FORAGE AND SEED PRODUCTION OF SIGNAL GRASS (*Brachiaria decumbens* Stapf.) UNDER DIFFERENT MANAGEMENT PRACTICES

By

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THESIS
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Dedicated

to my beloved

Parents

DECLARATION

I hereby declare that this thesis entitled **"Forage and seed production of Signal grass (*Brachiaria decumbens* Stapf.) under different management practices"** is a *bonafide* record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellayani,
16-12-1999.

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CERTIFICATE

Certified that this thesis entitled **"Forage and seed production of Signal grass (*Brachiaria decumbens* Stapf.) under different management practices"** is a record of research work done independently by **Miss. SONIA. V. K.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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ABBREVIATIONS USED IN THE THESIS

@	-	At the rate of
C	-	Cutting management
°C	-	Degree celsius
Ca	-	Calcium
cc	-	Cubic centimetre
cm	-	Centimetre
DAS	-	Days after sowing
Fig.	-	Figure
FYM	-	Farm yard manure
g	-	Gram
ha	-	Hectare
K	-	Potassium
kg	-	Kilogram
LAI	-	Leaf area index
m	-	Metre
Mg	-	Magnesium
mm	-	Millimetre
MSL	-	Mean sea level
N	-	Nitrogen
P	-	Phosphorus
t	-	Tonnes

INTRODUCTION

INTRODUCTION

The importance of livestock in Indian agriculture is well recognised. However the livestock have very low productivity and fail to express their full genetic potential mainly due to the non-availability of good quality fodder and feed resources. Currently the forages and feeds available in our country is sufficient to meet only 46.6 per cent of the requirement mainly due to the very limited area available for fodder cultivation. However, the possibility of diverting agricultural areas for fodder production is limited because of the increasing pressure on agricultural land for food production and for the cultivation of cash crops and plantation crops. Hence the only way to bridge the wide gap between demand and supply is to increase productivity from unit area.

A major constraint which comes in the way of expanding the cultivation of forage crops is the inadequate supply of good quality seeds. The production of quality seeds in fodder crops is a highly specialised job requiring sufficient technical know-how. Lack of technical knowledge has often limited seed production to a considerable extent.

The contribution of livestock to Kerala's economy is well known. This is evident from the remarkable increase in milk production in the state in the past three decades as a result of improvement in the genetic quality of stock through cross breeding. However the full potential has not been realised mainly due to the inadequacy of good quality fodder and feeds. The dry roughage production in the state is only 40 lakh tonnes as against the requirement of 67.6 lakh tonnes; the production meeting only 60 per cent of the requirement.

One of the main reasons for short supply of green fodder has been the lack of adequate area for raising fodder as pure crop due to increased pressure from food and cash or plantation crops. The only way to bring in more area under fodder crops is by utilising the interspaces available in existing coconut gardens. In a mature coconut garden, the land area unexplored by palm roots can be very well utilized for fodder intercropping. The situation has been made all the more grave by the short supply of quality forage seeds, which has limited the popularisation of fodder crops. This has necessitated the need for obtaining seed from outside the state to meet the requirement. In our state, Kerala Livestock Development Board is the principal agency producing and marketing fodder seeds. Seed production in the state is undertaken in the Palakkad district and also in the hilly areas of Idukki district at 800-1000 mm above MSL where the annual rainfall ranges between 2000-2500 mm.

Studies conducted in Kerala Agricultural University have also indicated the possibility of enhancing the seed productivity of different crops under specific agroclimatic conditions and adoption of a well balanced nutrient management strategy for optimising seed production.

Signal grass is a trailing, perennial forage grass native to Africa and recently introduced to our state by Kerala Livestock Development Board. Preliminary trials conducted by KLD Board have shown its adaptability for tropical conditions and fairly high degree of drought tolerance. This has made the grass suitable for cultivation in Northern parts of Kerala where the drought period is comparatively longer than Southern Kerala. The prostrate growth habit also make it suitable for soil conservation purpose.

There is an urgent need to take up studies on the forage and seed production aspects of this grass under different management practices to assess the forage and seed production potential of suitable fodder crops. Keeping this in view the present study entitled "Forage and Seed production of Signal grass (*Brachiaria decumbens* Stapf.) under different management practices" was taken up with the following objectives.

1. To study the effect of nitrogen and potassium on forage production of signal grass.

2. To study the effect of nitrogen and potassium on seed yield of signal grass.

3. To study the effect of cutting management on seed production in signal grass.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Signal grass (*Brachiaria decumbens* Stapf.) has been identified to be drought tolerant, evergreen, fast growing, high yielding and producing forage of good quality (Tai and Luo, 1994). It is adaptable to a wide range of soils and responds well to fertilizers. Preliminary trials conducted by Kerala Livestock Development Board and the AICRP centre at Vellayani revealed that the grass is suitable for cultivation under Kerala conditions. The present investigation was undertaken at the College of Agriculture, Vellayani from July 1998 to July 1999 with the object to find out the effect of nitrogen and potassium on the forage and seed yield and also to study the influence of cutting management on seed production of signal grass. The literature pertaining to the study is reviewed here:

2.1. Growth characters

2.1.1. Height of grass

In fodder crops, where vegetative growth contributes to the green matter production, plant height has got a dominant role in increasing fodder yields. Boonman (1972) noticed a pronounced increase in length of stem of setaria grass (*Setaria sphacelata*) cv. Nandi by nitrogen application in Kenya. A considerable increase in the height of plants was observed by Singh *et al.* (1973) by the application of nitrogen to oats (*Avena sativa*). A lack of response in plant height upto the level of 50 kg N ha^{-1} was reported by Thangamuthu *et al.* (1974) in guinea grass (*Panicum maximum*). Rathore and Vijayakumar (1977) reported the influence of nitrogen in increasing plant height in fodder sorghum (*Sorghum bicolor*). A linear increase in plant height was noted by Abraham (1978) in dinanath grass (*Pennisetum pedicellatum*) with increase in nitrogen application. A significant increase in plant height with nitrogen doses upto 250 kg ha^{-1} was noticed by Thomas (1978) in hybrid napier. According to Rai and Sankaranarayanan (1981) plant height increased with nitrogen application upto 40 kg N ha^{-1} in giant anjan (*Cenchrus ciliaris*). They also reported that the plant height was not affected by the application of phosphorus in giant anjan. Singh and Singh (1983) observed an increase in plant height in sorghum applied with 120 kg N ha^{-1}. A significant increasing trend in plant height was noticed upto 30 kg N ha^{-1} (Bhati and Mathur, 1984). Balyan and Singh (1985) noticed a marked increase in the height of sorghum upto 40 kg N ha^{-1}. Significant increase in plant height of grain sorghum fertilised upto 90 kg N ha^{-1} was reported by Devasenapathy and Subbarayalu (1985). Manohar *et al.* (1992) reported that plant height increased significantly with increasing levels of nitrogen from 30 to 90 kg ha^{-1} in fodder pearl millet (*Pennisetum glaucum*). A significant increase in plant height by nitrogen application was reported by Krishnan (1993) in guinea grass (*Panicum maximum*).

Thakuria (1993) concluded that plant height was not affected by application of potash in teosinte (*Euchlaena mexicana*).

2.1.2. Number of tillers

Booman (1972) noticed increased tiller number by application of nitrogen in setaria grass (*Setaria sphacelata*). Reports from Rahuri (Annual Report, 1976) revealed lack of influence of nitrogen on tiller production in dinanath grass (*Pennisetum pedicallatum*) and fodder sorghum (*Sorghum bicolor*). High doses of nitrogen was found to increase the tiller number of bahia grass (Beaty *et al*., 1977). Rathore and Vijayakumar (1977) observed increased number of tillers with increase in nitrogen fertilization in dinanath grass (*Pennisetum pedicellatum*) and fodder sorghum (*Sorghum bicolor*). A significant increase in tiller number with nitrogen doses upto 250 kg ha^{-1} was noticed by Thomas (1978) in hybrid napier. Tiller number increased with increasing levels of nitrogen in giant anjan grass (*Cenchrus ciliaris*) (Rai and Sankaranarayanan, 1981). They also reported that application of phosphorus did not produce any significant increase in number of tillers. According to Taneja *et al*. (1981) application of nitrogen produced more number of tillers in barley and oats. Significant increasing trend in number of tillers was noticed upto 30 kg N ha^{-1} by Bhati and Mathur (1984). Perez *et al*. (1984) observed lack of response to nitrogen in guinea grass (*Panicum maximum*). Sangakkara (1988) observed that increasing nitrogen rates increased the number of tillers per plant in guinea grass (*Panicum maximum*). A significant increase in the number of tillers per plant with increasing levels of nitrogen from 30 to 90 kg ha^{-1} was reported by Manohar *et al.* (1992). Krishnan (1993) observed significant influence of nitrogen applied at 100 kg ha^{-1} on number of tillers. However the work also revealed that phosphorus and potassic fertilizers did not influence tiller production. Increasing levels of applied nitrogen increased tiller density, but reduced individual tiller vigour as reported by Mckenzie (1996) in *Lolium perenne*.

2.1.3. Number of leaves

Increase in the number of leaves with nitrogen application was reported by Shinde *et al.* (1987) in forage sorghum. Singh *et al.* (1988) observed similar results with nitrogen fertilization in tropical forage. Malik *et al.* (1992) noticed a pronounced positive effect of nitrogen on leaf number in fodder sorghum. A significant increase in the leaves per plant was observed with an increase in nitrogen from 30 to 90 kg ha^{-1} (Manohar *et al.*, 1992) in fodder pearl millet.

2.1.4. Leaf : stem ratio

A gradual decrease in leaf : stem ratio with increase in nitrogen level was observed in forage oats (Singh *et al.*, 1973). Rathore and Vijayakumar (1977) observed a significant decline in leaf : stem ratio with the addition of nitrogen in dinanath grass and forage sorghum.

Nitrogen did not significantly influence the leaf : stem ratio of dinanath grass (Abraham, 1978). In hybrid napier, a significant reduction in leaf : stem ratio was observed with higher dose of 200 and 250 kg N ha^{-1} (Thomas, 1978). Nitrogen application had not much effect on leaf : stem ratio of hybrid napier as reported by Yeh (1988). Yadav and Sharma (1989) opined that various nitrogen levels did not influence the leaf stem ratio of dinanth grass. Potassium rates also did not influence the leaf : stem ratio.

2.2. Yield and yield attributes

2.2.1. Green fodder yield

Rabago and Rodriguez (1976) reported a significant increase in green fodder yield of forage sorghum upto a nitrogen level of 90 kg ha^{-1}. A significant increase in forage yield was revealed by increased application of nitrogen upto 150 kg ha^{-1} in hybrid napier (Annual Report, 1977). Balasko (1977) reported an increase in yield by nitrogen fertilization in tall fescue forage. An increase in green matter yield of dinanath grass with increase in nitrogen application was revealed from experiments at Vellayani (Annual Report, 1978). Significant increase in green fodder yield by nitrogen application was reported by Boruah and Mathur (1979) in fodder oats. Ravikumar *et al.* (1979) reported a significant increase in forage production of buffel grass by nitrogen application. Increase in forage yield by application of nitrogen upto 120 kg ha^{-1} was observed in oats (Tripathi *et al.*, 1979). Vega and Martinez (1979) concluded that nitrogen application did not cause any significant change in green fodder yield of sorghum. Bhati and Mathur (1984) reported increased fodder yield in *Cenchrus ciliaris* with nitrogen fertilizer along with FYM. Increase in nitrogen levels was found to have a pronounced effect on green fodder yield of maize as reported by Sawant and Khanvilkar (1987). Rai (1989) reported a significant increase in yield of *Cenchrus ciliaris* by nitrogen application. Application of 200 kg N ha^{-1} produced significantly higher yield over 100 kg N ha^{-1} in forage maize (Thaware *et al.*, 1991). A significant increase in green forage yield was observed by Malik *et al.* (1992) by increased nitrogen levels upto 120 kg N ha^{-1} in fodder sorghum. Green fodder yield increased significantly with an increase in level of applied nitrogen and the maximum yield of 506.84 q ha^{-1} was obtained under 90 kg N ha^{-1} in fodder pearl millet (Manohar *et al.*, 1992). Meerabai *et al.* (1992) observed a profound increase in green fodder yield of congosignal upto 100 kg N ha^{-1} beyond which the yield increase was non-significant. Nitrogen was found to have significant effect on green fodder yield of oats which increased with increasing levels of nitrogen upto 100 kg ha^{-1}, but lacked a significant response beyond 50 kg N ha^{-1} (Thakuria, 1992). Joon *et al.* (1993) reported increased fodder production in oats upto 160 kg N ha^{-1}. Maximum green forage yield was obtained with nitrogen applied at the rate of 120 kg ha^{-1} in oats (Patil *et al.*, 1993). Shukla and Sharma (1994) noticed increased green fodder yield with increased nitrogen application from 30 to 120 kg ha^{-1} in fodder sorghum. Cameron and

Ross (1996) reported that yields with applied nitrogen were approximately 2.5 times those without nitrogen on established grass pastures. Maximum green fodder yield in fodder maize supplemented with 90 kg N ha^{-1} was reported by Ghosh and Singh (1996).

Phosphorus fertilization had little effect on yield components as reported by Balasko (1977) in tall fescue forage. Ravikumar *et al.* (1979) observed a significant increase in forage production with phosphorus application in buffel grass. Application of 30 kg P_2O_5 ha^{-1} gave significant increase in fresh fodder yield as reported by Bhati and Mathur (1984) in *Cenchrus ciliaris*. Mc Ivor *et al.* (1988) found no effect with phosphorus application on yield of verano stylo. Herbage yield increased with increase in phosphorus rates in thin napier grass (*Pennisetum polystachyon*) (Dwivedi *et al.*, 1991b). Hall (1993) observed increased verano yield with phosphorus application at the rate of 30 kg ha^{-1}. In congosignal, green fodder yield increase upto fertilizer levels of 30 kg ha^{-1} P_2O_5 and 90 kg ha^{-1} K_2O was reported by Meerabai *et al.* (1993) in the red loam soils of Vellayani. Thakuria (1993) reported no significant effect on green fodder yield of teosinte by potassium application. Vasanthi *et al.* (1994) noticed decreased yield of green fodder with higher levels of P and the maximum green fodder yield was obtained at P application of 26.4 kg ha^{-1}.

Barker and Kidar (1989) observed that plants that received 30 per cent defoliation treatment produced significantly more herbage than the 60 per cent defoliated plants. Fodder yield was three times higher when cutting was done 75 DAS than when it was done 55 DAS (Joon *et al.*, 1993).

2.2.2. Dry fodder yield

Boonman (1972) reported higher yields of dry matter at the highest nitrogen levels in *Setaria sphacelata*. A significant increase in dry matter yield of *Heteropogon contortus* (L.) upto 40 kg N ha^{-1} was reported by Sankaranarayanan *et al.* (1973). Ganguli *et al.* (1976) observed increased dry matter yield with increase in levels of nitrogen in fodder oats. Application of 150 kg N ha^{-1} recorded the maximum dry matter yield (Gupta and Gupta, 1976) in fodder sorghum. Ravikumar *et al.* (1979) observed significant differences in dry matter yield with increase in levels of nitrogen in *Cenchrus ciliaris*. Ravikumar *et al.* (1980) reported a linear response upto 90 kg N ha^{-1}, resulting in a 135 per cent increase in the yield of dry forage over the control in *Cenchrus setigerus*. A decrease in dry matter yield of *Brachiaria brizantha, B. miliformis* and *Panicum maximum* with nitrogen application was observed by Eriksen and Whitney (1981). Taneja *et al.* (1981) observed a significant effect of nitrogen on dry matter yield and a linear response upto 120 kg N ha^{-1} in barley and oats. Munda *et al.* (1984) reported that total dry matter production was 33.9 per cent more by 120 kg N ha^{-1} over no nitrogen in hybrid pearl millet. In sorghum, the dry matter production markedly increased due to addition of 40 kg N ha^{-1} over no nitrogen, but there was no significant response to nitrogen beyond 40 kg

N ha^{-1} (Balyan and Singh, 1985). Dwivedi and Kanodia (1986) observed significant effect of nitrogen on dry matter yield in setaria grass. Increased dry fodder yield upto 150 kg N ha^{-1} in guinea grass and upto 200 kg N ha^{-1} in setaria grass was reported by Pillai (1986). Singh (1987) observed a linear relationship between increased nitrogen doses and dry matter yields. Application of nitrogen increased the dry matter yield significantly in oats (Gill *et al.*, 1988). Yeh (1988) observed decreased dry matter yields of hybrid napier with increased nitrogen rates. Highest dry forage yield (10.99 t ha^{-1}) was recorded with application of 60 kg N ha^{-1} in *Cenchrus ciliaris* x *Cenchrus setigerus* hybrid (Rai, 1991). Tripathi and Singh (1991) noticed significant effects of increasing levels of nitrogen on dry fodder yield of dinanath grass upto 90 kg ha^{-1}. In *Brachiaria* sp. the dry fodder yield increased with nitrogen rates (Carvalho *et al.*, 1992). A pronounced positive effect of nitrogen on dry matter yield of fodder sorghum was observed by Malik *et al.* (1992) upto 120 kg N ha^{-1}. Thakuria (1992) noticed a significant effect of nitrogen on dry matter wherein dry matter yield increased only upto 75 kg N ha^{-1}, but there was no significant response beyond 25 kg N ha^{-1}. According to Hall (1993) dry matter yield of native pasture increased from 2050 to 3060 kg ha^{-1} by application of nitrogen. Significant increase in dry matter yields upto 90 kg N ha^{-1} was noticed in teosinte (Thakuria, 1993). Prakash *et al.* (1994) suggested application of nitrogen @ 120 kg ha^{-1} $harvest^{-1}$ to obtain high dry matter yields in Rhodes grass. Pieterse and Rethman (1995) found that highest production efficiency was with 80 kg ha^{-1} nitrogen application, with efficiency decreasing at lower and higher levels of nitrogen. Ezenwa *et al.* (1996) observed more dry matter production without nitrogen fertilizer than with nitrogen fertilizers in *Brachiaria ruziziensis*, when grown in pure stand or under a mature oil palm canopy.

Faroda (1970) could not obtain a significant effect of phosphorus alone on dry matter yield in anjan grass. In dinanath grass (*Pennisetum pedicellatum*), no significant difference in dry matter yield was noticed due to different levels of phosphorus during first year (Narwal *et al.*, 1977). Ravikumar *et al.* (1980) reported increase in yield of dry forage in *Cenchrus setigerus* by P application. Application of 30 kg P_2O_5 ha^{-1} gave a significant increase in dry matter yield in *Cenchrus ciliaris* (Bhati and Mathur, 1984). Chandini *et al.* (1985) observed that P application did not influence the dry matter yield of *Panicum maximum*, *Brachiaria ruziziensis* and *Setaria* sp. According to Filho *et al.* (1989) dry matter production increased with P_2O_5 levels upto 100 kg ha^{-1} in *Brachiaria brizantha*. Hall (1993) reported that the dry matter yields of native pasture increased to 3080 kg ha^{-1} by the application of superphosphate in the first year. Thakuria (1993) reported that application of potash did not give any significant response to fodder yield. Fertilizer P was found to increase dry matter yield of pastures of *Stylosanthes hamata* cv. Verano. (Coates, 1994). No significant response to P application was recorded by Prakash *et al.* (1994) in Rhodes grass. According to them K application could not produce any significant response.

Fernandes *et al.* (1985) observed an increase in dry matter yield of *Brachiaria decumbens* with increased levels of nitrogen in the presence of K. Vallejos (1986) revealed that there was significant effect of N x K interactions on dry matter production but P or K alone had no effect in increasing the dry matter yields of *Brachiaria decumbens.* Dry matter yields increased only slightly with N and P given alone but there was a significant interaction between N and P in signal grass (Lira *et al.*, 1994). Applying 60 kg N + 120 kg P_2O_5 increased dry matter yield from 2.3 t ha^{-1} cut^{-1} with no fertilizers to 4.2 t.

Thakuria (1992) reported that cutting treatment reduced straw yield compared with no cutting in oats. The reduction was maximum when the crop was cut for fodder at 70-75 DAS compared with cut at 50-55 DAS.

2.2.3. Days to 50 per cent flowering

Chadhokar and Humphreys (1973) reported earlier inflorescence emergence by application of nitrogen in *Paspalum plicatulum.* Increased rates of nitrogen applied decreased the days to silking in maize (Sharma, 1973). George *et al.* (1990) observed that mean anthesis date was not affected by nitrogen fertilization in switch grass (*Panicum virgatum*).

2.2.4. Number of seeds per panicle

In *Andropogon gayanus* inflorescence density increased upto 100 kg ha^{-1} of nitrogen applied with no further increase at 200 kg ha^{-1} (Haggar, 1966). Boonman (1972) noticed a reduction in seed set of *Setaria sphacelata* associated with nitrogen application. In perennial rye grass (*Lolium perenne*) applied nitrogen was found to decrease the number of seeds per spike (Hebblethwaite and Mc Laren, 1979). Nitrogen treatment was found to have no significant effect on number of seeds per panicle in guinea grass (Sangakkara, 1988).

Sadanandan and Sasidhar (1976) could not obtain any effect for phosphorus on number of grains per panicle in rice. Application of phosphorus was found to significantly increase the number of seeds per panicle in guinea grass (Krishnan, 1993).

Kalyanikutty and Morachan (1974) revealed that the number of grains per panicle was not affected by different levels of potassium application.

2.2.5. Seed yield

Chadhokar and Humpherys (1973) revealed that the response of nitrogen was much less in the year of establishment and higher in the suceeding years, based on studies conducted on seed production of Paspalum. Cameron and Humphreys (1976) obtained seed yield of 361 kg ha^{-1} when fertilized with 400 kg N ha^{-1} in *Paspalum plicatulum*. Trials on seed yield of oats cv. Kent at different levels of nitrogen revealed that 90 kg N ha^{-1} increased seed yield by 470 kg ha^{-1} over 30 kg N ha^{-1} (Gill and Karnani, 1979). Mukherjee *et al.* (1981) op increase in seed yield of teosinte due to per kg nitrogen applica... 7.6 kg and 9.2 kg with application of 60 and 120 kg N ha^{-1} respectively. In Pusa Giant Anjan (*Cenchrus ciliaris*) there was a significant increase in seed yield by 19.6 kg ha^{-1} with increase in nitrogen from 20 to 40 kg ha^{-1} (Rai and Sankaranarayanan, 1981). Mecelis and Oliveira (1984) observed a marked increase in seed production by nitrogen application in *Brachiaria humidicola*. Carmo *et al.* (1988) observed that in signal grass (*Brachiaria decumbens*) increasing nitrogen levels increased yield of crude seed from 96 to 229 kg ha^{-1} in March but had no effect on yield in April, when yields were 57 to 94 kg ha^{-1}. In *Panicum maximum* two defoliations in combination with 150 to 200 kg N ha^{-1} produced approximately two fold increase in seed yields (Sangakkara, 1988). Dwivedi *et al.* (1991b) reported that the mean seed yield increased with increasing levels of nitrogen upto 60 kg ha^{-1} in thin napier grass (*Pennisetum polystachyon*). Studies conducted on multicut oat (*Avena sativa*) revealed that grain yield increased with nitrogen upto 80 kg N ha^{-1} (Joon *et al.*, 1993). Nitrogen applied at 120 kg ha^{-1} gave a high mean seed yield of 21.5 q ha^{-1} in oat (*Avena sativa*) (Patil *et al.*, 1993). Ramirez and Hacker (1994) reported that the application of N significantly increased pure seed yield in *Digitaria eriantha*, but levels of N exceeding 150 kg ha^{-1} tended to reduce seed yield. Seed yield increased significantly as nitrogen fertilizer application rate was increased from 0 to 240 kg ha^{-1} in brown top (*Agrostis capillaris* L.) (Jin *et al.*, 1996).

Sinha (1985) reported that foliar application of 4 kg KNO_3 ha^{-1}. at pre-flowering stage increased seed yield of cowpea and berseem by 15 to 20 per cent. In perennial rye grass (*Lolium perenne*) potassium application at 0 and 100 kg ha^{-1} could not produce much variation in seed yields (Nordestgaard, 1990). Krishnan (1993) reported that in guinea grass, potassium did not show any influence on seed yield. Potassium failed to produce any significant influence on seed yield of gamba grass (*Andropogon gayanus*) (Vineetha, 1995).

According to Joon *et al.* (1993) there was no significant difference among the cutting management practices for grain yield in oat (*Avena sativa*). Patil *et al.* (1993) found that seed yields were significantly influenced by cutting management. The seed yield was maximum (23.92 q ha^{-1}) from no cut treatment followed by one cut at 50 days for forage and the seed from the regrowth (19.75 q ha^{-1}) in oat (*Avena sativa*). Cutting treatment was found to reduce grain yield compared with no cutting in oat (*Avena sativa*) (Thakuria and Rafique, 1993). Bajwa *et al.* (1996) reported that not cutting the crop significantly reduced seed yield, while one cut out yielded two cuts in *Lolium perenne.* Taking one cut and subsequent seed production gave a seed yield of 409 kg ha^{-1} compared to 358 kg ha^{-1} from two cuts.

Joon *et al.* (1993) opined that taking grain after cutting for fodder 75 DAS and fertilized with 120 kg N ha^{-1} was ideal and profitable for seed production of oat (*Avena sativa*). Higher grain yield was recorded with no cut treatment at all levels of nitrogen and it was highest with 120 kg N ha^{-1} at all levels of cutting management in oat (*Avena sativa*) (Patil *et al.*, 1993). Thakuria and Rafique (1993) concluded that application of 40 kg N ha^{-1} without any cut for fodder was the most profitable for seed production of oat.

2.2.6. Thousand seed weight

Carmo *et al.* (1988) reported an increase in 100 seed weight from 0.33 g in March to 0.42 g in April with increase in N application in signal grass (*Brachiaria decumbens*). In guniea grass, the 1000 seed weight increased from 1.77 g in pure stand to 2.13 g when intercropped with *Stylosanthes hamata* or given 40 kg N ha^{-1} (Dwivedi *et al.*, 1991a). Studies on the effect of nitrogen on seed yield of thin napier grass (*Pennisetum polystachyon*) revealed that 1000 seed weight was increased by nitrogen (Dwivedi *et al.*, 1991b). Ramirez and Hacker (1994) observed that 1000 seed weight was not affected by N fertilization in *Digitaria eriantha*. Studies on Brown top revealed that thousand seed weight increased significantly with increasing rates of nitrogen (Jin *et al.*, 1996). Trials conducted on Chicory (*Cichorium intybus* L.) revealed that thousand seed weight was not affected by nitrogen. There was no significant response to increasing nitrogen, although there was a tendency to increase from 1.4 g at 0 kg N ha^{-1} to 1.5 g at high rates of N (Rowarth *et al.*, 1996).

Sangakkara (1988) working on guinea grass (*Panicum maximum* Jacq.) reported that defoliation and nitrogen treatments had no significant effect on 1000 seed weight. In lucerne, thousand seed weight was not found to differ among cutting treatments (Tiwana and Puri, 1997).

2.3. Physiological parameters

2.3.1. Leaf area index (LAI)

Singh and Chatterjee (1968) found that in thin napier grass (*Pennisetum polystachyon*) maximum LAI of 4 was attained with high nitrogen application. In fodder cowpea, leaf area index was not influenced by nitrogen application (Dhanram *et al.*, 1971). Das and Chatterjee (1976) working on dinanath grass (*Pennisetum pedicellatum*) observed that 95 per cent of light interception occured at a LAI of 7.5. In bahia grass a higher LAI was observed with high N rates (Beaty *et al.*, 1977). Balyan and Singh (1985) noted that LAI markedly increased due to 40 kg N ha^{-1} over no nitrogen, but there was no significant response to nitrogen beyond 40 kg ha^{-1} in sorghum. A pronounced positive effect of nitrogen on LAI was observed by Malik *et al.* (1992) in fodder sorghum. Jena *et al.* (1995) noticed that in fodder cowpea maximum leaf area index was achieved at 40 kg N ha^{-1}.

2.3.2. Seed germination

Cameron and Humphreys (1976) reported a reduction in germination of *Paspalum plicatulum* with increased nitrogen. Nitrogen application was reported to significantly increase seed germination in *Brachiaria humidicola* (Mecelis and Oliveira, 1984). Dannhauser (1985) noted that fertilizer treatment of seed crops did not affect germination of harvested seed of *Digitaria eriantha.* Carmo *et al.* (1988) working on signal grass (*Brachiaria decumbens*) reported that with increasing nitrogen, germination decreased from 51 to 32 per cent in March and increased from 42 to 71 per cent in April. Trials conducted on setaria grass (*Setaria sphacelata*) by Cruz *et al.* (1989) revealed that seed germination was unaffected by nitrogen rates. According to Dwivedi *et al.* (1991a), the percentage germination was not affected by nitrogen treatment in guinea grass (*Panicum maximum*). The germination rate of seeds harvested from N fertilised and unfertilised plots were similar in *Digitaria eriantha* (Ramirez and Hacker, 1994).

Tiwana and Puri (1997) observed that seed germination did not vary with cutting treatment in lucerne (*Medicago sativa* L.).

2.4. Chemical analysis

2.4.1. Content of N, P and K in fodder

2.4.1.1. Nitrogen content of fodder

Gupta and Gupta (1976) observed that increased N application upto 150 kg ha^{-1} led to an increase in nitrogen content of sorghum fodder. Increase in nitrogen application in para grass (*Brachiaria mutica*) substantially increased the nitrogen content of fodder (Chadhokar, 1978) Rathore and Vijayakumar (1978) obtained a higher concentration of nitrogen in dinanath grass (*Pennisetum pedicellatum*) by increased N application. According to Munda *et al.* (1984), nitrogen uptake at maturity was increased by 36.6 per cent due to 120 kg N over the zero level in hybrid pearl millet. An inverse relationship between applied levels of nitrogen and plant nitrogen content was reported by Fernandes *et al.* (1985). Singh (1987) observed that higher levels of applied nitrogen increased the forage nitrogen content in hybrid napier. Trials conducted in *Cenchrus ciliaris* revealed that the nitrogen concentration of fodder was increased by N fertilizer (Rai, 1989). Peake *et al.* (1990) reported that addition of nitrogen to green panic resulted in a slight reduction in nitrogen concentration whereas nitrogen content increased in buffel grass. Nitrogen concentration of Rhodes grass was significantly increased by nitrogen application (Prakash *et al.*, 1994).

2.4.1.2. Phosphorus content of fodder

Bahl *et al.* (1970) reported increase in phosphorus content with increase in nitrogen application in black anjan (*Cenchrus ciliaris*). The phosphorus concentration of forage was significantly increased by P fertilization in tall fescue forage (Balasko, 1977). Rathore and Vijayakumar (1977) observed a decrease in phosphorus content due to nitrogen application in dinanath grass (*Pennisetum pedicellatum*). The phosphorus content of dinanath grass was found to increase by phosphorus application (Rathore and Vijayakumar, 1978). According to Rai *et al.* (1979) the phosphorus content of forage remained unchanged under various levels of nitrogen in Sehima - Heteropogon grassland. A decreasing trend in phosphorus content with nitrogen application was observed by Abraham *et al.* (1980) in dinanath grass (*Pennisetum pedicellatum*). An increasing level of N caused a decrease in P content of herbage of *Cenchrus setigerus*, while the P content was unaffected by application of P (Ravikumar *et al.*, 1980). Fernandes *et al.* (1985) observed decreasing P concentration in the plant with increasing nitrogen levels in presence of potassium in signal grass (*Brachiaria decumbens*). In *Stylosanthes hamata* increase in concentration of P from 0.03 to 0.12 per cent in the native pasture by superphosphate application was reported by Hall (1993). Prakash *et al.* (1994) noticed a decrease in P concentration in rhodes grass by increased N application. According to Andrade *et al.* (1996) forage P concentration was decreased by N and K application in congosignal.

2.4.1.3. Potassium content of fodder

Balasko (1977) observed that potassium fertilization greatly increased K concentration of tall fescue forage. Trials conducted in tall fescue and blue grass revealed that increasing N application from 50 to 200 kg ha^{-1} consistently increased herbage K concentration of both grasses (Hojjati *et al.*, 1977). Abraham *et al.* (1980) obtained an increase in potassium content of dinanath grass (*Pennisetum pedicellatum*) due to application of nitrogen. In hybrid pearl millet potassium uptake was increased by 35.1 and 40.5 per cent due to 120 kg N and 60 kg P_2O_5 ha^{-1}

respectively over no application of nitrogen and phosphorus (Munda *et al.*, 1984). According to Fernandes *et al.* (1985) application of high level of K to the soil however decreased the plant potassium content in *Brachiaria decumbens.* Contrary to this, Dampney (1992) observed that potash application increased herbage potassium concentration.

2.4.2. Crude protein

Hedge and Relwani (1974) noticed that in fodder sorghum, increasing levels of N did not have much influence on crude protein content. Studies on Kentucky blue grass and tall fescue indicated that raising N levels from 50 to 200 kg ha^{-1} increased overall average crude protein concentrations from 18.1 to 23.7 per cent in the former and from 16.9 to 23.1 per cent in the latter reaching peak values of 32.8 and 32.5 per cent in blue grass and tall fescue respectively at the highest level of N application (Hojjati *et al.*, 1977). Rathore and Vijaykumar (1977) revealed that application of 80 kg N ha^{-1} had a dilution effect on the crude protein content of dinanath grass but a higher dose of 160 kg N ha^{-1} gave a significant increase in crude protein content over the control as well as 80 kg N ha^{-1}, the extent of increase due to 160 kg N ha^{-1} over the control being 111 per cent. Studies conducted on *Cenchrus* spp. revealed that inorganic fertilizers enhance nitrogen uptake and thereby improve crude protein content (Chauhan and Faroda, 1979) Dwivedi *et al.* (1980) obtained highest crude protein content with 90 kg N ha^{-1} in

Chrysopogon fulvus. Studies conducted on *Cenchrus setigerus* revealed that crude protein content increased by 153 per cent by application of 90 kg N ha^{-1} over no N application (Ravikumar *et al.*, 1980). However the crude protein content was found to decrease with increase in levels of P. No significant increase in crude protein content of fodder was observed with 120 kg ha^{-1} of N applied in maize (Thind and Sandhu, 1980). Khader *et al.* (1985) reported a significant increase in crude protein content with nitrogen fertilization in fodder sorghum. An increase in crude protein content with addition of nitrogen was reported in hybrid napier NB-21 - Lucerne mixture by Shanmugasundaram (1985). Crude protein content was increased from 8.41 to 9.90 per cent in bajra napier hybrid with application of 150 kg N ha^{-1} (Govindaswamy and Manickam, 1988). Raj and Patel (1988) also reported a similar trend in sorghum with increased nitrogen. Studies conducted on fodder pearl millet revealed that crude protein content increased significantly with increase in level of nitrogen. An application of 90 kg N significantly increased the crude protein content at each cutting over 30 kg N at both the cuttings (Manohar *et al.*, 1991). Rai (1991) recorded the highest crude protein yield of 1.65 t ha^{-1} from pure stand with 60 kg N ha^{-1} in *Cenchrus ciliaris* x *Cenchrus setigerus* hybrid. In fodder sorghum crude protein yield increased significantly with increase in N levels upto 120 kg ha^{-1} (Malik *et al.*, 1992). Thakuria (1992) noted a significant increase in crude protein yield upto 50 kg N ha^{-1} in oat (*Avena sativa*). Trials conducted in teosinte revealed that application of 20 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1} increased the crude protein content (Thakuria, 1993). Pieterse *et al.* (1997) found that in guinea grass, the cv. Gatton recorded highest crude protein level of 11.75 per cent at 160 kg N ha^{-1}, while another cv. Vencidor recorded lowest crude protein content of 5.2 per cent with 320 kg N ha^{-1}.

2.4.3. Crude fibre

Nitrogen fertilizer did not cause any difference in crude fibre content of cock's foot and timothy grass (Koter, 1974). Tiwana *et al.* (1975) observed a decrease in crude fibre content of hybrid napier with increase in nitrogen application. Trials conducted in dinanath grass and sorghum revealed that the crude fibre content in the forage did not undergo any appreciable change due to nitrogen and phosphorus levels (Rathore and Vijaykumar, 1977). Abraham (1978) noticed a decrease in crude fibre content of dinanath grass (*Pennisetum pedicellatum*) with increased N application. In hybrid napier, the application of nitrogen significantly reduced the crude fibre content of fodder (Thomas, 1978). Khader *et al.* (1985) found an increase in crude fibre content of fodder sorghum with increase in N application. In fodder pearl millet (*Pennisetum glaucum*) application of nitrogen did not affect the crude fibre content significantly (Manohar *et al.*, 1991).

2.4.4. Calcium content

Koter (1974) observed that the calcium content was reduced by nitrogen fertilization in cock's foot and timothy grass. In hybrid napier, an increase in calcium content was observed with increased nitrogen application (Tiwana *et al.*, 1975). Balasko (1977) noticed that calcium concentration of tall fescue forage was decreased by N and K fertilizers. Hojjati *et al.* (1977) concluded that raising the nitrogen level increased calcium concentration in the herbage of Kentucky blue grass and tall fescue. The calcium content of both grasses decreased with time, then increased and finally reached peak values. Rai *et al.* (1979) failed to observe effect of nitrogen application on fodder calcium content of Sehima - Heteropogon species. Increasing levels of nitrogen was found to slightly increase calcium content in *Chrysopogon fulvus* (Dwivedi *et al.*, 1980). Botrel *et al.* (1990) revealed that in *Brachiaria brizantha* and *B. humidicola*, forage Ca content was not affected by nitrogen application. According to Andrade *et al.* (1996) forage Ca concentration in *Brachiaria ruziziensis* was decreased by nitrogen and potash applications.

2.4.5. Magnesium content

The magnesium content of fodder was not affected by nitrogen fertilization in cock's foot and timothy grass (Koter, 1974). Balasko (1977) observed that the magnesium concentration of harvested fodder of tall fescue was increased by nitrogen fertilization. He also reported that potassium fertilization decreased the magnesium content of tall fescue forage. Hojjati *et al.* (1977) noticed that high nitrogen levels increased magnesium concentration of tall fescue forage. Increasing levels of potash application was found to reduce herbage Mg content (Dampney, 1992).

2.4.6. K : (Ca + Mg) ratio

Grumes *et al.* (1970) reported that the safe limit of K : (Ca + Mg) ratio was 2.2. Increased levels of nitrogenous fertilizers favoured increase in Ca and Mg content of forage and thereby reduced the K : (Ca + Mg) ratio (Mayland *et al.*, 1975). Thill and George (1975) concluded that the critical value for K : (Ca + Mg) ratio is 2.2. According to Hojjati *et al.* (1977) the effect of N on K : (Ca + Mg) ratio of blue grass and tall fescue was inconsistent, but values once reached the critical level of 2.2.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present investigation was taken up to find out the effect of varying levels of nitrogen and potassium as well as cutting management on the fodder yield, quality and seed production potential of signal grass and also to work out the economics of grass cultivation. This grass has been recently introduced to our state by the Kerala Livestock Development Board and was found to be highly adapted to our state with high degree of drought tolerance and with good soil conservation ability. The materials and methods adopted for the study are furnished below.

3.1 Materials

3.1.1 Experimental site

The experiment was conducted at the Instructional Farm attached to the College of Agriculture, Vellayani located at 8.5°N latitude and 76.9°E longitude at an altitude of 29m above mean sea level.

3.1.2 Season and climate

The experiment was started in the month of July 1998 and the investigations were continued upto July 1999. The meteorological parameters viz., rainfall, maximum and minimum temperature, relative humidity and evaporation during the cropping period were recorded. The average values of the weather parameters during the cropping period are presented in appendix 1 and represented graphically in Fig. 3.1.

3.1.3 Soil

The soil of the experimental site was red sandy clay loam belonging to the order oxisol and taxonomic class, loamy kaolinitic isohyperthermic rhodic haplustox (Vellayani series). The data on important physical and chemical properties of the soil are presented in Table 3.1 and 3.2.

3.1.4 Cropping history of the experimental site

The experimental area was under fodder grass cover for the past two years.

3.1.5 Planting material

Slips of signal grass cv. Basilisk obtained from Kerala Livestock Development Board, Regional Unit at Kulathupuzha were used for raising the crop.

3.1.6 Fertilizers

Urea (46 per cent N), mussoriephos (18 per cent P_2O_5) and muriate of potash (60 per cent K_2O) were used for the experiment.

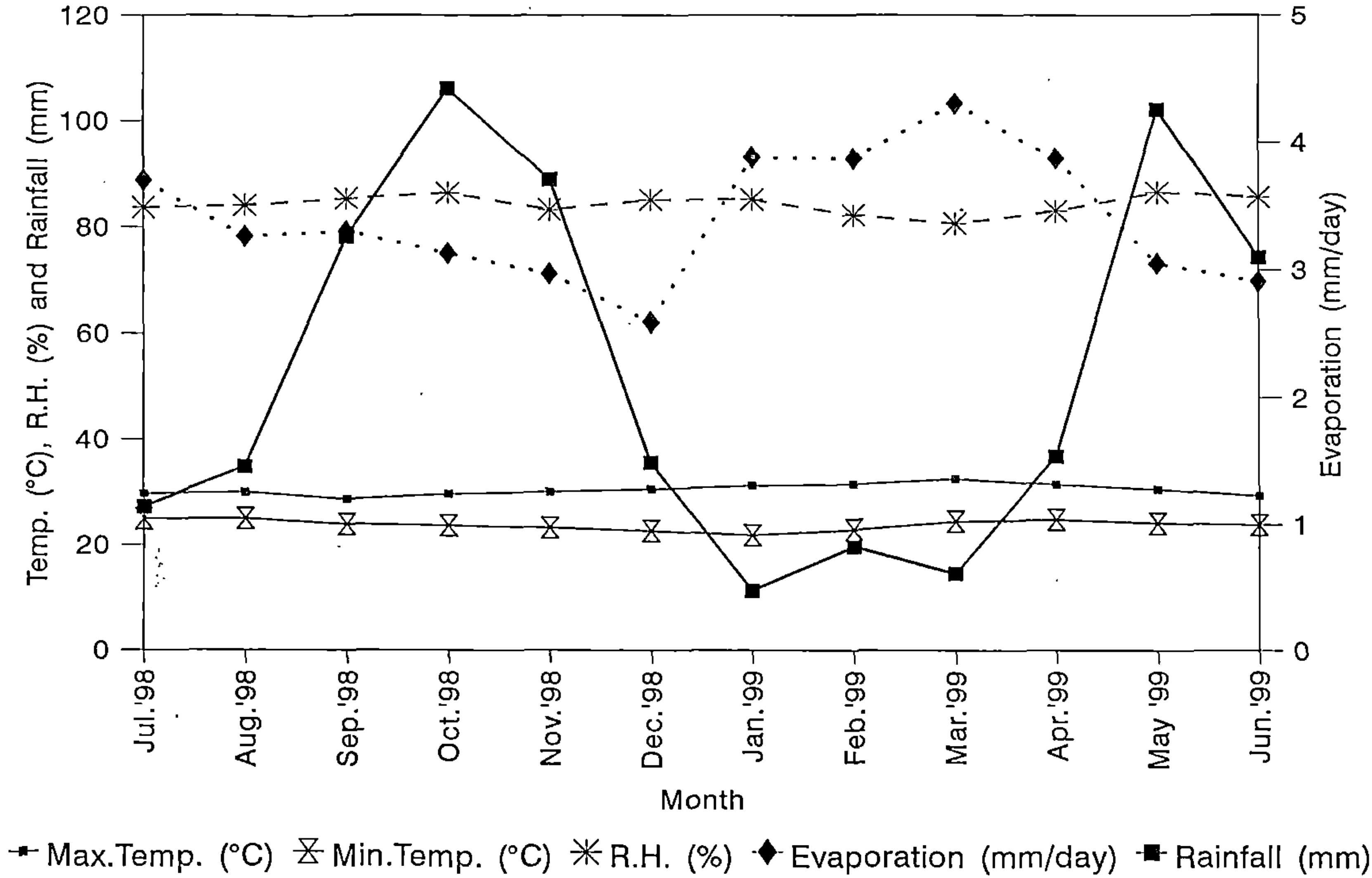

Fig. 3.1. Weather parameters during the crop period (July 1998 to June 1999)

Table 3.1. Physical properties of soil of the experimental site

Sl. No.	Particulars	Mean value	Method
1.	Mechanical composition		
	Constituents (per cent)		
	Coarse sand	16.7	Bouyoucos Hydrometer method (Bouyoucos, 1962)
	Fine sand	31.3	
	Silt	25.5	
	Clay	26.5	
2.	Bulk density (g cc^{-1})	1.38	International Pipette method (Gupta and Dakshinamoorthy, 1980)
3.	Water holding capacity (per cent)	20.03	
4.	Porosity (per cent)	30.65	

Table 3.2. Chemical properties of the soil before the experiment

Sl. No.	Constituent	Content	Rating	Method
1.	pH	5.00	Acidic	pH meter with glass electrode (Jackson, 1973)
2.	Available N (kg ha^{-1})	173.5	Low	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
3.	Available P_2O_5 (kg ha^{-1})	46.5	Medium	Bray's colorimetric method using chlorostannous reduced molybdophosphoric blue colour in HCl system (Jackson, 1973)
4.	Available K_2O (kg ha^{-1})	26.32	Low	Neutral normal Ammonium acetate method and flame photometry (Jackson, 1973)

3.2 Methods

3.2.1 Treatments

The treatments included

A. Two levels of cutting management

c_1 - Seed collection after 1 cut

c_2 - Seed collection after 2 cuts

B. Three levels of nitrogen

n_1 - 100 kg N ha^{-1}

n_2 - 150 kg N ha^{-1}

n_3 - 200 kg N ha^{-1}

C. Three levels of potassium

k_1 - 50 kg K_2O ha^{-1}

k_2 - 100 kg K_2O ha^{-1}

k_3 - 150 kg K_2O ha^{-1}

Common dose of P_2O_5 @ 30 kg ha^{-1} was uniformly applied to all treatments.

D. Treatment combinations

T_1 - $c_1n_1k_1$ - One cut + 100 kg N + 50 kg K_2O

T_2 - $c_1n_1k_2$ - One cut + 100 kg N + 100 kg K_2O

T_3 - $c_1n_1k_3$ - One cut + 100 kg N + 150 kg K_2O

T_4 - $c_1n_2k_1$ - One cut + 150 kg N + 50 kg K_2O

T_5 - $c_1n_2k_2$ - One cut + 150 kg N + 100 kg K_2O

T_6	-	$c_1n_2k_3$	-	One cut + 150 kg N + 150 kg K_2O
T_7	-	$c_1n_3k_1$	-	One cut + 200 kg N + 50 kg K_2O
T_8	-	$c_1n_3k_2$	-	One cut + 200 kg N + 100 kg K_2O
T_9	-	$c_1n_3k_3$	-	One cut + 200 kg N + 150 kg K_2O
T_{10}	-	$c_2n_1k_1$	-	Two cut + 100 kg N + 50 kg K_2O
T_{11}	-	$c_2n_1k_2$	-	Two cut + 100 kg N + 100 kg K_2O
T_{12}	-	$c_2n_1k_3$	-	Two cut + 100 kg N + 150 kg K_2O
T_{13}	-	$c_2n_2k_1$	-	Two cut + 150 kg N + 50 kg K_2O
T_{14}	-	$c_2n_2k_2$	-	Two cut + 150 kg N + 100 kg K_2O
T_{15}	-	$c_2n_2k_3$	-	Two cut + 150 kg N + 150 kg K_2O
T_{16}	-	$c_2n_3k_1$	-	Two cut + 200 kg N + 50 kg K_2O
T_{17}	-	$c_2n_3k_2$	-	Two cut + 200 kg N + 100 kg K_2O
T_{18}	-	$c_2n_3k_3$	-	Two cut + 200 kg N + 150 kg K_2O

3.2.2 Design and layout

Experimental design : 2 x 3 x 3 partially confounded factorial experiment confounding CNK in replication I and NK in replication II.

Replications	:	2
Spacing	:	40 x 20 cm
Gross plot size	:	4 x 4 m
Net plot size	:	2.4 x 3.2 m
Total number of plots	:	36

Each plot will be divided into two equal halves, one half will be maintained for seed purpose and the other half will be maintained for fodder.

The layout plan is given in Fig. 3.2

R_1			R_2		
B.1	B.2	B.3	B.1	B.2	B.3
T_4	T_{18}	T_{13}	T_{17}	T_9	T_{18}
T_{15}	T_7	T_1	T_7	T_5	T_4
T_{16}	T_2	T_5	T_2	T_{11}	T_3
T_8	T_{10}	T_9	T_6	T_{16}	T_{14}
T_{11}	T_6	T_{17}	T_{13}	T_{15}	T_{10}
T_3	T_{14}	T_{12}	T_{12}	T_1	T_8

4m 4m

Fig. 3.2. Layout of the experiment

An overall view of the experiment is shown in Plate 1.

3.2.3 Details of cultivation

3.2.3.1 Field preparation

The experimental area was cleared off the previous grass cover, dug twice, stubbles removed, clods broken and the field was laid out into 6 blocks each with 6 plots.

3.2.3.2 Fertilizer application

Fertilizers viz., urea, mussoriephos and muriate of potash were applied as per treatment. One-fourth dose of nitrogen, full dose of phosphorus and half dose of potassium as per treatment were applied as basal. The remaining three - fourth dose of nitrogen was given in three splits after each fodder harvest. The half dose of potassium was also given in three splits after each harvest

3.2.3.3 Planting

Young and healthy rooted slips were selected from the planting material obtained and planted at the rate of three slips per hill at a spacing of 40 x 20 cm. Planting was done on Ist and 2nd of August 1998. One life irrigation was given immediately after planting to facilitate better establishment. Gap filling was done wherever required.

a. Overall view of the experiment

b. Fodder harvested from half the plot and the other half left for seed production

c. Individual panicle showing initiation of seed set

Plate 1

3.2.3.4 Irrigation

During the initial establishment phase and also during the summer season, protective irrigation was given as and when necessary.

3.2.3.5 Weeding and intercultivation

The first weeding was done 20 days after planting and second weeding after 45 days. Intercultural operations and weeding were done after each cut and before each split of fertilizer application.

3.2.3.6 Fodder harvest

First cutting was taken 90 days after planting. Subsequent harvests were taken at intervals of 45 days in rainy season and at 60 days interval during summer. Fodder was harvested from half of the plot and the other half was left for seed production as per treatment, which is shown in Plate 1. During summer months, no harvest was done since the growth of the crop was not sufficient. Two border rows all around the plots were discarded and the crop was harvested from the net plot at a height of 15 cm from the base.

3.2.3.7 Seed harvest

Initiation of seed set was noticed by the Ist week of July. An individual panicle showing initiation of seed set is shown in Plate 1. Seeds were collected at weekly intervals when seeds appeared to be visibly mature on account of the pale yellow colour as well as the tendency of seeds to drop off from the panicle.

The first seed harvest was done 24 days after the appearance of first flower and seed harvests were continued for a period of 30 days at weekly intervals. The seed harvests were done during morning hours by shaking the panicle and collecting mature dropping seeds plotwise. The shattered seeds from the ground were also collected carefully from each plot devoid of contamination. The seeds were then dried and stored.

3.2.4 Observations recorded

Observations on growth characters were recorded from 10 sample plants selected randomly from the net plot area of each plot and the averages worked out. Observations on growth characters were taken on the day before each harvest.

3.2.4.1 Growth characters

3.2.4.1.1 Height of plants

Plant height was measured from the base of the plant to the tip of the top most leaf. The mean height was worked out and expressed in cm.

3.2.4.1.2 Number of tillers

The number of tillers of each observational hill was counted and the means worked out.

3.2.4.1.3 Number of leaves

The number of leaves in each sample plant was counted and mean number of leaves worked out.

3.2.4.1.4 Leaf : stem ratio

The sample plants collected before each harvest for dry matter estimation were separated into leaf and stem, dried, weighed and the ratio was worked out on dry weight basis. The means were then found out and expressed as unit of leaf weight per unit of stem weight.

3.2.4.2 Yield and yield attributes

3.2.4.2.1 Green fodder yield

The green fodder yield from the net plot area was recorded immediately after each harvest and the total green fodder production in t ha^{-1} was worked out.

3.2.4.2.2 Dry fodder yield

The sample plants collected from the plot prior to each harvest were weighed to determine the fresh weight, cut into small pieces, sundried and then oven dried to a constant weight at 70°C. The dry matter content for each treatment was computed and the dry matter yield worked out from the respective green matter yields.

3.2.4.2.3 Days to 50 per cent flowering

The number of days taken by more than half of the plants in each plot from panicle initiation to flowering was recorded as the days to attain fifty per cent flowering.

3.2.4.2.4 Number of seeds per panicle

From each sample plant, one panicle was collected and the number of seeds present in each panicle was counted.

3.2.4.2.5 Seed weight per plot

The seeds as and when mature were collected from each net plot, and the shattered seeds collected were also thoroughly cleaned, mixed and dried. The seed weight was computed for each treatment.

3.2.4.2.6 Thousand seed weight

From the seed sample of each treatment, one thousand seeds were drawn and weighed in an electronic balance and weight recorded.

3.2.4.3 Physiological parameters

3.2.4.3.1 Leaf area index

Leaf area index was worked out using the length and width method suggested by Gomez (1972) and averages worked out.

3.2.4.3.2 Germination test

The bold seeds (with kernels) were taken from the seed sample and subjected to germination test. Whatman No. 40 filter paper was used as substratum. Daily moistening was done upto three weeks. The germination count was very low as the freshly harvested seeds tend to remain dormant for a period of time (Rivero and Espinosa, 1988).

3.2.4.4 Chemical analysis of plant samples

The oven dried plant samples used for determination of dry matter content were ground to a fine powder in a Wiley mill. The samples thus prepared were used for chemical analysis for estimation of nutrients.

3.2.4.4.1 Content of N, P and K

The total nitrogen content of the samples were determined by modified Microkjeldhal method involving digestion in sulphuric acid and distillation (Jackson, 1973).

The phosphorus content was determined by Vanado - Molybdo - Phosphoric Yellow colour method using spectrophotometer (Jackson, 1973).

The potassium content in the plant samples were determined by using Flame Photometry (Jackson, 1973).

3.2.4.4.2 Crude protein content

The crude protein content was calculated by multiplying the nitrogen content of plant by the factor 6.25 (Simpson *et al.*, 1965).

3.2.4.4.3 Crude fibre content

Crude fibre content was determined by AOAC method (A.O.A.C., 1975).

3.2.4.4.4 Calcium content

The calcium content was determined in a suitable aliquot of the diacid digest using atomic absorption spectrophotometer (Piper, 1966).

3.2.4.4.5 Magnesium content

The magnesium content of the plant sample was determined in an aliquot of the diacid digest and atomic absorption spectrophotometry (Piper, 1966).

3.2.4.4.6 K : (Ca + Mg) ratio

The ratio was worked out from the values of K, Ca and Mg content obtained from the analysis of plant samples.

3.2.4.5 Soil chemical analysis

The composite soil sample collected from the plot prior to the experiment and the soil samples collected from individual plots after the experiment were dried in shade, passed through a 2mm sieve and analysed for available nutrients viz., available nitrogen, available phosphorus and available potassium. Available nitrogen was estimated by alkaline permanganate method (Subbiah and Asija, 1956), available phosphorus by Bray's method (Jackson, 1973) and available potassium by neutral normal ammonium acetate method (Jackson, 1973).

3.2.4.6 Economic analysis

The economics of cultivation was worked out based on cost of cultivation and present market price of fodder grass and seed. The gross returns per hectare for each treatment was worked out based on prevailing market rate.

The net returns were calculated by subtracting the cost of cultivation from the gross returns.

$$\text{Benefit : Cost ratio} = \frac{\text{Gross income}}{\text{Total expenditure}}$$

3.2.4.7 Statistical analysis

The experimental data were subjected to analysis of variance for 2 x 3 x 3 partially confounded factorial experiment confounding CNK and NK (Cochran and Cox, 1965). Wherever significant effects were detected, the critifcal difference (CD) at 5 per cent level of significance was worked out.

RESULTS

4. RESULTS

A field experiment was conducted at the Instructional Farm, College of Agriculture, Vellayani to study the effect of varying levels of nitrogen, potassium and cutting management on the forage and seed production potential of signal grass. The treatments consisted of the combinations of three levels of nitrogen, three levels of potassium and two levels of cutting management. The data obtained from the study were statistically analysed and the results are presented here.

4.1 Growth characters

4.1.1 Plant height (Table 4.1.1.1 and 4.1.1.2)

The effect of nitrogen on plant height was observed in all the harvests. Plant height was significantly influenced by increasing nitrogen application from 100 to 150 kg ha^{-1} throughout all the harvests. The highest level of nitrogen recorded the maximum height in all the harvests. However, an increase of nitrogen from 150 to 200 kg ha^{-1} did not produce any significant increase in plant height. In the third harvest, an increase in nitrogen increased the plant height but no significant effect was observed between the different levels.

Table 4.1.1.1. Effect of nitrogen, potassium and cutting management on plant height (cm) of signal grass

Treatments	Harvest I	Harvest II	Harvest III	Harvest IV
Nitrogen				
n_1	66.67	67.87	75.95	71.15
n_2	78.33	81.02	81.88	80.60
n_3	87.13	82.50	84.08	83.42
$F_{2,13}$	10.70**	12.91**	1.64	9.73**
SE	3.14	2.24	3.29	2.06
CD	9.59	6.85	—	6.29
Potassium				
k_1	74.25	74.52	81.23	76.83
k_2	75.43	75.58	81.00	75.32
k_3	82.45	81.28	79.68	83.02
$F_{2,13}$	1.99	2.63	0.06	3.92*
SE	3.14	2.24	3.29	2.06
CD	—	—	—	6.29
Cutting				
c_1	75.82	76.58	82.14	77.40
c_2	78.93	77.68	79.13	79.38
$F_{1,13}$	0.74	0.18	0.63	0.69
SE	2.56	1.83	2.69	1.68
CD	—	—	—	—

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 4.1.1.2. Interaction effect of nitrogen, potassium and cutting management on plant height (cm) of signal grass

Treatments	Harvest I	Harvest II	Harvest III	Harvest IV
n_1k_1	58.30	71.25	79.10	71.25
n_1k_2	64.60	62.25	75.20	60.95
n_1k_3	77.10	70.10	73.55	81.25
n_2k_1	80.15	77.50	78.00	80.25
n_2k_2	74.95	80.70	78.30	81.50
n_2k_3	79.90	84.85	89.35	80.05
n_3k_1	84.30	74.80	86.60	79.00
n_3k_2	86.75	83.80	89.50	83.50
n_3k_3	90.35	88.90	76.15	87.75
$F_{4,13}$	0.59	1.33	1.65	2.61
SE	5.45	3.88	5.70	3.57
CD	—	—	—	—
n_1c_1	63.37	68.07	79.23	69.33
n_1c_2	69.97	67.67	72.67	72.97
n_2c_1	77.93	79.00	83.03	78.70
n_2c_2	78.73	83.03	80.73	82.50
n_3c_1	86.17	82.67	84.17	84.17
n_3c_2	88.10	82.33	84.00	82.67
$F_{2,13}$	0.24	0.32	0.25	0.53
SE	4.44	3.17	4.65	2.91
CD	—	—	—	—
k_1c_1	75.73	74.27	84.43	78.00
k_1c_2	72.77	74.77	78.03	75.67
k_2c_1	73.50	74.43	83.17	71.17
k_2c_2	77.37	76.73	78.83	79.47
k_3c_1	78.23	81.03	78.83	83.03
k_3c_2	86.67	81.53	80.53	83.00
$F_{2,13}$	0.84	0.05	0.41	1.84
SE	4.44	3.17	4.65	2.91
CD	—	—	—	—

The response of potassium was visible only at the fourth harvest, where the application of potassium at 150 kg ha^{-1} was found to increase the plant height significantly. Potassium application at 50, 100 and 150 kg ha^{-1} produced more or less the same results during the first three harvests.

Cutting management did not influence the plant height. The plant height was not influenced by any of the interactions between N x K, N x C and K x C in any of the harvests.

4.1.2 Tiller number (Table 4.1.2.1 and 4.1.2.2)

The effect of nitrogen on tiller number was noticed from the second harvest onwards. The effect was not visible in the first harvest. A significant difference in tiller number per hill was observed at the second, third and fourth harvest when nitrogen application was increased from 100 to 150 kg ha^{-1}. However, an increase of nitrogen from 150 to 200 kg ha^{-1} did not produce any significant increase in tiller number in the second and fourth harvests. In the first and third harvests an increase in nitrogen from 150 to 200 kg ha^{-1} did not show any influence on tiller number.

The application of potassium at the three doses viz., 50, 100 and 150 kg ha^{-1} did not produce any significant difference in tiller number and recorded more or less the same tiller number in all the harvests.

Table 4.1.2.1. Effect of nitrogen, potassium and cutting management on tiller number per hill of signal grass

Treatments	Harvest I	Harvest II	Harvest III	Harvest IV
Nitrogen				
n_1	22.48	31.82	30.82	31.32
n_2	26.20	34.28	38.42	36.23
n_3	24.87	38.50	37.72	38.23
$F_{2,13}$	1.62	14.11**	6.46*	16.74**
SE	1.48	0.90	1.65	0.87
CD	—	2.75	5.05	2.65
Potassium				
k_1	23.47	33.90	35.83	34.75
k_2	25.25	34.88	36.13	35.51
k_3	24.83	35.82	34.98	35.52
$F_{2,13}$	0.40	1.13	0.13	0.26
SE	1.48	0.90	1.65	0.87
CD	—	—	—	—
Cutting				
c_1	23.34	35.51	36.20	35.86
c_2	25.69	34.22	35.10	34.66
$F_{1,13}$	1.89	1.54	0.33	1.42
SE	1.21	0.73	1.34	0.71
CD	—	—	—	—

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 4.1.2.2. Interaction effect of nitrogen, potassium and cutting management on tiller number per hill of signal grass

Treatments	Harvest I	Harvest II	Harvest III	Harvest IV
n_1k_1	22.40	32.00	30.40	31.20
n_1k_2	23.45	31.55	34.60	33.08
n_1k_3	21.60	31.90	27.45	29.68
n_2k_1	25.20	33.70	41.10	37.05
n_2k_2	27.20	33.35	37.00	35.18
n_2k_3	26.20	35.80	37.15	36.48
n_3k_1	22.80	36.00	36.00	36.00
n_3k_2	25.10	39.75	36.80	38.28
n_3k_3	26.70	39.75	40.35	40.40
$F_{4,13}$	0.17	0.83	2.22	2.82
SE	2.56	1.56	2.86	1.51
CD	—	—	—	—
n_1c_1	21.27	31.97	30.60	31.28
n_1c_2	23.70	31.67	31.03	31.35
n_2c_1	26.00	34.47	40.00	37.00
n_2c_2	26.40	34.10	36.83	35.47
n_3c_1	22.77	40.10	38.00	39.28
n_3c_2	26.97	36.90	37.43	37.17
$F_{2,13}$	0.41	0.85	0.32	0.42
SE	2.09	1.27	2.34	1.23
CD	—	—	—	—
k_1c_1	21.00	35.30	37.97	36.40
k_1c_2	25.93	32.50	33.70	33.10
k_2c_1	25.87	36.67	35.70	36.18
k_2c_2	24.63	33.10	36.57	34.83
k_3c_1	23.17	34.57	34.93	34.98
k_3c_2	26.50	37.07	35.03	36.05
$F_{2,13}$	1.17	3.37	0.70	1.58
SE	2.09	1.27	2.34	1.23
CD	—	—	—	—

The effect of cutting on tiller number was not significant. None of the interactions between the three treatments was found to influence the tiller number.

4.1.3 Number of leaves (Table 4.1.3.1 and 4.1.3.2)

The response of nitrogen at different levels on the number of leaves was not visible at the first two harvests. A significant difference in the number of leaves with nitrogen levels was observed in the third and fourth harvests. The maximum number of leaves was recorded at 150 kg ha^{-1} in the third harvest, which was on par with that of 200 kg N ha^{-1}. The number of leaves was increased significantly by increasing the nitrogen application from 100 to 150 kg ha^{-1} and then further to 200 kg ha^{-1} in the fourth harvest. The fourth harvest recorded the maximum number of leaves.

There was no significant influence due to application of potassium.

The influence of cutting management on number of leaves was found to be significant only at the fourth harvest. Cutting twice and leaving for seed purpose was found to decrease the number of leaves when compared to cutting once in all the harvests. A decrease in number of leaves was noticed when compared to cutting only once. But a significant decrease in leaf number was however observed by cutting twice in the fourth harvest.

Table 4.1.3.1. Effect of nitrogen, potassium and cutting management on the number of leaves per hill of signal grass

Treatments	Harvest I	Harvest II	Harvest III	Harvest IV
Nitrogen				
n_1	112.42	163.67	123.20	145.92
n_2	131.00	168.67	153.58	163.17
n_3	124.33	185.92	150.83	192.25
$F_{2,13}$	1.62	2.33	6.48*	19.96**
SE	7.39	7.64	6.60	5.24
CD	—	—	20.17	16.01
Potassium				
k_1	117.33	159.92	143.25	161.92
k_2	126.25	170.50	144.50	166.25
k_3	124.17	187.83	139.87	173.17
$F_{2,13}$	0.40	3.40	0.13	1.17
SE	7.39	7.64	6.60	5.24
CD	—	—	—	—
Cutting				
c_1	116.72	174.72	144.69	176.17
c_2	128.44	170.78	140.39	158.06
$F_{1,13}$	1.89	0.20	0.32	8.95*
SE	6.03	6.24	5.39	4.28
CD	—	—	—	13.07

* Significant at 5 per cent level

** Significant at 1 per cent level

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Table 4.1.3.2. Interaction effect of nitrogen, potassium and cutting management on number of leaves per hill of signal grass

Treatments	Harvest I	Harvest II	Harvest III	Harvest IV
n_1k_1	112.00	160.00	121.50	156.00
n_1k_2	117.25	164.25	138.50	148.00
n_1k_3	108.00	166.75	109.60	133.75
n_2k_1	126.00	158.75	164.25	166.50
n_2k_2	136.00	159.00	148.00	159.50
n_2k_3	131.00	188.25	148.50	163.50
n_3k_1	114.00	161.00	144.00	163.25
n_3k_2	125.50	188.25	147.00	191.25
n_3k_3	133.50	208.50	161.50	222.25
$F_{4,13}$	0.17	0.83	2.25	6.84**
SE	12.80	13.23	11.44	9.08
CD	—	—	—	27.73
n_1c_1	106.33	159.33	122.23	146.50
n_1c_2	118.50	168.00	124.17	145.33
n_2c_1	130.00	172.00	159.83	172.33
n_2c_2	132.00	165.33	147.33	154.00
n_3c_1	113.83	192.83	152.00	209.67
n_3c_2	134.83	179.00	149.67	174.83
$F_{2,13}$	0.41	0.57	0.32	2.58
SE	10.45	10.80	9.34	7.41
CD	—	—	—	—
k_1c_1	105.00	162.83	151.83	169.33
k_1c_2	129.67	157.00	134.67	154.50
k_2c_1	129.33	176.33	142.67	180.83
k_2c_2	123.17	164.67	146.33	151.67
k_3c_1	115.83	185.00	139.57	178.33
k_3c_2	132.50	190.67	140.17	168.00
$F_{2,13}$	1.17	0.33	0.73	0.88
SE	10.45	10.80	9.34	7.41
CD	—	—	—	—

* Significant at 5 per cent level ** Significant at 1 per cent level

Regarding interaction effect, n_1 in combination with k_2 resulted in an increase in the number of leaves per hill. However the response was more or less same at n_1k_2 and n_1k_3. But n_2 and n_3 in combination with different levels of K produced a linear trend in response.

4.1.4 Leaf : stem ratio (Table 4.1.4.1. and 4.1.4.2)

The different levels of nitrogen and potassium had no significant influence on leaf : stem ratio.

The leaf : stem ratio was not significantly influenced by cutting management. None of the interactions were significant except N x C at third harvest.

4.2 Yield and yield attributes

4.2.1 Green fodder yield (Table 4.2.1.1)

Significant difference in green fodder yield was observed in the second and fourth harvests, by the application of higher dose of nitrogen. However, the green fodder yield did not increase significantly by increasing nitrogen application from 150 to 200 kg ha^{-1}. The lowest dose of nitrogen recorded the lowest green fodder yield in all the harvests. In the fourth harvest significant yield increase was observed when nitrogen was applied at 200 kg ha^{-1}. For all the different levels of nitrogen, highest green fodder yield was recorded in the fourth harvest.

Table 4.1.4.1. Effect of nitrogen, potassium and cutting management on leaf : stem ratio of signal grass

Treatments	Harvest I	Harvest II	Harvest III	Harvest IV
Nitrogen				
n_1	0.90	1.04	0.93	0.96
n_2	0.84	0.96	0.86	0.89
n_3	0.82	1.02	0.91	0.92
$F_{2,13}$	2.25	1.20	2.89	3.68
SE	0.03	0.04	0.02	0.02
CD	—	—	—	—
Potassium				
k_1	0.84	1.02	0.92	0.93
k_2	0.87	1.04	0.91	0.94
k_3	0.86	0.96	0.86	0.89
$F_{2,13}$	0.22	1.23	2.21	1.75
SE	0.03	0.04	0.02	0.02
CD	—	—	—	—
Cutting				
c_1	0.88	1.00	0:89	0.92
c_2	0.83	1.02	0.91	0.92
$F_{1,13}$	2.78	0.35	0.44	0.03
SE	0.02	0.03	0.02	0.02
CD	—	—	—	—

Table 4.1.4.2. Interaction effect of nitrogen, potassium and cutting management on leaf : stem ratio of signal grass

Treatments	Harvest I	Harvest II	Harvest III	Harvest IV
n_1k_1	0.90	1.04	0.96	0.97
n_1k_2	0.98	1.04	0.89	0.97
n_1k_3	0.82	1.03	0.93	0.93
n_2k_1	0.81	0.95	0.91	0.89
n_2k_2	0.83	1.03	0.89	0.91
n_2k_3	0.90	0.92	0.77	0.86
n_3k_1	0.82	1.07	0.90	0.93
n_3k_2	0.78	1.06	0.95	0.93
n_3k_3	0.86	0.94	0.88	0.89
$F_{4,13}$	2.24	0.60	1.21	0.08
SE	0.05	0.06	0.04	0.03
CD	—	—	—	—
n_1c_1	0.95	1.04	0.95	0.98
n_1c_2	0.85	1.04	0.90	0.93
n_2c_1	0.82	0.96	0.78	0.85
n_2c_2	0.87	0.97	0.93	0.92
n_3c_1	0.87	0.99	0.94	0.93
n_3c_2	0.77	1.06	0.88	0.90
$F_{2,13}$	2.94	0.31	6.94**	3.40
SE	0.04	0.05	0.03	0.03
CD	—	—	0.096	—
k_1c_1	0.87	0.99	0.89	0.92
k_1c_2	0.81	1.05	0.96	0.94
k_2c_1	0.84	1.01	0.91	0.92
k_2c_2	0.90	1.07	0.91	0.96
k_3c_1	0.94	0.99	0.87	0.93
k_3c_2	0.78	0.94	0.85	0.86
$F_{2,13}$	3.84*	0.81	1.22	2.93
SE	0.04	0.05	0.03	0.03
CD	0.117	—	—	—

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 4.2.1.1. Effect of nitrogen, potassium and their interaction on green fodder yield (t ha^{-1}) of signal grass

Treatments	Harvest I	Harvest II	Harvest III	Harvest IV
Nitrogen				
n_1	15.53	16.53	25.95	28.23
n_2	17.64	20.97	28.99	31.75
n_3	18.47	21.44	30.80	38.13
$F_{2,13}$	3.09	19.30**	1.60	4.78*
SE	0.86	0.62	1.94	2.29
CD	—	1.88	—	7.01
Potassium				
k_1	16.62	19.30	27.38	34.98
k_2	17.00	18.42	29.91	29.79
k_3	18.01	21.22	28.45	33.33
$F_{2,13}$	0.70	5.43*	0.43	1.33
SE	0.86	0.62	1.94	2.29
CD	—	1.88	—	—
Interaction				
n_1k_1	14.84	16.02	26.12	33.75
n_1k_2	13.74	14.77	27.40	25.00
n_1k_3	18.01	18.82	24.32	25.94
n_2k_1	16.13	22.73	26.43	35.25
n_2k_2	18.60	19.46	30.27	31.25
n_2k_3	18.21	20.72	30.27	28.75
n_3k_1	18.91	19.15	29.59	35.94
n_3k_2	18.66	21.02	32.07	33.13
n_3k_3	17.83	24.14	30.76	45.31
$F_{4,13}$	1.41	2.14	0.18	1.00
SE	1.49	1.07	3.37	3.97
CD	—	—	—	—

* Significant at 5 per cent level ** Significant at 1 per cent level

The effect of potassium was observed on green fodder yield in the second harvest. The highest dose of potassium resulted in a higher green fodder yield in the harvest. The green fodder yield increased with the number of harvests. N x K interaction was not significant.

4.2.2 Dry fodder yield (Table 4.2.2.1)

Dry fodder yield was significantly influenced by nitrogen application in the second and third harvests. The maximum dry fodder yield was recorded under the highest level of nitrogen ie., 200 kg ha^{-1} which was on par with 150 kg N ha^{-1} at the second harvest. In the third harvest, nitrogen levels of 100 and 150 kg ha^{-1} were found to be on par whereas 200 kg ha^{-1} resulted in an increased dry fodder yield in comparison to the lower level. Consequently, the dry fodder yield progressively increased as the harvests progressed and the fourth harvest recorded the highest dry fodder yield at all nitrogen levels.

Potassium did not have any significant influence on dry fodder yield. N x K interaction was not significant.

4.2.3 Days to 50 per cent flowering (Table 4.2.3.1 and 4.2.4.1)

Nitrogen had a significant influence on number of days to 50 per cent flowering. Minimum number of days to 50 per cent flowering was recorded by highest nitrogen dose of 200 kg ha^{-1}. As the nitrogen application increased from 100 to 150 kg ha^{-1} there was a reduction in the number of days to 50 per cent flowering.

Table 4.2.2.1. Effect of nitrogen, potassium and their interaction on dry fodder yield (t ha^{-1}) of signal grass

Treatments	Harvest I	Harvest II	Harvest III	Harvest IV
Nitrogen				
n_1	5.99	7.22	8.48	9.32
n_2	6.89	9.10	9.55	10.66
n_3	6.71	9.35	10.76	13.11
$F_{2,13}$	1.81	6.98**	5.50*	3.19
SE	0.35	0.44	0.49	1.07
CD	—	1.34	1.48	—
Potassium				
k_1	6.64	8.38	9.33	12.12
k_2	6.49	7.86	9.80	9.91
k_3	6.46	9.43	9.66	11.05
$F_{2,13}$	0.08	3.32	0.25	1.05
SE	0.35	0.44	0.49	1.07
CD	—	—	—	—
Interaction				
n_1k_1	6.22	7.03	8.82	11.46
n_1k_2	5.55	6.38	8.85	8.17
n_1k_3	6.21	8.26	7.77	8.34
n_2k_1	6.68	9.87	9.38	12.67
n_2k_2	7.30	8.65	9.18	9.59
n_2k_3	6.68	8.77	10.08	9.72
n_3k_1	7.03	8.23	9.79	12.24
n_3k_2	6.62	8.55	11.35	11.98
n_3k_3	6.49	11.27	11.14	15.10
$F_{4,13}$	0.47	1.94	1.06	0.69
SE	0.61	0.76	0.84	1.86
CD	—	—	—	—

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 4.2.3.1. Effect of nitrogen, potassium and cutting management on days to 50 per cent flowering and number of seeds per panicle of signal grass

Treatments	Days to 50 % flowering	Number of seeds per panicle
Nitrogen		
n_1	9.67	163.00
n_2	9.51	172.50
n_3	9.32	185.92
$F_{2,13}$	31.65**	13.72**
SE	0.03	3.11
CD	0.10	9.50
Potassium		
k_1	9.56	165.33
k_2	9.47	173.58
k_3	9.47	182.50
$F_{2,13}$	2.88	7.63**
SE	0.03	3.11
CD	—	9.50
Cutting		
c_1	9.51	168.44
c_2	9.48	179.17
$F_{1,13}$	0.59	8.92*
SE	0.02	2.54
CD	—	7.75

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 4.2.4.1. Interaction effect of nitrogen, potassium and cutting management on days to 50 per cent flowering and number of seeds per panicle of signal grass

Treatments	Days to 50 % flowering	Number of seeds per panicle
n_1k_1	9.73	156.50
n_1k_2	9.55	159.25
n_1k_3	9.73	173.25
n_2k_1	9.60	162.50
n_2k_2	9.50	175.75
n_2k_3	9.42	179.25
n_3k_1	9.35	177.00
n_3k_2	9.35	185.75
n_3k_3	9.25	195.00
$F_{4,13}$	2.12	0.47
SE	0.05	5.38
CD	—	—
n_1c_1	9.68	158.67
n_1c_2	9.65	167.33
n_2c_1	9.50	165.67
n_2c_2	9.52	179.33
n_3c_1	9.35	181.00
n_3c_2	9.28	190.83
$F_{2,13}$	0.46	0.18
SE	0.04	4.40
CD	—	—
k_1c_1	9.62	158.17
k_1c_2	9.50	172.50
k_2c_1	9.42	169.83
k_2c_2	9.52	177.33
k_3c_1	9.50	177.33
k_3c_2	9.43	187.67
$F_{2,13}$	3.32	0.31
SE	0.04	4.40
CD	—	—

Potassium as well as cutting management did not exert any significant influence on days to 50 per cent flowering.

None of the interactions were found to be significant.

4.2.4 Number of seeds per panicle (Table 4.2.3.1 and 4.2.4.1)

The number of seeds per panicle was significantly influenced by nitrogen. When the nitrogen application was increased from 100 to 150 and 200 kg ha^{-1}, the number of seeds per panicle was found to increase considerably. Maximum number of seeds per panicle (185.92) was recorded by the highest level of nitrogen viz., 200 kg ha^{-1}.

Potassium also exerted a significant influence on number of seeds per panicle. The number of seeds per panicle was increased by increasing potassium application from 50 to 150 kg ha^{-1}. The highest level of potassium ie., 150 kg ha^{-1} recorded the maximum number of seeds per panicle (182.5).

Cutting management significantly influenced the number of seeds per panicle. Seed collection after two cuts recorded more number of seeds per panicle when compared to seed collection after one cut.

The number of seeds per panicle was not influenced by any of the interactions.

4.2.5 Seed yield (Table 4.2.5.1 and 4.2.6.1)

The seed yield was significantly influenced by nitrogen. As the nitrogen dose was increased from 100 to 150 kg ha^{-1}, the seed yield registered a significant increase from 87.61 to 124.52 kg ha^{-1}. The highest seed yield of 176.75 kg ha^{-1} was recorded with the highest level of nitrogen ie., 200 kg ha^{-1}.

Potassium application also resulted in a significant increase in seed yield. A progressive increase in seed yield was recorded with incremental levels of potassium. The highest level of potassium viz., 150 kg ha^{-1} recorded the highest seed yield of 138.62 kg ha^{-1}.

A significant influence of cutting management on seed yield was also observed. Seed collection after two cuts registered a significant increase in seed yield when compared to seed collection after one cut.

None of interactions viz., N x K, N x C or K x C were found to significantly influence seed yield.

4.2.6 Thousand seed weight (Table 4.2.5.1 and 4.2.6.1)

Thousand seed weight was significantly influenced by increasing nitrogen from 100 to 150 and 200 kg ha^{-1}. The highest thousand seed weight of 2.48 g was recorded by the highest level of nitrogen of 200 kg ha^{-1}.

Table 4.2.5.1. Effect of nitrogen, potassium and cutting management on seed yield (kg ha^{-1}) and thousand seed weight (g) of signal grass

Treatments	Seed yield	1000 seed weight
Nitrogen		
n_1	87.61	2.42
n_2	124.52	2.44
n_3	176.75	2.48
$F_{2,13}$	1035.53**	56.79**
SE	1.39	0.004
CD	4.25	0.011
Potassium		
k_1	120.78	2.44
k_2	129.48	2.45
k_3	138.62	2.46
$F_{2,13}$	41.11**	7.08**
SE	1.39	0.004
CD	4.25	0.011
Cutting		
c_1	125.05	2.44
c_2	134.21	2.45
$F_{1,13}$	32.47**	5.71*
SE	1.14	0.003
CD	3.47	0.009

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 4.2.6.1. Interaction effect of nitrogen, potassium and cutting management on seed yield (kg ha^{-1}) and thousand seed weight (g) of signal grass

Treatments	Seed yield	1000 seed weight
n_1k_1	81.04	2.42
n_1k_2	89.24	2.43
n_1k_3	92.55	2.42
n_2k_1	115.57	2.43
n_2k_2	121.33	2.45
n_2k_3	136.65	2.45
n_3k_1	165.72	2.46
n_3k_2	177.87	2.48
n_3k_3	186.67	2.50
$F_{4,13}$	2.42	1.80
SE	2.41	0.007
CD	—	—
n_1c_1	85.23	2.42
n_1c_2	90.00	2.43
n_2c_1	118.45	2.44
n_2c_2	130.59	2.44
n_3c_1	171.47	2.47
n_3c_2	182.04	2.49
$F_{2,13}$	1.95	1.14
SE	1.97	0.005
CD	—	—
k_1c_1	115.90	2.43
k_1c_2	125.65	2.44
k_2c_1	125.23	2.45
k_2c_2	133.74	2.45
k_3c_1	134.01	2.45
k_3c_2	143.23	2.47
$F_{2,13}$	0.05	1.10
SE	1.97	0.005
CD	—	—

Potassium also had a highly significant influence on thousand seed weight. Increasing the potassium dose from 50 to 150 kg ha^{-1} registered a significant increase in thousand seed weight.

Significant influence of cutting management on thousand seed weight was also observed. Seed collection after two cuts recorded a higher thousand seed weight compared to seed collection after one cut.

None of the interaction effects was found to be significant in influencing the thousand seed weight.

4.3 Physiological parameters

4.3.1 Leaf Area Index (Table 4.3.1.1 and 4.3.1.2)

A significant influence of nitrogen on leaf area index was noticed in the third and fourth harvests. In the third harvest, the leaf area index showed a considerable increase when nitrogen was increased from 100 to 200 kg ha^{-1}. However an increase of nitrogen from 100 to 150 and 200 kg ha^{-1} produced a significant increase in LAI in the fourth harvest. The LAI was found to be maximum in the second harvest for all nitrogen levels, after which it showed a decline.

The effect of potassium on LAI was significant in the second harvest, where the highest dose of potassium ie., 150 kg ha^{-1} recorded the highest LAI in comparison with the result at 50 kg ha^{-1}.

Table 4.3.1.1. Effect of nitrogen, potassium and cutting management on leaf area index of signal grass

Treatments	Harvest I	Harvest II	Harvest III	Harvest IV
Nitrogen				
n_1	6.79	8.12	4.09	6.00
n_2	7.95	8.32	5.00	7.99
n_3	7.87	9.53	5.27	8.68
$F_{2,13}$	0.77	0.85	4.02*	8.36**
SE	0.74	0.82	0.31	0.48
CD	—	—	0.94	1.47
Potassium				
k_1	7.00	7.16	5.01	7.57
k_2	7.65	8.19	5.03	7.46
k_3	7.96	10.62	4.32	7.66
$F_{2,13}$	0.44	4.66*	1.71	0.05
SE	0.74	0.82	0.31	0.48
CD	—	2.52	—	—
Cutting				
c_1	6.96	8.50	4.98	7.58
c_2	8.11	8.81	4.60	7.54
$F_{1,13}$	1.80	0.10	1.12	0.004
SE	0.60	0.67	0.25	0.39
CD	—	—	—	—

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 4.3.1.2. Interaction effect of nitrogen, potassium and cutting management on leaf area index of signal grass

Treatments	Harvest I	Harvest II	Harvest III	Harvest IV
n_1k_1	6.54	8.73	4.28	6.12
n_1k_2	6.25	6.27	4.87	5.86
n_1k_3	7.57	9.37	3.12	6.03
n_2k_1	7.33	5.94	5.55	8.57
n_2k_2	8.08	8.10	4.76	8.22
n_2k_3	8.46	10.92	4.68	7.19
n_3k_1	7.14	6.80	5.21	8.01
n_3k_2	8.62	10.21	5.45	8.29
n_3k_3	7.86	11.57	5.16	9.76
$F_{4,13}$	0.18	1.27	1.39	1.77
SE	1.29	1.43	0.53	0.83
CD	—	—	—	—
n_1c_1	6.53	7.27	4.02	5.75
n_1c_2	7.04	8.97	4.16	6.25
n_2c_1	7.28	8.50	5.38	8.20
n_2c_2	8.62	8.13	4.62	7.78
n_3c_1	7.07	9.74	5.54	8.78
n_3c_2	8.68	9.32	5.01	8.59
$F_{2,13}$	0.15	0.54	0.58	0.25
SE	1.05	1.16	0.44	0.68
CD	—	—	—	—
k_1c_1	5.86	7.25	5.38	7.45
k_1c_2	8.14	7.06	4.65	7.68
k_2c_1	7.60	7.97	5.26	7.82
k_2c_2	7.71	8.42	4.79	7.09
k_3c_1	7.43	10.30	4.28	7.46
k_3c_2	8.50	10.94	4.36	7.86
$F_{2,13}$	0.53	0.07	0.46	0.40
SE	1.05	1.16	0.44	0.68
CD	—	—	—	—

Cutting management was not significant in influencing the leaf area index.

The leaf area index was not significantly influenced by any of the interactions viz., N x K, N x C or K x C.

4.3.2 Seed germination (Table 4.3.2.1 and 4.3.2.2)

Seed germination was significantly increased by increasing levels of nitrogen from 100 to 200 kg ha^{-1}. Nitrogen doses of 100 and 150 kg ha^{-1} however recorded the same effect.

Potassium and cutting management did not have any significant influence on seed germination.

None of the interaction effects were significant in influencing seed germination.

4.4 Chemical analysis

4.4.1 Content of N, P and K

4.4.1.1 Content of nitrogen in fodder (Table 4.4.1.1 and 4.4.1.2)

Nitrogen application was found to have a significant effect on the N content of fodder. The highest N content was recorded by the treatment receiving the lowest dose of nitrogen viz., 100 kg ha^{-1}. Further, as the

Table 4.3.2.1. Effect of nitrogen, potassium and cutting management on seed germination (%) of signal grass

Treatment	Seed germination
Nitrogen	
n_1	1.79
n_2	1.79
n_3	1.83
$F_{2,13}$	4.47*
SE	0.011
CD	0.033
Potassium	
k_1	1.81
k_2	1.80
k_3	1.80
$F_{2,13}$	0.13
SE	0.011
CD	—
Cutting	
c_1	1.81
c_2	1.80
$F_{1,13}$	0.33
SE	0.009
CD	—

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 4.3.2.2. Interaction effect of nitrogen, potassium and cutting management on seed germination (%) of signal grass

Treatment	Seed germination
n_1k_1	1.80
n_1k_2	1.80
n_1k_3	1.78
n_2k_1	1.79
n_2k_2	1.77
n_2k_3	1.80
n_3k_1	1.83
n_3k_2	1.82
n_3k_3	1.84
$F_{4,13}$	0.69
SE	0.019
CD	—
n_1c_1	1.80
n_1c_2	1.79
n_2c_1	1.80
n_2c_2	1.78
n_3c_1	1.83
n_3c_2	1.83
$F_{2,13}$	0.31
SE	0.015
CD	—
k_1c_1	1.81
k_1c_2	1.80
k_2c_1	1.80
k_2c_2	1.80
k_3c_1	1.81
k_3c_2	1.81
$F_{2,13}$	0.15
SE	0.015
CD	—

Table 4.4.1.1. Effect of nitrogen, potassium and cutting management on the content of nitrogen, phosphorus and potassium (%) in signal grass

Treatments	N	P	K
Nitrogen			
n_1	1.30	0.112	1.52
n_2	1.20	0.108	1.38
n_3	1.17	0.106	1.37
$F_{2,13}$	13.10**	1.14	3.00
SE	0.019	0.003	0.05
CD	0.057	—	—
Potassium			
k_1	1.28	0.108	1.19
k_2	1.21	0.113	1.41
k_3	1.18	0.106	1.66
$F_{2,13}$	8.13**	1.77	23.31**
SE	0.019	0.003	0.05
CD	0.057	—	0.15
Cutting			
c_1	1.21	0.109	1.45
c_2	1.24	0.108	1.40
$F_{1,13}$	1.82	0.035	0.79
SE	0.015	0.002	0.04
CD	—	—	—

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 4.4.1.2. Interaction effect of nitrogen, potassium and cutting management on the content of nitrogen, phosphorus and potassium (%) in signal grass

Treatments	N	P	K
n_1k_1	1.44	0.104	1.28
n_1k_2	1.38	0.125	1.53
n_1k_3	1.09	0.108	1.75
n_2k_1	1.18	0.110	1.14
n_2k_2	1.11	0.105	1.38
n_2k_3	1.30	0.111	1.61
n_3k_1	1.23	0.111	1.15
n_3k_2	1.13	0.109	1.33
n_3k_3	1.15	0.100	1.63
$F_{4,13}$	14.81**	0.54	0.08
SE	0.033	0.004	0.09
CD	0.099	—	—
n_1c_1	1.31	0.113	1.61
n_1c_2	1.29	0.112	1.43
n_2c_1	1.09	0.109	1.41
n_2c_2	1.30	0.108	1.34
n_3c_1	1.22	0.107	1.32
n_3c_2	1.12	0.107	1.42
$F_{2,13}$	19.04**	0.008	2.14
SE	0.027	0.004	0.07
CD	0.082	—	—
k_1c_1	1.24	0.111	1.23
k_1c_2	1.32	0.106	1.15
k_2c_1	1.26	0.112	1.45
k_2c_2	1.15	0.114	1.38
k_3c_1	1.12	0.106	1.67
k_3c_2	1.24	0.107	1.66
$F_{2,13}$	10.63**	0.59	0.16
SE	0.027	0.004	0.07
CD	0.082	—	—

* Significant at 5 per cent level ** Significant at 1 per cent level

nitrogen application was increased there was a steady decline in the N content of the grass. Significant difference in N content was observed between consecutive levels of nitrogen.

The N content of the fodder was significantly influenced by potassium application. As the potassium application was increased from 50 to 100 and 150 kg ha^{-1}, the N content of the fodder decreased. The highest N content of fodder was recorded by lowest dose of potassium treatment, which was significantly higher than the other levels.

There was no significant effect of cutting management on nitrogen content of fodder.

Significant interactions were noticed by nitrogen and potassium application. When the lowest dose of nitrogen, ie., 100 kg ha^{-1} (n_1) was combined with the lowest dose of potassium ie., 50 kg ha^{-1} (k_1), a significant increase in nitrogen content of fodder was observed which was on par with n_1k_2 treatment. When the highest dose of potassium ie., 150 kg ha^{-1} was combined with 150 kg N ha^{-1}, it led to a phenomenal increase in the nitrogen content of fodder. With the highest dose of nitrogen ie., 200 kg ha^{-1} and 50 kg ha^{-1} of potassium, a comparatively higher nitrogen content of fodder was observed. But when the potassium dose was increased to 100 and 150 kg ha^{-1} there was a decrease in the nitrogen content of fodder.

Significant interactions were observed between N and C as well as K and C. At the lowest level of nitrogen, cutting management did not record any significant difference. At n_2 level, c_2 resulted in a higher nitrogen content and at n_3 level, c_1 resulted in a higher nitrogen content. A similar result was observed between potassium and mode of cutting. Significant interaction was observed at the highest dose of potassium. At the lowest level of K, no significant difference was observed at c_1 and c_2, while at 100 kg ha^{-1} of potassium, c_1 recorded highest N content, and at 150 kg ha^{-1} of potassium c_2 recorded highest N content.

4.4.1.2 Content of phosphorus in fodder (Table 4.4.1.1 and 4.4.1.2)

The phosphorus content of fodder was not significantly different at various levels of either N or K. None of the interactions were found to influence the phosphorus content of the fodder.

4.4.1.3 Content of potassium in fodder (Table 4.4.1.1 and 4.4.1.2)

The potassium content of fodder was not significantly influenced by the different levels of nitrogen applied.

There was significant influence of potassium application on the potassium content of fodder. Increase in potassium levels from 50 to 100 kg ha^{-1} registered a significant progressive increase in the potassium content of fodder.

The potassium content was not influenced by cutting management.

No significant interaction was noticed by N x K, N x C and K x C.

4.4.2 Content of crude protein in fodder (Table 4.4.2.1 and 4.4.3.1)

The crude protein content was significantly influenced by nitrogen. As the nitrogen application was increased from 100 to 150 and 200 kg ha^{-1}, a significant decrease in crude protein content of the fodder was observed. With the lowest level of nitrogen, highest crude protein content was observed.

Potassium also showed a similar trend on crude protein content. The lowest dose of potassium recorded the highest crude protein content. Increase in potassium application resulted in a decrease in crude protein content. Significant decrease was noted when potassium application was increased from 50 to 100 kg ha^{-1}.

No significant response was seen by cutting management on crude protein content.

Significant interactions were observed with N x K, N x C as well as K x C with respect to crude protein content.

The lowest dose of nitrogen combined with the lowest dose of potassium recorded the highest crude protein content, followed by the next higher dose of potassium in combination with the lowest dose of

Table 4.4.2.1. Effect of nitrogen, potassium and cutting management on crude protein and crude fibre content of signal grass on dry weight basis

Treatment	Crude protein (%)	Crude fibre (%)
Nitrogen		
n_1	8.12	29.05
n_2	7.47	27.92
n_3	7.31	27.45
$F_{2,13}$	13.09**	74.16**
SE	0.12	0.10
CD	0.360	0.292
Potassium		
k_1	8.01	28.73
k_2	7.53	27.53
k_3	7.36	28.15
$F_{2,13}$	8.19**	39.43**
SE	0.12	0.10
CD	0.360	0.292
Cutting		
c_1	7.54	28.10
c_2	7.72	28.18
$F_{1,13}$	1.85	0.48
SE	0.10	0.08
CD	—	—

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 4.4.3.1. Interaction effect of nitrogen, potassium and cutting management on crude protein and crude fibre content of signal grass on dry weight basis

Treatments	Crude protein (%)	Crude fibre (%)
n_1k_1	8.97	29.55
n_1k_2	8.59	28.45
n_1k_3	6.78	29.15
n_2k_1	7.39	29.35
n_2k_2	6.92	27.25
n_2k_3	8.10	27.15
n_3k_1	7.66	27.30
n_3k_2	7.08	26.90
n_3k_3	7.19	28.15
$F_{4,13}$	14.83**	18.88**
SE	0.20	0.17
CD	0.62	0.51
n_1c_1	8.18	28.83
n_1c_2	8.05	29.27
n_2c_1	6.80	27.93
n_2c_2	8.14	27.90
n_3c_1	7.64	27.53
n_3c_2	6.98	27.37
$F_{2,13}$	19.18**	2.72
SE	0.17	0.14
CD	0.51	—
k_1c_1	7.77	28.70
k_1c_2	8.24	28.77
k_2c_1	7.87	27.43
k_2c_2	7.19	27.63
k_3c_1	6.97	28.17
k_3c_2	7.74	28.13
$F_{2,13}$	10.62**	0.39
SE	0.17	0.14
CD	0.51	—

* Significant at 5 per cent level ** Significant at 1 per cent level

nitrogen. The lowest order interaction between nitrogen and cutting management was found to increase the crude protein content. The interaction between potassium and cutting management also produced a significant response.

4.4.3 Content of crude fibre (Table 4.4.2.1 and 4.4.3.1)

Significant response was obtained by the application of nitrogen on crude fibre content. As the nitrogen dose increased from 100 to 150 kg ha^{-1}, a significant reduction in crude fibre content of the fodder was noticed. However a further increase in nitrogen from 150 to 200 kg ha^{-1} did not result in a similar decrease. The highest nitrogen dose resulted in the lowest crude fibre content.

The crude fibre content was significantly influenced by potassium levels. The lowest potassium dose recorded the highest crude fibre content. An increase in potassium application from 50 to 100 kg ha^{-1} resulted in a significant decrease in crude fibre content. But a similar trend were not obtained with a still higher dose of potassium.

The crude fibre content of the fodder was not influenced by cutting management.

A significant interaction was observed between nitrogen and potassium with respect to crude fibre content. When the lowest dose of nitrogen was combined with the lowest dose of potassium, it resulted in the highest crude fibre content. When the next higher dose of potassium ie., 100 kg ha^{-1} was combined with lowest level of nitrogen, a reduction in crude fibre content was observed. When the medium dose of nitrogen ie., 150 kg ha^{-1} was combined with the three different levels of potassium, the crude fibre content decreased with increase in potassium levels. The interaction between N and C as well as K and C did not show any significant effect on crude fibre content.

4.4.4 Content of calcium in fodder (Table 4.4.4.1 and 4.4.5.1)

The calcium content of the fodder was not significantly influenced by the different nitrogen levels.

Potassium showed a significant influence on calcium content of fodder. The highest calcium content was recorded by the lowest potassium dose. As the potassium dose was increased from 50 to 150 kg ha^{-1}, a significant decrease in calcium content of fodder was observed. The calcium content was on par at 100 and 150 kg ha^{-1} of potassium.

The calcium content of fodder was not influenced by cutting management.

No significant interaction was observed between N and K as well as K and C on calcium content of fodder. However a significant interaction was noticed between nitrogen and cutting management. At the lowest level of nitrogen, higher calcium content was observed at c_2.

Table 4.4.4.1. Effect of nitrogen, potassium and cutting management on calcium content, magnesium content and K : (Ca + Mg) ratio in signal grass

Treatment	Ca (%)	Mg (%)	K : (Ca + Mg)
Nitrogen			
n_1	0.25	0.31	3.05
n_2	0.27	0.30	2.49
n_3	0.24	0.30	2.68
$F_{2,13}$	1.18	0.25	5.85*
SE	0.016	0.009	0.12
CD	—	—	0.36
Potassium			
k_1	0.29	0.33	2.04
k_2	0.25	0.30	2.81
k_3	0.23	0.28	3.37
$F_{2,13}$	4.15*	5.53*	32.83**
SE	0.016	0.009	0.12
CD	0.048	0.029	0.36
Cutting			
c_1	0.25	0.30	2.86
c_2	0.26	0.30	2.62
$F_{1,13}$	0.11	0.05	3.25
SE	0.012	0.008	0.09
CD	—	—	—

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 4.4.5.1. Interaction effect of nitrogen, potassium and cutting management on calcium content, magnesium content and K : (Ca + Mg) ratio in signal grass

Treatments	Ca (%)	Mg (%)	K : (Ca + Mg)
n_1k_1	0.29	0.34	2.25
n_1k_2	0.20	0.30	3.63
n_1k_3	0.25	0.30	3.26
n_2k_1	0.28	0.33	1.92
n_2k_2	0.32	0.29	2.30
n_2k_3	0.23	0.28	3.26
n_3k_1	0.30	0.30	2.00
n_3k_2	0.23	0.33	2.50
n_3k_3	0.19	0.26	3.58
$F_{4,13}$	3.14	2.16	4.21*
SE	0.027	0.016	0.20
CD	—	—	0.62
n_1c_1	0.19	0.28	3.62
n_1c_2	0.30	0.33	2.47
n_2c_1	0.31	0.31	2.50
n_2c_2	0.24	0.30	2.49
n_3c_1	0.26	0.32	2.46
n_3c_2	0.23	0.28	2.89
$F_{2,13}$	8.43**	6.07*	12.22**
SE	0.022	0.013	0.16
CD	0.069	0.040	0.50
k_1c_1	0.28	0.32	2.15
k_1c_2	0.30	0.33	1.93
k_2c_1	0.23	0.31	3.07
k_2c_2	0.27	0.29	2.54
k_3c_1	0.24	0.27	3.36
k_3c_2	0.21	0.29	3.38
$F_{2,13}$	1.68	1.24	1.45
SE	0.022	0.013	0.16
CD	—	—	—

* Significant at 5 per cent level ** Significant at 1 per cent level

But at n_2, c_1 recorded higher calcium content while no significant difference was observed between c_1 and c_2 at n_3.

4.4.5 Content of magnesium in fodder (Table 4.4.4.1 and 4.4.5.1)

The different levels of nitrogen showed no significant effect on the Mg content of fodder. The lowest level of nitrogen ie., 100 kg ha^{-1} recorded the highest magnesium content, but the higher levels of nitrogen viz., 150 and 200 kg ha^{-1} were found to be on par with respect to magnesium content.

A significant response was noted by potassium application on magnesium content. Higher magnesium content was observed with the lowest level of potassium. An increase in potassium from 50 to 100 and 150 kg ha^{-1} resulted in a significant decrease in magnesium content.

The magnesium content of fodder was not significantly influenced by cutting management.

No significant interaction was observed between nitrogen and potassium as well as potassium and mode of cutting. However, N x C interaction was found to be significant wherein the lowest level of nitrogen (100 kg ha^{-1}) in combination with c_2 resulted in a higher magnesium content of fodder.

4.4.6 K : (Ca + Mg) ratio of fodder (Table 4.4.4.1 and 4.4.5.1)

The nitrogen levels markedly influenced the K : (Ca + Mg) ratio. The lowest dose of nitrogen recorded the highest K : (Ca + Mg) ratio. As nitrogen was increased from 100 to 150 kg ha^{-1} there was a decrease in K : (Ca + Mg) ratio. However a significant difference in the ratio was not observed with a further increase in nitrogen from 150 to 200 kg ha^{-1}.

A significant response was noted by the different potassium levels on K : (Ca + Mg) ratio. Increase in potassium levels from 50 to 100 and 150 kg ha^{-1} significantly increased the K : (Ca + Mg) ratio.

K : (Ca + Mg) ratio was not influenced by cutting management.

The N x K interaction significantly influenced K : (Ca + Mg) ratio. The lowest level of nitrogen combined with potassium recorded no significant difference in K : (Ca + Mg) ratio. When nitrogen was combined with potassium, n_1k_2 recorded highest ratio. Though the ratio was high when N is combined with K, no significant difference was seen at n_1k_3, n_2k_3 and n_3k_3.

A significant interaction was noticed between nitrogen and cutting management. At n_1 level, c_1 recorded highest ratio while no significant difference was seen with other levels of N and different cutting management. K x C interaction was not significant.

4.5 Soil analysis

4.5.1 Available nitrogen status of soil (Table 4.5.1.1 and 4.5.1.2)

The available nitrogen status of soil was influenced by the different nitrogen levels to a significant extent. An increase in nitrogen application resulted in an increase in available nitrogen status of the soil, which is evident from n_3. The potassium levels as well as cutting management failed to produce any significant effect on available nitrogen status of soil.

None of the interactions were found to significantly influence the available nitrogen status of soil.

4.5.2 Available phosphorus status of soil (Table 4.5.1.1 and 4.5.1.2)

The different nitrogen levels did not produce any significant effect on available phophorus status of soil. Potassium, however exerted a significant influence on available P status of soil. Potassium application at 100 kg ha^{-1} resulted in higher available phosphorus status of soil, which was on par with 150 kg ha^{-1}. The lower dose of potassium ie., 50 kg ha^{-1} recorded a reduction in the available phosphorus status. Cutting management did not influence the P status of soil.

Significant interactions were noticed with N x K, N x C as well as K x C. The highest level of nitrogen combined with the medium of dose of potassium resulted in higher available P status of soil. The n_3c_1 interaction also resulted in a significantly higher available P status of soil.

Table 4.5.1.1. Effect of nitrogen, potassium and cutting management on available nitrogen, phosphorus and potassium content of soil (kg ha^{-1})

Treatments	Available Nitrogen	Available Phosphorus	Available Potassium
Nitrogen			
n_1	150.53	50.33	62.07
n_2	171.96	45.10	42.84
n_3	176.40	52.76	42.09
$F_{2,13}$	11.71**	3.07	22.02**
SE	4.04	2.24	2.41
CD	12.35	—	7.37
Potassium			
k_1	167.78	42.30	39.01
k_2	165.42	55.65	48.16
k_3	165.68	50.25	59.83
$F_{2,13}$	0.10	9.02**	18.69**
SE	4.04	2.24	2.41
CD	—	6.83	7.37
Cutting			
c_1	163.42	48.52	48.28
c_2	169.17	50.28	49.72
$F_{1,13}$	1.52	0.47	0.26
SE	3.30	1.82	1.97
CD	—	—	—

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 4.5.1.2. Interaction effect of nitrogen, potassium and cutting management on available nitrogen, phosphorus and potassium content of soil (kg ha^{-1})

Treatments	Available Nitrogen	Available Phosphorus	Available Potassium
n_1k_1	168.56	38.00	45.92
n_1k_2	186.59	49.46	65.52
n_1k_3	174.05	63.54	74.76
n_2k_1	166.99	36.89	34.44
n_2k_2	173.27	49.76	39.48
n_2k_3	175.62	48.64	54.60
n_3k_1	167.78	52.00	36.68
n_3k_2	136.42	67.73	39.48
n_3k_3	147.39	38.56	50.12
$F_{4,13}$	3.13	9.31**	0.82
SE	7.00	3.87	4.18
CD	—	11.83	—
n_1c_1	171.96	50.88	61.23
n_1c_2	180.84	49.79	62.91
n_2c_1	167.25	37.81	43.12
n_2c_2	176.66	52.38	42.56
n_3c_1	151.05	56.85	40.51
n_3c_2	150.01	48.67	43.68
$F_{2,13}$	0.53	6.78**	0.15
SE	5.72	3.16	3.41
CD	—	9.66	—
k_1c_1	161.50	43.04	38.45
k_1c_2	174.05	41.56	39.57
k_2c_1	163.60	49.76	47.60
k_2c_2	167.25	61.54	48.72
k_3c_1	165.16	52.75	58.80
k_3c_2	166.21	47.75	60.85
$F_{2,13}$	0.56	3.92*	0.013
SE	5.72	3.16	3.41
CD	—	9.66	—

* Significant at 5 per cent level ** Significant at 1 per cent level

4.5.3 Available potassium status of soil (Table 4.5.1.1 and 4.5.1.2)

The various nitrogen levels significantly influenced the available potassium status of soil. As the nitrogen dose was increased from 100 to 150 kg ha^{-1}, there was a significant decrease in available potassium status. A further increase in nitrogen to 200 kg ha^{-1} did not result in a similar decrease in available potassium.

The potassium status of soil was significantly influenced by the different levels of potassium. An increase in potassium levels from 50 to 100 and 150 kg ha^{-1} registered a significant increase in available potassium status of soil.

Available potassium status of soil was not influenced by cutting management.

Interaction effects of the treatments were found to be non significant.

4.6 Economics of treatments

4.6.1 Benefit : cost ratio (Table 4.6.1.1)

Highest B : C ratio of 2.31 and maximum net income (48972.64 Rs ha^{-1}) was recorded by the treatment combination, T_{18} with 200 kg ha^{-1} nitrogen, 150 kg ha^{-1} potassium and seed production after two cuts. The

Table 4.6.1.1. Economics of cultivation

Treatments	Net income (Rs ha^{-1})	B : C ratio
T_1	23422.95	1.66
T_2	21228.73	1.59
T_3	24207.75	1.66
T_4	38394.17	2.07
T_5	32678.95	1.90
T_6	32094.97	1.87
T_7	37820.39	2.05
T_8	34226.17	1.93
T_9	41678.19	2.12
T_{10}	32733.40	1.92
T_{11}	20172.18	1.56
T_{12}	24845.20	1.68
T_{13}	30701.67	1.85
T_{14}	33988.40	1.93
T_{15}	31276.42	1.84
T_{16}	34600.84	1.95
T_{17}	39028.62	2.06
T_{18}	48972.64	2.31

lowest B : C ratio of 1.56 and lowest net return (20172.18 Rs. ha^{-1}) was observed in T_{11} with 100 kg ha^{-1} nitrogen, 100 kg ha^{-1} potassium and seed production after two cuts.

DISCUSSION

5. DISCUSSION

The present study was taken up with the objectives to assess the effect of varying levels of nitrogen, potassium and cutting management on the forage and seed production of signal grass (*Brachiaria decumbens* Stapf.). The data collected were subjected to statistical analysis and the results of the study presented in chapter four are discussed here.

5.1. Growth characters

5.1.1. Plant height

The results revealed that nitrogen levels significantly increased the plant height at the first, second and fourth harvests only (Fig. 5.1.1.1). The highest level 200 kg ha^{-1} of nitrogen recorded 20.46 per cent increase in plant height over the lowest level. However a significant increase in plant height was noticed only upto 150 kg N ha^{-1}. The increase in plant height due to enhanced N application might be due to increase in cell division and cell elongation, which is a function of nitrogen (Tisdale *et al.*, 1985). A similar increase in plant height by N was reported by Thomas (1978) in hybrid napier and by Rai and Sankaranarayanan (1981) in giant anjan. The present findings are also in agreement with the

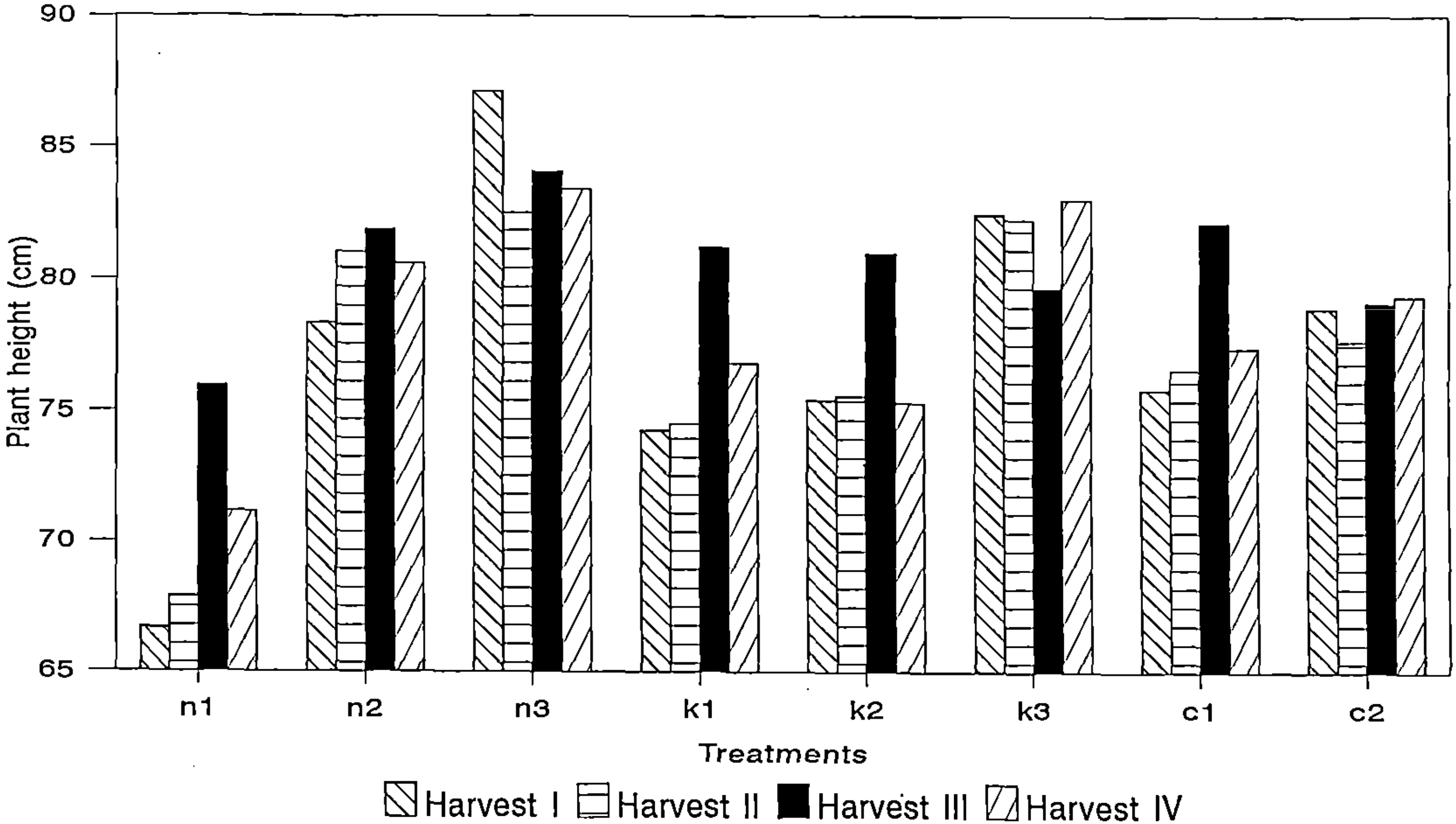


Fig. 5.1.1.1. Effect of nitrogen, potassium and cutting management on plant height (cm) of signal grass

observations of Manohar *et al.* (1992) in fodder pearl millet and Krishnan (1993) in guinea grass.

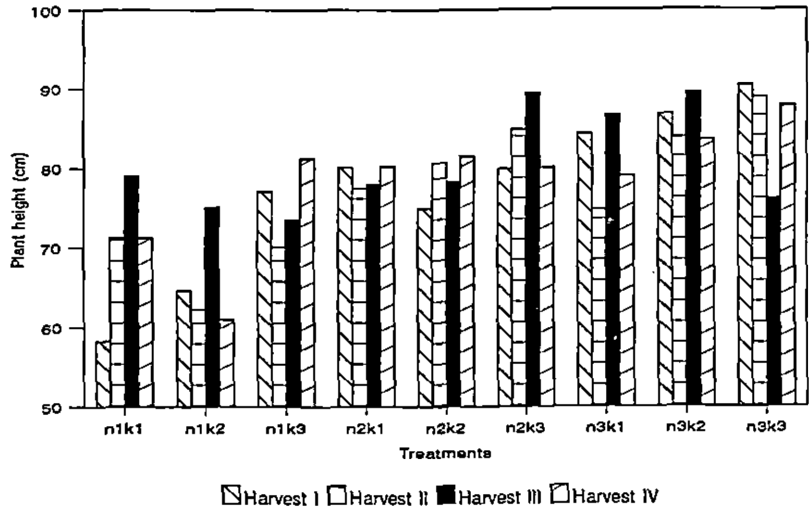
Response to potassium was noticed only in the fourth harvest. The first three harvests however did not show any response to potassium application. Thakuria (1993) also could not obtain any response to application of K on the height of teosinte.

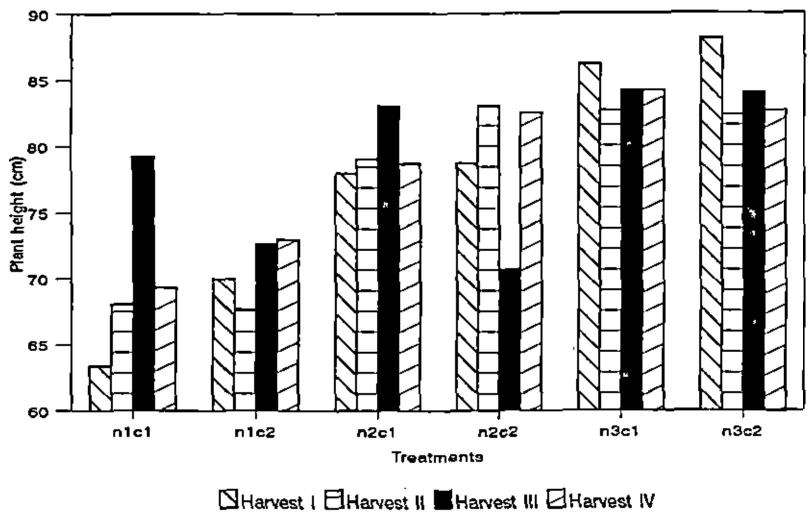
Though not significant, an increasing trend in plant height was observed in all harvests (Fig. 5.1.1.2) due to application of 200 kg N and 100 kg K in combination.

5.1.2. Tiller number per hill

A significant difference in tiller number due to nitrogen application was observed from the second harvest onwards (Fig. 5.1.2.1). In the second harvest, the highest level of N at 200 kg ha^{-1} recorded 20.99 per cent increase in tiller number over the lowest level. This increase might be due to better availability of N and its stimulating effect on various physiological processes of the plants (Manohar *et al.*, 1992). These findings are in confirmity with the results of Thomas (1978) in hybrid napier, Rai and Sankaranarayanan (1981) in giant anjan and Krishnan (1993) in guinea grass.

The tiller number was not influenced by variation in potassium application. In guinea grass, Krishnan (1993) noticed a similar trend due to K application. The interaction effects could not produce any significant response (Fig. 5.1.2.2).





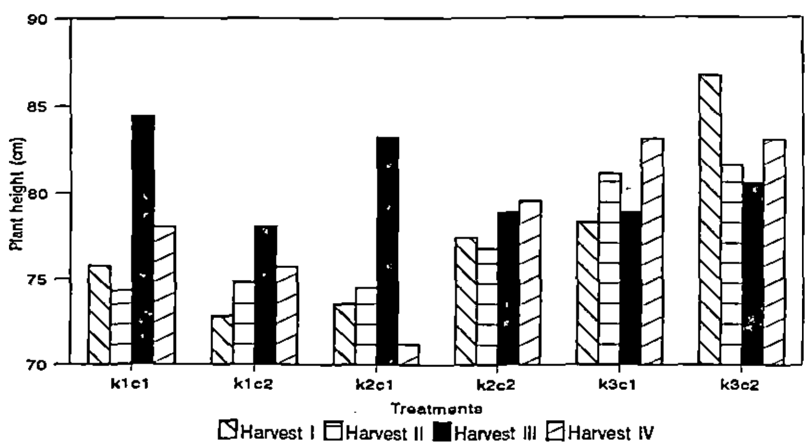


Fig. 5.1.1.2. Interaction effect of nitrogen, potassium and cutting management on plant height (cm) of signal grass

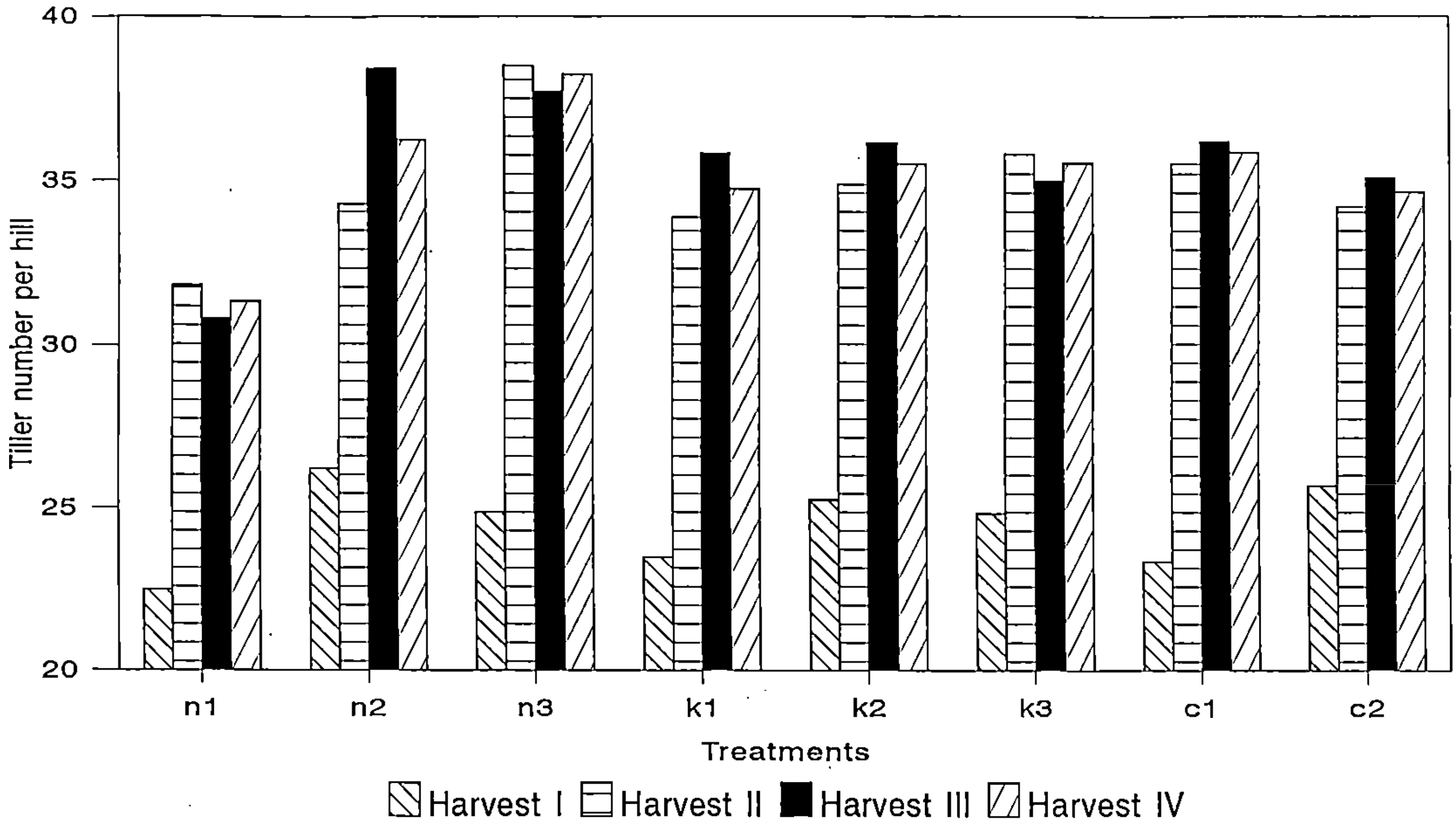


Fig. 5.1.2.1. Effect of nitrogen, potassium and cutting management on tiller number per hill of signal grass

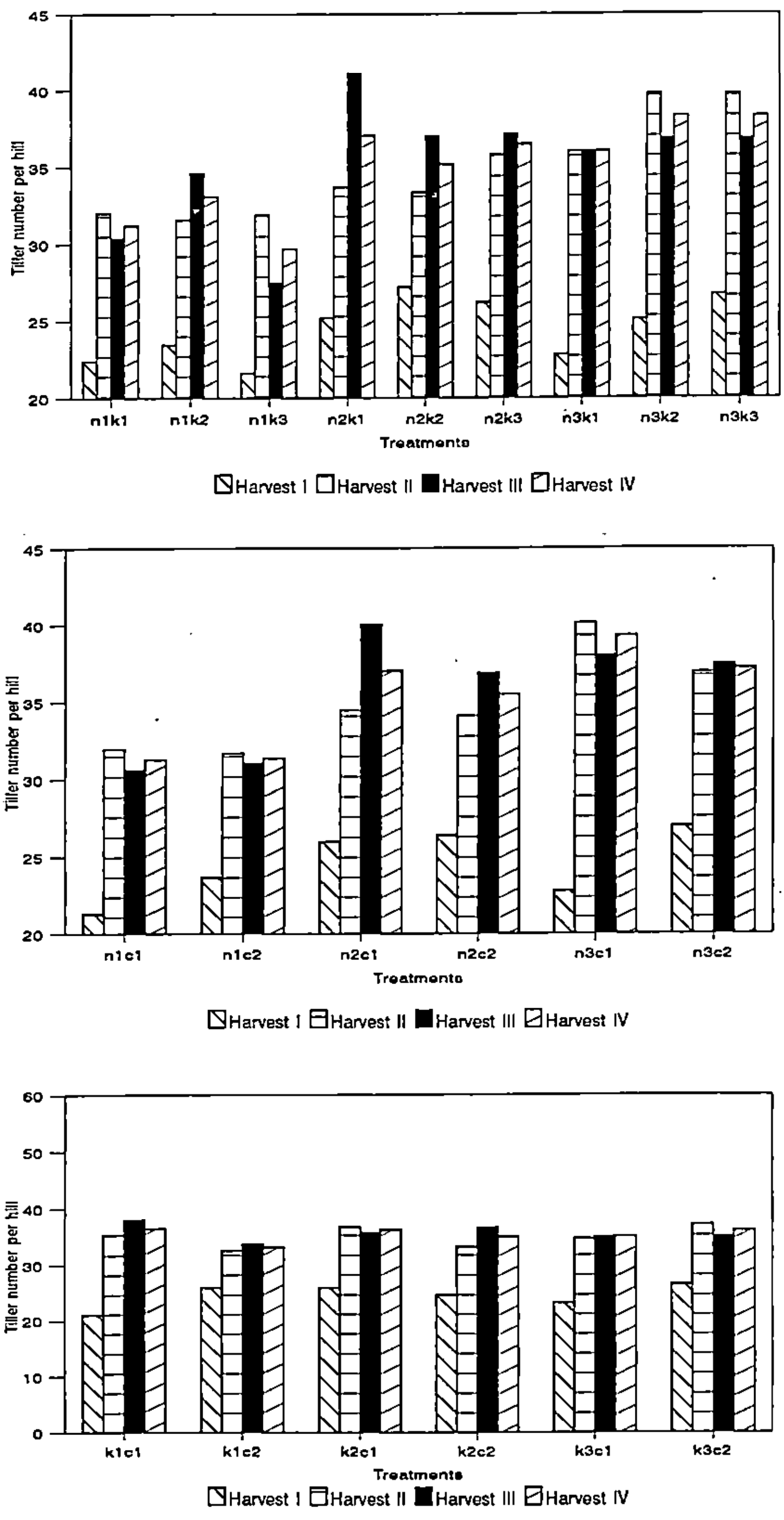


Fig. 5.1.2.2. Interaction effect of nitrogen, potassium and cutting management on tiller number per hill of signal grass

5.1.3. Leaf number per hill

The data pertaining to number of leaves per hill showed significant variation due to nitrogen application at third and fourth harvests only. This might be due to the production of increased number of tillers as a result of stimulating effect of nitrogen (Manohar *et al.*, 1992). Malik *et al.* (1992) observed enhanced leaf production in fodder sorghum by incremental levels of nitrogen.

The decrease in leaf number observed during the fourth harvest might be due to the lesser time available for regrowth as a result of two consecutive cuts.

The NxK interaction significantly influenced the leaf number in signal grass. This might be due to the mutually synergistic effect of the two nutrients N and K at higher concentration which resulted in growth stimulation and enhanced uptake of both the elements (Sumner and Farina, 1986). At the same time, the lowest level of potassium (50 kg ha^{-1}) in combination with the highest level of nitrogen (200 kg ha^{-1}) resulted in reduced number of leaves obviously due to nutrient imbalance. Reneau *et al.* (1983) concluded that the balance between nutrients is important. The findings might be due to the fact that potassium is required for nitrogen uptake by the plant (Tisdale *et al.*, 1985).

Treatment combination $c_1n_3k_3$ with greater number of leaves per hill is shown in Plate 2.

a. Treatment combination of nitrogen, potassium and cutting management with greater number of leaves per hill

b. Treatment combination of nitrogen, potassium and cutting management with greater green fodder yield

c. Treatment combination of nitrogen, potassium and cutting management with greater number of seeds per panicle

d. Treatment combination of nitrogen, potassium and cutting management with greater seed yield

Plate 2

5.1.4. Leaf : stem ratio

The leaf : stem ratio was not influenced by the variation in the levels of N and K. In all the harvests, the leaf : stem ratio decreased with increase in N from 100 to 150 kg ha^{-1}. Abraham (1978) could not obtain a significant influence of nitrogen on leaf : stem ratio of dinanath grass. Similar trend was noticed by Yeh (1988) in hybrid napier and Yadav and Sharma (1989) in dinanath grass.

5.2. Yield and yield attributes

5.2.1. Green fodder yield

A perusal of the data on green fodder yield (Fig. 5.2.1.1) clearly indicate that with increase in N level, green fodder yield progressively increased till final harvests, though significant response was recorded in second and fourth harvests. The highest level of N recorded a 29.7 and 35.1 per cent increase in green fodder yield over the lowest level in the second and fourth harvests respectively. This increase in green fodder yield due to application of N is a reflection of the growth attributes viz., increased plant height, tiller number and leaf number as a result of increased nitrogen availability. An adequate supply of nitrogen which is associated with vigorous vegetative growth (Tisdale *et al.*, 1985) might have contributed to this increased green fodder yield in the present study. Similar enhancement in herbage production by increased nitrogen was

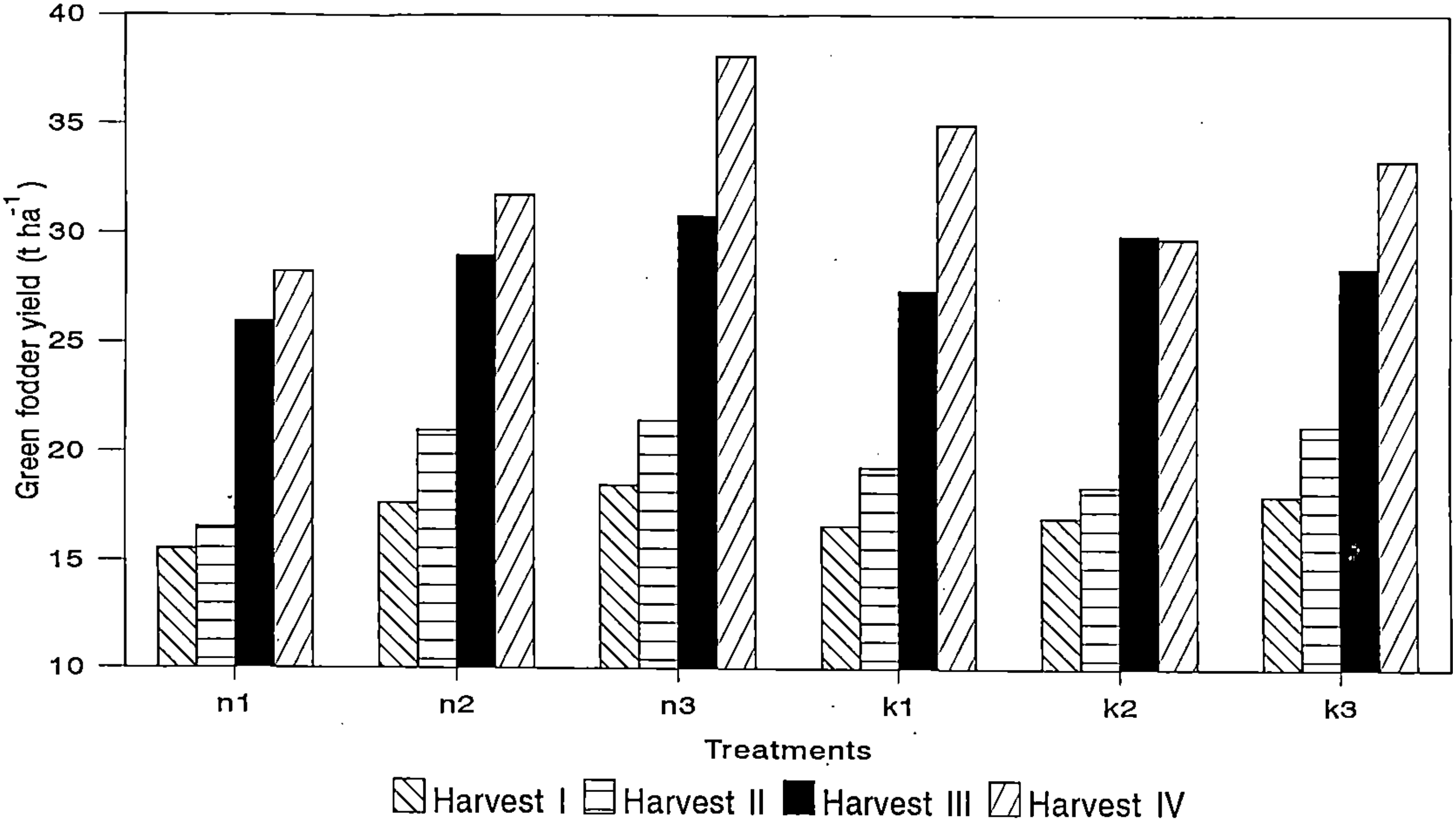


Fig. 5.2.1.1. Effect of nitrogen and potassium on green fodder yield (t ha^{-1}) of signal grass

reported by Dwivedi *et al.* (1991b) in thin napier, Shukla and Sharma (1994) in fodder sorghum and Ghosh and Singh (1996) in fodder maize. It can be observed from the data that with per kg of nitrogen application, green fodder yields of 862 kg and 544 kg ha^{-1} were realised at the lowest level (100 kg ha^{-1}) and highest level (200 kg ha^{-1}) of N respectively.

In the second harvest alone increase in the level of K from 100 to 150 kg ha^{-1} showed variation in green fodder yield. However in the other harvests, a significant response to potassium could not be obtained. This might be due to the fact that potassium did not have a marked influence on vegetative attributes. Thakuria (1993) working on teosinte could not obtain an appreciable response on green fodder yield by potassium application.

Though not significant, the highest levels of N and K recorded more green fodder yield than other combinations (Fig. 5.2.1.2) This trend might be due to a balanced N-K ratio requirement and its cumulative effect on fodder production. Treatment combination $c_2n_3k_3$ with greater green fodder yield is shown in Plate 2.

5.2.2. Dry fodder yield

The dry fodder yield was significantly influenced by nitrogen in the second and third harvests (Fig. 5.2.2.1). The highest level of nitrogen (200 kg ha^{-1}) resulted in a 29.5 and 44.7 per cent increase in dry fodder yield over the lower level (100 kg ha^{-1}) in the second and third harvest respectively.

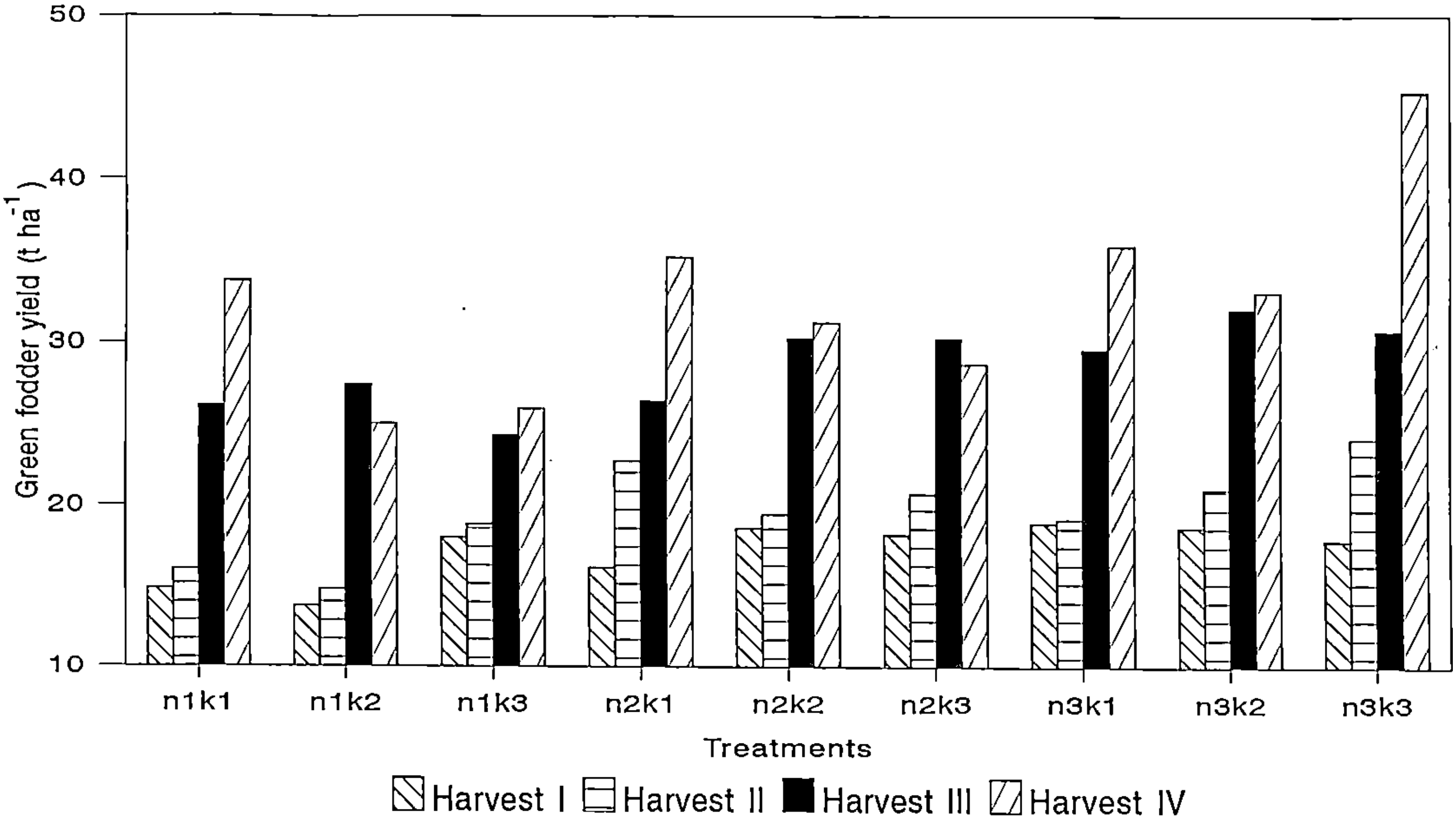


Fig. 5.2.1.2. Interaction effect of nitrogen and potassium on green fodder yield (t ha^{-1}) of signal grass

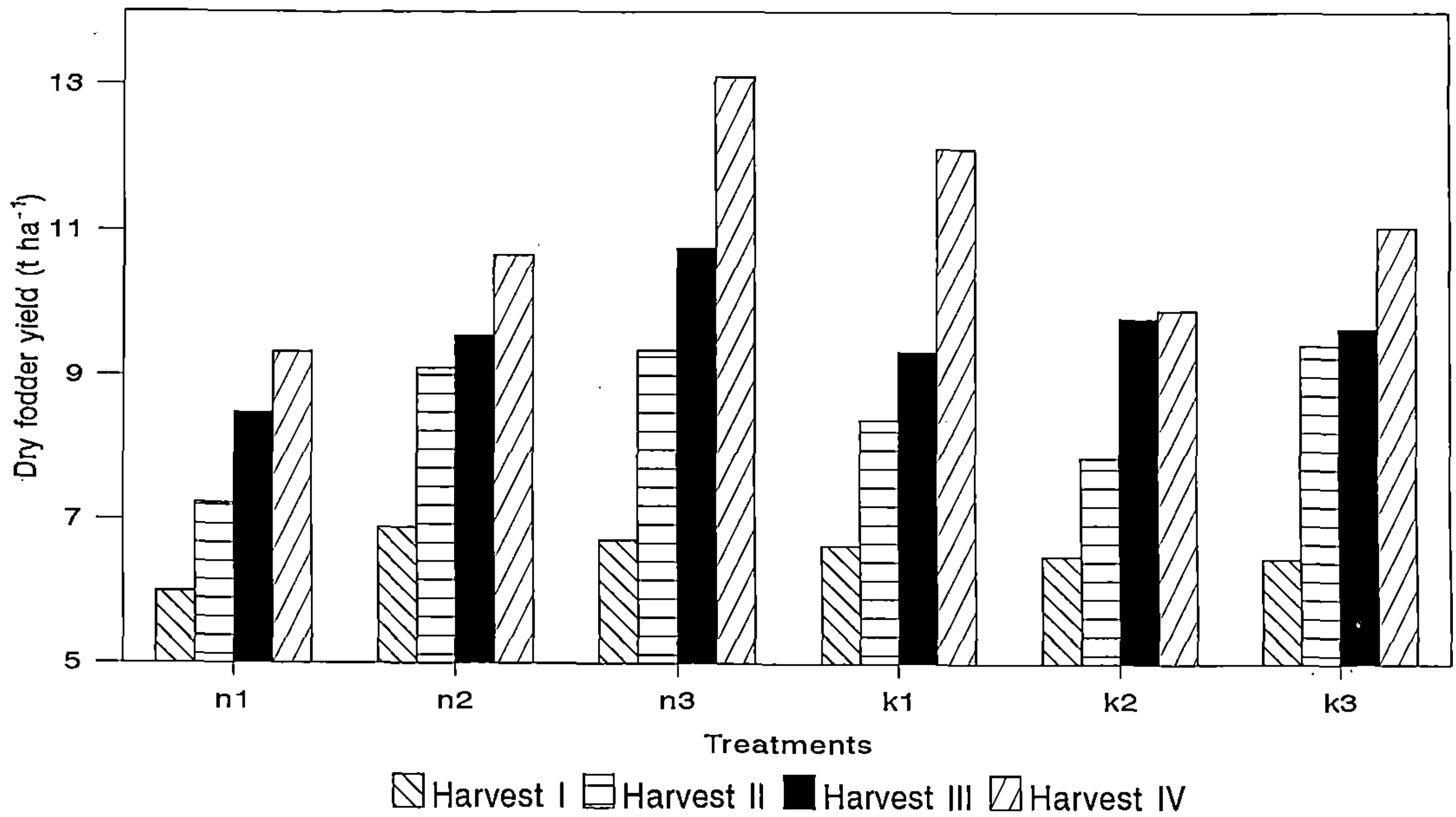


Fig. 5.2.2.1. Effect of nitrogen and potassium on dry fodder yield (t ha^{-1}) of signal grass

Increased supply of nitrogen might have resulted in overall vegetative growth which contributed to increased dry fodder yield. The higher dry fodder yield realised in the study might be due to a narrowing of leaf : stem ratio and a higher proportion of fibrous stem. The results are in confirmity with the findings of Pillai (1986) in guinea and setaria grass, Tripathi and Singh (1991) in dinanath grass, Malik *et al.* (1992) in fodder sorghum, Thakuria (1993) in teosinte and Prakash *et al.* (1994) in Rhodes grass. At lower (100 kg N ha^{-1}) and higher level (200 kg ha^{-1}) of nitrogen, per kg of N produced 310 and 199 kg ha^{-1} of dry fodder yield respectively.

The dry fodder yield was not varied due to the levels of potassium at any of the harvests. Lack of response to potassium application was reported by Thakuria (1993) in teosinte and Prakash *et al.* (1994) in Rhodes grass. The NxK interaction effects also failed to produce any significant response on dry fodder yield (Fig. 5.2.2.2).

5.2.3. Days to 50 per cent flowering

The number of days taken for 50 per cent flowering was significantly lowered by enhanced nitrogen application upto 200 kg ha^{-1} (Fig. 5.2.3.1). The quick vegetative growth and early attainment of phenophases might have induced early flowering at the highest level of nitrogen. The results are in confirmity with the findings of Chadhokar and Humphreys (1973) in *Paspalum plicatulum* and Sharma (1973) in maize. However George *et al.* (1990) reported that the mean anthesis date was not affected by nitrogen fertilization in switch grass (*Panicum virgatum*).

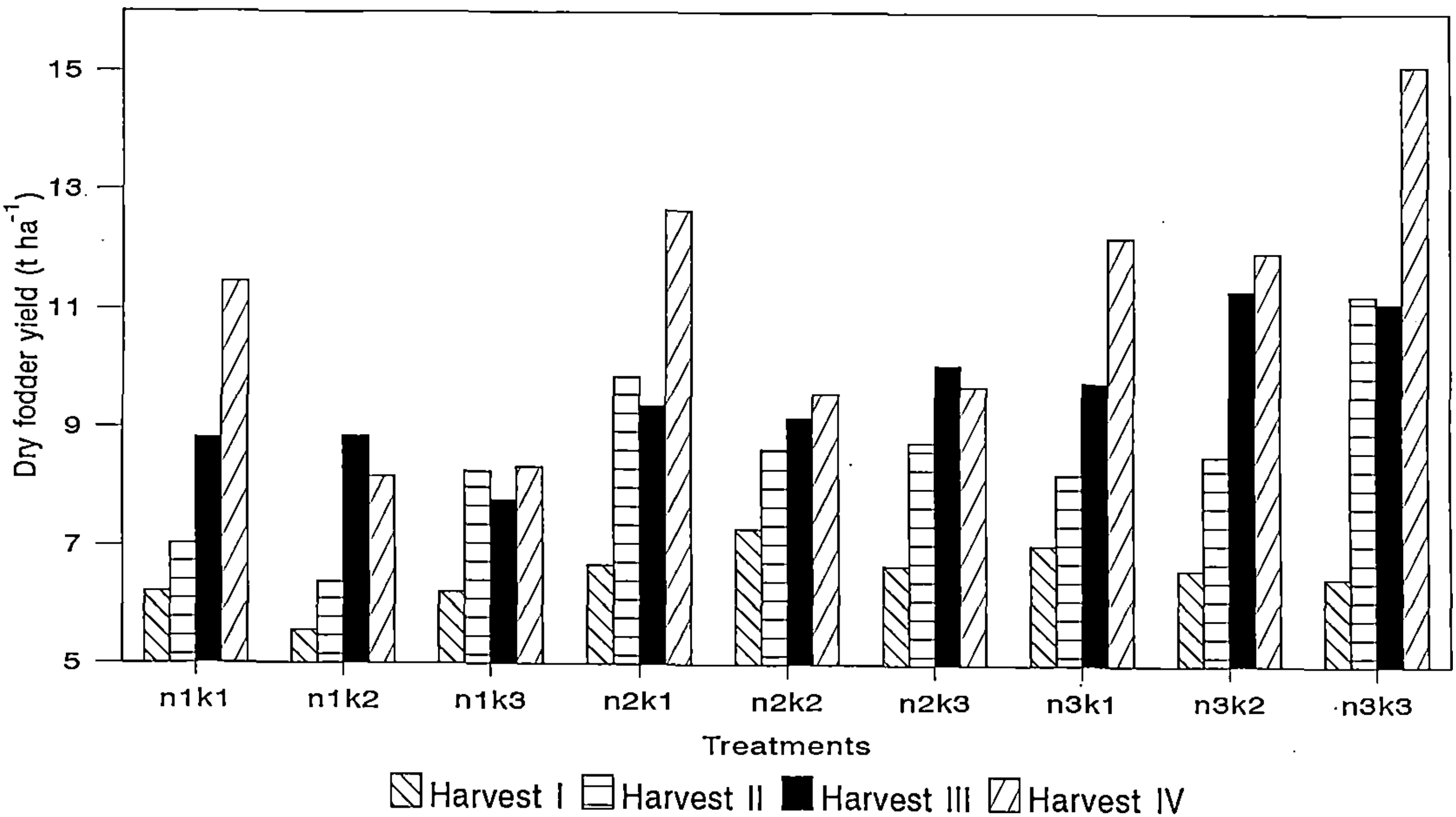


Fig. 5.2.2.2. Interaction effect of nitrogen and potassium on dry fodder yield (t ha^{-1}) of signal grass

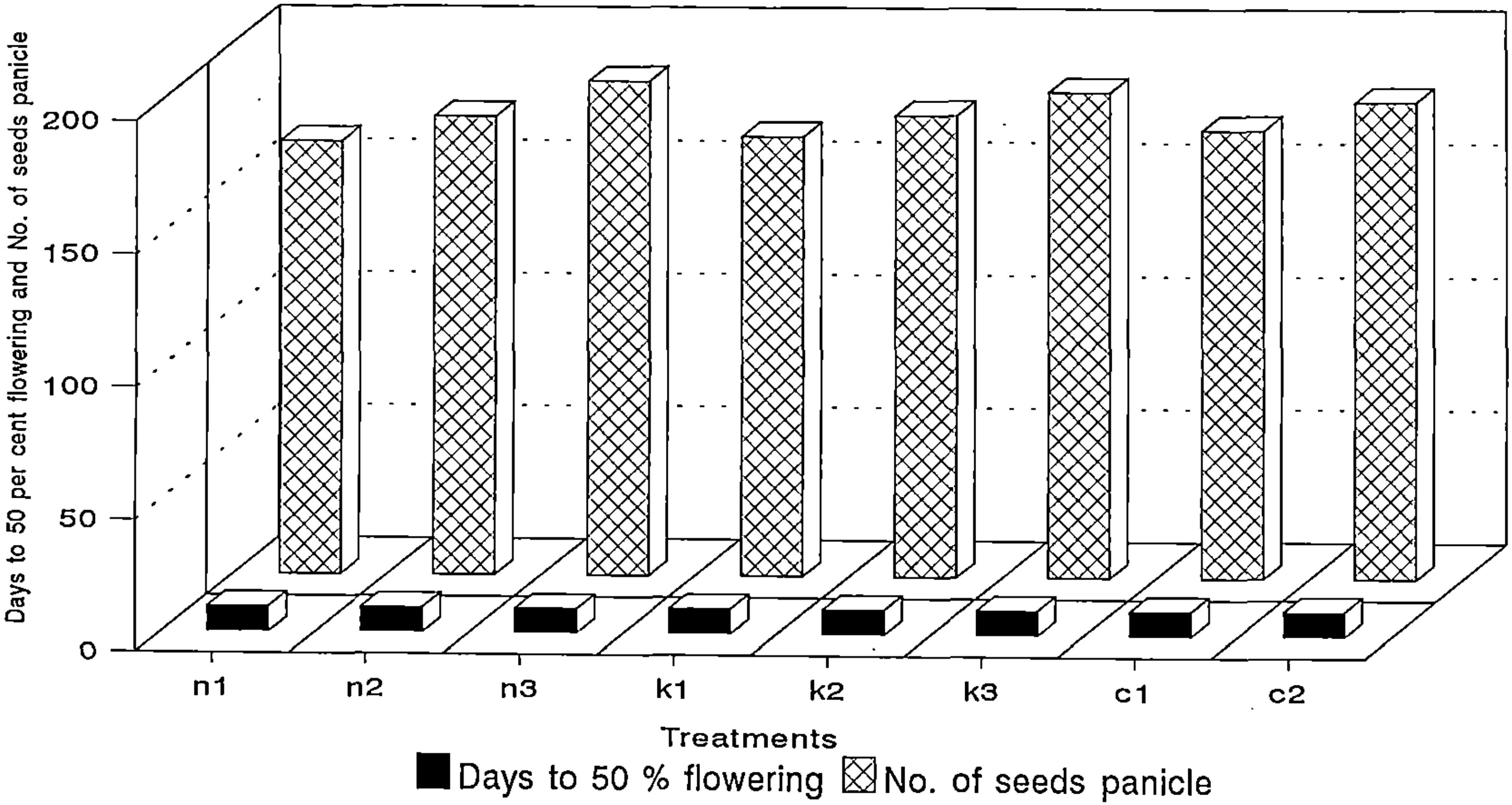


Fig. 5.2.3.1. Effect of nitrogen, potassium and cutting management on days to 50 per cent flowering and number of seeds per panicle of signal grass

Potassium as well as cutting management had not influenced the days taken to attain 50 per cent flowering.

The interactions between N, K and C were also non-significant to influence the days taken to attain 50 per cent flowering. However the highest order interaction between the treatments recorded the least number of days to 50 per cent flowering (Fig. 5.2.4.1). The present findings are in accordance with the findings of Vineetha (1995) in gamba grass (*Andropogon gayanus*).

5.2.4. Number of seeds per panicle

The results of the experiment clearly revealed that the number of seeds per panicle were significantly influenced by levels of nitrogen (Fig. 5.2.3.1). Increased N application progressively increased the number of seeds per panicle. The increase in N application might have induced early flowering which might have contributed to the increased number of seeds per panicle. Similar trend was observed by Dixit and Singh (1979) in rice wherein the number of grains per panicle was positively influenced by N application.

Potassium levels exerted a marked variation in number of seeds per panicle (Fig. 5.2.3.1). The highest level of potassium ie., 150 kg ha^{-1} showed remarkable increase in number of seeds per panicle. This enhancement may be attributed to the role of K in physiological processes associated with seed formation. Similar results were obtained by Bavappa and Rao (1956) in rice.

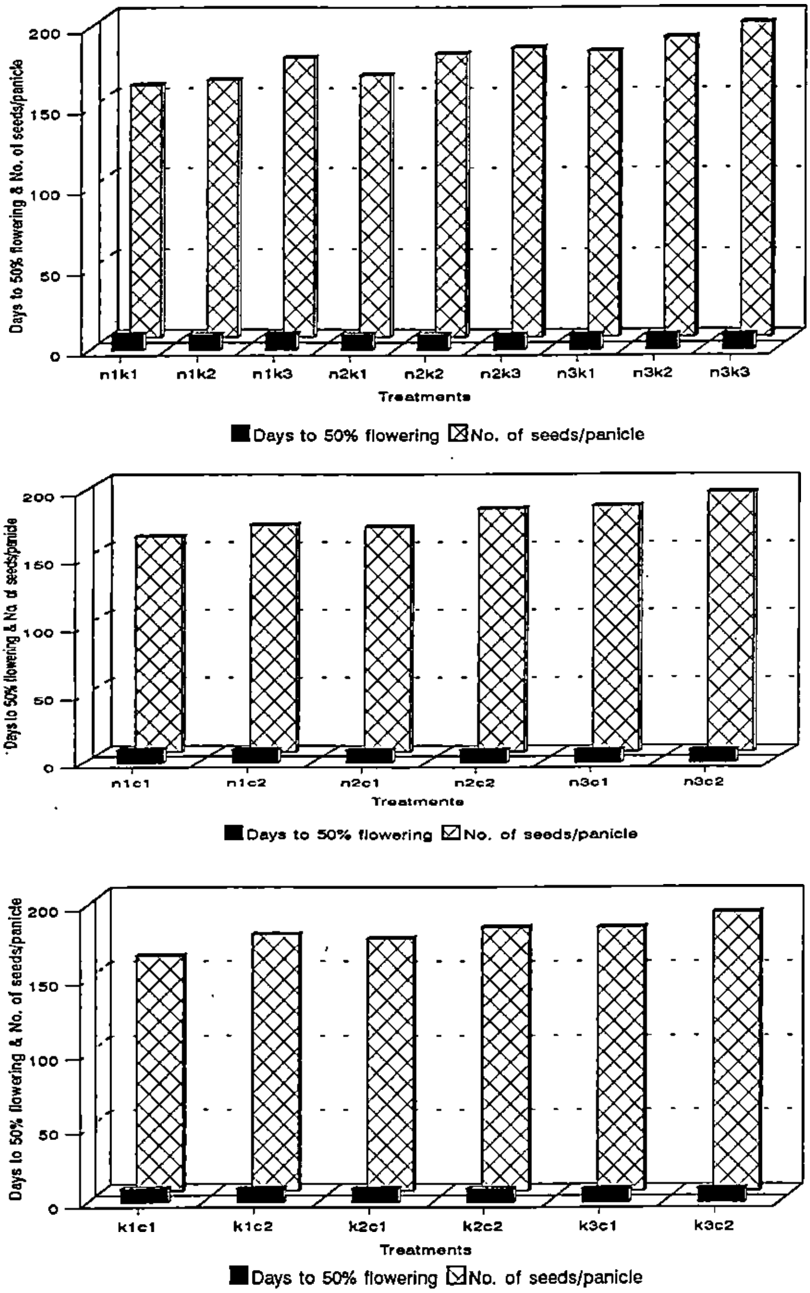


Fig. 5.2.4.1. Interaction effect of nitrogen, potassium and cutting management on days to 50 per cent flowering and number of seeds per panicle of signal grass

Cutting management also produced a pronounced response on the number of seeds per panicle, wherein seed collection after two cuttings resulted in more number of seeds per panicle compared to seed collection after single cutting. This might be due to lodging habit of the plants in the field, which was harvested once and left for seed production. Interaction effects could not produce any significant response (Fig. 5.2.4.1). Treatment combination $c_2n_3k_3$ with greater number of seeds per panicle is shown in Plate 2.

5.2.5. Seed yield

The data pertaining to seed yield showed a significant increase with increased nitrogen levels (Fig. 5.2.5.1). The markedly higher seed yield realised by higher nitrogen doses might be due to greater number of spikelets and higher leaf area (Patil *et al.*, 1993) and higher number of seeds per panicle realised by increased nitrogen. Rowarth *et al.* (1996) attributed this to an increase in stem size and branch number resulting in more number of flower sites. The higher seed yield might be due to a significant increase in heads per plot (Cookson *et al.*, 1997). The results are in confirmity with the findings of Dwivedi (1991b) in napier grass and Ramirez and Hacker (1994) in *Digitaria eriantha.*

Potassium levels also registered appreciable increase in seed yield which might be due to increased seed weight at higher levels of K. The beneficial effect of K on increased seed yield might be due to higher kernel weight which results from increasing either the photosynthetic capacity or the productive life of flag leaves which accounts for upto 80 per cent of grain filling (Tisdale *et al.*, 1985). Similar trend was observed

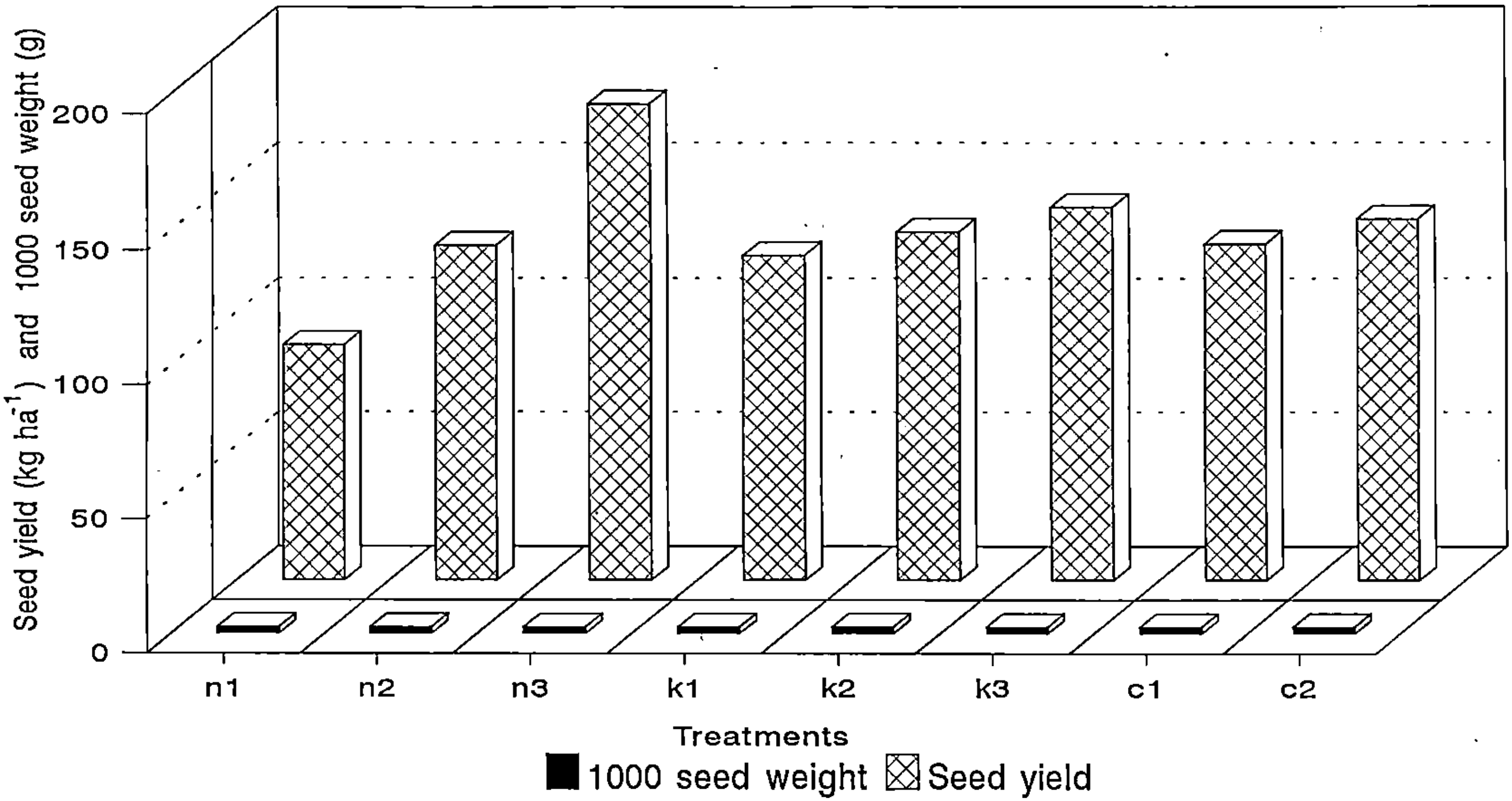


Fig. 5.2.5.1. Effect of nitrogen, potassium and cutting management on seed yield (kg ha^{-1}) and thousand seed weight (g) of signal grass

by Sinha (1985) who noticed a 15-20 per cent increase in seed yield of berseem with potassium application.

A profound influence of cutting management on seed yield was also noticed. Cutting twice and leaving for seed production resulted in a significant increase in seed yield. This might be due to lodging of plants in plots harvested only once which caused a reduction in seed yield. Increased seed yield might also be due to increased number of seeds per panicle and higher thousand seed weight in plots harvested twice and left for seed production. The findings were in agreement with that of Taneja *et al.* (1981) in barley and oats and Singh *et al.* (1985) in fodder oats.

The interaction effects were non significant (Fig. 5.2.6.1). Treatment combination $c_2n_3k_3$ with greater seed yield is shown in Plate 2.

5.2.6. Thousand seed weight

The results pertaining to thousand seed weight indicated a significant response of nitrogen levels on test weight (Fig. 5.2.5.1). This might be due to greater translocation of assimilates to the developing spikelets. Similar trend was noticed by Dwivedi *et al.* (1991b) in napier grass and Jin *et al.* (1996) in brown top.

Potassium levels caused considerable variation in test weight. Higher levels of K significantly increased the thousand seed weight. This might be due to higher kernel weight as a result of better grain filling due to the beneficial effect of K (Tisdale *et al.*, 1985).

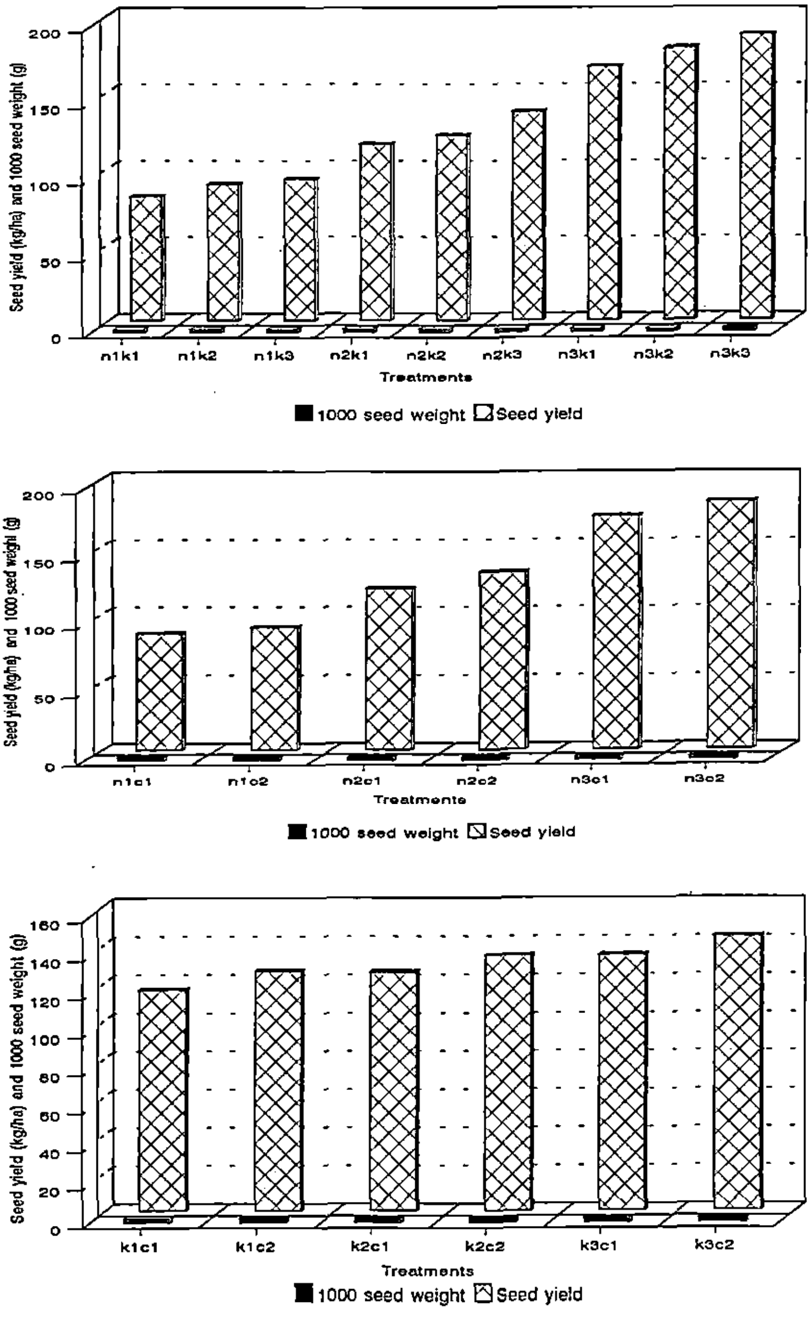


Fig. 5.2.6.1. Interaction effect of nitrogen, potassium and cutting management on seed yield (kg/ha) and thousand seed weight (g) of signal grass

Thousand seed weight was significantly influenced by cutting management wherein seed collection after two cuttings recorded a higher thousand seed weight. However the results were contrary to the findings of Tiwana and Puri (1997) where a significant difference could not be obtained. None of the interactions were found to be significant (Fig. 5.2.6.1).

5.3. Physiological parameters

5.3.1. Leaf area index

Nitrogen application had a favourable effect on leaf area index in the third and fourth harvests only. The LAI attained a maximum with the second harvest at all nitrogen levels. This might be due to greater number of leaves per hill recorded during the second harvest.

The results were supported by the findings of Singh and Chatterjee (1968) in thin napier, Beaty *et al.* (1977) in bahia grass and Malik *et al.* (1992) in fodder sorghum.

The favourable effect of potassium on LAI was visible only in the second harvest.

Cutting management as well as the interaction effects with N and K could not produce any significant response on LAI.

5.3.2. Seed germination

Seed germination was favourably influenced by increasing nitrogen from 150 to 200 kg ha^{-1}. The results were in confirmity with the findings of Chadhokar (1971) in *Paspalum plicatulum*, Mecelis and Oliveira (1984) in *Brachiaria humidicola* and Carmo *et al.* (1988) in *Brachiaria decumbens*. The very low germination per cent recorded in the study might be due to the prolonged duration of dormancy (207 to 325 days) in *Brachiaria decumbens* seeds which can be overcome by storage (151 to 319 days). (Rivero and Espinosa, 1988). Fertilzers have no effect on period of dormancy.

The main effect of potassium as well as cutting management and its interaction with nitrogen also could not produce any marked variation on seed germination.

5.4. Chemical analysis

5.4.1. Content of N, P and K in fodder

The nitrogen content of the fodder showed a negative correlation with N levels. The results are in confirmity with that of Fernandes *et al.* (1985) who obtained an inverse relationship between applied levels of nitrogen and plant nitrogen content. Similar results were also obtained by Peake *et al.* (1990) in green panic.

Potassium levels significantly influenced the nitrogen content of fodder. Increased potassium application significantly reduced the nitrogen content in the fodder. This may be due to the antagonistic effect of ammonium and potassium ions as reported by Loue (1980).

All the interactions, NxK, NxC and KxC significantly influenced the nitrogen content of the fodder. However, variable interaction effects were noticed with the different treatment levels.

The phosphorus content of the fodder was not influenced by the main effects or interactions. However, a decreasing trend was noticed with increase in nitrogen application. This is in confirmity with the findings of Rathore and Vijayakumar (1977) and Abraham *et al.* (1980) in dinanath grass and Fernandes *et al.* (1985) in signal grass.

The different levels of nitrogen failed to influence the forage potassium content, although a non-significant decrease was observed with increased nitrogen application. The different potassium levels appreciably increased the fodder potassium concentrations. Similar results were obtained by Balasko (1977) in tall fescue forage and Dampney (1992).

5.4.2. Crude protein content of fodder

An inverse relationship between applied nitrogen and crude protein content was observed (Fig. 5.4.2.1) in the study. This might be due to decrease in nitrogen content of fodder with incremental levels of nitrogen. Similar results were obtained by Thangamuthu *et al.* (1974) in guinea grass wherein the crude protein content was not affected by nitrogen upto 150 kg ha^{-1}.

Potassium levels also significantly reduced the crude protein content. This might be due to a comparatively higher level of potassium

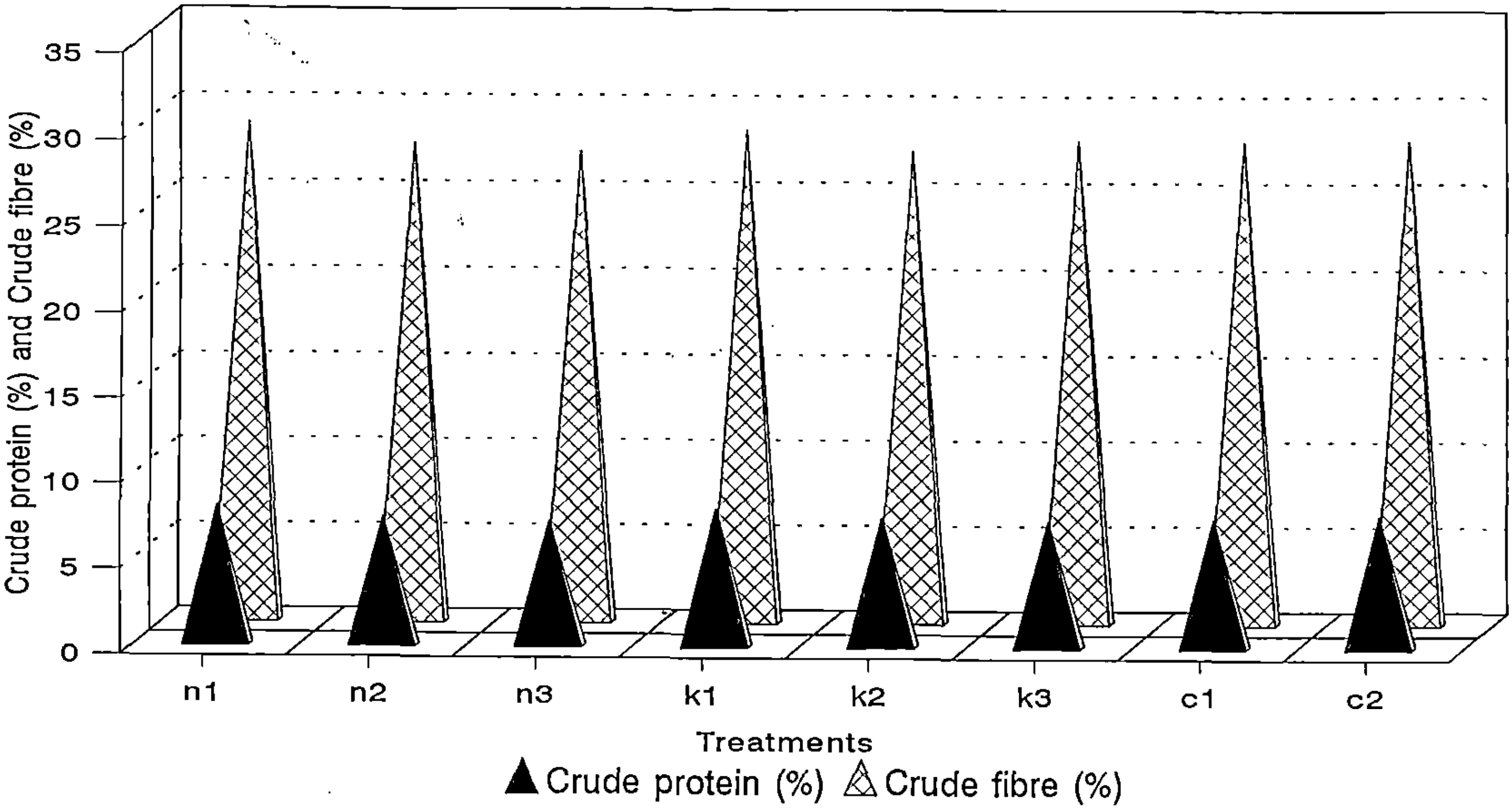


Fig. 5.4.2.1. Effect of nitrogen, potassium and cutting management on crude protein and crude fibre content of signal grass

in the soil which in turn reduced the uptake of N, resulting in a consequent reduction in crude protein synthesis (Raheja, 1966).

All the three interactions NxK, NxC and KxC significantly influenced the crude protein content.

5.4.3. Crude fibre content of fodder

Crude fibre content registered a significant decrease with increase in nitrogen levels (Fig. 5.4.2.1). This might be due to an indirect effect of nitrogen on carbohydrate metabolism. Higher levels of nitrogen might have resulted in more succelence in plants which reduced the crude fibre content (Black, 1957). The results were in confirmity with the findings of Tiwana *et al.* (1975) in napier-bajra hybrid and Abraham (1978) in dinanath grass.

Potassium application also resulted in a decrease in crude fibre content. Similar results were obtained by Vineetha (1995) in gamba grass. Among the interaction effects, NxK interaction alone was found to be significant.

5.4.4. Calcium content of fodder

The different nitrogen levels failed to show a significant response on calcium content (Fig. 5.4.4.1). The results were in confirmity with the findings of Rai *et al.* (1979) and Botrel *et al.* (1990) in *Brachiaria*

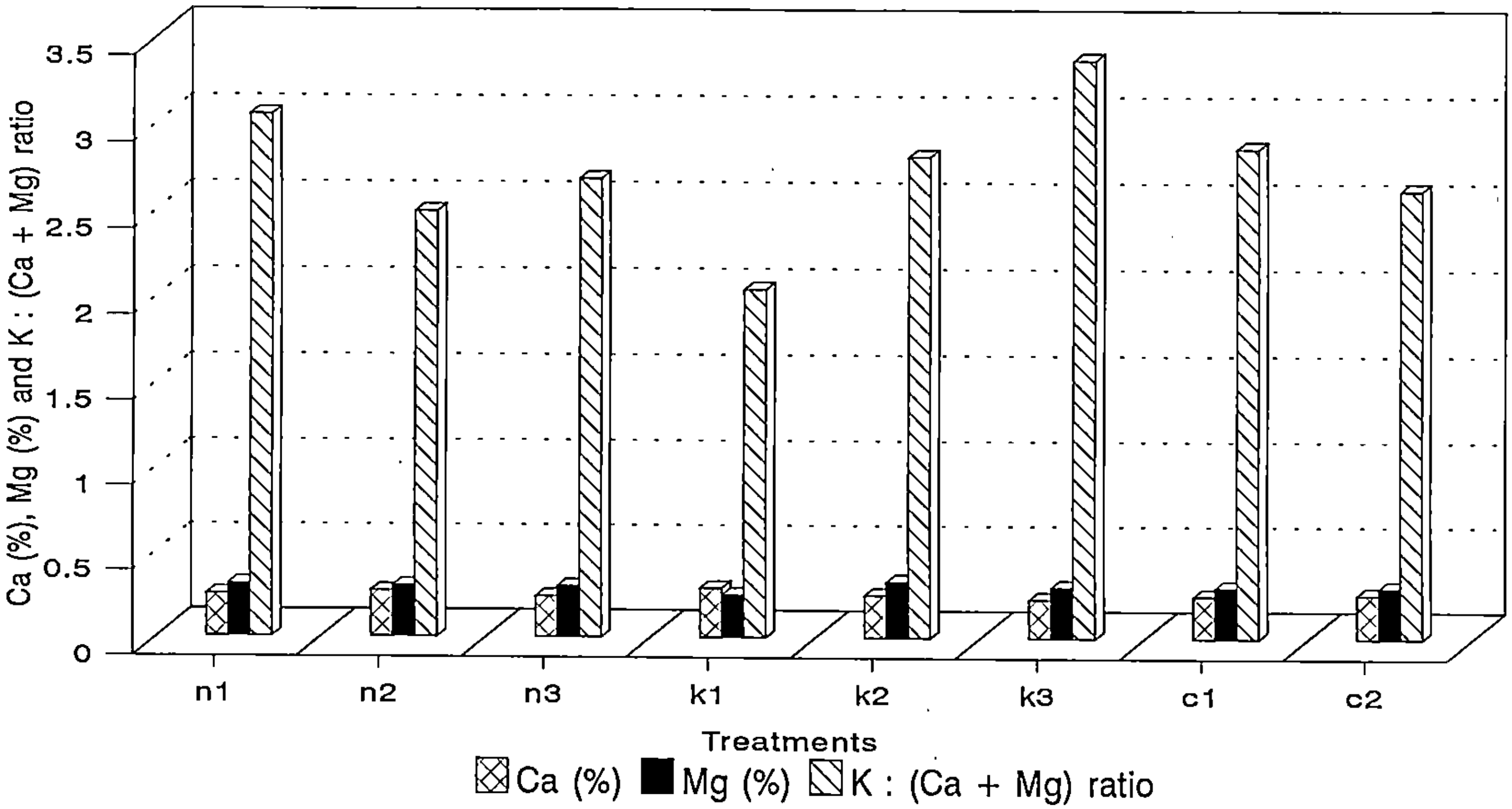


Fig. 5.4.4.1. Effect of nitrogen, potassium and cutting management on calcium content, magnesium content and K : (Ca+Mg) ratio in signal grass

brizantha and *B. humidicola*, where the forage Ca content was not affected by nitrogen application.

Potassium levels were found to decrease the calcium content. Similar results were obtained by Balasko (1977) in tall fescue and Andrade *et al.* (1996) in *Brachiaria ruziziensis*.

Cutting management failed to produce a significant effect on calcium content of fodder. Among the interactions, NxC interaction alone was significant.

5.4.5. Magnesium content of fodder

The magnesium content of the fodder was not affected by nitrogen fertilization (Fig. 5.4.4.1). The findings were in agreement with that of Koter (1974) in cock's foot and timothy grass.

The potassium levels significantly reduced the magnesium content of the fodder. This is in confirmity with the results obtained by Balasko (1977) in tall fescue forage.

The magnesium content was not affected by cutting management. The NxC interaction alone was found to influence the magnesium content of fodder.

5.4.6. K : (Ca + Mg) ratio

The nitrogen levels influenced the K : (Ca + Mg) ratio to a considerable extent (Fig. 5.4.4.1). Increased levels of nitrogen reduced the K : (Ca + Mg) ratio, but a steady decrease was not observed. The results are in confirmity with the findings of Hojjati *et al.* (1977) who revealed an inconsistent effect of N on K : (Ca + Mg) ratio in blue grass and tall fescue.

An increase in levels of potassium significantly increased the K : (Ca + Mg) ratio.

Among the interactions, the NxK and NxC interactions were found to influence the K : (Ca + Mg) ratio.

5.5. Soil analysis

5.5.1. Available nitrogen status

The different nitrogen levels significantly influenced the available nitrogen status of soil (Fig. 5.5.1.1.). Higher levels increased the available N status of soil. The results confirm the findings of Bhavanase *et al.* (1992).

The main treatment effects of potassium and cutting management as well as the interaction effects were not significant.

5.5.2. Available phosphorus status

The nitrogen levels did not influence the available phosphorus status of the soil (Fig. 5.5.1.1). The results confirm the findings of

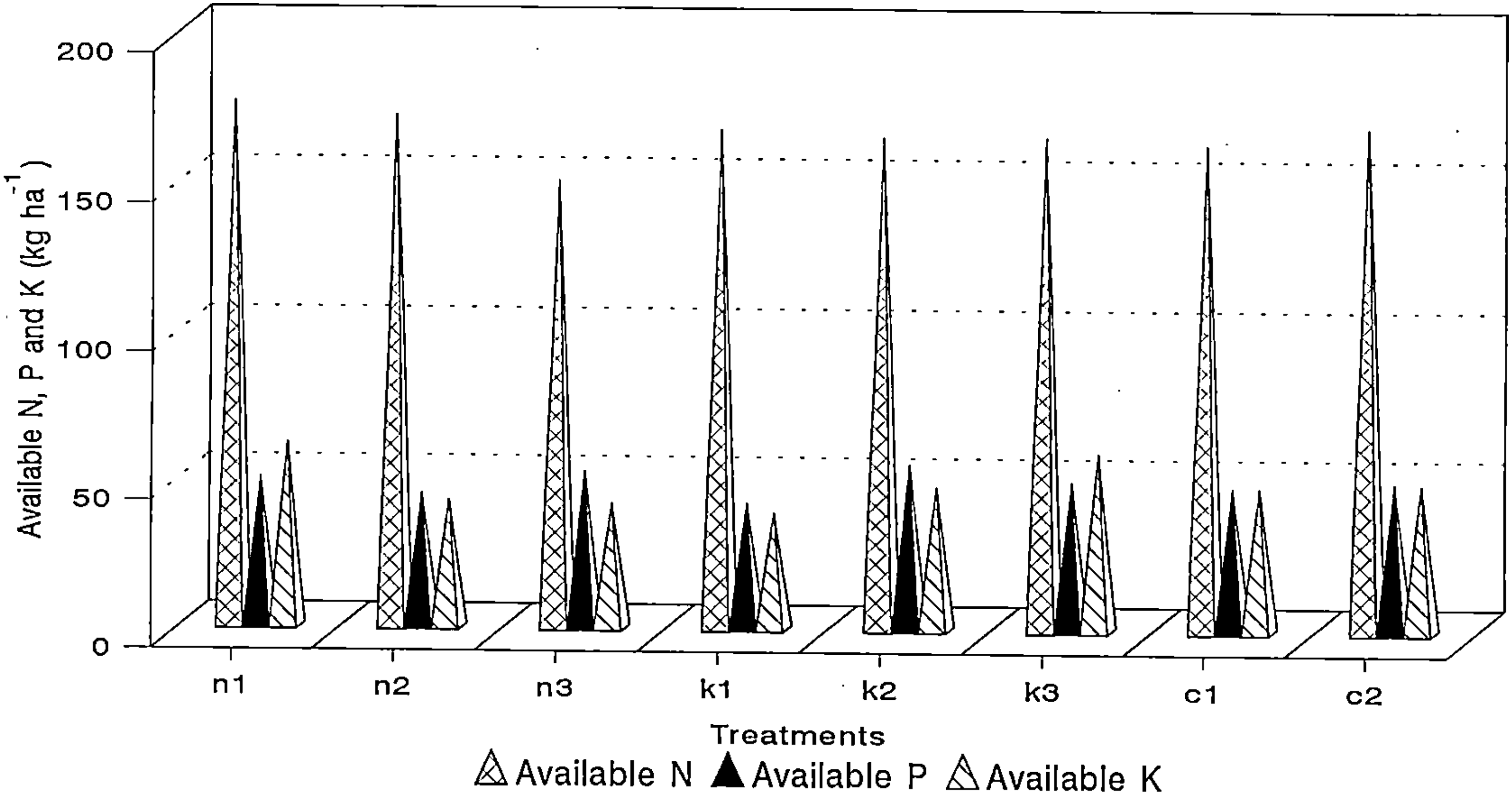


Fig. 5.5.1.1. Effect of nitrogen, potassium and cutting management on available nitrogen, phosphorus and potassium content of soil (kg ha^{-1})

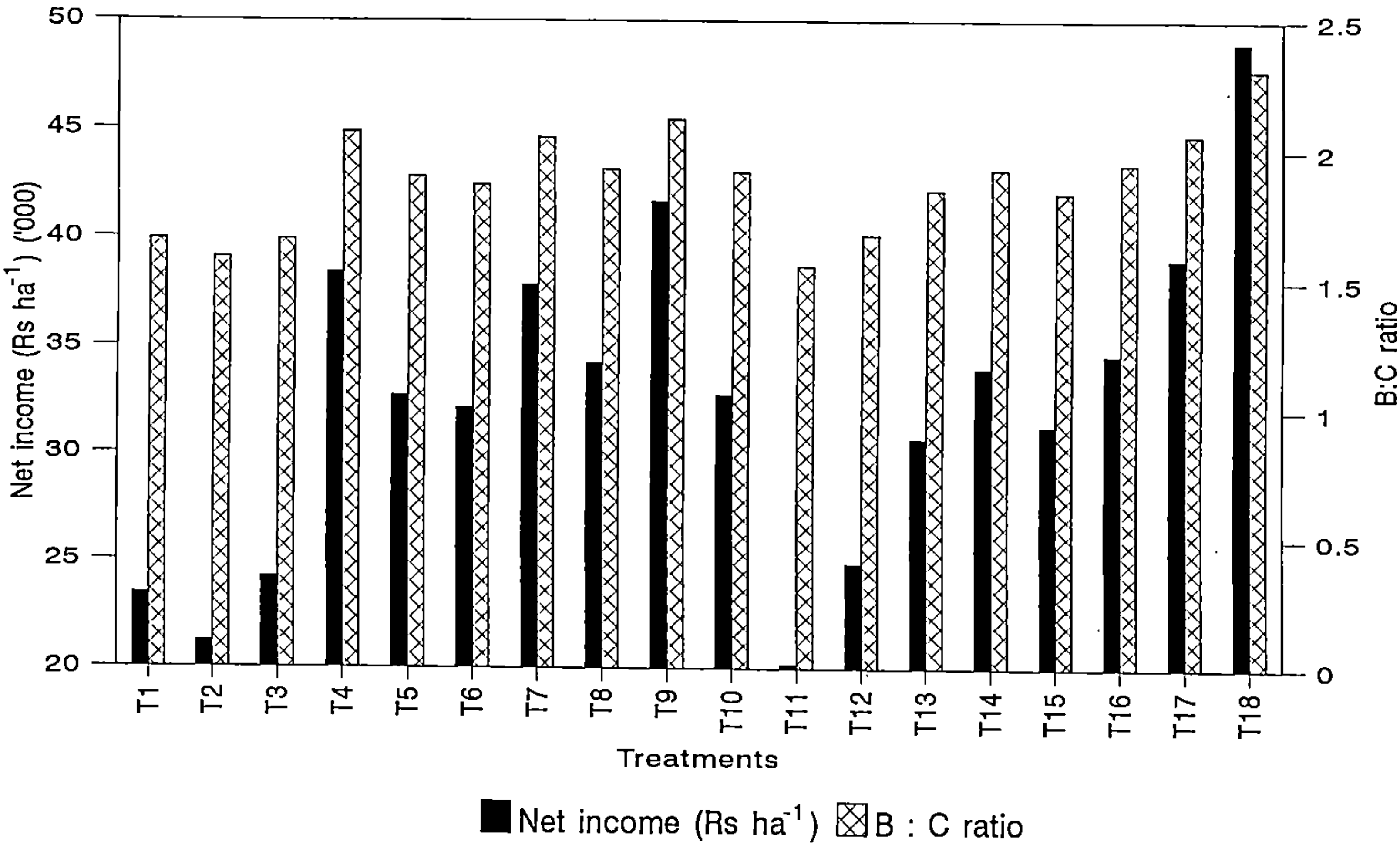


Fig. 5.6.1.1. Economics of cultivation

Kanwar (1978). Potassium application at 100 kg ha^{-1} however increased the available P status of soil. The higher P status of soil might be due to lesser uptake. The interaction effects however showed a varied response.

5.5.3. Available potassium status

The soil potassium status was significantly reduced by nitrogen application (Fig. 5.5.1.1). However a significant increase in available potassium was observed with increase in potassium application. This might be due to increased K fixation which increases the slowly available fixed form therby increasing K status of soil (Johnkutty, 1981). The results were in confirmity with the findings of Vineetha (1995) in gamba grass (*Andropogon gayanus*).

5.6. Economics of treatments

5.6.1. Benefit : cost ratio

Highest B : C ratio was recorded by the treatment which received the highest dose of nitrogen and potassium (Fig. 5.6.1.1). This was mainly due to the higher green fodder and seed yield realised from the said treatment. The lowest B : C ratio was realised from the treatment receiving lowest nitrogen which reduced the green fodder yield.

SUMMARY

6. SUMMARY

The present study entitled "Forage and seed production of signal grass (*Brachiaria decumbens* Stapf.) under different management practices" was conducted at the Instructional Farm, College of Agriculture, Vellayani during the period from July 1998 to July 1999. The objective was to find out the effect of nitrogen, potassium and cutting management on the forage and seed production of signal grass. The experiment was laid out in a 2x3x3 partially confounded factorial experiment with two replications. The treatments consisted of three levels of nitrogen (100, 150 and 200 kg ha^{-1}), three levels of of potassium (50, 100 and 150 kg ha^{-1}) and two levels of cutting management (seed collection after one cut and after two cuts) thereby forming 18 treatment combinations.

The salient findings of the experiment are summarised below:

1. Plant height was significantly increased by the application of nitrogen. Maximum height was recorded at the highest level of nitrogen (200 kg ha^{-1}). Potassium had a significant effect on plant height only in the fourth harvest.

2. Nitrogen application markedly increased the number of tillers at the second, third and fourth harvests. A progressive increase in tiller number with incremental doses of nitrogen was noticed. Potassium levels, cutting management as well as interaction effects were non-significant.

3. A significant response in number of leaves due to nitrogen levels was observed in the third and fourth harvests. The highest level of nitrogen recorded the maximum number of leaves in the second and fourth harvests. Cutting the forage twice and then leaving the crop for seed production decreased the number of leaves compared to cutting once.

4. The highest level of nitrogen (200 kg ha^{-1}) in combination with the highest level of potassium produced the maximum number of leaves.

5. There was no marked difference between the lower and higher levels of nitrogen and potassium with regard to leaf : stem ratio.

6. The green fodder yield profoundly increased by the application of nitrogen in the second and fourth harvests. The highest dose of nitrogen produced the maximum green fodder yield.

7. A significant response of green fodder yield to potassium application was noticed only in the second harvest. The green fodder yield increased as the harvests progressed.

8. Nitrogen application remarkably increased the dry fodder yield in the second and third harvests. Maximum dry fodder yield was recorded in all except first harvest.

9. The days to 50 per cent flowering was significantly influenced by nitrogen. The highest level of nitrogen recorded the lowest number of days to attain 50 per cent flowering stage.

10. Potassium did not have any influence on number of days to attain 50 per cent flowering stage.

11. Nitrogen application significantly influenced the number of seeds per panicle. Maximum number of seeds per panicle was realised with the highest dose of nitrogen (200 kg ha^{-1}).

12. Potassium exerted significant influence on number of seeds per panicle. Higher levels of potassium increased the number of seeds per panicle.

13. Seed collection after taking two cuts recorded more number of seeds per panicle when compared to seed collection after one cut.

14. Nitrogen levels showed highly significant influence on seed yield. The highest dose of nitrogen (200 kg ha^{-1}) recorded the highest seed yield.

15. A progressive increase in seed yield was observed with incremental doses of potassium, wherein the highest level of potassium (150 kg ha^{-1}) recorded higher seed yield.

16. Mode of cutting also showed profound effect on seed yield. Seed collection after two cuts recorded a higher seed yield compared to seed collection after one cut.

17. A remarkable increase in thousand seed weight with increasing levels of nitrogen was noticed. Maximum thousand seed weight was observed with the highest level of nitrogen.

18. Potassium levels also registered a marked influence on thousand seed weight. Higher levels of potassium resulted in a higher thousand seed weight.

19. Seed collection after taking two cuts registered a higher thousand seed weight compared to seed collection after one cut.

20. Leaf area index was significantly influenced by nitrogen in the third and fourth harvests, wherein leaf area index showed a considerable increase with incremental levels of nitrogen.

21. Leaf area index recorded the maximum value in the second harvest after which the value declined.

22. Potassium had a notable effect on LAI in the second harvest and the highest dose of potassium recorded higher LAI.

23. Seed germination was influenced by the application of nitrogen alone wherein the highest dose of nitrogen (200 kg ha^{-1}) improved seed germination over the other two levels (100 and 150 kg ha^{-1}) which were on par.

24. An inverse relationship was observed between levels of applied nitrogen and nitrogen content in the fodder.

25. Higher levels of applied potassium reduced the nitrogen content of the fodder.

26. The potassium content of the fodder showed a steady increase with incremental levels of applied potassium.

27. The crude protein content of the fodder was significantly reduced by nitrogen and potassium.

28. Incremental levels of nitrogen reduced the crude fibre content to a significant extent.

29. N x K interaction effects significantly influenced the crude fibre content wherein the same dose of nitrogen combined with the three different levels of potassium resulted in decrease in crude fibre content with increase in potassium levels.

30. Incremental levels of applied potassium significantly reduced the calcium content in the fodder. Lowest potassium dose recorded highest calcium content.

31. Magnesium content of the fodder showed a marked decrease with increase in levels of potassium applied.

32. An appreciable increase in K : (Ca+Mg) ratio was observed with increase in levels of applied potassium.

33. The available nitrogen status of the soil was influenced only by the levels of nitrogen. The highest nitrogen level recorded the maximum nitrogen status. Potassium did not have any significant effect.

34. The available potassium status of the soil was improved by potassium application to a significant extent.

35. Maximum net income and higher B:C ratio was realised by the treatment which received the highest dose of N (200 kg ha^{-1}) and K (150 kg ha^{-1}).

Future line of work

The results of the present investigation point towards taking up further studies on forage and seed production of signal grass under partially shaded conditions in coconut garden also. Seed production of forage crops being the need of the time to enhance fodder production of the country, technologies are to be developed and suitable packages are to be formulated for maximising seed production in other fodder crops also. The effect of irrigation on forage and seed production also needs to be investigated.

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APPENDIX

APPENDIX - I

Weather data for the crop period - Weekly averages (July 1998 - June 1999)

Period	Max.temp. (°C)	Min.temp. (°C)	Relative humidity (%)	Rainfall (mm)	Evaporation (mm)
1998					
July 1 - July 7	30.30	23.63	80.21	0.0029	1.81
July 8 - July 14	30.39	28.41	82.79	2.77	6.80
July 15 - July 21	28.83	23.89	85.79	4.00	2.71
Jyly 22 - July 28	29.19	23.91	86.07	1.57	3.46
Jyly 29 - Aug 4	29.59	24.84	84.71	0.70	3.13
Aug 5 - Aug 11	30.07	24.24	83.00	2.77	3.56
Aug 12 - Aug 18	30.74	24.83	81.93	0.31	3.80
Aug 19 - Aug 25	29.01	26.80	87.50	16.74	2.21
Aug 26 - Sep 1	30.19	24.17	82.29	0.04	3.59
Sep 2 - Sep 8	29.96	24.13	83.14	8.69	3.80
Sep 9 - Sep 15	29.75	23.97	85.29	13.46	3.06
Sep 16 - Sep 22	25.97	24.03	88.21	7.54	3.73
Sep 23 - Sep 29	28.71	23.50	84.93	15.00	2.61
Sep 30 - Oct 6	29.60	24.16	86.57	0.94	2.96
Oct 7 - Oct 13	28.24	23.21	94.29	51.91	1.94
Oct 14 - Oct 20	30.20	23.70	83.50	5.69	3.60
Oct 21 - Oct 27	30.54	23.70	81.64	—	4.01
Oct 28 - Nov 3	30.07	23.04	81.86	2.54	2.86
Nov 4 - Nov 10	28.77	23.39	89.14	41.57	2.20
Nov 11 - Nov 17	30.07	23.10	82.71	7.43	3.30
Nov 18 - Nov 24	30.57	23.07	78.36	—	3.57
Nov 25 - Dec 1	30.74	23.76	84.36	1.51	2.94
Dec 2 - Dec 8	30.90	23.43	83.07	16.77	2.60
Dec 9 - Dec 15	29.20	23.11	87.09	5.54	1.90
Dec 16 - Dec 22	30.79	23.08	82.00	6.86	2.87
Dec 23 - Dec 29	31.34	21.14	85.50	0.86	2.79
Dec 30 - Jan 5	30.93	22.63	92.93	0.46	2.11

Appendix (Contd...)

Period	Max.temp. (°C)	Min.temp. (°C)	Relative humidity (%)	Rainfall (mm)	Evaporation (mm)
1999					
Jan 6 - Jan 12	31.49	22.27	94.77	—	6.14
Jan 13 - Jan 19	31.34	22.53	92.50	—	3.59
Jan 20 - Jan 26	31.36	21.27	77.43	—	2.27
Jan 27 - Feb 2	30.63	21.37	76.29	0.29	3.53
Feb 3 - Feb 9	30.94	22.27	83.00	11.23	3.97
Feb 10 - Feb 16	31.40	23.06	81.64	—	3.77
Feb 17 - Feb 23	31.80	23.14	84.39	—	3.77
Feb 24 - Mar 2	31.93	23.11	80.00	—	3.96
Mar 3 - Mar 9	32.20	23.09	78.79	—	4.31
Mar 10 - Mar 16	32.70	24.31	80.71	0.26	4.34
Mar 17 - Mar 23	32.53	25.23	81.21	7.74	4.51
Mar 24 - Mar 30	32.73	25.34	82.00	0.31	4.03
Mar 31 - Apr 6	32.44	24.90	80.71	—	4.23
Apr 7 - Apr 13	32.30	25.06	81.14	4.15	4.44
Apr 14 - Apr 20	32.04	25.41	82.57	0.14	4.06
Apr 21 - Apr 27	29.10	24.00	87.64	15.83	2.73
Apr 28 - May 4	31.69	25.51	87.64	0.89	4.03
May 5 - May 11	30.97	24.40	83.07	6.11	2.99
May 12 - May 18	31.03	24.00	85.43	21.14	2.93
May 19 - May 25	29.54	23.16	88.07	15.91	2.61
May 26 - June 1	29.43	23.69	88.57	15.41	2.71
June 2 - June 8	28.01	23.51	89.71	36.63	2.47
June 9 - June 15	28.21	23.09	91.43	14.77	1.74
June 16 - June 22	30.24	24.79	82.86	5.14	3.49
June 23 - June 29	31.10	24.17	78.79	—	3.94

FORAGE AND SEED PRODUCTION OF SIGNAL GRASS (*Brachiaria decumbens* Stapf.) UNDER DIFFERENT MANAGEMENT PRACTICES

By

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ABSTRACT OF THE THESIS
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VELLAYANI, THIRUVANANTHAPURAM

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ABSTRACT

A field experiment was conducted in the Instructional Farm, College of Agriculture, Vellayani to assess the forage and seed production potential of signal grass under open conditions. The effect of varying levels of nitrogen, potassium and cutting management on the yield and quality of fodder and on the seed production potential of the grass were studied. The investigation was carried out for a period of one year from July 1998 to July 1999.

The results revealed that nitrogen applied at the rate of 200 kg ha^{-1} improved the growth parameters like plant height, tiller number per hill and leaf number per hill. Potassium showed no significant response on growth parameters.

The green fodder and dry fodder yields were favourably enhanced by nitrogen application. Nitrogen had a favourable effect on the number of days to attain 50 per cent flowering. Other yield attributes like number of seeds per panicle, seed yield and thousand seed weight were favourably influenced by all the main treatment effects viz., nitrogen, potassium and cutting management.

Nitrogen exerted significant influence on leaf area index in the later harvests. Maximum leaf area index was noticed in the second harvest stage. The treatment with highest level of nitrogen alone influenced seed germination significantly.

Application of nitrogen as well as potassium reduced the nitrogen content of the fodder. Potassium application resulted in a significant increase in potassium content of forage. Incremental levels of nitrogen reduced the crude fibre content. Potassium application resulted in a decreasing trend in crude protein content. The calcium and magnesium contents increased by potassium application alone. Incremental levels of applied potassium exerted a reducing effect on calcium and magnesium content of fodder. The K : (Ca+Mg) ratio of the fodder increased with increase in levels of applied potassium.

The available nitrogen status of the soil was improved by nitrogen application. The available potassium status of the soil declined with increase in applied nitrogen while higher potassium levels substantially enhanced the available K status of soil. Considering the economics of fodder cultivation, highest B:C ratio was realised for the treatment which received the highest dose of nitrogen and potassium.