



HYBRID NAPIER

A Better Option for Fodder and Resource Conservation

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Foreword

The North-Western Himalayan region comprising of gentle to steep slopes, suffers from severe losses of soil, water, nutrients and productivity due to water erosion. Natural resource management in the region is critical as it concerns not only the inhabitants of the hills but also the lives and prosperity of the large population in the down plains. Rearing animals is an integral part of economy in this area. Therefore, it is necessary to maintain the livestock resources of this area upto an optimum productivity level and sound health which requires sufficient production of forage. The traditional sources of forage to maintain animal population in the area are insufficient and dwindling due to various reasons. The limited cultivated area of the region is also under pressure due to increasing human and cattle population. Therefore, urgent and necessary steps are required to investigate and scan the new sources of fodder.

Plantation of grasses on field bunds is one of the tested conservation technique which helps in reducing soil and water losses and improving soil fertility, crop productivity and fodder availability. Hybrid Napier is a suitable grass species for planting on degraded lands, sloppy areas, in silvipastoral systems, field boundaries & terrace risers for fodder production and as bio-engineering measure for resource conservation. The production and resource conservation efficiencies of Hybrid Napier grass has been demonstrated by CSWCRTI, Dehradun on farmers' fields in Dungakhet, Pasauli, Devthala and Godaria villages of Vikas Nagar block of district Dehradun under the project "*Participatory Dissemination and Assessment of Land and Water Management Technologies for Livelihood Security in Rainfed Areas of North-West Himalayas*" funded by Department of Land Resources, Ministry of Rural Development, Government of India, New Delhi. The results of demonstrations were very much encouraging where 16-18 kg of green fodder yield per running meter was realized alongwith efficient soil and water conservation impacts.

Research findings tested in real field situations have been documented. I am confident that the findings presented in this bulletin based on the work carried out on farmer's field will not only help in getting additional forage to the farming community but also in preventing land degradation and maintaining soil quality. I am also quite hopeful that this compilation shall be beneficial to user agencies engaged in the development of Himalayan region. I complement the authors for this useful publication.

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Acknowledgement

The western Himalayan region, though endowed with rich natural resources, is a fragile eco-system. Intense and erosive rains coupled with steep slopes and faulty land use management practices lead to washing away of top soil, loss of biodiversity, environmental hazards and very often creating uncertainties in socio-economics of the region. Several soil and water conservation measures have been suggested to check and restore the degradation of lands in the region. Among these, mechanical measures demand high capital cost and technical skill for its execution and maintenance. Efficient use of locally available resources and skills are the need of hour for conservation of natural resources in a cost effective manner alongwith ensuring production potential of the available resources.

Napier grass is an important high value fodder crop having high soil and water conservation potential. The technology developed by the Institute has been demonstrated on farmer's field in the villages of Vikas Nagar block of District Dehradun, adopted under the project "Participatory Dissemination and Assessment of Land and Water Management Technologies for Livelihood Security in Rainfed Areas of North-West Himalayas" funded by Department of Land Resources, Ministry of Rural Development, GOI, New Delhi under TDET scheme. The results of the demonstrated technology have been documented in the form of bulletin for wider publicity among potential stake holders.

We express our deep sense of gratitude to Department of Land Resource, Ministry of Rural Development, Govt. of India, New Delhi for providing financial support for the execution of different interventions planned under the project. We place our sincere appreciation to Dr V.N. Sharda, Ex-Director and Dr P.K. Mishra, present Director of the Institute for their guidance and necessary support for successful implementation of the project.

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Authors

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INTRODUCTION

Napier grass (*Pennisetum purpureum Schumach.*) commonly known as elephant grass or King grass or Napier grass belongs to Family Poaceae (Gramineae). It is a robust perennial grass with a creeping rhizome, well adapted to warm humid climate and can be seen in all tropical and sub-tropical parts of India, especially in north and central India. It is a very fast growing species rapidly recovers from stagnation of growth with the onset of rains after extended dry periods. The Napier being very hardy, easily adoptable, vigorous and highly productive species, can withstand in drought conditions considerably. It can be grown successfully as pure crop, on field bunds and under silvipastoral systems with many multipurpose trees (MPTs) like Bhimal, Subabul, Kachnar, Siris *etc.* Napier grows up to an elevation of 2000 m above mean sea level, on variety of soils but sandy loam is best suited for luxuriant growth. Its growth is very fast, varies from place to place and according to variety/clone. There are many varieties of the Napier grass but Hybrid clone performs better in terms of growth and biomass production. Its clumps establish very easily and grow up to 3-4 m in height with broad blade shaped leaves and thick stem. Maximum length and width of leaves is up to 1.0 m and 2.5 cm, respectively.

Napier requires more sunlight for its growth and development but it can also tolerate moderate shade. Temperature for its best growth ranges between 25-40°C. The shoot portion of the plant is badly affected by frost but recovers very fast with onset of warm, moist conditions. Once the grass is established, it may continue to give fodder for 10-15 years but the productivity decreases with increase in age particularly after 10 years of establishment. Napier is one of the higher biomass yielding tropical forage grasses which is palatable and could be fed fresh, as silage, or can directly be grazed by the animals. Presence of higher content of protein in leaves make it an excellent fodder species. Its fodder quality is best when young shoots are harvested. Green leaves contain 9.0, 16.3, 0.17 and 3.16 per cent of crude protein, mineral matter, phosphorous and potash, respectively. Leaf fodder obtained from young plants is more palatable and better in quality than mature plants. The first cut is generally obtained after three months of planting when the plants are about 1.0-1.2 m tall. Normally three cuts are obtained per year but six cuts can also be obtained every year by adopting better management practices. Hybrid

Napier is an important fodder grass for resource conservation and utilization of common lands, degraded lands, wastelands and terrace risers.

Scientific classification of Napier grass

Kingdom	:	Plantae
Class	:	Angiosperms
(Unranked)	:	Monocots
(Unranked)	:	Commelinids
Order	:	Poales
Family	:	Poaceae
Tribe	:	Paniceae
Genus	:	<i>Pennisetum</i>
Species	:	<i>Purpureum</i>
Binomial name	:	<i>Pennisetum purpureum</i> Schumach.
Hybrid Napier	:	<i>P. purpureum</i> X <i>P. americanum</i>

Distribution

Native to Kenya, Tanzania, Uganda, Ethiopia, Angola, Malawi, Mozambique, Zambia, Zimbabwe, Ghana, Guinea, Liberia, Nigeria, Sierra Leone, Togo, Cameroon and found



Hybrid Napier for lean period fodder availability

throughout humid, tropical Africa and the island of Bioko (Burkill, 1994). It has been planted for forage and has naturalized in many tropical areas in Asia, the America's, and Oceania. It grows wild in the U.S. territories of Florida, Texas, California, Hawaii, Guam, American Samoa, Puerto Rico and U.S. Virgin Islands (Natural Resource Conservation Service, 2002; Pacific Island Ecosystems at Risk, 2002). It has been introduced to most tropical and sub-tropical countries where it has become naturalized. It is generally found along rivers and forest margins on more fertile soils.

The Napier being hardy, perennial and suitable for fodder (Singh, *et al.*, 2008) was also introduced in India during 1912-15 and now it can be seen in all tropical and sub-tropical parts of India, especially in Assam, Bengal, Bihar, Orissa, Uttar Pradesh, Uttarakhand, Punjab and to some extent in Madhya Pradesh, Tamil Nadu, Karnatka and Maharashtra.

Distinguishing features of Hybrid Napier

- It is a very robust grass forming large, bamboo like clumps (2-4 m tall).
- The leaf sheaths are hairless to stiffly hairy and there is a dense fringe of hairs at joints with the leaf blades.
- The large leaf blades (20-120 cm long and 1-5 cm wide) have a prominent whitish central vein.
- The seed-head is spike like (8-30 cm long and 1.5 - 3.0 cm wide) and very bristly.
- The flower spikelets are surrounded by numerous bristles, one of which is larger than the others (2-4 cm long).

Better option for fodder

- Hybrid Napier is a nutritious green fodder liked by the almost all type of animals (wild and domestic) due to its richness in essential elements and dry matter required in a good quality fodder.
- Hybrid Napier is easily propagated vegetatively by stem cuttings or rooted slips and start producing a huge amount of green fodder from the same year after planting in the field.
- Hybrid Napier can easily be planted on field bunds, terrace riser, bouldery lands, community lands, waste lands, poor and abandoned soils.

- Hybrid Napier can be harvested as and when green fodder is required, up to six cut can be obtained annually.
- Hybrid Napier is not infected by any insect & disease and provides green fodder regularly even in off season when other fodder is not available.
- Hybrid Napier is able to produce better quantity of biomass per unit area than many other grasses viz. *Panicum maximum*, *Chrysopogon fulvus*, *Cenchrus ciliaris*, *Apluda mutica*, *Dicanthiun annulatum* and *Brachiaria mutica* because of its fast growth and quick establishment.
- Hybrid Napier can be grown in association with many fodder tree species like, Bhimal (*Grewia optiva*), Kachnar (*Bauhinia purpurea*), mulberry (*Morus alba*), Kharik (*Celtis australis*), Semla (*Bauhinia retusa*) etc. in silvipastoral system.
- Hybrid Napier is a better option for natural resource conservation and erosion control by reducing runoff and soil loss.

AGRO-ECOLOGY OF PROJECT AREA

Climate of the area

Hybrid Napier for its optimal growth requires high and well distributed rainfall (more than 1000 mm per annum), it can tolerate a moderate dry season (3-4 months) because of its deep root system. At higher altitudes (above 2100 m) the growth is slow due to low temperature. Optimal temperature for its growth ranges from 25 to 40° C with high rainfall. Growth ceases if temperatures reaches below 10°C (Bogdan, 1977) and the tall varieties cannot withstand frost, in contrast to the dwarf type which is frost tolerant. However, even though the herbage (shoot system) may be killed by frost, the underground parts (root system) remain alive as long as the soil is not frozen. Hybrid Napier grass can grow in a wide range of soils, performing best in fertile and well drained soils but cannot tolerate flooding or water logging conditions (Bogdan, 1977). It establishes well in clay or sandy loam soils but best growth and maximum biomass yield is obtained in deep loamy soils.

Study was conducted with the objectives of assessing the growth performance, green biomass yield and fodder quality of Hybrid Napier (CO-3 and NB-5) grass planted on the bunds in the farmer's field under TDET-MoRD Project for meeting the daily fodder requirement by maximizing the grass productivity and to reduce the dependency on natural forests. The study area of Vikas Nagar community development block in Dehradun district of Uttarakhand lies between 29 58' to 31 02'30" N latitude and 77 34'45" to 78 18' 30"E longitude in the outer Himalaya. The climate is sub-tropical with average annual rainfall varying from 1600 mm (hills and piedmont plain) to 2200 mm (mountainous area) and a mean annual temperature of 19.6° C.

Area receives good annual rainfall. The monsoon rains generally commence from the end of June and recede by the second fortnight of September. Summers are hot and dry while winters are cold with occasional frost. The rainfall received during the study period averaged 1600 mm, nearly 80 per cent received during the monsoon period (July to September) and the rest during December-January. The rainfall generally shows a bimodal pattern with peaks during July-August and January-February. During the hot summer vegetative growth of Hybrid Napier

grass is comparatively slow. While during rainy season it is very fast. The grass often suffers from drought during the summer and remains virtually dormant during the winter season.

Soil conditions

Soil properties of the representative sites are presented in Table 1. The pH varied from 5.4 to 7.3 for the whole region. Interestingly, the distribution of native soils in the region is generally influenced by geological substrate and topographic positions. Soil texture was found to be sandy loam in higher topographic areas and clay loam to silty clay loam in lower topographic areas. The higher pH values in Godaria (5.7-7.3) could be attributed to the release of bases from higher elevation and deposition over a long period. The lowest range of pH (5.4-5.8) was observed in Dungakhet. Organic Carbon (OC) content ranged from 0.64 to 2.76 % in the entire region indicating that OC content varied greatly with landuse. However, the significantly higher values of OC in mango orchards are probably because of a more rapid recovery of the natural vegetation, less erosion and slower oxidation of the new organic material. Available Phosphorus (AP) values were statistically *at par* in different land use systems at Dungakhet. The available Phosphorus content varies from 3.64 ppm to 38.75 ppm. The highest concentrations of available Phosphorus, usually in the irrigated cropland's surface horizon, were due to the carry over effects of continuous application of Phosphorous fertilizer for the past three decades @ 30-40 kg per hectare. Wide variation was observed with respect to the values of available potassium which ranged between 32 to 302 ppm. The influences of soil texture and land use and land management might be responsible for such wide variation in available K values.

Table 1: Soil texture and fertility status of four villages under the study area of TDET-MoRD project

Soil properties	Villages of study area			
	Dungakhet	Devthala	Pasauli	Godaria
Soil : Stone	1:0.09-1:0.70	1:0.05-1:0.47	1:0.08-1:0.68	1:0.10-1:0.64
Soil texture	SCL-CL	SL-SCL	SL-L-CL	SL-SCL
Extractable P (ppm)	3.64-30.00	7.74-38.75	5.75-24.50	11.2-27.0
Extractable K(ppm)	32-101	60-245	24.0-302	69-210
Soil Organic Carbon (%)	0.85-0.1.44	0.71-2.77	0.64-2.00	0.75-1.13
Soil pH	5.4-5.8	5.9-6.6	5.7-6.5	5.7-7.3

About the technology

The technology was developed for utilization of cultivated field bunds and degraded or wastelands which are unsuitable for field crops or lying unutilized and covered with uneconomic vegetation or weeds. Hybrid Napier (variety CO-3 and NB-5), *Panicum maximum* and *Chrysopogon fulvus* were planted on community lands and on the bunds of cultivated fields just to save the land from erosion and further degradation. The grass was planted on field bunds at a spacing of 75 cm in form of stem cuttings and rooted slips during the rainy season (July-August) which established very quickly.

In the first year of implementation of forestry interventions, farmers were very much reluctant to plant the Napier grass but they were motivated to grow on a very smaller area near to drainage channels and in their court yards. Once farmers planted and witnessed its growth performance, other farmers of the all four adopted villages (Dungakheth, Pasauli, Devthala and Godaria) started indenting their demand for planting the Hybrid Napier on bunds around the cultivated fields. Planting material in form of stem cuttings and rooted slips were supplied for 3 consecutive years. Afterwards farmers were trained in propagation and planting techniques of the grass. Fourth year onwards they themselves started planning and planting of the Hybrid Napier grass.

In all four adopted villages viz. Dungakheth, Pasauli, Devthala and Godaria, many forestry interventions like planting of fodder trees (Semla, Kachnar, Bhimal, Bakain, Toon and mulberry), establishment of silvipastoral systems with the different grasses like Hybrid Napier, *Panicum maximum*, *Chrysopogon fulvus*, *Eulaliopsis binata*. etc., fruit plants (Mango, Litchi, Guava, Jackfruits, Anar, Papaya, Chiku etc.) were introduced. Among these, the planting of Hybrid Napier on bunds became first choice of the farmers because of its easy establishment, production potential, easy propagation and simple planting techniques. Due to the fast growth and higher green fodder yield, Hybrid Napier was preferred by the farmers of all four adopted villages of the project area.

3

PACKAGE OF PRACTICES FOR NAPIER PRODUCTION

Napier or Elephant grass (*Pennisetum purpureum*) is a clumping grass of tropical area that grows 3.5 m tall and is mainly propagated from cuttings of three to four nodes in length. It is widely used as a fodder crop and is also planted for environmental protection to stabilize soils and act as windbreaks. Its flowering takes place mainly in the winter. Because of asynchrony of male and female flower parts, the plant relies on cross-pollination by wind and birds. Napier grass is an inconsistent seed producer and rarely develops seeds in few habitats only. When seeds are produced, they are often of low viability and about 3.8 million seeds per kg were reported in United States (Skerman and Riveros, 1990). The seeds were dispersed by wind. Colonization of new habitats is slow (Skerman and Riveros, 1990). Hybrid Napier is usually planted by stem cuttings and rooted slips. To control weeds at the first stage of establishment, inter-row cultivation and herbicides can be used (Bogdan, 1977). The following steps were considered for development and establishment of the Hybrid Napier:

Land preparation

In preparation of the land area for planting, clearing of the bushes, removal of thorns, weeds *etc.* must be done at the beginning. Hybrid Napier requires a deep, thorough, weed free and compact seed bed. One disc ploughing may be followed by two or three fork ploughing, leveling and removal of clods for planting in the field as pure crop. While using field bunds or ridges are made across the slope as far as possible at a spacing of 75 cm distance with a height of about 25 cm which enables establishment of Hybrid Napier uniform and easy. Soil preparation is not required on bunds, only cleaning and shaping of bunds is required initially. With minimum soil working rooted grass slips can be planted or stem cuttings can be inserted in to the bunds of cultivated fields. Otherwise the lower base of the bund towards the cultivated field can be utilized for planting of slips or cuttings without any kind of land preparation.

Preparation of planting material

Hybrid Napier is an obligate quantitative short-day plant with a critical photoperiod of 12-13 hrs, flowering under a relatively wide range of photoperiods. There is some variation among ecotype in flowering time. Seed setting is usually poor, possibly due to low pollen

viability. Although the plants seeds well, the seed drops early and is difficult to collect. Hence, the Hybrid Napier grass is propagated from stem cuttings and rooted slips/rhizomes conveniently.

Usually Hybrid Napier is propagated vegetatively, if grown from seed; it is done in a well managed nursery and then transplanted in the field. The advantage of Hybrid Napier grass is that can be easily propagated by stem cuttings, rooted slips and rhizomes. The Hybrid Napier was planted from setts or cuttings (pieces of cane) about 30-45 cm long with a thickness of 2.5 cm in diameter along with the active buds and or splits (rooted pieces of clump). Setts are taken from the basal two-third of moderately mature stems. Rooted slips can be taken out from clump of the Hybrid Napier. Small slips can be detached from the clump and after pruning the roots it is used as planting material.

Planting Season

Best season for Hybrid Napier planting is just after starting the rains either in the second fortnight of June or first week of July when planted with rooted slips. If the stem cuttings are used for planting, it can be done during the month of August when mature stems of the Napier are available for making cuttings. Normally, planting of the Hybrid Napier can be done at the beginning of rains provided mature stems or good quality rooted slips of Hybrid Napier are available otherwise planting should be performed during the rainy season in the month of July-



Napier as demarcation on cultivated fields



Napier planted on field bunds in CBT



Hybrid Napier along the irrigation channel



Napier on bunds between cultivated fields

August every year when the mature stems are easily available for planting. In the present study plantation of Hybrid Napier was done mostly by stem cuttings during the month of August and gap filling was done by rooted slips in all the four adopted villages of the project area.

Planting Methods

Hybrid Napier grass is best suited to high rainfall areas but it is drought-tolerant and can also grow well in dry areas. It does not grow well in waterlogged areas. It can be grown with fodder trees, along field boundaries or along contour lines or on terrace risers to help in erosion control. It can be intercropped with crops such as legumes and fodder trees and can be raised as pure crop. It has a soft stem, easy to cut and roots very well. The tender young leaves and stems are very palatable for livestock and grow very fast. Hybrid Napier planting material can be prepared in the same way as setts of sugarcane (*Saccharum officinarum*) stems. In case of Hybrid Napier setts after cutting into pieces, each with three nodes are buried in the soil just deep enough to cover the second node on stem and to leave the third node above the ground at an angle of 45°. These are push into the soil at 45° basal ends down, with two nodes buried.

Hybrid Napier rows were planted at a spacing of about 75 cm (2.5 feet) on field bunds and even between the interspaces of the trees planted in a silvipastoral systems. If planted “slips” or “splits”, then we do not have to wait till August for the grass to mature before planting it can be multiply from clumps. Grass from the slips establish more quickly than those grown from cuttings. While preparing the slips, cut the Hybrid Napier stems at ground level to remove all the

green material and dug up the whole clump growing under the ground for making root slips, separate each slip from the clump and trim the roots to about 5.0 cm (2.0 inches) long. Each slip must have both roots and shoot. The grass slips were planted on the field bunds with a small hole and after planting the grass slips were covered with soil leaving the shoot portion open in the air space. Planting whole stem is useful during the heavy rains and in hilly areas where you need the grass to sprout quickly to cover the ground. Planting was done along the contour to control erosion after cutting whole young stems of Hybrid Napier grass, about 2.0 m (6 feet) long and cover them with soil and water it immediately. If any of the cuttings die, fill the gaps in the rows with fresh cuttings.

Napier grass establishment

Conventionally, Napier grass can be established in well prepared land (ploughed and harrowed) from setts or cuttings (pieces of cane) or splits (rooted pieces of clump) with three nodes or from whole cane. The planting material has to be planted 15-20 cm deep with splits planted upright, three node canes planted at an angle of 30-45° while whole cane is buried in the furrow 75 cm apart. Root splits generally take more labour to prepare (uproot) and to plant but result in early and quicker establishment and higher forage yield. Once the Napier is established well, the original planting material generally has little effect on dry matter yield although some varieties may establish best from cane like Hybrid Napier. Where root splits or canes are used, they should be sufficiently mature to tiller well and produce tall and high yielding forage plants. While planting from the stem cuttings material collected from 20-28 weeks old Hybrid Napier plants. Hybrid Napier grass can be established well by filling a mixture of top soils in pits during planting. Close spacing is required for soil conservation, contour hedge rows in high rainfall area but wider spacing is practised in dry areas.

Planting on community land

The Hybrid Napier grass was planted on community land and vacant lands of Panchayats in all four adopted villages where it was established and survived well. But due to illicit grazing in initial phase it could not establish in these common lands. Another reason for failure of Napier in common land was lack of protection against uncontrolled grazing by animals resulting in uprooting of grass. During grazing small clumps were destroyed by animal hoofs. Poor management and lack of protection from adverse factors was the biggest reason for failure of Hybrid Napier plantations in open areas or in common lands. Without protection it is not



Growth of Hybrid Napier in the project area

possible to establish the Hybrid Napier grass or any other grass which is palatable to the animals. However, in some patches where *Eulaliopsis binata* (Bhabar) was planted, it survived due to its hardiness and non-palatable character. This was useful only for soil conservation and utilization of degraded or waste lands rather other than fodder production.

Harvesting

The first harvesting of Hybrid Napier grass was done after attaining a height of about 1.0-1.2 m which was usually three to four months after planting. At this stage, Hybrid Napier grass has superior quality and sufficient dry matter. Thereafter the grass was harvested at intervals of six to eight weeks, at the average height of 1.0-1.2 meters. To some extent it was depending on the grass variety and its ability to grow, weather conditions, soil fertility, management practices and livestock needs. If managed well, can be harvested every month during the rainy season while during dry season can be harvested after every two months. Although harvesting at longer intervals produces higher dry matter yields, increased crude fiber and decreased crude proteins, digestibility, leaf to stem ratios and ash contents. During harvesting, a stump (stubble height) of 10-15 cm was left; this influences yield, quality and life span of the grass. Herbage yields from Hybrid Napier grass cut too low or too high leaving no stubble or very long stubble tend to decrease in yield over time and the persistence of the stand is also greatly reduced as this interfere with the growing points and weakens the rooting system

resulting in lower production in subsequent harvests. Leaving appropriate stubble height (15-25 cm) provides sufficient carbohydrate reserves for subsequent growth and especially the stubble of the last harvest before the long dry period encourages fast growth after the onset of rains.

Grass harvesting can be started from one end of the row to cut enough grass regularly until you reach the end of the row. Cut the grass 15-25 cm (6-10 inches) above the ground for further better growth of the clumps. In some cases, on farmer's field it was observed that cut from the ground level may damage the plant.

Hybrid Napier grass management

The management of the Hybrid Napier grass is very simple and easy which can be managed with the minimum inputs under rainfed and irrigated conditions. Being a hardy grass does not require much care as planted on bunds. In the adopted project area no fertilizer, no irrigation, no manuring etc. was done except whatever was applied for crops in the cultivated fields as per requirements of the crop. Hybrid Napier grass was harvested throughout the year depending on demand for fodder and also some times even if it had not attained the recommended harvesting height as may happen during the dry season when Hybrid Napier grass growth was minimal. However, more Hybrid Napier grass was usually available during and after (for a limited period) rainy seasons. Women were usually the implementers and decision makers on planting and harvesting of the Hybrid Napier grass. However, in most of the situations, the men decided to put fields under Hybrid Napier grass cultivation for protection and production.

Grazing management

Hybrid Napier/napier grass (*Pennisetum purpureum*) is the most popular fodder used by dairy farmers because of its high yield potential and drought tolerance, making it suitable as a cut-and-carry system for fodder as compared to other tropical grasses (Boonman, 1993). Although Hybrid Napier grass is a high biomass yielding fodder species commonly used in cut-and-carry system and feeded in stalls or made silage but it should be heavily stocked to maintain it in a lush vegetative form for grazing. The mature leaves are razor sharp and sometimes provide problem for grazing animals. The coarse stems produce new shoots and leaves and the grass is best grazed when the new growth consists of five new leaves and associated stem growth. Grazing at six to nine week intervals at a height of about 90 cm gives good results. Nitrogen can be applied after each grazing or cutting in high-rainfall areas where it grows as a pure crop.

RESULTS AND ACHIEVEMENTS

Grass sodding was carried out on the cultivated field bunds of 153 farmers covering 75.0 hectare area with Hybrid Napier and other grasses like *Panicum maximum* (Guinea) and *Chrysopogon fulvus* (gorda) during 2007 - 2010 (Table 2). The most preferred grass was Hybrid Napier planted on bunds around the cultivated fields. The green biomass produced from Hybrid Napier ranging from 11.8 to 18.2 kg per running meter from the project area. The harvesting of grass was varying from one cut to four cuts per year in all the four village of the project area.

Table 2: Successful establishment of horticulture/forestry tree based alternate land use interventions during 2007 - 10

Alternate Land use system	Farmers Covered	Area (ha)	No. of plants/slips	Survival (%)
1. Agri-horticulture Systems (Fruit Plants): Mango (Dashari), Chicku (Cricket ball), Litchi (Rose scented), Lemon (Kagzi), Jack fruit, Guava (L-49), Anar.	427	37.5	6485	84.2
2. Grass Sodding on bunds (Slips): (Hybrid Napier (Hathi Ghass), <i>Panicum maximum</i> (Guinea), <i>Chrysopogon fulvus</i> (Gorda), <i>Saccharum munja</i> (kains).	140	75.0	64000	77.3
3. Agroforestry MPTs Species: <i>Dalbergia sissoo</i> (Shisham), <i>Toona ciliata</i> (Toon), <i>Bauhinia purpurea</i> (Khairwal), <i>Bauhinia retusa</i> (Semla), <i>Morus alba</i> (Sahtoot), <i>Grewia optiva</i> (Bhimal).	198	6.5	3550	84.5
4. Afforestation on community land: (Dendrocalamus spp., Shisham, Toon, Khairwal, Semla, Sahtoot, Jatropa, Bakain, Salix, Bhimal, Bahera).	216	36.5	7400	72.5

The technologies presented in the table 2 clearly indicate that a large number of forest and fruit plants were planted under different forest/fruit tree based interventions like agroforestry, agri-horti system, home stead gardens and afforestation on farmers field and community lands in all four adopted village viz; Dungakhet, Pasauli, Devthala and Godaria during 2007-2010 under TDET- MORD project at Langha, Vikas Nagar. About 6485 fruit plants were established with a survival of 84% under rainfed conditions by 227 farmers which covered 37.5 ha of land area. Similarly, 10950.0 multipurpose trees (MPTs) and Bamboo were also planted under different tree based farming system (Agroforestry, Silvipastoral, Home stead gardens and afforestation) on community lands. These forest tree based interventions cover an area of 43.0 ha in the adopted villages with the participation of villagers. Soding of grass on bunds proved one of most successful technology among all the technologies which was preferred by the farmers of all adopted villages. Among the grasses viz. Hybrid Napier (Hathi ghass), *Chrysopogon fulvus* (Gorda), *Panicum maximum* (Guinea) and *Eulaliopsis binata* (Bhabar), Hybrid Napier was most preferred by the farmers and they planted 64000.0 slips on 75.0 ha area and about 140 farmers established this grass on field bunds.

Table 3 shows that in the first year (2007) of the project, farmers of the adopted villages were almost reluctant or were not even agree to plant the fodder grass Hybrid Napier. Very few numbers of farmers agreed to spare their field bunds of only 10 hectares cultivated land for grass soding. But after seeing the growth performance of Hybrid Napier grass during 2007 other farmers also motivated towards grass planting and they developed silvipastoral systems with the help of the Hybrid Napier grass. Alongwith Hybrid Napier, other grasses like Gorda (*Chrysopogon fulvus*), Guinea (*Panicum maximum*), Bhabar (*Eulaliopsis binata*) and Kudzu vine (*Pureria hirsute*) were also introduced. But ultimately the growth performance of the Hybrid Napier grass attracted the farmers for extending its soding on bunds of almost all the cultivated fields. Other grasses were less preferred. The maximum area covered was about 75 hectare under the Hybrid Napier plantation during the project period (2007-2010).



Awareness creation & motivation about Napier grass through Kisan Goshties

Table 3: Area covered (hectare) under different grass plantations on farmer's field bunds in four adopted villages during 2007-10

Grass Species	2007	2008	2009	2010	Total	Remarks
<i>Hybrid Napier</i> (Hathi Ghass)	10.0	20.0	20.0	25.0	75.0	Soding on field bunds
<i>Panicum maximum</i> (Guinea)	-	10.0	2.0	-	12.0	Soding on field bunds
<i>Chrysopogon fulvus</i> (Gorda)	-	2.0	0.25	-	2.25	Soding on field bunds
<i>Eulaliopsis binata</i> (Bhabhar)	-	1.0	-	-	1.0	Soding on field bunds and community lands
<i>Arundo donax</i> (Narkul)	-	3.0	2.0	-	5.0	Along torrents for protection
<i>Pureria hirsute</i> (Kudzu)	-	2.0	1.0	-	3.0	Protection of land slide areas



Sustainable leaf biomass production from Napier grass plantation on field bunds

Survival and growth of Hybrid Napier grass

Survival percentage of the grasses depends upon the several factors like quality of

diameter. The number of tillers increased from minimum value (first year) to highest number at maturity of the grass. The similar trend reported by Premaratene and Pramalal (2006) and Singh *et al.* (2008). The data presented in table 5 reflected that the highest number of tillers per clump (19.7) was recorded in Godaria village followed by Pasauli (19.6) and minimum (15.2) in Devthala village. The rate of tillering was higher after cutting than the pre-harvest phase and this could be due to the perennial nature of Hybrid Napier grass which produces more tillers and vegetative growth as the growing period progresses. The number of tillers was more under the Godaria village. The slower rate of tillering under other villages did not affect herbage (fodder)

Table 4: Survival (%) of the different grasses under the interventions during 2007 - 12

GRASS SPECIES	2007	2008	2009	2010	2011*	2012	Remarks
Hybrid Napier (Hathi Ghass)	68	98*	68	89	100	100	Soding on field bunds
Panicum maximum (Guinea)	83	-	83	-	100	100	Soding on field bunds
Chrysopogon fulvus (Gorda)	81	81	81	-	94.6	100	Soding on field bunds

(*During the year-2011 gape filling was done for all the grasses to bring the hundred per cent survival)

yield, probably because of faster growth rate of the Hybrid Napier grass.



Performance of Napier grass on farmer's field under rainfed conditions during stress period (June).



Performance of Napier grass on farmer's field under irrigated conditions.

with a variation in production from 5.0 to 8.0 kg per running meter while minimum production obtained from *Chrysopogon fulvus* (2.0 kg to 4.0 kg/ running meter). Although *E. binata* is not a fodder grass but we planted with a hope for cottage industry as raw material for rope making and soil conservation purpose. Its production was very less (3.0 to 4.0 kg/running meter) from field bunds but it performed very well on community lands for soil conservation and utilization of degraded vacant lands.

Green fodder yield (kg/running meter) of the Hybrid Napier grass from field bunds in the four adopted villages is presented in the table 7. The biomass production showed an



Growth performance of Hybrid Napier grass on cultivated field bunds

increasing trend over the years in all the adopted villages. However, the single year highest green biomass was recorded during 2011 in Godaria village (18.5 kg/running meter). It is also evident that the Devthala and Godaria has similar average green biomass production (15.9 kg/running meter) followed by Pasauli (14.1 kg/running meter) whereas the minimum average (2007-2013) biomass yield (11.3 kg/running meter) was obtained in village Dungakhet. In adopted area green fodder yield from Hybrid Napier varied from 11.3 kg/running meter to 15.9 kg/running meter being an average of 14.3 kg/running meter. Green

fodder production of the Hybrid Napier grass from the project area irrespective of villages varied 7.75 kg/running meter during 2007 (first year) to highest (16.6 kg/running meter) in the year 2013 which showed an increasing trend over the years in all the adopted villages. Overall average fodder production from Hybrid Napier was recorded 14.3 kg/running meter from the project area when planted on field bunds. Overall average fodder production from Hybrid Napier was recorded 14.3 kg/running meter from the project area when planted on field bunds. The total annual fodder yield of about 4290.0 quintals was recorded from the 75 hectare covered area (field bunds).

Green leaf biomass yield (quintal/annum) over the years obtained from the Hybrid Napier grass planted on field bunds in the four adopted villages is presented in table 8 which reveals that the fresh biomass production (leaf fodder) of Hybrid Napier increased rapidly over the years (2007-2013) but increased many folds in second year (2008) in all the adopted villages. The maximum total fresh biomass yield (51.55 quintals) was recorded in village

Table 5: Growth characteristics and green biomass production of Hybrid Napier planted on cultivated field bunds in adopted villages during 2007-10

Village	Height (m)	Collar Diameter (cm)	No. of Tillers per clump	Fodder Yield (kg/rm)	Fodder (q/ha)
Devthala	2.8	17.7	15.3	15.9	63.6
Pasauli	2.7	29.1	19.6	14.1	56.4
Dungakhet	2.6	23.4	15.4	11.3	45.2
Godaria	3.0	23.5	19.7	15.9	63.6

(rm= running meter)

Pasauli followed by Devthala village (4365.0 quintals) whereas the minimum average fresh leaf biomass yield was obtained from village Dungakhet (1400.3 quintals). The availability of the fresh fodder reduced the dependency on natural forests for green fodder requirement of the project area. The fresh leaf fodder yield showed an increasing trend over the years and highest yield (3796.0 quintals) was obtained during the year 2013. Whereas the total fresh leaf biomass yield of 13064.0 quintals was obtained from the project area. The total annual fodder yield of about 13064.0 quintals was recorded from the 75 hectare area (cultivated field bunds).

This higher fodder production shall reduce the burden on forest for fodder and will save the time spent for fodder collection from forest by the villagers. This saved time can be utilized for field operations to enhance the crop production. The area utilized for cultivation of fodder

Table 6: Green biomass production (kg/running meter) of the different grasses under the interventions during 2007-10

GRASS SPECIES	2007	2008	2009	2010	Average	Remarks
Hybrid Napier (Hathi Ghass)	7.75	12.5	15.4	15.6	12.8	Soding on field bunds
<i>Panicum maximum</i> (Guinea)	-	5.0	6.0	8.0	5.3	Soding on field bunds
<i>Chrysopogon fulvus</i> (Gorda)	-	2.0	3.0	4.0	3.0	Soding on field bunds
<i>Eulaliopsis binata</i> (Bhabar)	-	1.5	2.5	3.5	2.5	Soding on field bunds and community lands

crops for fodder purpose can also be spared for grain production. In this way area under crop cultivation will also increase.

Chemical composition and nutritive value

The proximate composition of *Pennisetum purpureum* has high moisture content (89.0%) in the green forage biomass. This implies that *Pennisetum purpureum* may have a short shelf-life due to its high moisture content. This high moisture content also implies that dehydration would increase the relative concentrations of the other food nutrients and improve the shelf-life/preservation of the *Pennisetum purpureum* meal. Result shows that the protein content of Hybrid Napier is higher in Dungakhet village (16.2%) followed by Pasauli (14.5%) and Devthala village (14.3%) (Table 9). The average protein content present in the Hybrid Napier leaves was recorded 14.6% in the project area during 2007-2013. The Hybrid Napier protein can be compared with those of most conventional protein sources like *Grewia optiva* leaf fodder (19-21%), *Leucaena* and *Gliricidia* contain high crude protein (1930%). The relative proportion of protein can even be increased further by dehydrating the *Pennisetum purpureum* forage. Thus when dehydrated, *Pennisetum purpureum* can be regarded as a good source of protein. This high protein content is suggestive of being used in combating protein deficiency. The higher Organic Carbon (35.9%) was present in the leaf samples obtained from Dungakhet followed by the Devthala village (35.7%). The other

Table 7: Green biomass yield (Kg/running meter) from Hybrid Napier planted on cultivated field boundaries in four adopted villages.

Name of the Village	2007	2008	2009	2010	2011	2012	2013	Average
Godaria	8.3	12.5	18.2	18.0	18.5	18.0	17.9	15.9
Devthala	9.6	15.5	16.4	17.2	17.0	17.5	18.2	15.9
Pasauli	6.1	13.0	15.2	14.9	15.9	16.8	16.7	14.1
Dungakhet	7.0	8.8	11.8	12.1	12.5	13.5	13.8	11.3
Average	7.75	12.45	15.4	15.55	15.97	16.45	16.57	14.3



Utilization of cultivated field bunds for sustainable production of leaf fodder from Hybrid Napier grass plantations

nutrients, nitrogen and potassium were recorded higher in Dungakhet village (2.59% and 3.20%) while phosphorus was higher in Devthala village (3.0%). The higher values for these nutrients did not show any definite pattern in all the four villages. The average values of the Organic Carbon, Nitrogen, Phosphorus, potassium and protein content present in the leaf fodder of Hybrid Napier are 33.75, 2.34, 0.949, 2.74 and 14.6 per cent respectively. Grass maturity is usually negatively related to crude protein content. Napier grass decline in crude protein content more rapid in stems than leaves. Hybrid Napier becomes an attractive feed since it can retain a given level of digestibility for a slightly longer period compared with other tropical grasses. Nutritious silage, highly palatable to animals can be prepared after adding molasses (2.0%) and salt (0.8%) (CSIR, 1948-1976).

In the adopted project area two methods of animal rearing were being followed i.e. open grazing and stall feeding. Data presented in the table 10 reflected that initially during 2007 open grazing was practiced on larger scale due to scarcity of fodder. As Hybrid Napier produces a higher quantity of green fodder, therefore, the open grazing was reduced to 167% and farmers started adopting stall feeding system because quality leaf fodder of Hybrid Napier was available on the fields which reduce the dependency on natural forests. Open grazing was reduced to 71%

Table 8: Production (q) of green leaf fodder from Hybrid Napier in adopted villages under (TDET- MoRD) project during 2007- 14

Village Name	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	Total
Dungakhet	7.0	52.8	118.0	205.7	250.0	270.0	496.8	1400.3
Pasauli	18.3	65.0	349.6	745.0	795.0	1512.0	1670.0	5154.9
Devethala	48.0	325.5	656.0	688.0	680.0	875.0	1092.0	4364.5
Godaria	16.6	37.5	273.0	370.0	370.0	540.0	537.0	2144.1
Total	89.9	480.8	1396.6	2008.7	2095.0	3197.0	3795.8	13063.8

from 2007 to 2014 (Table 10).

The fodder requirement during 2007 was maximum (1370 tons/annum) in Devthala village followed by Pasauli village (1156.0 tons/annum) and minimum (200.0 tons/annum) in Godaria village. Proportionately the requirement for green fodder was reduced in all the villages during 2014. The total green fodder requirement of 3138 tons/annum during 2007 was reduced to 2468.6 tons/annum in the year 2014 which is about 21.3% (Table 11). Reduction in forest dependency for fodder varies from 7.0% in village Devthala to 34.0% in village Pasauli during the project period (2007-2014). The highest fodder requirement was met out in Pasauli village (34%) followed by Godaria village (32%) and Dungakhet village (27%). The average green fodder from the project area was meeting out about 21% from Hybrid Napier grass planted on the cultivated field bunds. It is a higher reduction in dependency on forest for fodder from one component of Hybrid Napier plantation on field bunds only in the project area which is the achievement of the project.

During the PRA and Socio economic survey, analysis of farmer's preference for different grasses was also conducted based on various attributes like growth and establishment, survival, hardiness, palatability, fodder quality, nutritive value, fodder production and soil conservation value of the grass. The farmers of the project area recorded their preferences about grasses based on above attributes. The analysis of preference of farmers clearly showed that among all the grasses (table 12) Napier was the most preferred grass, satisfying all the criteria of the farmers. In the later years preference of Hybrid Napier has reached to the top, surpassing choices of other grasses in the project area and also in the neighboring villages.

Other uses of Napier grass

The two major uses of the Hybrid Napier grass in order of importance are soil erosion control and green fodder production for animals. Growing Hybrid Napier grass for sale is also

Table 9: Proximate composition of plant nutrients (%) present in Hybrid Napier grass planted on cultivated field bunds in four adopted villages in the project area

Village	OC	N	P	K	Protein
Dungakhet	35.9	2.59	0.275	3.20	16.19
Pasauli	32.6	2.32	0.247	2.39	14.50
Devthala	35.7	2.28	0.300	2.41	14.25
Godaria	30.8	2.15	0.273	2.97	13.45
Average	33.75	2.34	0.949	2.74	14.60

important in the semi-intensive cultivation system which is an emerging economic activity. Hybrid Napier is equally important in its use for control of soil erosion when planted along the terraces and contour lines. The Hybrid Napier grass was also used for mulching as it was introduced in Kenya as a mulch crop for coffee during the colonial times (Boonman, 1993). As innovators, farmers soon realized its potential as animal feed and currently Hybrid Napier grass is intimately associated with the smallholder dairy production as the most important feed stuff. Some farmers indicated that Hybrid Napier canes were used in making chicken houses and

Table 10: Percentage (%) change of animals grazing under (TDET- MoRD) Project during 2007-14

Method of rearing of animals	2007	2014	Change (%)
Open grazing	70	20	-71.42
Stall feeding	30	80	166.66

Hybrid Napier grass refusals were used in the cow stalls as bedding with the aim of getting manure later. The different alternative uses for Hybrid Napier grass showed versatility. Hybrid Napier grass has multiple uses in different parts of the world which include fire breaks, mulch, green manure, wind break, grazing, soil erosion control and as constituent of fish ponds (Farrell *et al.*, 2002).

Advantages of Napier grass

1. Hybrid Napier grass is propagated easily either by rooted slips or stems cuttings.
2. It has a soft stem that is easy to cut as fodder and eaten by animals.

Table 11: Total fodder requirement @ 8 kg / SLUI /day in different villages of (TDET-MoRD) Project during 2007- 14

Village	Fodder requirement (t/annum)		Decrease in fodder requirement (%)
	2007	2014	
Dungakhet	312.4	226.7	27.42
Pasauli	1156.3	763.6	33.96
Devethala	1369.5	1273.4	7.01
Godaria	299.9	204.7	31.74
Total	3138.1	2468.6	21.33



Napier grass plantation on cultivated field bunds for off season fodder availability

PREFERENCE RANKING OF FARMERS

3. It has deep roots, so is fairly drought-resistant.
4. The tender, young leaves and stems are very palatable as high quality forage for livestock.
5. Hybrid Napier grass grows very fast and needs less management.
6. Because of the better growth Hybrid Napier grass is preferred by the farmers. They also claim increase in milk production by feeding Napier to the milch animals.

Table 12 : Preference rankings for different grasses

Name of the grasses	Nutritive value of fodder and palatability					Establishment, growth and productivity					Soil conservation value					Overall Score	Overall Rank
	Devthala	Godaria	Pasauli	Dungakhet	Total Score	Devthala	Godaria	Pasauli	Dungakhet	Total Score	Devthala	Godaria	Pasauli	Dungakhet	Total Score		
Bhabhar	5	4	6	4	19	5	3	5	6	19	6	5	4	7	22	60	IV
Guinea	8	7	6	6	27	6	5	6	5	22	4	5	4	6	19	68	II
Napier	9	8	9	8	34	7	8	9	7	31	7	6	8	9	30	95	I
Gorda	6	6	7	5	24	5	4	6	4	19	5	4	6	3	18	61	III
Narkul	0	0	0	0	0	7	6	6	7	26	8	8	6	7	29	55	VI
Kudzu wine	4	5	6	3	18	5	3	4	4	16	7	5	5	5	22	56	V

7. Hybrid Napier grass is a fast growing aggressive plant that spreads through rhizomes under the ground which is suitable for bio-engineering measures to reduce runoff and soil loss.
8. Less cost of initial establishment was enumerated by most of the farmers as a major advantage of the technology.

As per the participatory agro-ecosystem analysis report of adopted villages of TDET-MoRD project (2007) it was estimated that the 75% of fodder requirement was

being met out from the forest and rest 25% from the farmlands including crops and fodder trees. The farmers of all four adopted villages in the project area who were close to the reserve forest mainly consist of Sal (*Shorea robusta*) used to collect fodder from the Sal forest. The Godaria was the only village which had low (15%) dependency on natural forests for fodder followed by Dungakhet (50%), Devthala (75%) and pasauli (91.5%). Higher dependency on forest at Pasauli village was due to small land holdings and least number of multipurpose trees (MPTs) in agriculture fields. Keeping in view the



Growth performance of Hybrid Napier grass during June, 2014 on farmer's field as off season fodder outside the project area

shortage of fodder and small land holdings soding of Hybrid Napier on cultivated fields' bunds was done in all four adopted villages. The production of green fodder obtained from Hybrid Napier in the project area is presented in table 11 which indicate that the requirement of fodder from forest has come down to about 21.3% which reduced the

fodder dependency from the forest. The highest reduction (34.0%) for fodder dependency was observed in Pasauli village followed by village Godaria (31.7%), by planting of Hybrid Napier on field bunds. During the year 2007 the total fodder requirement of the village Godaria was about 300.0 tons/annum which reduced to 205 tons/annum in the year 2014 means 95 tons/annum (31.7%) was available against the requirement of 45 tons/annum to feed the animals while the dependency on forest for fodder was only 7.0%. The Hybrid Napier fodder production from field bunds saved the cultivated land which was earlier used to cultivate fodder crops like berseem and other fodder crops now can be used for grain production.

The farmers of the selected village increase the number of animals per family particularly milch animals (cow, buffalo) due to the availability of the green fodder from Hybrid Napier. The availability of Hybrid Napier fodder also saved the time of individual family which they spent in fodder collection from forests and now the more time is being devoted for cultivation of field crops which improved the production and productivity of their cultivated fields

Facts about Hybrid Napier



REDUCTION IN FODDER DEPENDENCY ON FOREST

- Harvesting of Hybrid Napier from the ground level may damage the clump. It observed during the demonstrations on farmer's field.
- Don't use older stems as planting materials, as they will not germinate well.
- Don't allow animals to graze Hybrid Napier grass as they may damage or kill the plants.
- Don't allow the grass to overgrow, as it may become a weed.
- Don't allow the Hybrid Napier grass to grow too high (more than 120 cm or 4 feet) as Goats will not eat the tough bits.

Recommendations

1. Hybrid Napier is the best option for green fodder and erosion control upto an elevation of 2000 m in North-West Himalayan region.
2. Resource poor farmers who can not afford concentrate feeding to their animals Hybrid Napier is the best option for enhancement of livestock productivity.
3. It is the best option for green fodder availability during lean period.
4. It reduces about 21.0% pressure for green fodder on the natural forests.
5. Hybrid Napier is the best option for utilization of field bunds and their protection.

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