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Butterfly Pea (*Clitoria ternatea*): A Nutritive Multipurpose Forage Legume for the Tropics - An Overview

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Abstract: Butterfly pea (*Clitoria ternatea*) is a multi-purpose forage legume. It provides bioactive compounds for medicinal use and it is also an ornamental plant and cover crop. It is adaptable to a wide range of temperature, rainfall and altitude. Butterfly pea, a highly palatable forage legume is generally preferred by livestock over other legumes. It has thin stem and large leaves, nil bloat and non toxic which make it ideal for forage and hay making. It's vigorous growth, tolerance to frost and dry periods and heavy grazing pressures make this suitable for waste land development. Production and utilization of this legume for animal production will provide adequate nutrition and also reduce grazing pressure on natural ranges. This paper reviews distribution, plant description, agronomic characteristics, genetic variation, medicinal use, chemical composition and utilization of butterfly pea in livestock production.

Key words: *Clitoria ternatea*, bioactive compound, forage legume, ornamental value

Introduction

In India about 70% of people live in villages; their livelihood is dependent mainly on agriculture and animal husbandry. Though India has a huge livestock population of over 343 millions besides poultry, yet the production of milk and other livestock products is the lowest in the world (http://www.krishiworld.com). Per capita availability and minimum nutritional requirement set by the nutritionists are given in Table 1. From the figures set out in Table 1, it is evident that India is highly deficit in various livestock products, though it has about one-fourth of the total cattle population in world. The analysis of this situation reveals that one of the main reasons for the low productivity of Indian livestock is malnutrition and under nutrition (or) both, besides the low genetic potential of the animals. This fact is adequately supported by the figures given in Table 2. It is seen from the figures of availability, vis-à-vis the requirement of green fodder crops, crop residues and concentrates, there is a huge gap between demand and supply of all kinds of feeds and fodders. So, there is a need to increase the productivity of each hectare of grazing land without degrading the natural resources of the country. This can be achieved by increasing the production of cultivated pastures (Aganga and Tshwenyane, 2003).

If forage cultivation is being introduced into an area, species suitable for the local ecological conditions and farming systems have to be selected. Appropriate species can be selected only if the purpose of forage cultivation is clear, for example to increase the amount of forage available during a particular season and to increase the quality of the ration etc. (Bayer and waters-Bayer, 1998). They also stated that, the new forage plants must bring significant advantages in at least one of the characteristics in comparison with existing forage and husbandry practices. It is important to appreciate veld and pastures which can play complementary roles in providing fodder to livestock (Tainton, 2000).

Livestock production is low because of poor nutrition, which is primarily derived from natural pastures and limited amounts from crop residues (Karachi, 1997). The availability of natural pastures is low, roughages also have low nutritive value, but this can be improved by supplementing them with forage legumes. Butterfly pea (*Clitoria ternatea*) is a highly palatable forage legume generally preferred by livestock over other legumes. It exhibits excellent regrowth after cutting (or) grazing within short-period and produce high yields also. It can be grown with all tall grasses for rotational grazing, hay or silage. Butterfly pea is also used as a cover crop, green manure and medicinal plant. Besides its forage value, it is also grown as an ornamental crop, because of it's attractive flower colours. Considering the importance of the crop this paper aims to highlight the botanical aspect, forage value, genetic variability, medicinal importance, ornamental value and tissue culture improvement.

Agronomic characteristics: The butterfly pea (*C. ternatea*) is a deep-rooted, tall slender, climbing legume with five leaflets and a deep blue flower. It is well adapted to a variety of soil types (pH 5.5-8.9) including calcareous soils. It is surviving in both the extended rainfall regions and prolonged periods of drought. Propagation is through seed; the plants may be grown with support crops (or) staked with bamboo to facilitate hand picking of the pods. Butterfly pea produce a large

Table 1: Per-head availability and minimum requirements of some livestock products*

Product	Availability	Minimum requirement
Milk	100g/head/day	201 g/ head/ day
Meat	1 million tones (mt) (annually)	7, 122 million tones (mt) (annually)
Eggs	12 eggs/head/ year	1 egg/ head/ year

(* courtesy: http://www.krishiworld.com)

Table 2: Balance-sheet of animal feeds and fodders*

Feeds and fodders	Availability	Requirement	Deficit
Green fodder	224.08 mt	611.99 mt	387.91 mt
Crop residues	231.05 mt	869.79 mt	638.74 mt
Concentrates	31.6 mt	65.4 mt	81.8.m tonnes

(*courtesy: http://www.krishiworld.com)

amount of seeds and will readily self-seed, when the dry pod shatter. The seeds are normally sown from the beginning until the middle of the wet season. Competes fairly well with weeds once established; some weed control can be achieved by mowing the crop, as the successive regrowth of the legume will gradually dominate the weeds. If a pure stand is required, cultivation or hand-weeding will be required during early growth. Use of pre-emergence herbicide (Spinnaker at 200-400 ml/ha) 2 to 8 weeks prior to sowing is essential to achieve successful control of weeds during establishment (Conway *et al*., 2001).

Butterfly pea is highly palatable, and hence is susceptible to continuous heavy grazing. It persists best when grazed lightly during the wet season. It combines well with buffel grass. (*Cenchrus ciliaris*) pangola grass (*Digitaria decumbns*) or with native pastures to grow as a mixed pastures (Humphreys and partridge, 1995). Some important agronomic characteristics of this species are given in Table 3.

Origin and distribution: Butterfly pea most likely originated in tropical Asia, though its true origin is obscured by extensive cultivation and naturalization around the globe (www.echonet.org). Butterfly pea has been widely distributed to many tropical and subtropical countries where it has become naturalized. (South and Central America, East and West Indies, China and India). It is grown as a persistent perennial. In these areas, the flowers are used to give a blue tinge to rice cakes and boiled rice. The young pods may be consumed like string beans. Leaves are also used to dye food or are eaten as a pot herb.

Plant description: Botanically, butterfly pea (*C. ternatea*) belongs to the family Fabaceae and sub family papilionaceae and it has a variety of recognized names. There are at least 12 other species recognized in this genus. They are *C. albiflora*, *C. bracteata*, *C. coelestris*, *C. parviflora*, *C. pilosula*, *C. purpurea*, *C. ternatensium*, *Lathyrus spectabilis*, *Ternatea ternatea*, *Ternatea vulgaris* (http://www.ildis.org). *C. ternatea and C. purpurea* are partially domesticated and may have potential for forage use.

The butterfly pea is a 90 to 162 cm tall, long-lived perennial herb with an erect habit (Kalamani and Michael Gomez, 2001). Its flowers are blue scabbards linear and flat, 6-12 cm long (Kalamani and Michael Gomez, 2003) similar to those of beans. The thick horizontal root, which may grow to more than 2m long, bears one to several purplish, glaucous, wiry stems. The leathery leaves consist of three-five leaflets. *Clitoria* have chasmogamous (insect pollinating) and cleistogamous (self-pollinating) flowers. Flower colour, position and structure varies from species to species.

C. purpurea has attractive papilionaceous dark blue coloured flowers and *C. ternatea* has creamy white flowers which are solitary and very attractive. The pods are slightly pubescent (or) glabrous and contains 6-8 brown/ black coloured seeds/per pod. (Kalamani and Michael Gomez, 2003). In the case of *C. fragrans* chasmogamous flowers usually occur in pairs, each corolla consisting of 3.5 to 4.5 cm-long (Fantz, 1977) or 4.5 to 5 cm-long (Isley, 1990) standard petal and a small white keel petal.

Forage yield and chemical composition: Under favourable conditions, butterfly pea yields upto 30 tons dry matter ha^{-1} $year^{-1}$ (http://www.grupopapalotla.com). The seed is very high in protein (15-25%) hence increasing the nitrogen levels in run-down cultivated paddocks. After just two years of establishment, the butterfly pea planted in to run down cultivated paddocks, the soil fertility returns to its original level. Grass growing along the side of butterfly pea will be higher in protein due to the higher soil nitrogen levels. This has led to a higher carrying crude fibre capacity as well as better gains by cattle. The levels of crude protein and crude fibre in the leaves were 21.5% and 21.5-29% respectively. (Kalamani and Michael Gomez, 2001). Total plant protein ranges from 14-20%. Seed contains 25-38% protein, 5% total sugar and 10% oil (echo@echonet.org). Nitrogen concentrations of whole

Table 3: Some Agronomic and Biochemical characteristics of *Clitoria**

Soil pH	7 to 8
Soil fertility	Average to low
Drainage	Does not tolerate saturated soils
Altitude above sea level	0-1600 m (0-5,249 ft)
Precipitation	800mm(31.5 in)
Planting rate	Monoculture: 20-25 kg/ha (18-22.5 lb/ac) Mixed with grasses: 10-15 kg/ha (9-13.5lb/ac)
Planting depth	<2 cm (<0.8 in)
Fertilization at planting	40 kg N/ha (36 lb/ac)
80 kg P/ha (71.5 lb/ac)	
Maintenance fertilization	80 kg N/ha (71.5 lb/ac)
Crude protein content	18%-24%
Digestibility	60%-75%
Management	Cutting and rotational grazing when associated with grasses
Stocking rate	2500 kg LW/ha
Seed rate	2-4 kg/ha for permanent pastures 6 kg/ha for short-term phase pastures
Spacing	15-30 cm (Narrow row spacing preferred)
Sowing depth (moist soils)	2.5-6.5 cm

(Courtesy*: http://www.grupopapalotla.com)

Table 4: Amino acid composition as per cent of crude protein*

Aminoacid	Arg	Cys	Gly	Hys	Iis	Leu	Lys	Met	Phe	Thr	Try	Tyr	Val
Percentage	7.4	2.5	4.1	2.4	4.2	7.4	6.1	1.0	3.6	2.2	1.2	3.3	4.4

(*Barro and Ribeiro, 1983)

Table 5: Genetic variability in *C. ternatea* x *C. Purpurea**

Characters	Range	PCV%	GCV%	H^2	GA% of mean
Plant height (cm)	90 to 162	14.3	13.9	94.48	27.9
Number of leaf/plant	162 to 380	17.9	17.3	93.6	34.5
Leaf length (cm)	4 to 6.2	16.2	12.6	62.6	23.5
Leaf breadth (cm)	2.3 to 3.9	18.9	15.5	66.9	26.2
Number of branches	18 to 36	16.1	13.6	71.5	23.8
Total number of pods/plants	51 to 116	16.6	15.6	87.8	30.23
Crude fibre (%)	29 to 21.5	10.2	9.8	92.3	18.6
Crude protein (%)	20.4 to 21.5	21.5	20.9	94.1	41.8
Seed weight (g)	2.3 to 5.8	22.5	22.05	97.88	46.387

(* courtesy: Kalamani and Michael Gomez, 2001).

tops range from 1.7-4.0% and amino acid composition as percentage of crude protein in seed, listed in Table 3. One of the challenges of growing forage in tropical environments is the effect of environment on the nutritional characteristics of plants. High temperatures decrease the soluble carbohydrate content of plants, resulting in increased fibre content and decreased digestibility (Agange and Tshwenyane, 2003). Digestibility of forage dry matter by the ruminant is the summation of the digestibility of the component tissues as affected by morphology/anatomy and chemical composition (Murphy and Colucci, 1999). In *C. ternatea* the dry matter digestibility levels vary between 60-75%. Good quality hay can be made from *Clitoria*. It is well accepted by livestock. In a trial in North east Brazil, dry matter, ash, ether extract, crude protein and total carotenoid contents of *C. ternatea* hay fell from 89.04, 8.92, 4.24, 34.84% of dry matter and 587.28 mg/kg, respectively, after 42 days growth to 91.1%, 7.24%, 3.46, 32.34% of dry matter and 399.93 mg/kg at 84 days. Crude fibre content rose from 28.94 to 38.25% dry matter during this period. After storage for 6 months, carotenoid content was 400-587 mg/kg. (Barro and Ribeiro, 1983). From *Clitoria* leaves we can recover concentrates of 55% protein (N x 6,25), with average yields of 1.43 kg/100kg of fresh weight. *Clitroia* plants were cut at 45 days intervals, obtaining a maximum yield of 35 tons ha^{-1} $cutting^{-1}$, which yielded 3 kg of protein and 50 kg of hay per year, with a minimum of 11% protein under experimental conditions. IGFRI-S-23-1 and IGFRI-S-12 are the famous high yielding varieties available for forage cultivation.

Advantages over other pastures: *Leucaena*

Table 6: Mean performance of hybrids (*C. ternatea* x *C. purpurea*) and segregants (F_2) for morphological and Biochemical traits*

Characters	Mean of hybrid	Range of segregants		Average
		Maximum	Minimum	
Plant height (cm)	136.00	90.00	162.00	126.00
Number of leaf per plant	320.00	162.00	380.00	271.00
Leaf length (cm)	5.10	3.20	6.20	4.70
Leaf breath (cm)	3.20	2.10	4.00	3.05
Pod length (cm)	6.40	6.20	7.90	7.05
Number of seed per pod	8.00	8.00	12.00	10.00
Stigma length (mm)	4.00	2.50	4.10	3.30
Style length (mm)	13.20	11.00	14.50	12.75
Pollen length (mm)	6.00	3.50	6.50	5.00
Pollen breadth (mm)	4.00	3.00	6.00	4.50
Crude fibre (%)	26.50	21.50	29.00	24.25
Crude protein (%)	19.20	18.50	21.50	20.00

(Courtesy: Kalamani and Michael Gomez, 2003)

Table 7: Variation in floral traits in F_2 population of *C. ternatea* x *C. purpurea**

Flower colour	Ovary length (mm)	Stigma length (mm)	Style length (mm)	Anther length (mm)	Anther breadth (mm)	Filament length (cm)	Pollen length (mm)	Pollen breadth (mm)	Flower length (cm)	Flower breadth (cm)
Pure white (parental form)	8.0	4.0	14.0	80	85	2.1	4.4	5.4	5.5	4.0
Purple (parental form)	1.0	2.5	12.0	56	77	1.7	4.0	1.8	5.5	3.6
Light blue (F_1)	9.5	4.0	12.2	80	65	2.2	4.8	5.6	6.0	5.5
Light pink (F_2)	9.0	3.0	12.0	68	88	2.0	5.3	4.6	4.9	4.0
Cream flower with blue border (F_2)	10.0	3.0	13.5	84	39	2.3	4.9	4.1	4.4	3.1
Medium blue (F_2)	9.8	2.6	13.0	72	63	2.0	4.2	4.0	4.6	3.8
Dark blue (Velvety (F_2)	9.2	2.4	11.0	70	50	1.9	4.8	4.6	5.2	4.0
Violet (F_2)	10.0	2.5	12.6	56	77	1.7	4.9	4.1	5.0	3.6
Dark violet (F_2)	9.0	2.7	11.2	95	46	2.2	4.0	4.4	4.9	3.7

(Courtesy*: Kalamani and Michael Gomez, 2003)

leucocephala is the most widely used fodder to increase the animal production in the tropics (Khamseekniew *et al.*, 2001). Despite rapid adoption of *Leucaena* the below mentioned attributes make butterfly pea preferable in some situations. (Conway *et al.*, 2001)

- *Leucaena* is very persistent and costly to remove. It is a plant for permanent pastures. In contrast butterfly pea is a herbaceous plant and easy to remove to get back in to cropping.
- A good phase legume (Doughton *et al.*, 2001).
- Perennial-doesn't require re-sowing.
- Butterfly pea has lower establishment costs than *leucaena*.
- High risk is involved in establishing *Leucaena* because of its sensitivity to weed competition and sowing technique whereas in the case of *clitoria* weed control at establishment is relatively easy and competes with weeds and grasses once established.
- Where the legume is being in a crop rotation, the cost of removing *Leucaena* is prohibitive.
- Butterfly pea is faster to establish and has a much shorter time to the first grazing and production.
- Suited to heavy clay cropping soils.
- Self-regenerating from seed-populations increase over time.
- Recovers from "abusive" grazing.
- Builds soil fertility.
- Productive with good quality forage.

Genetic improvement: Variability refers to the presence of difference among the individuals of plant population. Variability results due to differences either in the genetic constitution of the individuals of a population (or) in the environments in which they are grown. The existence of variability is essential for resistance to biotic and abiotic factors as well as for wide adaptability. Selection is also effective when there is genetic variability among the individuals in a population. Hence, insight into the magnitude of genetic variability present in a population is paramount importance to a plant breeder for starting a judicious breeding programme (Singh and Narayanan, 2000). High phenotypic (PCV) and genotypic (GCV) co-efficient of (Table 6)variability existing in the population of *C. purpurea* x *C. ternatea* for the following traits viz., seed weight, crude protein, crude fibre, leaf breadth,

number of leaf per plant, total number of pods per plant, leaf length and plant height (Kalamani and Michael Gomez, 2001), provides enough scope for selection and these genotypes can provide materials for a sound breeding programme for forage improvement.

Heritability and genetic advance are important selection parameters. Heritability estimates along with genetic advance normally more helpful in predicting the gain under selection than heritability alone (Johnson *et al*., 1955). Heritability (H^2) and genetic advance (GA) estimates of economic (or) yield contributing traits (Table 5) indicate the preponderance of additive gene action (Kalamani and Michael Gomez, 2001). Since most of the economic traits are governed by additive genes, progeny selection, hybridization and diallele selective mating system may be adopted for improvement of forage yield and quality.

***In vitro* propagation:** Among the different techniques of biotechnology, plant tissue culture is the one being applied in crop improvement programme (Prakash *et al*., 1994). There is an increasing awareness of the potential application and limitation of plant cell and tissue culture technology for the production of novel genotypes with valuable attributes. In *C. ternatea* leaf explants showed shoot regeneration accompanied by callus formation (Malabadi and Nataraja, 2001). MS medium + auxins (NAA (or) IAA) + BAP (0.5 mg-1) induced large number of multiple shoot buds directly from the young shoot tip explants of *C. ternatea*. (Kalamani and Michael Gomez, 2002). The media developed for micro propagation of *Clitoria* spp. seems to be more advantageous for achieving increased number of multiple shoots. Formation of multiple plantlets from shoot tip culture could be of practical application for raising hybrid seedlings of difficult crosses and mutagenesis *in vitro*. Regeneration of multiple plantlets from shoot tip explants on simple medium may be used for the mass production of plants, storage and maintenance of germplasm.

Medicinal Value: Butterfly pea commonly known as Shankupushpam, is widely used in traditional Indian systems of medicine as a brain tonic and is believed to promote memory and intelligence. The study conducted on rats revealed that *C. ternatea* root extracts increase rat brain acetyl choline content and acetyl choline esterase activity in a similar fashion to the standard cerebro drug pyritinol (Taranalli and cheeramkuzhy, 2003). The plant is considered as a good brain tonic and is useful for throat and eye infections, skin diseases, urinary troubles even in cattle, ulcer and antidotal properties. (Malabodi and Nataraja, 2001). Besides its medicinal property butterfly pea is also a good source of phytochemical substances. It contains antifungal proteins and has been shown to be homologous to plant defensins (ct-AMP1) (Thevissen *et al*., 2000).

Ornamental value: Among the several species of *Clitoria*, *C. ternatea* and *C. purpurea* have attractive flowers. *C. purpurea* has dark blue coloured papilionaceous flowers and *C. ternatea* has creamy white coloured flowers which are solitary and very attractive. Because of their attractive nature of the flowers they are valued as an important ornamental crop for the garden lovers.

The hybrids between *C. purpurea* and *C. ternatea* produced intermediate coloured (light blue) flowers and the flower size (Table 6 and 7)was bigger when compared with parents (Kalamani and Michael Gomez, 2003). In the segregating progenies (F_2) of above said crosses variation in flower colour (Table 6) was noticed viz., light pink colour, cream flower with blue borders, medium blue, dark blue with velvety appearance, violet, dark violet, besides the parental colours (Kalamani and Michael Gomez, 2003). For ornamental purpose medium height segregants with attractive flower such as deep violet, light pink and velvety blue with less numbers of leaves can be exploited.

Conclusion: Given the current state of inadequate forage availability and importation of animal feed in India, a discerning move into cultivated legume pastures is an absolute requirement for any major increase in protein forage production in the country. There is a need to incorporate multipurpose legume / Pastures like *Clitoria* into the farming systems and this requires high level of management and objective planning.

Hence, cultivation of *Clitoria* in waste lands may be suggested to narrow down the gap between the demand and supply of forage legumes in live stock production in India. Since, it has high nutritive value, it will be a better solution to poor quality ruminant diets.

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