

Agronomy – Kharif Crops

Crops for Fodder

- Fodder Sorghum (Jowar)
- Maize (Fodder)
- Pearl Millet (*Bajra*) (Fodder)
- Cowpea
- Clusterbean (*Guar*)
- Guinea Grass
- Napier X Bajra Hybrid (Nbh)

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FODDER SORGHUM (JOWAR)

Botanical name: *Sorghum bicolor*

Family: Poaceae (Gramineae)

Sorghum besides an important food crop of world is also valued for its fodder and stover. Sorghum fodder is suitable silage and hay making and thus can supplement the fodder supply during lean season. The dry stover forms important feeding stock for animals especially in dry areas. It is suitable for cultivation in areas that are too dry for maize.

Geographic Distribution

It is cultivated for fodder purpose in the country over 2.6 m ha mainly in the states of western Uttar Pradesh, Haryana, Punjab, Gujarat, Rajasthan and Delhi. It meets over $\frac{2}{3}$ of the total forage demand of *kharif* season.

Soil and its Preparation

Sorghum is grown on all types of soils, except sandy soils. Heavy soils should be well drained. It can tolerate moderate levels of salinity, and suitable pH ranges from 5.0-8.5. It does not require fine seedbed. Two-three harrowings are sufficient for seed-bed preparation.

Varieties

A large number of single and multicut sorghum varieties have been evolved with 50-70 t/ha/year (season) green fodder yield. The varieties with less menace of leaf diseases and stem borers are ideal for fodder purpose. In north India, grain types are grown during *kharif* for fodder production. The important improved varieties of sorghum recommended for fodder production in various states are given in Table 1.

Table 1. Fodder varieties of sorghum for different areas

Variety	Region
Single cut	
PC-6, PC-9, PC-23, HC-171, HC 260, HC 308, Pro-Agro-chari, Jawahar Chari 6	For whole country (early medium duration)
HC-136, Raj chari-1, Raj chari-2, Haryana Chari, HJ-523, MFSH-3	Whole country (late varieties)
Sl-44, MP Chari, UP chari-2	North India
Pant chari-3, UP chari-1, Haryana chari-6, JS-3	Uttar Pradesh, Andhra Pradesh, Tamil Nadu, Maharashtra
Double cut	
Co-27	Tamil Nadu
AS-16, GFS-1	Gujarat
Multicut	

<i>PCH-106, Punjab Sudex*, Pusa chari-23, Jawahar chari-69, Hara sona*, Pioneer-988, SSG-59-3 (Meethi Sudan), MFSH-3, SPV-932</i>	Whole country
Dual purpose (grain & fodder)	
<i>CSV 15</i> <i>CSH 13</i>	As single cut variety for north-west India Single cut hybrid superior to HC 6

* Hybrid

The characteristics of important varieties are given below.

Single cut varieties

- *Haryana chari (JS 73/53)*: A selection from germplasm collected from Uttar Pradesh and released in 1975. It is susceptible to red leaf spot and stem borer. Green fodder yield is 30 t/ha.
- *HC-136*: A derivative of cross between 3214 x PJ 7R, released in 1981 for irrigated conditions. Low in HCN and tannin contents with green fodder yield of 58 t/ha. Tolerant to major diseases and insect pests.
- *HC-171*: A derivative of cross between SPV-8X x IS-4776, released in 1984 for irrigated conditions. Suitable for *kharif* and summer seasons. Highly resistant to foliar diseases and tolerant to major pests. Green fodder yield is 60 t/ha.
- *Raj chari-1*: Developed from the cross between CSV6 x NCL3 and released in 1981. Resistant to stem borer and is non-lodging. Green fodder yield is 45 t/ha.
- *Raj chari-2*: A selection from local type of Udaipur region. Resistant to stem borer with high digestibility. Green fodder yield is 33 t/ha.
- *UP chari-1*: A single plant selection from *Durra caudatum* (Maje Vari-Junagarh) IS-4776, released in 1983. It is not suitable for high rainfall areas. Very low in HCN and can be fed to animals at any growth stage.
- *UP chari-2*: Developed from the cross between Vidisha-60-1 x IS 6953 by pedigree selection, released in 1984. It is not suitable for high rainfall areas. Suitable for late sown conditions too. Green fodder yield is 38 t/ha.
- *Pusa chari-1*: Selection form sample collected from Uttar Pradesh released in 1974. It is resistant to lodging, drought and pests. Highly responsive to fertilizers. Green fodder yield is 33 t/ha.

Multicut varieties/ hybrids:

- *PCH 106*: It has profuse tillering and quick regeneration capacity and provides 3-4 cuts. Yields up to 65 t/ha of green fodder
- *Meethi Sudan*: It provides 55-60 t/ha of fodder in 4 cuts. It is tolerant to drought and waterlogging. The stems are sweet and thin with profuse tillering.

Dual purpose varieties/ hybrids:

- *CSV 15*: It is a single cut variety with 45 t/ha of green fodder yield. Its stems are tall, sweet and juicy. It is resistant to leaf diseases and drought.

- **CSH 13:** A hybrid suitable for taking single cut of fodder. It is resistant to leaf diseases and yields about 45-50 t/ha of green fodder.

Land preparation:

The land is prepared by 2-3 harrowings.

Seeds and Sowing

The seed rate varies from 25 (small seeded) to 40 kg/ha (bold seeded varieties) in single cut varieties. For multicut varieties the seed rate of 10 kg/ha is optimum. The crop is sown in rows of 30 cm (single cut) to 45 cm (multicut) apart with a plant to plant spacing of 15 cm. The seed is sown at a depth of 2-5 cm. Mid to end of June is the optimum time of sowing for single cut varieties and April – mid May for multicut varieties under assured irrigation. In *tarai* region of Uttar Pradesh, last week of May to first week of June is the best, as it helps in avoiding pests. In rainfed areas, it should be sown immediately after onset of monsoon.

Manures and Fertilizers

FYM application @ 10 (rainfed) to 25 t/ha (irrigated) before sowing is needed for higher fodder production. All single cut varieties respond up to 120 kg N/ha. However, crop is fertilized with 80-40-0 (single cut), 120-60-0 (double cut) and 210-60-60 (multicut) kg/ha of N-P₂O₅-K₂O, respectively.

50% of total N (single cut, 40 kg; double cut, 60 kg; and multicut, 60 kg/ha) N along with entire P₂O₅ and K₂O are applied as basal. The remaining 50% N is top dressed 35-40 days after sowing (single cut) and 30 days after first cut (double cut varieties). In multicut varieties, 50 kg N is top dressed after each cut. At top dressing, adequate moisture should be ensured either through irrigation or it should be applied after rainfall.

Irrigation

Sorghum as a rainfed *kharif* crop needs no irrigation. However, at times of drought irrigation 35 days after sowing is advantageous. In summer, the crop requires 5-6 irrigations at 10-15 days interval depending on soil and climate.

Weeding

Weeds at early stages of crop growth compete for water and nutrients, and finally leading to heavy yield losses. Summer ploughing followed by 1-2 hand-weedings or intercultivations between 15-35 days after sowing may considerably reduce weeds and associated losses. However, interculturing becomes difficult during rainy season. Therefore, use of herbicides is recommended. Atrazine @ 1 kg/ha (pre-emergence) and 2,4-D @ 0.75-1.0 kg/ha (post-emergence 25-35 days after sowing) can effectively control weeds in fodder sorghum. For control of witch weed [*Striga gesnerioides* (Willd.) Vatke], use of dicamba (foliar spray) or metolachlor (pre-emergence) herbicides along with trap cropping have been advocated.

Cropping Systems:

For higher and quality fodder production, intercropping of sorghum with legumes is advised. Its intercropping with cowpea (normal rainfall areas) and *guar* (low rainfall areas) in 2:1 ratio is promising. For intercropping, erect genotypes of legume are ideal.

Plant protection measures

Diseases

Sorghum crop suffers from a number of diseases. The important diseases and their control measures are described below.

Downy mildew (*Sclerospora sorghi*):

Infested seedlings have pale yellow narrow leaves that are covered on both sides by soft white downy growth of fungus. The affected plants remain stunted and dry up permanently. It is severe in Tamil Nadu, Karnataka, Maharashtra, Uttar Pradesh and Madhya Pradesh.

The control measures include treatment of seed with agrosan GN or cerasan @ 4 g/kg seed and spray of dithane Z 78 (0.2%) to reduce secondary infection. The diseased plants should be removed and buried into the soil.

Anthracnose (*Cercospora sorghi*):

The disease appears as small spots on leaves and lower parts of the plant, which spread upwards later on. The leaf spots are light brown at center and dark at the margins.

Seed treatment with agrosan GN @ 3 g/kg seed followed by spray of zineb (0.2%) at 10 days interval starting from 35 days after sowing can control the disease.

Insect Pests**Sorghum shoot fly (*Atherigona variegata*)**

The maggots bore into the stem and feed on main shoot, and finally destroy the growing point. This results in tillering, and in severe infestation the tillers are also attacked then also. The seedling stage is more prone to attack though the attack continues up to early boot stage.

Application of carbaryl 10 G or phorate 10 G or endosulfan 3 G @ 5 kg/ha and foliar spray of endosulfan @ 0.07% is effective in borer management. Early sowing (1st week of June) may avoid shoot fly attack.

Stem borer (*Chilo partellus*)

The caterpillars bore into the stem, and also the leaf prior to entering the stem. The young larvae feed on the leaves before boring downwards through the central whorl and reach the growing point. The characteristic symptoms are production of “Dead Hearts”.

Foliar spray of endosulfan (0.07%) or carbaryl (0.05%) 2-3 times at 10-15 days interval is effective in borer management. Release of *Trichogramma* egg parasites may also reduce the stem borer incidence.

Cyst nematode (*Heterodera sorghi*)

This is most commonly observed in Delhi and Haryana regions.

A deep summer ploughing reduces nematode population. Carbofuran seed treatment @ 2-3% and soil treatment with seabuphos @ 2 kg/ha and tobacco dust application @ 2.5 q/ha are effective in nematode management.

Harvesting

Single cut varieties are harvested at 50-100% flowering stage. In multicut varieties, the first cut is taken 55 days after sowing and the subsequent at 40 days interval. In multicut varieties, first cut should be taken 8-10 cm above ground level so as to facilitate profuse tillering.

The crop at early stages contains hydrocyanic acid (HCN) or Dhurrin. HCN in excess of 200 ppm concentration is toxic to animals. Hence harvesting should not be done prior to 45 days from sowing. Heavy nitrogen fertilization and water stress (drought) increases HCN content. Silage or hay making removes the toxin. In summer, an irrigation before harvest may be effective in reducing HCN.

For hay making, pre-flowering is ideal stage for harvest. At this stage, the biomass is soft and rich in nutrients.

Yield

The green fodder production varies from 30-45, 45-65 and 65-105 t/ha in single, double and multicut varieties, respectively. The protein content of single/ dual purpose cultivars is ~7% and has an *invitro* dry matter digestibility (IVDMD) of ~50%.

MAIZE (FODDER)
Botanical name: *Zea mays* L.
Family: Poaceae (Gramineae)

Maize is most important fodder crop for milch animals. It is grown on over 9 lakh ha in different parts of the country throughout the year. It is a C₄ plant having high fodder production capacity in shorter durations.

Climate

Maize is grown in areas with a rainfall of 50 cm, but the best yields are achieved in 120-150 cm rainfall areas. It is more oftenly grown under assured irrigation. It is drought tolerant at early stages (up to 35 days) and is susceptible to waterlogging.

Soil and Land preparation

Deep, fertile, rich in organic matter and well-drained soils are most preferred for the crop. The soil should be medium textured with good water-holding capacity. Maize will not thrive on heavy clay especially lowlands. It can be grown successfully in soils, having pH 5.5 to 7.5. The alluvial soils of Uttar Pradesh, Bihar and Punjab are suitable for raising maize crop.

The land should be thoroughly prepared. Four to five ploughings and three to four plankings should be done to get a seed bed free from clods and weeds.

Varieties

Maize varieties recommended for fodder production in different states are given below.

Varieties/Composites	Recommended for	Yield (t/ha)
South African tall, Vijay composite	Entire country	50-80
Jawahar, Moti composite, Manjari composite	Entire country	50-80
Ade Cuba	North east	25-45
J-1006	Punjab	45-55

Other varieties: Kisan composite, BL-7, Ganga-5, Ganga Safed-2

South African Tall

A composite of seven varieties released in 1983 for year round cultivation. Plant height is 260 cm and yields 40 t/ha of green fodder. Resistant to foliar diseases and stem borer.

J-1006

This variety was developed by crossing 'Makki safed 1-DR' x 'Turpeno PBL' and released in 1993 for Punjab. It is resistant to maydis blight, brown striped downy mildew and stem borer.

Seed and Sowing

Maize requires 50-60 kg seed/ha. Generally maize is sown in lines at a distance of 25-30 cm. Maize can be sown for fodder production from March to mid-April for getting fodder continuously from May to October. Generally, it is sown in mid-July

Manures and Fertilizers

The crop needs heavy fertilization. FYM application @ 10 t/ha before sowing is necessary. Besides organic manures, fertilizers @ 90-30-30 kg/ha of N-P₂O₅-K₂O are necessary for higher yields. A dose of 60-30-30 kg/ha of N-P₂O₅-K₂O is applied at the time of sowing. The remaining 30 kg N is top dressed 30 days after sowing.

Crop rotation

Crops like wheat, potato, *toria*, sugarcane, gram, berseem, lucerne, barley, oat can be grown after harvest of maize. In hills, potato is grown after maize.

Water management

A rainfed crop needs no irrigation. However, at time of drought, irrigation 35 days after sowing is advantageous. However, during non-rainy and summer seasons, the crop requires 7-8 irrigations at 10-12 days interval depending on soil and climate.

Weed management

During *kharif* season, there is severe weed problem at early stage of crop growth. Atrazine/simazine @ 1 kg/ha (pre-emergence) effectively controls the weeds in maize. In intercropping systems, weed menace is relatively less.

Plant Protection Measures

Diseases

Maize crop suffers from the attack of number of bacterial and fungal diseases. Rust (*Puccinia sorghi*), stalk rot (*Phythium cephanidermatum*) and leaf blight are important diseases of the crop.

Leaf blight:

In maydis leaf blight (*Helminthosporium maidis*), individual spots are greyish, and up to 3.75 cm in length, oval shaped with strategic zonations. *Turcicum* leaf blight (*Helminthosporium turcica*) spots are greyish green or straw coloured and boat shaped. They are comparatively fewer in number and large in size than those of maydis.

These disease can be controlled by 2-4 sprayings of maneb or zineb (1.5 kg in 600 litres of water/ha).

Insect pests

Some of the major insects are:

Shoot fly (*Athrigona* sp.)

It is very serious pest of maize in south India. In north India, however, maize crop is not affected much except in spring season in *tarai* area. The attack is more at the seedling stage. The tiny maggots creep down under the leaf shoots till they reach the base of seedling. After this they cut the growing point, which results in the formation of characteristic 'dead hearts'.

Application of thimet 10 G @ 15 kg/ha at the time of sowing in furrows pest or spraying of 0.02% of metasystox will control the pest.

Maize jassids and thrips (*Anaphothrips flavi cinctus*)

These pests cause serious losses of *Sathi* crop (60 days crop) in Punajb during March-May. They are also becoming important on the normal *kharif* crop.

Spray metasystox 25 EC or Rogor 30 EC @ 500 ml/ha in 100 litres of water with a low-volume sprayer.

Cutworm (*Agrostisipsilon*)

The larvae of this pest cut the seedlings at the ground level. Caterpillars are grey in colour. They live in soil during day and feed at night. The adults of cutworm may be trapped on light source and may be killed later.

Dusting of 2% folidol or 3% heptachlor dust at the base of the plant @ 20-25 kg/ha will control the pest.

Cyst nematode (*Heterodora sorghi*)

The yield losses range from 10-25%. They are most commonly observed in Delhi and Haryana regions.

A deep summer ploughing reduces nematode population. Carbofuran seed treatment @ 2-3, and soil treatment with sebuphos @ 2 kg/ha and tobacco dust application @ 2.5 q/ha are effective in nematode management.

Harvesting

The crop is ready for harvest in 60-75 days. The ideal stage for harvest is tasseling stage for green fodder and medium dough stage for silage purposes.

Yield

The green fodder yield under proper management varies from 35-55 t/ha. The crude protein and fibre content of fodder is 7-10% and 25-35%, respectively.

PEARL MILLET (BAJRA) (fodder)
Botanical name: *Pennisetum glaucum* L. R. Br. emend. L. Stuntz
Family: Poaceae (Gramineae)

Pearl millet is an important forage crop of arid and semi-arid regions of the country besides its utility as food crop. The green or dry fodder (*karvi*) is fed to the cattle.

Origin and History

The exact place of its origin is yet to be known. However, looking to its cultivation pattern, it is believed that the pearl millet originated either in India or Africa. Pearl millet hybridizes spontaneously with elephant grass (*Pennisetum purpureum* Schum.), which is of African origin, and the 2 species had a common ancestor.

Climatic Requirements

It is highly drought tolerant and rapidly growing warm-weather crop in areas of 25-75 cm of rainfall. During the vegetative growth of the crop, moist weather is congenial. The crop performs best under conditions of light showers followed by bright sunshine. Pearl millet is grown as a *kharif* crop in northern India, but with assured irrigation it can be grown as a summer crop in Tamil Nadu, Karnataka and Punjab. The optimum temperature for the growth of pearl millet is between 20 and 28°C. It can not tolerate frost.

Varieties

Pearl millet varieties recommended for fodder production in different states are given in Table 1.

Table 1. Pearl millet varieties recommended for fodder production

State	Varieties/Hybrids
Uttar Pradesh, Punjab, Haryana, Madhya Pradesh and Rajasthan	Pusa Moti, UPFB 1, T 55, S 530, A 1/30, Rajko, AVKB-19 Hybrids: NB 3, NB 17, NB 18, NB 21, NB 25, PHB 12, MH 30, BJ 105, Composite 6, K 674, K 677, L 72, L 74, Anand S 11, Raj Bajra Chari 2, Haryana, Composite 10, Nandi 32, MH-564, Nandi-8, PB 106, RHB 90, DRSB-2, proagro-1, Pusa 605, Pusa 415, MLHB-44, HAB-9, Pusa Composite 334.
Maharashtra and Gujarat	Malbandro, G 2, G 5 (Drought resistant)
Tamil Nadu	Co 1, Co 2, Nad Kumbu, TN SC1 (Chumbu)
Karnataka	B 247
For saline soils	DL 454, DL 532, DL 36
Rainfed: Entire bajra tract, Rajasthan and Gujarat	Rajko

FBC16: Multicut, resistant to major diseases, high voluntary dry matter intake and low concentration of oxalates. Its yield potential is 70-80 tonnes green forage/ha. It is recommended for growing in plains of Punjab.

Giant Bajra: Evolved through a cross between Australian and local *bajra*. Released in 1984 in Maharashtra. Plants leafy, palatable, profuse tillering with 9-10% protein at boot stage. Fodder is good for heylage and silage making too. Moderately resistant to downy mildew and ergot, and yields 50-75 t/ha green fodder.

Raj bajra chari 2: Released in 1990 for all *bajra* growing tracts with 30-45 t/ha yield. Resistant to downy mildew and insect pests.

Fodder numbu-8 (TNSC-1): Released in 1993 for all *bajra* growing tracts with 27-40 t/ha yield. Resistant to foliar diseases and insect pests.

Field preparation

The crop does not require fine seed bed. The seed bed is prepared by one ploughing.

Seed rate

A seed rate of 8-10 kg/ha is sufficient for fodder production of pearl millet sown by drilling in 30 cm rows. The crop is sown by broadcast with 10-15 kg seed/ha.

Time of sowing

Pearl millet is generally sown in June-July. In recent times, pearl millet is increasingly grown in summer season in intensive cropping systems of Indo-Gangetic plains especially north-west India. It is sown from March-end of April.

Method of sowing

Pearl millet is generally sown behind the plough or by broadcast method. These methods are, however quite unsatisfactory and generally lead to poor germination and consequently poor yield. Sowing *bajra* with seed drill is the best method. It not only ensures best germination but uniform plant population as well. Seed should be sown in rows at 30-40 cm apart.

Manures and Fertilizers

The fertilizer requirement of local varieties of pearl millet can easily be met by application of 10-15 tonnes/ha of compost or FYM. The nutrient supply for the high-yielding varieties and hybrids should be supplemented with inorganic fertilizers. To get good fodder crop 40-60 kg N/ha and 20-30 kg P₂O₅/ha may also be applied at the time of sowing. In soils deficient in K, 30-40 kg K₂O/ha should be applied.

Water management

As a rainfed *kharif* crop, it requires no irrigation. However, at times of drought, irrigation at 35 days after sowing is advantageous. During summer season, the crop requires 4-6 irrigations at 7-10 days interval depending on the soil and climate.

Hoeing and weeding

The crop has rapid early growth habit and competes with late emerging weeds. The weeds emerging with the crop at early stages (2-4 weeks after sowing) pose threat to higher production. Therefore, timely control of weeds is quite essential to get higher yields. An interculture 3-5 weeks after sowing may take care of the weeds. A wheel hoe, *triphali* or hand-hoe can be used for interculture. Spray of atrazine @ 0.5 kg/ha in 800 litres of water on the same day of crop sowing controls most of the weeds.

Plant protection measures

Diseases

Downy mildew (*Sclerospora graminicola*)

Infected seedlings turn pale yellow that are narrow covered on both sides by soft white downy fungus growth. The affected plants remain stunted and dry pre-maturely.

The preventive measures include growing of resistant hybrids (NBH 5, PGB 10 PHB 14) and seed treatment with fungicide like agrosan GN, thiram (2.5 g fungicide/kg of seed), while prophylactic measures involves rouging of disease-infected plants at the seedlings stage (40 days after sowing) The uprooted plants should be destroyed and buried into soil. Foliar spray of dithane Z 78 @ 0.2% or copper oxychloride @ 0.35% at boot-leaf stage is effective in its control.

Ergot (*Claviceps microcephala*)

The disease first appears on the ears in the form of honey like pinkish liquid which is full of fungus spores, causing spread of the disease. The liquid turns brown and sticky. In the later stages, fungus sclerotia (ergots) appear as brown to black and elongate structures. They possess toxic alkaloids harmful to human and cattle health. These sclerotia fall down in the field and remain in soil, causing infection in subsequent crops. It is important in fodder *bajra* seed production.

The preventive measures include a ploughing during summer, avoiding late planting, use certified seeds and their treatment with 20% common salt solution followed by washing with fresh water and then treating with agrosan GN, thiram or cerasan @ 3 g/kg of seed. Spraying the crop with 0.15% thiram at boot-leaf stage is effective in its management.

Smut (*Tolyposporium pesicillaria*)

It is common under humid conditions in all the states where pearl millet is grown. The diseased kernels are green in the beginning and generally larger in size than the healthy ones. These are full of fungal spores.

The preventive measures include a deep ploughing during summer and following a three-year crop rotation. Use certified seeds, and treat them with fungicides like agrosan GN or thiram or cerasan @ 3 g/kg of seed. Spraying the crop with 0.15% vitavax (1.5 kg vitavax mixed in 1,000 litres of water/ha) at boot-leaf stage followed by 1-2 sprays at 15 days intervals is recommended.

Leaf blast (*Pyricularia setariae*)

2 or 3 sprays of 0.2% zineb can control this disease effectively.

Rust (*Puccinia penniseti*)

The symptoms of this disease can be seen on both surfaces of leaves. The rust pustules are small, orange and full of spores. In later stages, black pustules can be seen. In case of severe infection, leaves are completely dried.

Insects

Shoot fly (*Atherigona approximata*)

The maggots bore into the stem and feed on main shoot and destroy the growing point. This results in tillering and in case of severe infestation, the tillers are also attacked. The seedling stage is more prone to the attack, but the attack continues up to early boot stage.

Application of carbaryl 10 G / phorate 10G or endosulfan 3G @ 5 kg/ha and foliar spray of 0.07% endosulfan is effective in borer management. Early sowing with the onset of monsoon is also effective in controlling shoot fly.

Harvesting

The crop is ready for harvest in 60-70 days after sowing. Harvesting at 50% flowering stage is ideal. In multicut varieties, first cut is taken 50-55 days after sowing (a little earlier to 50% flowering) and subsequent cuts at 35-40 days interval.

Yield

The green fodder yield varies from 35-40 t/ha. The fodder contains 7-11% crude protein and 25-35% crude fibre. It is rich in P (0.5-0.7%) and calcium (0.2-0.4%). The high oxalic acid content at early stages needs to be taken care by avoiding early cuts. It yields 6-7 t/ha of dry fodder, which is least preferred by animals due to low amount of nutrients.

COWPEA

Botanical Name: *Vigna unguiculata* (L.) Walp.

It is also known as black eye pea, kaffir pea, marble pea, China pea and southern pea. In north India, it is grown during *kharif* and summer seasons, while in south it is grown all the year round. The area under fodder cowpea in the country is around 0.3 m ha.

Climate

Cowpea is best suited for moderately humid tropic and sub-tropics up to an elevation of 1500 m. Frost, excessive heat and prolonged waterlogging are, however, not conducive for its growth. The optimum temperature for its growth is 27°C, and the minimum is 15°C. It requires average soil temperature >19°C for 3 days from sowing to emergence, that limits its cultivation in north during winter.

Cowpea is adapted to wider types of soils ranging from sandy to clays, but deep, well-drained, fertile and neutral soils are ideal. Cowpea is moderately susceptible to soil salinity, resistant to drought, acidity and moderate levels of shade. It is a short day plant requiring a day length >12.5 hours for flowering.

Varieties

Varieties recommended for different regions and states of the country are given below.

Region/States	Varieties
Whole country	GFC-1, GFC-2, GFC-3 (<i>kharif</i>), GFC-4 (summer) with 25-35 t/ha of fodder yield; Bundel lobia-1 (32-35 t/ha), UPC-287, UPC-5286 (30-45 t/ha)
Haryana, Punjab and Delhi	FOS-1, FOS-10, K-395, K-585, IGFRI-S-450 (Kohinoor), C-88 (25-35 t/ha for Punjab). HFC-42-1 (Hara lobia) HFC-128
North India	UPC-5287 (30-45 t/ha), Russian Giant (30-35 t/ha), Pusa Rituraj, Pusa Sampada
Uttar Pradesh and Karnataka	Russian Giant, IGFRI-S-978;IGFRI-S-985, DFC-1, C-152
North, West and Central India	EC-4216 (35-40 t/ha), Bundel lobia-2 (30-50 t/ha for north-west) and UPC-4200 (34-45 t/ha for north east India), UPC-607, UPC-610, UPC-612, UPC-616, Pusa Barsati, UPC 9202, UPC 618
Gujarat	Chharodi 14-20, Chharodi 26-28, GC-3, GC-4
Southern states and West Bengal	Co-1, Russian Giant, EC-4216, TNFC-9901
Himachal Pradesh	PC-1, 3, 12, 14, 16 with resistant to collar rot

The characteristics of important varieties are given below:

GFC-1: A selection from the local collection from Chharodi area of Gujarat, released in 1980 for *kharif* season throughout the country. Plant height is 125 cm, trailing growth habit, less prone to lodging, 70 days to 50% flowering. Pods are dark green in colour. Grains 5-7 mm long having light brown to buff colour; protein content varies from 16-20%. Leafyness 42% with dark green and smooth leaves. Fairly resistant to diseases. Green (dry) fodder yield is 25-30 (3-5 t/ha).

GFC-2: Released in 1980 for summer season throughout the country. Plant height is 140 cm with trailing growth habit. Leafyness 42% with dark green and smooth leaves. Days to 50% flowering – 65 days. Pods are dark green in colour. Grains 5-7 mm long with brown colour. Protein content varies from 14-19%. The variety is capable of giving more than one cut. Green fodder yield is 27-35 t/ha.

GFC-3: Released in 1980 for *kharif* season throughout the country. Plant height is 196 cm with trailing growth habit. Leafyness 53% with dark green and smooth leaves. Days to 50% flowering – 70 days. Pods are dark green. Grains are 5-7 mm long having light brown colour. Protein content varies from 17.5-19.5%. Green fodder yield is 27-33 t/ha.

GFC-4: Released in 1980 for summer season throughout the country. Plant height is 197 cm with trailing growth habit. It has 56% leafyness with dark green and smooth leaves. Days to 50% flowering – 70 days. Pods are dark green. Grains are 6-8 mm long having buff colour. It is capable of giving more than one cut. Protein content varies from 17.5-19.5%. Resistant to diseases. Green fodder yield is 29-35 t/ha.

Hara lobia (HFC-42-1): Suitable for Haryana with a green fodder yield of 25-30 t/ha.

Russian giant: Adapted to Haryana state and yields 25-30 t/ha fodder.

S-450 (Kohinoor): A selection from the material obtained from Iran. Released in 1973. Adapted for parts of Haryana, Punjab, Gujarat and Uttar Pradesh. Plant height 55-70 cm, decumbent growth habit, stem and foliage green. Pods are green. Grains are bold and red in colour. Days to 50% flowering are 70. Tolerant to semi-looper, flee beetle and leaf hopper. Susceptible to grain pests during storage. Green (dry) fodder yield is 45(6) t/ha.

UPC-287: A single cut plant selection from germplasm line 28. Adapted to Uttar Pradesh, Haryana, Rajasthan, Maharashtra, Andhra Pradesh, Himachal Pradesh and Kerala. Plant height 200-235 cm, erect when young (40-45 days old), stem and foliage green, flowers pink, length of peduncle 23-32 cm. Pod length is 13-17 cm. Days to 50% flowering is 75-80. Resistant to yellow mosaic virus, *Anthraxnose*, wilt, stem and root rot under field conditions. Resistant to hairy caterpillar and pod borer, lodging, drought and shattering. Fertilizer responsive. Green (dry) fodder yield is 16.5 (3.5) t/ha.

UPC-5286: A single plant selection from germplasm line 5286. Released in 1981 for the plains of Uttar Pradesh, Madhya Pradesh, Bihar, West Bengal, Haryana, Punjab, Gujarat, Tamil Nadu, Kerala and Assam states. Plant height 195-225 cm. Stems are light green; leaves are dark green, with pink flowers. Days to 50% flowering are 80-85. Resistant to yellow mosaic virus, wilt, stem, root rot and *Anthraxnose* under field conditions. Moderately resistant to hairy caterpillar, pod borer and seed borer. Resistant to drought, frost and shattering. Fertilizer responsive. Green (dry) fodder yield is 30-35(5) t/ha.

UPC-5287: Developed by single plant selection from the line CK-74-5287 followed by further selection on single pod basis and further bulking on plant basis. Identified in 1985 for cultivation in all cowpea growing areas in the country. Plant height 175-200 cm at 50% flowering stage. Days to 50% flowering – 85-90 days. Leaves large, dark green, with violet

flowers and straw coloured pods when ripe. Resistant to cowpea yellow mosaic virus, *Pythium*, *Rhizoctonia* – *Fusarium* complex and pod rot. Also resistant to hairy caterpillar, pod and seed borers and pod sucking bug. Suitable for intercropping with maize, sorghum and sugarcane. Seed rate 45 kg/ha. Recommended spacing is 25 cm between rows. Green (dry) fodder yield is 26 (4) t/ha.

Land preparation

The crop performs well even with moderate seedbed preparation that can be achieved by one ploughing. In intercropping situations, the seedbed preparation of main cereal crop is sufficient for cowpea. With well-prepared land, crop encounters fewer weeds.

Seeds and Sowing

During *kharif*, the crop is sown after receipt of monsoon rains in June-July, while in *rabi* from September-January and in summer from February-April. Cowpea needs a seed rate of 40 kg/ha (line-sown), 50 kg/ha (broadcast sown) and 25-30 kg/ha (seed production purpose). For fodder production, a spacing of 30 cm x 10 cm with a 3.33 lakh plants/ha is optimum. Seed rate for intercropping with cereal forages depends on row proportion and varies from 15-20 kg/ha. A sowing depth of 3-5 cm is the optimum for seedling emergence.

Manures and Fertilizers

Cowpea needs less N fertilization as crop nodulates freely with native *Rhizobia*, and seed inoculation with efficient cowpea strains of *Rhizobium* enables crop to meet most of its N requirement. However, a starter N dose of 15-20 kg/ha is given to meet the crop requirement till N fixation starts. A nitrogen economy of 35 and 50 kg/ha in mixed cropping of *Pennisetum pedicellatum* and maize/jowar/bajra with cowpea with an additional 15 and 5 kg P₂O₅ /ha fertilization has been observed. Lime and molybdenum applications enhance the nodulation. Phosphorus fertilization promotes root growth and nodulation in cowpea. In most of the areas, application of 40 kg P₂O₅/ha has been found as the optimum dose. Further treatment of seeds with phosphate solubilizing bacteria (PSB) and vesicular arbuscular mycorrhiza (VAM) has been found useful in P nutrition of the crop. Potassium fertilization is not recommended, however, in soils deficient in K and where the crop is raised for seed purpose, response to K fertilization is usually observed. In general, application of FYM @ 10 t/ha at last ploughing along with 20-40 kg/ha of N-P₂O₅ is sufficient for raising successful crop.

Water management

Cowpea is a deep-rooted crop, and therefore can extract moisture from deeper layers of soil. It usually does not require irrigation in *kharif*. However, at times of monsoon failure, a life saving irrigation is advantageous. During summer, 3-4 light irrigations of 3-4 cm depth at 15 days interval are essential. Irrigation at 50% depletion of available soil moisture (DASM) is sufficient.

Weed management

Cowpea, due to its quick growing nature, possesses weed-suppressing ability. However, many weeds emerge at initial stages and compete for resources consequently reducing crop yields by 50-70% in both fodder and seed crop. The critical period of weed competition lies between 10-40 days after emergence of crop. Cultural practices of proper land preparation, use of weed free seeds and maintenance of optimum plant population may minimize weed problem to a great extent. One hand weeding 20-30 days after sowing almost nullifies the weeds impact on crop yield. Use of trifluralin @ 0.5 kg/ha (pre-plant incorporation) in sole cowpea and alachlor @ 1 kg/ha in maize + cowpea mixed cropping has been found to provide

satisfactory weed control. Intercropping of cowpea with annual cereal forages is also effective in reducing weed menace over sole cereals.

Witch weed (*Striga gesnerioides* (Willd. Vatke), a parasite, on cowpea is prevalent in Indian Sub-continent and reduces crop yields. Use of dicamba (foliar spray), metalachlor (pre-emergence.) were effective against witch weed.

Cropping systems

Cowpea is rarely grown as sole crop and more often intercropped with arable annual and perennial cereal forages for enhanced fodder production and improved nutritive value of fodder. The cowpea intercropping with *jowar/bajra/maize* is most prominent in different parts of the country. In *tarai* region, maize+cowpea-oat fodder cropping system is extensively followed. The most important sequential food cropping system involving cowpea in maize-potato-wheat-cowpea (fodder) of North India and rice-rice-cowpea in Kerala.

In coconut gardens of Kerala, cowpea besides guinea grass and *Stylosanthes guianensis* are grown. Further in foothill region of West Bengal and Assam, Dinanath grass (*Pennisetum pedicellatum*) + cowpea/ricebean/*Stylosanthes* intercropping is popular. Cowpea is also intercropped with guinea grass and napier bajra hybrids in western and south India, respectively. The performance of component crops in intercropping varies with cultivars and cowpea UPC-612 has been found best for intercropping with maize (African tall),.

Important cropping systems involving cowpea include *jowar+cowpea-berseem*-maize+cowpea, maize-oat-maize+cowpea, maize-berseem-maize+cowpea etc.

Plant protection

Diseases

Root rot (*Macrophomina phaseolina*) **Collar rot** (*Rhizoctina*, *Pythium*, *Phytophthora* spp.)

The root rot appears as watersoaked lesions on rootlets that finally enlarge to kill the root system. It is found in all cowpea growing tracts of the country. The pathogen survives with seed and in soil with plant debris that serves as primary source of infection. The collar rot is caused by the *Rhizoctina* complex attacks the collar region leading to death of the plant.

Seed treatment with Agrosan / Ceresan / Thiram @ 3g/ kg seed, cultivation of resistant varieties coupled with crop rotation are useful in its management to certain extent. UPC-616 variety is resistant to root rot.

Mosaic virus disease

It is a serious disease of cowpea and is seed borne in nature. The symptoms appear as chlorotic patches on cotyledons, that later cover entire foliage. The secondary infection spreads through aphids.

Selection resistant varieties, use of healthy seeds, control of aphids and roguing of infected plants are useful in its management.

The other diseases that attack cowpea grown for seed include seedling blight (*Phytophthora vignae*) wilt (*Fusarium oxysporum* f.sp. *tracheophila* (E.F. Smith) Syd. & Hans); Rust (*Uromyces phaseoli* var. *vignae*) and powdery mildew (*Erysiphe polygoni*).

PESTS

Jassids (*Empoasca kerri*)

Both nymphs and adults suck sap from leaves. Affected leaves turn yellow and fall off. Spray 0.03% monocrotophos or phosphamidon or endosulfan or dimecron 0.07% is effective.

Flea/Galerucid beetle (*Madurasia obscurella*):

The beetle feeds on leaves, buds and flowers. Severe attack can cause defoliation. Apply phorate 10G or disulfoton 5G @ 1.5 kg/ha at sowing along with early sowing to avoid pest attack.

Hairy caterpillar (*Amsacta moorei*):

The young larvae feed on lower surface of leaves and skeletonize them leading to severe yield losses. Collection and destroying eggs and larvae in early stages. Dusting 10% BHC or 0.05% dichlorovos spray is recommended.

Cowpea stem fly (*Melangromyza phaseoli*):

The maggots bore into younger stems and tunnels towards the base causing damage to stem. The affected plants wither and die. Clean culture, use of resistant varieties and 0.05% monocrotophos spray control stem fly.

Nematodes (*Meloidogyne incognita*, root knot nematode; *Heplolaimis cogini*, spiral nematode):

They attack roots and form lesions and galls resulting in stunted plant growth. Summer ploughing, crop rotation, chemical fumigation with 1, 3 dichloropropene (DD), ethylene dibromide (EDB) and dibromo chloropropane (DBCP) are effective in nematode control. Application of neem cake is effective in nematode management. Bundel lobia-1, Bundel lobia-2, UPC-5286 is resistant to nematodes.

Harvesting and yield

Cowpea is a single cut fodder crop usually harvested at the age of 70-90 days. However, summer crop can give 2 cuts. The crop is harvested along with the intercropped cereal, irrespective of age. A green fodder yield of 30-45 t/ha of superior quality is obtained and is free from anti-nutritional factors. It makes good silage with addition of molasses (30-40 kg/t), usually ensiled with *jowar* and maize in 1:2 ratio. Cowpea makes good hay and its seed is used as concentrate in animal feeds.

The crude protein content in cowpea fodder ranges between 16-21%. The nutritive value of fresh biomass of cowpea (dry matter basis) is 12.5% digestible crude protein (DCP), 62.0% total digestible nutrients (TDN), 2.7 M cal/kg of digestible energy (DE) and 2.2 M cal/kg Metabolizable Energy (ME).

CLUSTERBEAN (*Guar*)
Botanical name: *Cyamopsis tetragonoloba* (L.) Taub
Family: Fabaceae (Leguminosae)

Clusterbean is a multi purpose legume valued for its gum, seed, fodder production besides for green manuring. It is the most drought tolerant crop. The fodder of clusterbean as well as its grain is quite nutritive, rich in protein, fat and minerals.

Origin

Clusterbean is a native of tropical Africa and India.

Botanical Description

Clusterbean plant is erect, robust and annual which usually growing to a height of 90-180 cm. Its plant has well-developed tap-root system. The leaves are trifoliate and toothed. The flowers are borne in short axillary racemes and generally purplish in colour. The pods are borne in cluster, hence the plant is also known as clusterbean. Pods are somewhat flattened fleshy beaked, 2.5 to 13 cm long containing 5-12 seeds inside. Tender pods are used as vegetable. The seeds are square in shape and compressed.

Climate Requirements

Clusterbean can be raised successfully in areas where average rainfall is 30-40 cm. It is cultivated mostly as rainfed crop in semi-arid zones of northern India. It is a photosensitive crop. It comes into flowering and fruiting when grown in *kharif* season only. It can not withstand waterlogging conditions.

Varieties

Important fodder varieties and their characteristics are given below.

- *Guara-80*: Developed from a cross between FS 277 x No. 119, and released in 1982 for Punjab and Haryana. It is resistant to bacterial blight, alternaria leaf spot and stem breakage. Green fodder yield 20-30 t/ha.
- *FS-277*: It is adapted to Punjab and Haryana. It is an unbranched variety with dark green and broad leaves. It is non-shattering variety susceptible to bacterial blight. It is tolerant to drought and *Alternaria* leaf spot. It yields 21 t/ha green fodder.
- *HFG-119*: Released in 1982 for fodder purpose for entire country, except Punjab. A drought tolerant, non-shattering and *Alternaria* blight resistant variety with green fodder yield of 22.3 t/ha.

Ageta Guara-111	Released in 1980 for Punjab developed by crossing G326 x F277
Ageta Guara-112	Released in 1980 for Punjab developed by crossing G325 x FS277
Durgajay	A selection from Nagpur local, released in 1978 for Rajasthan
Durgapur safed	A selection from Rajasthan
HG-75	A selection from local stock released in 1981 for entire guar growing areas

HG-182L	A single plant selection from genetic stock. ACC. No. HFG-182 released in 1981 for Haryana
Maru Guar (2470/12)	A selection from NBPGR germplasm suitable for western Rajasthan
Type 1	A selection from a sample from Nandagaon (Mathura) in 1966 adopted for Uttar Pradesh
Type 2	A selection from a sample from Meerut in 1966 adapted to Uttar Pradesh

Other varieties:

Bundel Guar-3, Bundel Guar-2, IGFRI-2395-2, IGFRI-212, Sirsa-1, Sirsa-2, Usa, Sadabahr, HFS-156, RGC-986, RGC-1002, RGC-1003.

Geographical Distribution

Fodder clusterbean is grown on about 2 lakh ha in India mainly in the states of Rajasthan, Haryana, Gujarat, Punjab, Madhya Pradesh, Uttar Pradesh and Maharashtra.

Soil and its Preparation

For clusterbean, sandy loams and alluvial soils are suitable. It can not tolerate waterlogging. Soils with pH 7.0-8.5 are ideal. Increasing salt concentration (ECe) decreases germination drastically.

Two or three ploughings with country plough or 2 cross harrowings and planking is sufficient. There should be enough moisture in the field at the time of sowing.

Seed and Sowing

It is predominantly a rainfed crop sown after receipt of first monsoon in June-July. It is also raised under irrigated conditions of north by sowing in summer (March-April). Early sowing results in luxuriant growth under irrigated conditions.

A seed rate of 35-40 kg/ha is sufficient. The seeds are sown in 30 cm rows at a depth of 4-6 cm.

Manures and Fertilizers

Being a leguminous crop, clusterbean meets most of its N requirement from biological N fixation. However, a starter dose of 15-20 kg N/ha should be applied at the time of sowing. Seed inoculation with *Rhizobium* is promising for better performance of fodder crop. It is desirable to apply about 10 tonnes of FYM or compost at the time of sowing. The crop should be fertilized with 50 kg P₂O₅/ha. All the fertilizers should be applied at the time of sowing in furrows 4-5 cm below the seed.

Water management

Clusterbean is predominantly a rainfed *kharif* crop and does not require any irrigation. However, if the rains are not normal and timely, one or two irrigations may be required. For a summer crop, 4-5 irrigations are required at 12-15 days interval. During *kharif* season, drainage is more important than irrigation.

Weed management

During *kharif* season, one or two weedings are essential to control weeds in initial stage of plant growth.

Cropping System

Guar is grown for fodder as sole crop. It is also grown in association with *Cenchrus* and *Lasiurus* grasses for higher yield and better quality (protein). For year round fodder production, it is also intercropped with napier *bajra* hybrid. Its intercropping with *bajra* is most common in Rajasthan. It can also be grown in *Albizia lebbek* plantations. Following rotations could be adopted for fodder purpose in northern India.

Clusterbean-berseem-maize+cowpea

Pearlmilelt-clusterbean-berseem

Sorghum-clusterbean-berseem-maize+cowpea

Plant protection measures

Bacterial blight (*Xanthomonas cyamopsidis* Pv. *Cyamopsidis*).

The disease appears as small water soaked lesions, which later become necrotic on leaves, and may also appear on flower and pods. It is a seed borne disease.

Seed treatment with hot water at 50°C for 10 minutes controls the disease. Use resistant varieties like Guara 80, IGFR-212-1, IGFR-2395-2 is also suggested

Alternaria leaf spot (*Alternaria cyamopsidis*)

Dark brown round to irregular spots varying from 2 to 10 mm in diameter, appear mainly on leaf blades. In severe infection, several spots merge together and the leaflets become chlorotic and usually drop off. If the plants are infected in early stages of growth, there may not be any flowering.

Spray dithane Z 78 (0.2%) at an interval of 15 days is effective in its control.

Anthracnose (*Collectotrichum capsici* f. *cyamopsicola*)

The disease appears as black spots on leaves petiole, and stem are seen during rainy season. Spray dithane Z 78 (0.2%) at an interval of 15 days is effective in its control.

Root knot nematode (*Meloidogyne incognita*) and reniform nematode (*Rotylenchus reniformis*)

Nematodes also causes damage to this crop.

Harvesting

The crop is harvested 65-75 days after sowing coinciding with flowering stage.

Yield

The average yield of green fodder varies from 25-30 t/ha. A well managed crop yields up to 1.0 tonne/ha of seed. The crude protein and crude fibre content varies from 15-18% and 25-30%, respectively.

GUINEA GRASS

Botanical name: *Panicum maximum* Jacq.

Family: Poaceae (Gramineae)

Chromosome number: 2n=18, 36, 48

Guinea grass produces quality fodder all the year round. Both annual and perennial types are found. It has high leaf portion and its feeding results in high milk yield, and therefore it is known for its lactogenic effect in milch animals. The guinea fodder is suitable for silage and hay making too.

Origin and History

Guinea grass belongs to genus *Panicum*. More than 500 species are found in temperate and tropical regions of the world. It is believed that guinea grass is native of tropical Africa and later spread to countries like Australia, Philippines and USA. It was brought to India on Army Farms in 1793, and was grown along with old grasses. It is now grown on large scale in some of the states.

Geographical distribution

In India, it is cultivated on about 1 lakh hectares in Kerala and Andhra Pradesh. Under rainfed conditions, it is grown for 5-6 months during rainy season. During severe cold, this grass remains dormant and starts growing during summer with irrigation. It also comes up well under shade and therefore suitable for intercropping in orchards and plantations especially in coconut as in Kerala. The crop performs best in warm and moist climates of tropics.

Climate

It can be grown up to an elevation of 1,800 m. It is frost sensitive. It is suitable for areas with an annual rainfall of 85-100 cm.

Soil

Guinea grass can be raised on all types of soil, except waterlogged soils. Well drained medium fertile loams are the best. It does not tolerate saline conditions.

For sowing the crop by seed, it requires a fine seedbed that is attained by 1-2 ploughings followed by harrowing once or twice.

Varieties

The important varieties and their characteristics are given below:

JHGG 95-5: This is an improved strain of guinea grass. This has been identified for rainfed areas of Punjab, Himachal Pradesh, Maharashtra, Central U.P. and Tamil Nadu. The variety possesses good forage yield potential and is of a low seed-shattering type.

Punjab guinea grass-1 (PGG-1): An introduction from Australia under the name CPI-59985, released in 1981 in Punjab. It has about 40 tillers/plant and yield 107 t/ha green fodder and 0.3 tonne/ha seed.

PGG 19: Released in 1985 with 75-130 tonnes/ha fodder yield for Punjab.

PGG 101: Released in 1995 with 80-145 tonnes/ha fodder yield for Punjab.

PGG 518: Released in 1997 with 120-130 tonnes/ha fodder yield. It is an apomictic perennial cultivar.

PGG 616: Released in 2000 with 100-120 tonnes/ha fodder yield. It is an apomictic perennial cultivar.

Variety	Suitable for	Green fodder yield (t/ha)
Macueni	Kerala for rainfed conditions	60-80
Hamil	South, north east, east and central India	90-130
PGG-4, PGG-9	Hills, North-west and central India	85-130
PGG-13, PGG-14	Central India and Hills	95-140
PGG-19, PGG-518, PGG-1	Punjab	90-130

Other varieties:

Riversdale, Haritha, Marathakom, F 600, JHGG-2001-02; JHGG-2001-3, Haritha, Co-2, JHGG 96-5 (Bundel Guinea-1)

Seed and Sowing

It is propagated by seeds as well as stem cuttings/root slips. A seed rate of 3-5 kg/ha is recommended. Seeds are drilled in 45 cm rows at 1-2 cm depth. Stem cuttings or root slips are planted at 50 cm x 30 cm spacing on an irrigated soil after rains.

Time of planting

The time of sowing under rainfed situations depend on arrival of monsoon and vary from June-August. Under irrigated conditions, it can be planted throughout the year provided the temperatures are not fall below 15°C. In northern India, it is generally planted from February to August. After planting, the field should be irrigated so that the root slips may be established properly.

Manures and Fertilizers

Manures and fertilizers both play an important role in guinea grass cultivation. About 20 tonnes of FYM or compost/ha should be applied about a month before planting. Besides, 50-50-50 kg/ha N-P₂O₅-K₂O should be applied at the time of planting. After each harvest, 50 kg N/ha is top-dressed coinciding with irrigation.

Weed management

Weed competition at the time of establishment poses threat to crop stand establishment. Hence weed management up to 45 days after sowing is crucial. Two inter cultural operations during this period are sufficient for satisfactory weed control. Pre-emergence application of atrazine @ 1 kg/ha followed by 2,4-D @ 1 kg/ha 30-35 days after sowing effectively control all kinds of weeds.

Cropping System

Guinea grass can be grown mixed with cowpea, *stylo* and *Girabo*.

Water management

Guinea grass needs frequent irrigations. During winter (*rabi*), irrigations are given at 15-20 days interval, while in summer, the crop is irrigated at 7-10 days interval. The crop also grows well with sewage irrigation.

Harvesting and Grazing

First cut is taken 75 days after planting and subsequent cuts at 45 days interval. The crop should be harvested at 1-15 cm above ground level for better regeneration. It can also be grazed by animals. In perennial types, cuttings can be taken up to 4-5 years and thereafter it needs replanting.

Yield

The annual green fodder yield ranges from 50-60 tonnes in 4-6 cuts (rainfed) to 80-120 tonnes/ha in 7-9 cuts (irrigated). Under sewage irrigation up to 200 tonnes/ha yields can be realized in 10-12 cuts. The fodder contains 9-13% crude protein and 30-35% fibre with an in vitro dry matter digestibility is about 50%.

NAPIER x BAJRA HYBRID (NBH)

Botanical name: *Pennisetum purpureum* Schum x *Pennisetum glaucum*

Family: Poaceae (Gramineae)

Napier x bajra hybrid (NBH) is an interspecific cross between *bajra* x napier grass. It is a triploid grass and thus does not produce seeds. It provides nutritional and palatable green fodder all the year round, which contains 8.2% protein, 34% crude fibre, 10.5% ash with calcium and phosphorus in proper balance. A combination of napier grass with berseem, lucerne or cowpea provides good quality palatable fodder for cattle. For hay making this grass is coarse, but can be used for silage making. It is considered as a soil-restoring crop, as grass leaves the soil richer in organic matter. Napier grass is more nutritious and productive than the hybrid grass.

Origin and History

Napier grass is native of Rhodesia in South Africa, where it is found growing extensively. It is presumed that this plant has been used as a fodder for the first time in Rhodesia. The name napier grass is given in the honour of Col. Napier, who first drew the attention of the Rhodesian Department of Agriculture in 1909 to the fodder value of this grass. It was introduced in India in 1912 from South Africa. It was introduced in the USA in 1913.

The perennial and heavy tillering characteristics of napier grass have been combined with leafyness of *bajra*, and the Napier x bajra hybrid was evolved.

Geographic Distribution

It is widely distributed in tropical and sub-tropical regions of Asia, Africa, southern Europe and America. In India, it is cultivated on about 1 lakh ha mainly in the states of Punjab, Haryana, Uttar Pradesh, Bihar, Madhya Pradesh, Orissa, Gujarat, West Bengal, Assam, and Andhra Pradesh. This grass does not survive in heavy rainfall and frost prone areas.

Climatic Requirements

Napier *bajra* hybrid performs well in areas having temperatures above 15°C. It is a tropical grass, which can with stand drought for a short spell, and regenerate with rains. It is susceptible to frost.

Varieties

Characteristics of some of the important varieties of napier *bajra* hybrid are given below:

- *Pusa Giant Napier*: It was developed at IARI, New Delhi. It possesses 45-50 tillers/plant and produces 100-160 t/ha green fodder. Suitable for entire country.
- *NB 21*: This variety is quick growing, tall, with high tillering habit, and possesses thin and non hairy stem. The leaves are thin, long and smooth. Its yield potential is about 100-160 t/ha green fodder.
- *Co.1*: A derivative of the cross “PT 2787” *bajra* of ICRISAT and “Merkeri” Napier grass, released in 1982 for Tamil Nadu. It is tall, non lodging, profuse tillering (29 tillers/clump), and more leafy (354 leaves/clump). The leaves are broad and long with high leaf: stem ratio (0.94). The green fodder yield potential is 300 t/ha/year.
- *BH 18*: Released in 1988 by Univeristu of Agricultural Sciences, Bangalore. It is resistant to *Helminthosporium* blight disease. Green fodder yield in 7-8 cuts is 150 t/ha /year.
- *Hybrid Napier-3* (Swetika): Developed from the cross between Napier x *bajra* hybrid PSB-2, released in 1983 for cultivation in Andhra Pradesh, Himachal Pradesh and

Assam under irrigated conditions. It is profusely tillering type with erect growth and quick regeneration capacity. It is tolerant to low temperature and frost. Suitable for low pH soils and mixed cropping. Resistant to *Helminthosporium* blight. Green fodder yield is 68-80 t/ha/year.

Variety	Characteristics
IGFRI-3 , IGFRI-6	Suitable for central India, north-east and northern hills. It yields 90-160 t/ha of green fodder
IGFRI-7	It is suitable, hilly, sub-humid and sub-temperate areas of India. It yields 140-170 t/ha of green fodder.
IGFRI-10	It is suitable for whole country with a green fodder yield of 150-180 t/ha. Suitable for acidic and saline soils
PBN-83	Suitable for Punjab with a green fodder yield of 125-170 t/ha. Released in 1989.
RBN-9	Suitable for Maharashtra
PBN-16	Suitable for Punjab, Maharashtra, Karnataka
APBN-1	Suitable for Andhra Pradesh, Karnataka, Tamil Nadu with yield of 200-250 t/ha
Co-3	Released in 1997 for central and south India with a yield of 130-200 t/ha
Co-2	Released in 1995 for south India with 120-180 t/ha green fodder yield.

Other varieties:

NB 37 (Suitable for range lands of northern hills) and KKM-1 (ACK 2).

Soil and its Preparation

NBH flourishes well on variety of soils especially on those with high ure-retention capacity. It can withstand saline conditions, but it can not survive in waterlogged and flood prone areas. With good drainage, fertile loam is best suited for its optimum growth.

The land should be prepared well and should be free from weeds. A good seed-bed should be firm and well leveled. First ploughing should be done with a mould board plough, and subsequent 2 cross ploughings with cultivator or harrow. Planking should follow every ploughing.

Manures and Fertilizers

The crop needs heavy fertilization. FYM application @ 30 t/ha at the time of land preparation is recommended. In areas where sewage or cattle shed washings can be used as irrigation water, FYM application may not be required. A fertilizer dose of 50-60-50 kg/ha of N-P₂O₅-K₂O is applied as basal. After each harvest, 50 kg N/ha is applied with irrigation.

Seed and Sowing

NBH is propagated vegetatively as the crop can not produce seeds. Root slips and stem cuttings are used as propagating material. However, the former is most common means of propagation. The root slips/stem cuttings are planted at 50 cm x 50 cm (sole cropping) to 100 cm x 50 cm (in intercropping) spacing. Thus 40,000 and 20,000 root slips/stem cuttings/ha are required for sole and intercropping stands. It is planted through out the year in the country, when the temperatures are above 15°C. Once planted, cuttings can be taken for 4-5 years.

Water management

The crop needs frequent irrigations for realizing the yield potential of the crop. The crop requires irrigation during non-rainy season (October-March) at 15-20 days interval. During summer (April-May/June) irrigations are given at 7-10 days interval. The crop can also grow well under sewage irrigation. The water requirement of this crop varies from 80-100 cm.

Weed management

Weeding at early stages is crucial for establishment. Two or three weedings are required to control the weeds. When broad leaf weeds pose a serious problem, application of 2,4-D @ 1 kg/ha is recommended.

Cropping Systems

With the start of winter, the growth of hybrid napier is checked due to low temperature, particularly in the northern parts of India, and hence intercropping is necessary to get forage during that period. Important fodder based cropping systems for all the year round fodder production are given below.

Location	Cropping system
Palampur (Himachal Pradesh)	NBH + velvetbean-berseem-sarson
Pantnagar (Uttarakhand)	NBH + subabul
Hisar (Haryana)	NBH + berseem / lucerne
Jhansi (Uttar Pradesh)	NHB + cowpea-cowpea-berseem
Anand (Gujarat)	NBH + <i>guar</i> -lucerne
Coimbatore (Tamil Nadu)	NBH + hedge lucerne

Pests and Diseases

There are no major pests and diseases, except leaf blight damage caused by *Helminthosporium sacqhri* in some varieties.

Harvesting

In napier-*bajra* hybrid, the first cut is taken 65 days after sowing and subsequent cuttings at 45 days interval. In a year, 8-10 cuts are possible. While cutting the grass, it is desirable to leave a height of at least 10-15 cm from the ground level so as to avoid damage to the young growing roots near the base of the plant.

Yield

A good crop yields about 150-300 t green fodder/ha/year. The crude protein and fibre content of NBH fodder is 10 and 30% respectively. The fodder is rich in Ca (0.5%) and P (0.4%)