to plant competition. This is because plants grown with wider spacing have more area of land to draw the nutrients and compensate for the low nutrient level of the soil. The plants also were exposed to more solar radiation which encouraged tiller production. During the later stages of the experiment, it was observed that spacing did not influence tillering.

According to Gardner *et al.* (1985) plant density is an overriding factor in axillary shoot development. Influence of spacing in tiller development has been reported by many workers in various crops. Krishna and Biradarpatil (2009) reported that wider spacing of 40cm x 40cm produced significantly higher number of productive tillers in rice compared to closer spacing of 20cm x 20cm and 30cm x 30cm. According to Jimba and Adedeji (2003) individual plants fare better at wider spacing, but closer spacing produces higher number of tillers per unit area in vetever grass. In an experiment conducted at Nigeria, regarding the effect of plant spacing on growth and yield of rice at three different spacing of 10cm x 10cm, 20cm x 20cm and 30cm x 30cm, Ogbodo *et al*. (2010) has observed that tiller production was significantly higher at a spacing of 30cm x 30cm compared to closer spacings of 20cm x 20cm and 10cm x 10cm. Similar results were obtained by Baloch *et al*. (2002) and Channbasappa and Prabhakar (2003).

Leaf production was found to be the maximum in CO2. Number of leaves was found to be higher during June (Table 8). Higher number of leaves per tiller obtained during June to August period may be because of the favourable effect of physiological and environmental factors on plant growth. It could be observed that the number of laves decreased towards the end of the experimental period (November-December). This can be attributed to the high relative humidity and low temperature prevailed during this period. Leaf length also showed similar trend as that of leaf number. The leaf length as given in Table 9 was high during the initial stages, upto June-August and then declined towards the end of the experiment. Suguna, CO3, Supriya and KKM-1 had higher leaf length. Leaf width was found to be higher for CO2 as given in Table 10. Grardner *et al.* (1985) has reported that leaf number and size in plants are characters which are affected by genotype and environment. Since leaf length and width are varietal characters, the variation in length and width of hybrid Napier varieties under investigation can be attributed to the genetic make up of the plants.

The number and size of leaves did not show any significant difference with respect to spacing. All the cultivars performed alike under all the spacing with respect to leaf production. Spacing trial conducted by Bhatti *et al.* (1985) in Napier grass also showed similar results that spacing did not affect leaf production reinforcing the contention that leaf production in plants is a more genetically determined character.

Average leaf area index (LAI) in hybrid Napier varied from 7.49 to 7.74 between the cultivars. LAI was low during the initial stages, and increased during the third harvest and again decreased towards the end of the year. This can be due to the reduction in the leaf number and leaf area during this period. Yao *et al*. (1990) have observed that the rapid increase in LAI of rice at 40-50 days after planting and reduced LAI during dry period. Rapid increase in LAI during June to August was associated with stem elongation that coincided with good rainy period. The higher LAI for KKM-1 can be attributed to higher number of leaves and leaf length of KKM-1 (Table 11). Leaf area index was found to be higher at closer spacing of 60cm x 60cm compared to wider spacings of 90cm x 60cm and 90cm x 90cm as depicted in Fig.7. Results obtained by Macalinga, *et al.* (1997) in rice has shown that, among the four spacings tried (10cm x 20cm, 15cm x 15cm, 15cm x 20cm, 20cm x 20cm) there was an increase in LAI under close spacing of 10cm x 20cm in the irrigated low land rice during wet season. A field study conducted by Yao *et al*. (1990) at Southern Ivory Coast with two upland rice varieties

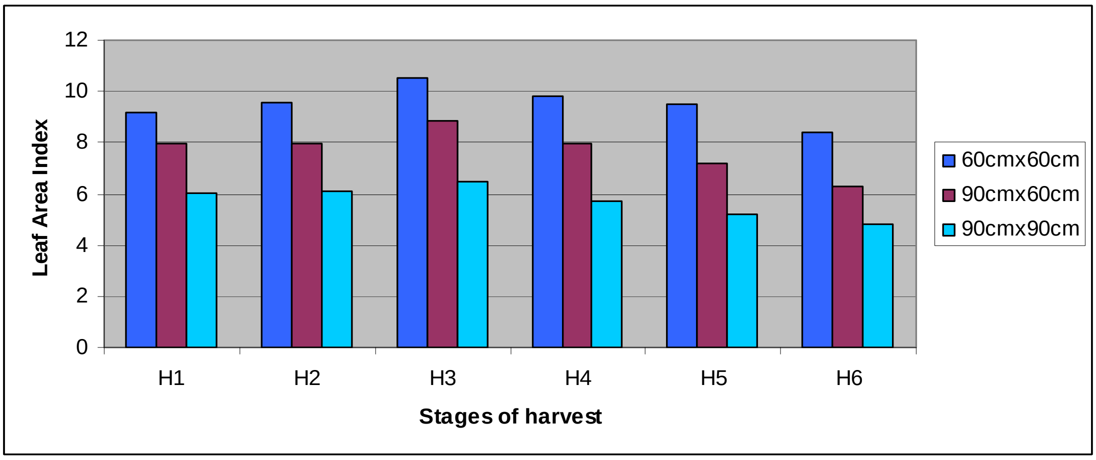


Fig. 7. Leaf Area Index of hybrid Napier at different spacing

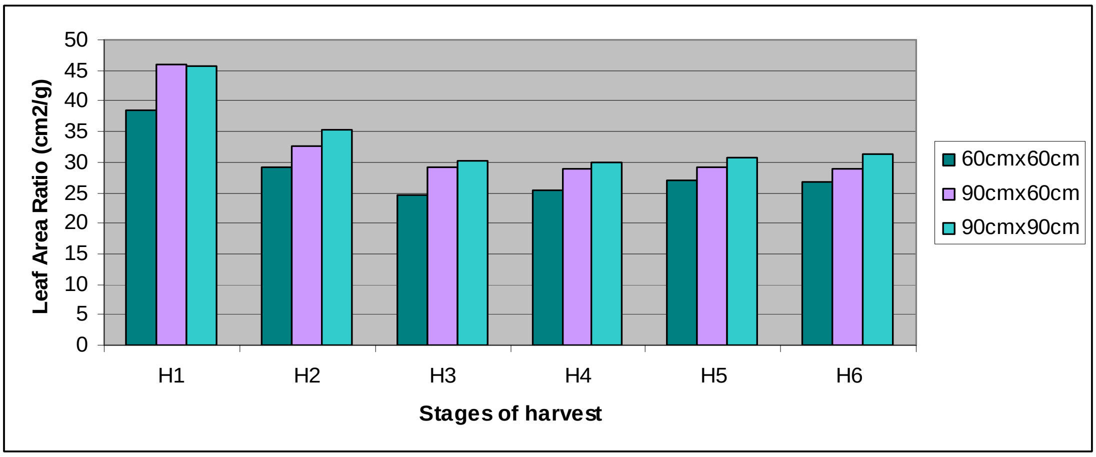


Fig. 8. Leaf Area ratio of hybrid Napier at different spacing

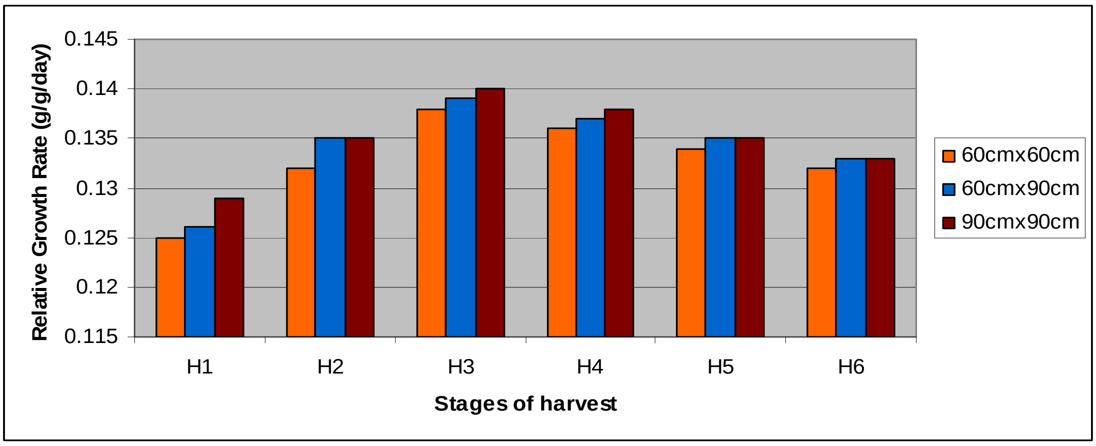


Fig. 9. Relative growth rate of hybrid Napier at different spacing

under two planting densities has revealed that LAI was significantly higher at high plant density treatments compared to that of the low density. This confirms the finding of the present study where higher LAI was observed in all eight hybrid Napier cultivars at a closer spacing of 60cm x 60cm compared to wider spacings of 90cm x 60cm and 90cm x90cm.

Leaf area ratio (LAR) is a measure of relative leafiness of a plant. In hybrid Napier, average LAR ranged from 30.69 to 35.82 g/cm^2 as given in Table 12 and graphically represented in Fig. 8. LAR of all the cultivars was high during the initial months and showed decreasing trend throughout the experiment due to decrease in the relative leafiness with age of the grass. Among the three different spacings tried, LAR was higher at widest spacing of 90cm x 90cm than closer spacing. This can be attributed to the higher leaf area under wider spacing. Leaf area ratio was found to be higher for IGFRI-3 compared to other cultivars during all the stages. The thin stem and high leaf stem ratio might have contributed to higher leaf area and lower plant dry weight which ultimately resulted in higher LAR. Pandey and Roy (2011) have reported that IGFRI-3 is characterised with thin stems similar to guinea grass.

Leaf: stem ratio of hybrid Napier cultivars remained almost unchanged till the end of the experiment (Table 13). The average leaf: stem ratio ranged from 0.66 (CO2) to 0.92 (IGFRI-3). The highest leaf stem ratio was observed for IGFRI-3. This is due to the fact that, IGFRI-3 is characterised by thin stem and numerous number of leaves. Pandey and Roy (2011) have reported that IGFRI-3 is characterised with thin stem like guinea grass. The average leaf: stem ratio of CO3 and CO(CN)4 was found to be 0.7 and 0.718. Vijayakumar *et al*. (2009) reported that in station trial conducted at TNAU, Coimbatore, leaf: stem ratio of hybrid Napier cultivar CO(CN)4 was found to be 0.71 which was higher than that of CO3 (0.6). Relative growth rate (RGR) is the dry weight increase during a time interval in relation to its initial weight. From the RGR values presented in Table 14 and Fig. 9, it could be inferred that all the cultivars showed low RGR values during the initial summer period and then again started showing higher RGR values in rainy season which declined during October – December months. According to Gardner *et al*. (1985) RGR of crop plants begin slowly just after germination, peaks rapidly soon afterwards and then falls off. According to Tesar (1984), RGR decreases with plant age and the structural development may not contribute to metabolically active tissue and as such does not contribute to growth. In all the cultivars, the rapid increase in plant height and plant dry weight coinciding with good rainy period during the month of June resulted in high RGR values. CO3, CO(CN)4 and KKM-1 exhibited higher relative growth rate than other cultivars. This may be attributed to higher plant height and higher number of tillers produced by these cultivars which ultimately resulted in higher plant dry weight. IGFRI-3 had the lowest RGR because of thin stem, lower plant height, and dry weight.

The growth rate of all the cultivars was higher at wider spacing of 90cm x 90cm compared to closer spacing during early growth stages. This variation was not observed during the later stages. The plants at wider spacing were exposed to more solar radiation which encouraged enhanced photosynthetic process. This situation definitely increased uptake of nutrients by the grasses and resulted in better growth during early stages. But later due to continuous harvesting, the plants under all the three spacing exhibited a reduced, uniform growth rate. According to Tesar (1989), competition for water nutrients and light may cause reduction in growth rate when plants in crop stand become larger. The findings of Yao *et al*. (1990) in rice under two planting densities were also in accordance with the above result that low plant density favoured high relative growth rates throughout the growing season.

Net assimilation rate (NAR) is a measure of the average photosynthetic efficiency of leaves. It is the net gain of assimilate or dry matter accumulation per unit leaf area per unit time. In hybrid Napier, NAR varied from 5.02 to 5.94 $g/m^2/day$. Gardner *et al*. (1985) suggested that as the plant grows and LAI increases, more and more leaves become shaded, causing a decrease in NAR as the growing season progress. The NAR of hybrid Napier cultivars tried in the present experiment are giver in Table 15 and graphically represented in Fig. 10. It could be seen from the data that NAR was high during the rainy season due to rapid accumulation of dry matter in these stages. During summer, all the cultivars showed decline in NAR due to senescence of leaves. By the receipt of rains, NAR improved due to vigorous growth of the plant. A study conducted by Cooper (1967) regarding the effects of shading and time of the year on NAR of young glasshouse tomato plants, has shown that NAR was the minimum during mid December and maximum during early July. The results of the present study are in confirmity with the above findings.

Among the cultivars, NAR was found comparatively higher for KKM-1. This can be attributed to the higher leaf area and RGR of KKM-1. Higher NAR was observed under low plant density treatments during the initial stages of the experiment, but towards the end of the experimental period, the variation in NAR with respect to spacing was not significant. A field study conducted by Yao *et al.* (1990) at Southern Ivory Coast with two upland rice varieties under two planting densities has shown that low plant density was favourable to net assimilation and relative growth rates throughout the growing season and NAR declined very rapidly during the dry period.

5.2. Fodder production

The data on green fodder and dry fodder production for one year from planting till the end of the experimental period is given in Tables 16 and 17. It indicates a clear yield advantage for KKM-1 and CO(CN)4 than other cultivars. Higher yields of KKM-1 and CO(CN)4 may be attributed to higher plant height, number of tillers, leaf length, leaf area index, relative growth rate and net assimilation rate. It is generally accepted that the rate of fodder production is a

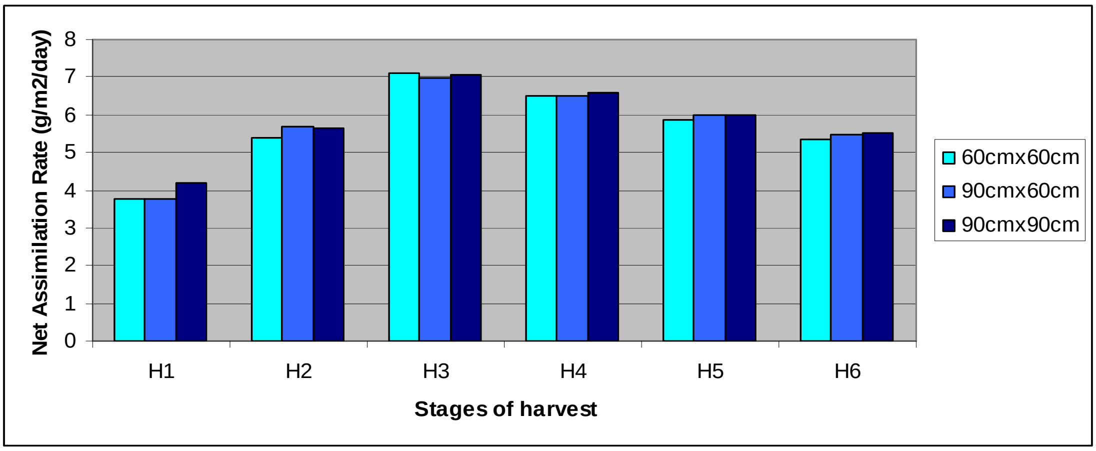


Fig. 10. Net assimilation rate of hybrid Napier at different spacing

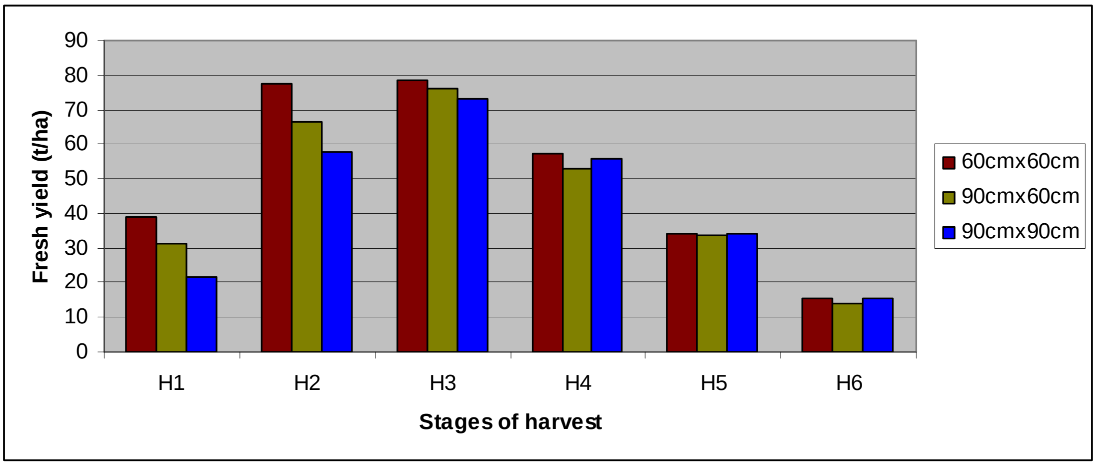


Fig. 11. Yield of hybrid Napier at different spacing

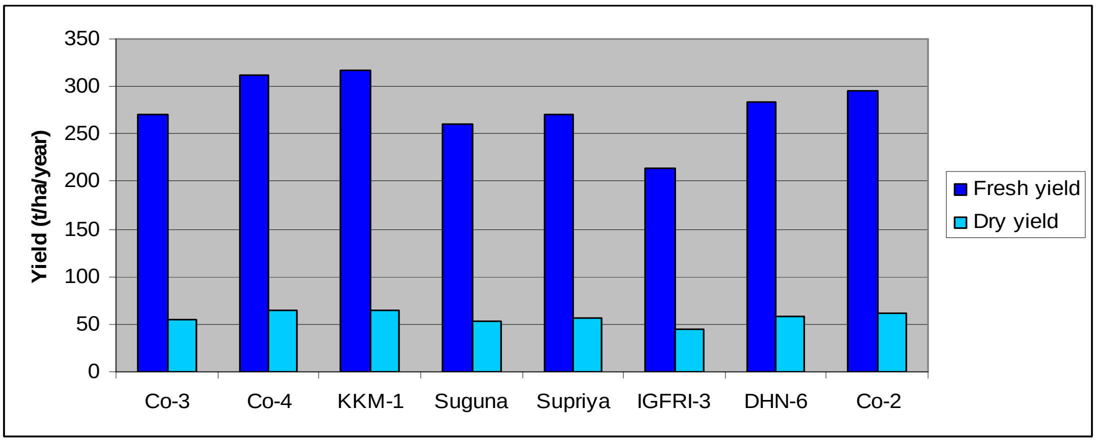


Fig. 12. Total yield of hybrid Napier cultivars

function of tiller production and leaf growth (Ryle, 1970 ; Barbbar, 1985; Selvi and Subramanian, 1993). Singh *et al*. (1995) has observed that, leafiness measured by leaf number and leaf area per plant is the most important parameter indicative of yield.

As depicted in Fig 12, the highest green fodder yield was recorded by KKM-1 (316.04 t/ha/year) and CO(CN)4 (311.70 t/ha/year) which were on par. Vijayakumar *et al*. (2009) has reported that under the trial conducted at TNAU, Coimbatore, CO(CN)4 gave a mean green fodder yield of 382 t/ha/year. Das *et al*. (2000) has reported that KKM-1 recorded an average green fodder yield of 288 t/ha/year in station trials at Killikulam. It seems that the performance of KKM-1 is better in Vellanikkara condition than Killikulam. The lowest yield was recorded by IGFRI-3 (213.92 t/ha/year). Pandey and Roy (2011) reported that IGFRI-3 is a cultivar suitable for central and north zone of the country and under north Indian condition it yielded 70-80 t/ha green fodder in a year. Faruqui *et al*. (2009) has reported that IGFRI-3 was having a green fodder potential of 90-160 t/ha. The results of the present study indicate that IGFRI-3 yield better under Kerala condition than north Indian condition. Taking fresh fodder yield into account, the cultivars can be ranked into four groups. As KKM-1 and CO(CN)4 are the best yielders, they can be ranked first. CO2 and DHN-6 are on par in fresh yield and can be ranked second. Supriya, CO3 and Suguna are third and IGFRI-3 comes fourth in yield.

Closer spacing of 60cm x 60cm was found to be better in yield compared to wider spacings of 90cm x 60cm and 90cm x 90cm as depicted in Fig.11. Under closer spacing, the number of plants per unit area increased and hence yield also increased. Willey and Heath (1969) observed that at higher population levels, total dry matter production generally increased. Studies conducted by Munegowda *et al.* (1989) on fertilizer and spacing of hybrid Napier variety BH-18 has shown that the highest yield was realised in all fertilizer levels at closer spacing of 60 x30 cm.

They also observed a progressive decrease in yield with increase in spacing to 75cm x 45cm, 100cm x 60cm and 120cm x 90cm. Velayudham *et al.* (2011) studied the impact of spacing on the performance of bajra Napier hybrid which revealed that adoption of lower spacing of 60cm x 50cm and 75cm x 50cm had enhanced the number of tillers per clump and the yield. Bhatti *et al*. (1985) also confirmed the above findings that closer spacing of 50cm x 50cm significantly produced higher dry matter yield in Napier grass than wider spacing. All these results confirmed that the plant population per unit area is a factor that contributes to final biomass production.

5.3. Nutritive value and quality

Palatability and nutritive value of roughages fed to cattle plays an important role in deciding animal production. It is essential to provide animals with forages having good palatability and high nutritive value. Nutrient composition of different cultivars of hybrid Napier was determined from samples taken at six months after planting. The protein content in the forage is expressed as crude protein which gives an approximate value of the protein content. The crude protein content of hybrid Napier leaves ranged from 11.23 per cent to 13.83 per cent and that of stem varied from 6.14 per cent to 8.40 per cent. Pandey and Roy (2011) reported that hybrid Napier grass contain an average crude protein content of 10.2 per cent. Fernandes *et al.* (2007) reported that, during rainy season, hybrid Napier grass contain an average crude protein content of 9.91 per cent. Significant difference in nitrogen and hence in crude protein content was observed among the cultivars, in the present study. Among the cultivars, CO(CN)4 was found superior in terms of crude protein (13.83 and 8.40 percent respectively in leaf and stem) while most of the other cultivars, except CO2 were on par. Vijayakumar *et al*. (2009) reported that in a station trial conducted at TNAU, hybrid Napier cultivar CO(CN)4 has got an average crude protein content of 10.71 per cent. The above result corroborate with the findings of the present study.

There were not much differences between hybrid Napier cultivars with regard to crude fibre content. In the present experiment, the crude fibre content of hybrid Napier leaves ranged from 27.56 per cent to 32.73 per cent and that of stem from 32.53 per cent to 37.68 per cent. Pandey and Roy (2011) reported that hybrid Napier grass contain an average crude fibre content of 30.5 per cent.

Ether extract, nitrogen free extract and ash content in the grass did not show any remarkable variation between different cultivars. Ether extract gives an estimate of crude fat content in the feed. Nitrogen free extract represents the digestable carbohydrates present in the feed. Ash content gives total mineral content. The crude fat content of hybrid Napier leaves ranged from 2.66 per cent to 2.82 per cent and that of stem varied from 1.79 per cent to 1.87 per cent. The nitrogen free extract of hybrid Napier leaves ranged from 41.33 per cent to 44.82 per cent and that of stem varied from 42.14 per cent to 45.22 per cent. The total ash content of hybrid Napier leaves ranged from 11.62 per cent to 13.07 per cent and that of stem varied from 12.30 per cent to 13.90 per cent. Fernandes *et al.* (2007) reported that, during rainy season, hybrid Napier grass contain an average crude fat content of 2.68 per cent and total ash content of 14.11 per cent.

Phosphorus and potassium content of hybrid Napier grass was similar in all the cultivars. Calcium and magnesium content also showed no significant difference between the cultivars. The oxalate content of hybrid Napier leaves ranged from 2.84 per cent to 4.19 per cent and stem varied from 1.20 per cent to 2.21 per cent. Fernandes *et al.* (2007) reported that, during rainy season, hybrid Napier grass contain high nutrient composition compared to winter and summer season and exhibit an average oxalate percentage of 3.07. Kaur *et al.* (2009) has reported that the hybrid Napier leaf exhibit significantly higher concentration of oxalate (3.8 per cent) compared to stem (1.95 per cent). Oxalate content significantly differed between cultivars and it was found to be more in CO2 and IGFRI-3.The least oxalate content was recorded in DHN-6, which is a favourable character from nutritional point of view. High oxalate content of forage is harmful to animal health and it will adversely affect calcium uptake in animals. Hence cultivar with less oxalate content is more preferable.

The results on nutrient composition of the herbage in different cultivars of hybrid Napier grass showed that there are significant differences in crude protein and oxalate content among the cultivars. Regarding other nutritional parameters the differences in value was quite narrow.

5.4. Nutrient uptake

Regarding the nutrient uptake from soil, KKM-1, CO(CN)4 and CO2 had higher rate of removal. The uptake of nutrients is primarily a function of total biomass production and nutrient content at cellular level. Among the three spacings, nutrient uptake by plants was found to be higher under closer spacing of 60cm x 60cm compared to wider spacings. Under closer spacing, the number of plants per unit area is higher and hence the higher rate of removal.

5. 5. Benefit cost analysis

The economic analysis of hybrid Napier cultivation during first year of crop growth was done separately for different spacings and different cultivars. It showed that adoption of 60cm x 60cm spacing is more economical than wider spacings. Among the cultivars tried, KKM-1 followed by CO(CN)4 was found to be more profitable as they gave higher yield and income than others.

The results of the present study has shown that hybrid Napier has high forage value as green fodder and holds greater promise for cultivation in the high rainfall areas as well as irrigated tracts of the country. Among the cultivars evaluated, KKM-1 and CO(CN)4 hold superior qualities with respect to high forage yield and crude protein content. Although the cultivars DHN-6 and CO2 are comparable in yield and ranked second, quality wise DHN-6 is better as shown by the lowest oxalate content, better leaf stem ratio and crude protein content. Therefore, along with KKM-1 and CO(CN)4, DHN-6 can also be recommended for Kerala under irrigated conditions.

Among the spacings tried, 60cm x 60cm was the ideal spacing for hybrid Napier cultivation under Kerala condition is for getting maximum fodder yield.

Summary

SUMMARY

Hybrid Napier is a fodder grass widely grown in Kerala. The present experiment was undertaken to have an understanding of the growth, fodder production potential and nutritive value of popular hybrid Napier cultivars under different spacing. The experiment was conducted at the Research Farm, Department of Agronomy, College of Horticulture, Vellanikkara during 2009-2010. The main objectives were to identify superior cultivars of hybrid Napier in terms of growth, yield and quality and to standardise optimum plant spacing for hybrid Napier.

Eight popular cultivars namely CO2, CO3, CO(CN)4, KKM-1, Suguna, Supriya, IGFRI-3 and DHN-6 were planted under three different spacing of 60cm x 60cm, 60cm x 90cm, and 90cm x 90cm. Totally six cuttings were taken during the period of one year at 50-55 days interval. Observations regarding biometric characters and growth indices were made at the time of each harvest. Nutrient compositions were also analysed at six months after planting. Comparisons were made between eight different cultivars of hybrid Napier under three different spacings.

Growth characteristics

In general, growth was comparatively fast during the rainy season. The cultivar KKM-1 attained maximum plant height and tillering immediately followed by CO(CN)4. Regarding the number of leaves, CO2 had the maximum number of leaves followed by CO(CN)4 and DHN-6. Suguna, Supriya, KKM-1 and CO(CN)4 exhibited higher leaf length. Leaf width was found to be higher for CO2 followed by DHN-6. IGFRI-3 showed high leaf stem: ratio as well as high leaf area ratio compared to other cultivars. Leaf area index (LAI) was high with respect to KKM-1 and CO(CN)4. Relative growth rate (RGR) and net assimilation rate (NAR) was higher for KKM-1. KKM-1 exhibited better plant growth with respect to plant height, number of tillers, leaf length, leaf area index, relative

growth rate and net assimilation rate. However in general, all the cultivars performed well were comparable with KKM-1.

Regarding spacing, number of tillers per plant was comparatively higher at wider spacing of 90cm x 90cm. Leaf area ratio and relative growth rate were also higher under lower plant densities. At the same time, leaf area index was higher at closer spacing of 60cm x 60cm. Other parameters such as plant height, number of leaves, leaf : stem ratio etc. were not significant with respect to spacing.

All the cultivars showed decline in growth during the initial and final three months of the year with respect to plant height, number of tillers, number of leaves per tiller, leaf length, leaf area index, relative growth rate and net assimilation rate. The impact of this was clearly reflected in yield also. Growth was better during the rainy period from June to August.

Fodder production potential

Fodder production potential of hybrid Napier cultivars, under three different spacing of 60cm x 60cm, 60cm x 90cm and 90cm x 90cm was compared by harvesting the herbage and assessing the dry matter production at 50-55 days interval, for a period of one year. The herbage production potential of all the cultivars tried was comparable with each other under the three different plant populations. Total yield was the highest for KKM-1 followed by CO(CN)4 and comparatively the least yield was obtained for IGFRI-3. The highest green fodder yield of 311.77 t/ha/year was recorded for KKM-1 followed by CO(CN)4 (311.77 t/ha/year) which were on par. The cultivars CO2 and DHN-6 can be ranked second based on yield. Supriya, CO3 and Suguna came third in fodder production and IGFRI-3, fourth with the lowest yield of 213.22 t/ha/year.

Between the different spacings tried, there were significant differences at the initial stages of the experiment. The growth was highly influenced by spacing as higher yield was recorded at a closer spacing of 60cm x 60cm. Later, the yield did not show any significant difference between different spacings. Considering annual fodder production, herbage and dry matter yields were higher at high plant density treatments.

A decline in growth was observed during summer months due to high moisture stress, whereas with the onset of monsoon, the grasses showed gradual increase in growth which had direct influence on yield. More fodder yield was obtained at third harvest for all the cultivars under all the plant densities.

Nutrient composition and uptake

Nutrient compositions like crude protein, crude fibre, ether extract, nitrogen free extract, total ash, phosphorus, potassium, calcium, magnesium, and oxalate content of all the cultivars were assessed at six months after planting. Generally, nutrient content showed no significant difference between the cultivars as well as spacings. However, crude protein and oxalate contents were found to show significant differences between the cultivars. CO(CN)4 had highest crude protein content while most of the other cultivars except CO2 were comparable with CO(CN)4. Oxalate content which is an anti nutritional factor, was found to be higher in CO2 and IGFRI-3 while the least oxalate content was recorded in DHN-6. Hence from nutritional point of view, the cultivar DHN-6 was found to be superior.

Regarding the nutrient uptake from soil, KKM-1, CO(CN)4 and CO2 had higher rate of removal. Among the three spacings, nutrient uptake by plants was higher under closer spacing of 60cm x 60cm compared to wider spacings.

Benefit cost analysis

The B:C ratio was more than one for of all the cultivars and spacings tried. This shows that hybrid Napier cultivation is a profitable enterprise which provide yield throughout the year. Cultivation of KKM-1 was found to be most economical for which the maximum B:C ratio could be obtained. Under the three spacings tried, closer spacing of 60cm x 60cm was found to be more profitable.

The results of the present study has shown the superiority of recently released hybrid Napier cultivars in fodder production. Among the cultivars evaluated, KKM-1 and CO(CN)4 ranked first with respect to high fresh and dry fodder yield and nutritional qualities. Although the cultivars DHN-6 and CO2 were comparable in yield and ranked second, quality wise DHN-6 was better as shown by the lowest oxalate content, better leaf: stem ratio and crude protein content. Therefore, along with KKM-1 and CO(CN)4, DHN-6 can also be recommended for Kerala under irrigated conditions. The spacing 60cm x 60cm was the ideal spacing for hybrid Napier cultivation under Kerala condition which gave the maximum green fodder and dry matter yield.

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APPENDIX-I

Monthly rainfall (mm), surface air temperature (^{0}C), Relative humidity (%) and sunshine hours (h/day) at COH, Vellanikkara from December 2009 to December 2010 (Latitude 10^{0}31' N, Longitude 76^{0}13' and Altitude 40.29 MSL)

Months	*Rainfall (mm)*	*Surface air Temperature (^{0}C)*		*Relative Humidity %*		*Mean wind speed (Km/hr)*	*Sunshine Hours (h/month)*
		Maximum	*Minimum*	*Morning*	*Evening*		
DEC	42.7	31.8	23.9	73	62	8.9	241.6
JAN	0	32.5	22.7	74	61	7.6	280.0
FEB	0	34.9	23.7	78	59	6	253.6
MAR	12.9	36.2	24.8	85	65	3.6	258.9
APRIL	103.6	35.1	25.2	89	73	3.6	221.7
MAY	128.8	33.1	25.6	91	79	3	166.5
JUNE	700.4	30.4	23.8	95	87	2.8	89.7
JULY	552	29.2	22.9	96	88	2	56.8
AUG	224.1	29.3	23.2	95	87	3	78.6
SEP	326.7	30.5	23.1	94	83	2.6	125.6
OCT	667.6	29.7	22.4	95	85	2.1	129.5
NOV	282.8	30.4	22.5	92	81	3.4	122.5
DEC	24.5	30.9	22.0	83	70	5	206.7

APPENDIX-II

Cost of cultivation of hybrid napier for one hectare

Particulars	Men @Rs. 255	Women @ Rs. 165	Quantity	Rate (Rs.)	Amount (Rs)
I. land preparation					
Land clearing	4	10			2,670
Tractor ploughing			5 hours	500/hr	2,500
Making ridges and furrow	12				3,060
Total					**8,230**
II. manures and fertilizers					
Farm yard manure			25 t	1000/t	25,000
Urea			200 kg	6/kg	1,200
Raj phos			50 kg	6/kg	300
Muriate of potash			50 kg	6/kg	300
Application - basal	4	8			2,340
Application – top dressing		8			1,320
Total					**30,460**
III. planting materials and planting					
60 x 60 cm		20	9260		24,135
90 x 60 cm		12	6175	0.75/slip	14,067
90 x 90 cm		08	4115		10,585
IV. Irrigation		24			3,960
V. Intercultivation					
Weeding		20			3,300
Digging & Raking (twice)	40				10,200
VI. Harvesting and loading (6 times)	72	432			89,640
Grand total	60 x 60 cm				**1,69,925**
	90 x 60 cm				**1,59,857**
	90 x 90 cm				**1,56,375**

EVALUATION OF PROMISING HYBRID NAPIER CULTIVARS UNDER VARYING PLANT POPULATION

By

SOUMYA P.

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

MASTERS OF SCIENCE IN AGRICULTURE

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ABSTRACT

Hybrid Napier grass, an interspecific cross between Napier grass (*Pennisetum purpureum* Schum.) and bajra (*Pennisetum glaucum* L.) is a popular fodder grass grown in many parts of Kerala. The present investigation was undertaken to have an understanding on the growth characteristics, fodder production potential and nutritive value of some popular cultivars of hybrid Napier grass and also to find out the effect of plant population on their performance. The experiment was conducted at the Agronomy research farm of College of Horticulture, Kerala Agricultural University, Vellanikkara during 2009-2010.

Eight popular cultivars, namely, CO2, CO3, CO(CN)4, KKM-1, Suguna, Supriya, IGFRI-3 and DHN-6 were planted under three different spacing of 60cm x 60cm, 90cm x 60cm, and 90cm x 90cm. Observations were taken during the period of one year on growth and fodder production potential. The nutrient composition of different cultivars of hybrid Napier grass was also analysed.

Among the cultivars evaluated, the growth was comparatively fast in KKM-1 followed by CO(CN)4 with respect to plant height, number of tillers, leaf length, leaf area index, relative growth rate and net assimilation rate. The fodder production potential of the cultivars was assessed by harvesting the herbage at 50-55 days interval. The green and dry matter yields indicated a clear yield advantage for KKM-1 and CO(CN)4, which were on par and hence can be ranked first. The cultivars CO2 and DHN-6 can be ranked second based on yield. Suguna, CO3 and Supriya came third in fodder production and IGFRI-3, fourth with the lowest yield.

Regarding spacing, number of tillers per plant was comparatively higher at wider spacing of 90cm x 90cm. Leaf area ratio and relative growth rate were also higher under lower plant densities. At the same time, leaf area index was found to

be higher at closer spacing of 60cm x 60cm. Other parameters such as plant height, number of leaves, leaf: stem ratio etc. were found to be non significant with respect to spacing. Considering annual fodder production, herbage and dry matter yields were higher at closer spacing of 60cm x 60cm.

Nutritional attributes like crude protein, crude fibre, ether extract, nitrogen free extract, total ash, phosphorus, potassium, calcium, magnesium, and oxalate content of all the cultivars were assessed. Nutritionally, the cultivars differed with respect to crude protein and oxalate content. All the cultivars except CO2 had higher crude protein content. Oxalate content which is an anti nutritional factor, was higher in CO2 and IGFRI-3 while, the least oxalate content was recorded in DHN-6. From nutrient point of view, the cultivar DHN-6 was found to be superior.

Regarding the nutrient uptake from soil, KKM-1, CO(CN)4 and CO2 had higher rate of removal. Among the three spacings, nutrient uptake by plants was higher under closer spacing of 60cm x 60cm compared to wider spacings. Among the cultivars, B:C ratio was maximum for KKM-1 and among the spacings, closer spacing of 60cm x 60cm was found to be more profitable.

Among the cultivars evaluated, KKM-1 and CO(CN)4 ranked first with respect to high fresh and dry fodder yield. Although the cultivars DHN-6 and CO2 were comparable in yield and ranked second, quality wise DHN-6 was better with the least oxalate content, better leaf: stem ratio and crude protein content. Therefore, along with KKM-1 and CO(CN)4, DHN-6 can also be recommended for Kerala under irrigated conditions. The spacing of 60cm x 60cm was the ideal spacing for hybrid Napier cultivation in Kerala condition for maximum yield.