Technical Bulletin No.2/2011

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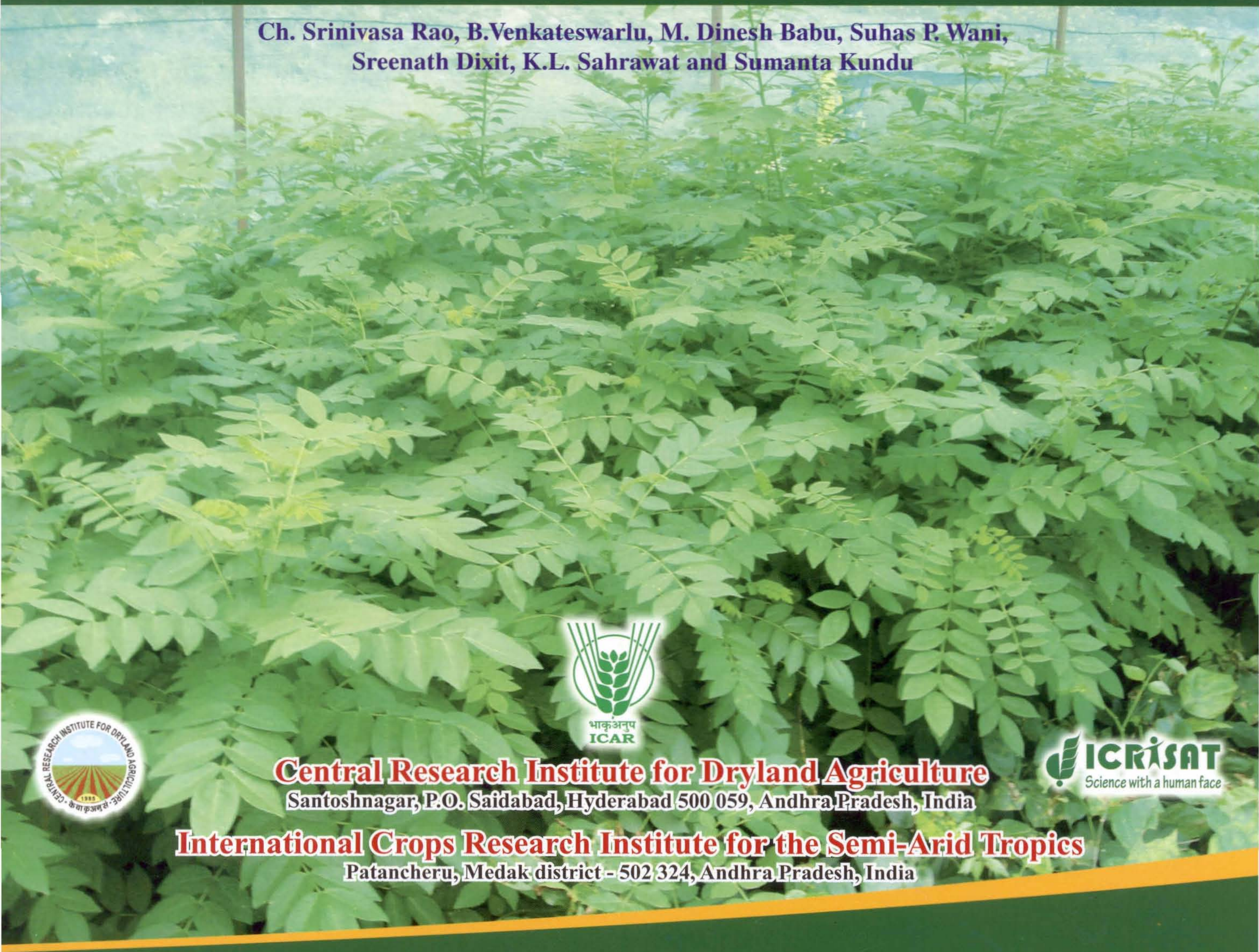

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Citation:
Srinivasa Rao, Ch., Venkateswarlu, B., Dinesh Babu, M., Wani, S.P., Dixit, S, Sahrawat, K.L. and Sumanta Kundu (2011). Soil Health Improvement with *Gliricidia* Green Leaf Manuring in Rainfed Agriculture, On Farm Experiences. Central Research Institute for Dryland Agriculture, Santoshnagar, P.O. Saidabad, Hyderabad 500 059, Andhra Pradesh, p:16.

Published by
Director,
Central Research Institute for Dryland Agriculture (ICAR),
Santoshnagar, Hyderabad, 500 059, Andhra Pradesh, India.

Phone: 040-24530177 (O), 24532262 (R)
FAX: 040-24531802/245353336
Web: http://www.crida.ernet.in

No. of Copies : 1000

Designed and Printed at:
VENU ENTERPRISES
Vanasthalipuram, Hyd-70
Mob.: 99492 36019
venuenterprises2010@gmail.com

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Foreword

Enrichment of soil organic carbon (SOC) stocks through sequestration of atmospheric CO_2 in agricultural soils is important because of its impacts on soil health, agronomic production, as well as adaptation and mitigation of climate change. A high SOC concentration can be achieved through the adoption of appropriate crop rotations, integrated nutrient management systems and conservation agriculture practices. In arid and semi-arid regions, crop productivity is strongly influenced by soil fertility and moisture retention capacity. Therefore, restoring soil health and enhancing SOC stocks are essential for improving and sustaining agronomic productivity.

In India, rainfed cropping is practiced on 80 Mha in arid, semi-arid and sub-humid climatic zones, constituting nearly 60% of the net cultivated area. These regions are characterized by erratic rainfall, degraded soils, poor infrastructure and tropical or subtropical environments where ambient temperature rises frequently above 40-45°C in summer. The magnitude of change in SOC due to continuous cultivation depends on the balance between the loss of C by oxidation and erosion, the quantity and quality of crop residues returned and additional biomass C added to the soils. Therefore, crop and soil management practices must be designed to ensure sustainability of long term cropping systems. There are several strategies to improve soil carbon status. Gliricidia green leaf manuring is one of the important strategies that improves soil organic carbon, adds soil nutrients, enhances soil moisture storage as a consequence of which the crops can cope with intermittent droughts, as well as biological health of the soil. I congratulate the authors for documenting this commendable action research that focused on promoting Gliricidia green leaf manuring on farmers fields in degraded lands in 8 rainfed tribal districts of Andhra Pradesh and several other regions. This bulletin will be of immense use to field level workers, administrators, policy makers etc for promoting Gliricidia leaf manuring on farm bunds and waste lands and on-farm generation of organic matter to improve soil health and sustainability of rainfed systems in India.

(A.K. Singh)

New Delhi
November, 2011

Soils of drylands are highly degraded besides having low soil organic carbon. Organic carbon in soil plays crucial role in various soil processes, nutrient dynamics, water relations and in maintaining biological and physical health of soil. Thus, it determines the extent of soil productivity. Most of the dryland soils are low in organic carbon (Figure 1) due to rapid oxidation process in dry regions of the country (Srinivasarao et al. 2006, 2008, 2009a; Srinivasarao 2011 a, b, c). Besides, low biomass generation and erosion of top organic carbon rich soil under intensive rainfall are other important factors leading to low soil organic carbon status in tropical regions. Depleted levels of organic matter have significant negative impacts on water use efficiency due to poor porosity and infiltration, local and regional water cycles, plant productivity, the resilience of Agroecosystems and global carbon cycles (Wani et al. 2009). By controlling infiltration rates and water holding capacity, soil organic matter plays a vital function in buffering yields through climatic extremes and uncertainty that exist in drylands. Therefore management practices that augment soil organic matter and maintain it at a threshold level are urgently needed for assessing further degradation and rather have better soil health, carbon sequestration, mitigating greenhouse gases (GHGs) and food security of the country (Srinivasa Rao et al. 2011 b, c, d, e, Wani et al. 2009). Optimum levels of soil organic carbon can be managed through the adoption of appropriate crop rotation, fertility management, using chemical fertilizers and organic amendments and conservation tillage. Improved management as evident from long term experiment at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India implies sustained productivity improvement as well as improved soil quality (physical chemical and biological parameters) along with increased carbon sequestration (Wani et al. 2003). Continuous application of organic matter as farm compost, farmyard manure, and plant residues is needed to maintain or increase soil organic matter content. However, shortage of organic manures and competing uses of farm residues as feed and fuel make it difficult to apply these to soil at desired levels.

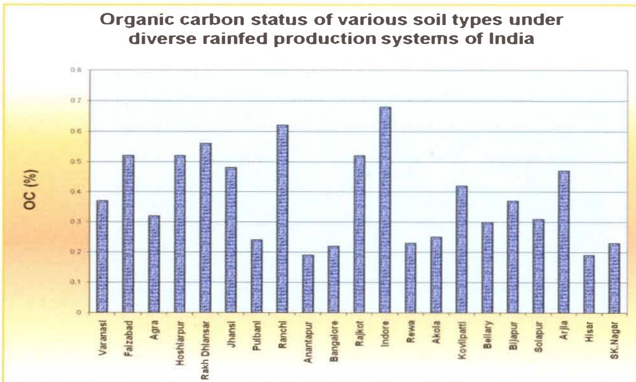

Figure 1: Drylands are highly degraded (left) and poor in soil organic carbon (right)

Strategies to enhance soil organic carbon

Various management options are being promoted by Central Research Institute for Dryland Agriculture (CRIDA) in farmers participatory action mode in several rainfed backward and tribal districts of Andhra Pradesh. Crop residue recycling, farm yard manure, biofertilizers, inclusion of legumes in the cropping sequence or as intercrops, green manure crops, green leaf manuring, tank silt addition, vermicomposting along with chemical fertilizers are some of the important options to improve soil health and crop productivity (Srinivasarao et al., 2011a,b,c,d). Among them, green leaf manuring with *Gliricidia sepium* is the most promising and climate friendly technology. *Gliricidia*, commonly known as *Kakawate*, used as insecticide, repellant and rodenticide, can thrive in dry moist, acidic soils or even poor degraded soils under rainfed conditions. Green leaf manuring is one of the important practices for increasing organic matter content in the soil. In degraded soils of the tropics, soils lack sufficient amount of nitrogen (N). Growing *Gliricidia* plants on farm bunds serves dual purpose of producing green leaf manure rich in N and also helps in conserving soil through reduced soil erosion (Srinivassarao et al., 2009 a, b, c).

Farm bunds could be productively used for growing nitrogen fixing shrubs and trees to generate nitrogen rich loppings. For example, growing *Gliricidia Sepium* at a close sparing of 75 cm on farm bunds cound provide 28-30 kg nitrogen per ha annual in addition to a valuable organic matter (Wani et al., 2009). Integrated nutrient management can go a long way in improving soil health for enhancing water use efficiency and increasing farmers incomes. Farmers should therefore be encourage to grow *Gliricidia* on farm bunds and border of fields for use in crop production which is a sustainable means of maintaining soil fertility along with inorganic soulses of nutrients.

Gliricidia: A potential green leaf manuring crop

Gliricidia sepium is a fast growing, tropical, leguminous tree. It is one of the commonest and best-known multipurpose trees in many parts of Central America, Mexico, West Africa, West Indies, South Asia, and tropical Americas. *Gliricidia sepium*, is also known as mata raton (spanish), cacao de nance, cacahnanance, madriado (honduras), kakawate (philippines), madre cacao (guatemala). It is one of the best-known trees probably originated from Central America, but has also spread to West Africa, West Indies, Southern Asia and tropical America. It is used as a live fencing in many tropical and sub-tropical countries. There are considered to be only four species of which *G. sepium* (common name '*gliricidia*') is the only species of real agronomic potential. The tree is used for timber, firewood, hedges, medicinal purpose, charcoal, live fence, plantation shade, poles, soil stabilization, and as green manure. The toxic property of the seeds and bark has given rise to the generic epithet (*gliricidia* = mouse killer). *Gliricidia sepium* adapts very well in a wide range of soils ranging from eroded acidic (pH 4.5-6.2) soils, fertile sandy soils, heavy clay, calcareous limestone and alkaline soils (Wani et al., 2009). *Gliricidia* tolerates fire and the trees quickly re-sprout with the onset of rains.

Tree Characteristics

Gliricidia sepium grows up to a height of 10-15 m. The branching of this thorn- less tree is frequently from the base with basal diameters reaching 50-70 cm. The bark is smooth and can vary in color from whitish grey to deep red-brown. The stem and branches are commonly flecked with small white lenticels. Trees display spreading crowns. Leaves are imparipinnate, usually alternate, sub opposite or opposite, to approximately 30 cm long; leaflets 5-20, ovate or elliptic, 2-7 cm long, 1-3 cm wide. Leaflet midrib and rachis are occasionally striped red. Inflorescences appear as clustered racemes on distal parts on new and old wood, 5-15 cm long, flowers borne singly with 20-40 per raceme. Flowers bright pink to lilac, tinged with white, usually with a diffuse pale yellow spot at the base of the standard petal, calyx glabrous, green, often tinged red. Standard petal round and nearly erect, approximately 20 mm long; keel petals 1520 mm long, 4-7 mm wide. Fruit green sometimes tinged reddish-purple when unripe, light yellow-brown when mature, narrow, 10-18 cm long, 2 cm wide, valves twisting in dehiscence; seeds 4-10, yellow-brown to brown, nearly round.

Environmental adaptation

The plant grows best in warm, wet conditions with optimal temperatures of 22-30°C and rainfall 800-2300 mm. It flourishes on fertile soils but has also been observed to grow well on acidic soils and those with high clay content.

Field management of *Gliricidia*

Gliricidia establishes readily from cuttings or 'quick sticks' and is ideal for shade trees, support trees or 'living fences'. Cuttings should be of mature branches (>7 cm in diameter), which are brownish-green in bark color. The cutting is normally made obliquely at both ends, discarding the younger tips, and the base inserted 20-50 cm into the soil depending on the length of the cutting. Cuttings for live fences may be up to 200 cm long whilst those for hedgerows may be 30-50 cm in length. The hedges can be periodically pruned to provide fodder, green manure, firewood or stakes for new fences. Hedges around crops need to be pruned regularly to control shading. Seed, usually sown in plastic sachets, can propagate it; the seedlings are usually cut back, as "stumps" prior to planting. Trees grow extremely quickly and may attain a height of 3 m before flowering at 6-8 months. Its rapid growth makes it an aggressive pioneer capable of colonizing secondary forest and fallow.

Seed production

Gliricidia is largely out crossing, needs to be isolated from other trees of the same or related species to prevent cross-pollination. It should be planted in blocks containing at least 30 trees and isolated by at least 200 m. A border row should be established around the block and seed should not be collected from this row. Flowering begins at the start of the dry season and continue for few months. The periodicity of pod ripening is partly dependent upon the climatic conditions and typically takes 45-60 days. *Gliricidia* grown in wet climates often flowers but sets little if any fruit. Sumberg (1985) reported seed yields of *Gliricidia* up to 89 g per tree per year, equivalent to approximately 37 kg ha^{-1} at the spacing used. Seed yield is closely related to the number of set racemes per tree. Seeds are shed from pods through explosive dehiscence with seed dispersal distances of up to 40 meters. Harvest is usually by collection of ripe pods before they dehisce, followed by drying in a site where seed from exploding pods can readily be recovered.

Propagation

Gliricidia can be propagated through stem cuttings or seed. *Gliricidia* cuttings are taken from stems of at least one-year-old plants. These should be from brownish-green mature branches and should measure 2-6 cm in diameter and 30-100 cm in length. The stem cutting is normally cut obliquely at both ends, discarding the younger tips and the base is inserted 20-50 cm into the soil. The cuttings should be planted on bunds in the rainy season immediately after these are cut from the stems. The plants grow quickly from cuttings. Propagation from stakes is simple but suitable mainly for situations where only a few trees are to be established. For hedges, cuttings are planted closely at 50 cm spacing. The hedges can be periodically pruned to provide fodder, green manure, firewood, or stakes for new fences.

For seed propagation *Gliricidia* seeds are soaked in water for 8-10 h, preferably overnight (Figure 2). The soaked seeds are sown in small polythene bags filled with a mixture of red soil, sand, and farmyard manure (1:1:1) and watered regularly. Generally, 3 to 4 month old seedlings can be planted on bunds in the rainy season. Seed propagation method is more convenient for establishing a large number of plants.

Planting

Gliricidia stem cuttings or 3 to 4-month-old seedlings can be planted on bunds at 50 cm spacing during the rainy season. For steep slopes, closer plant spacings

Figure 2 : Propagation through seedling

Figure 3 : Plants grown from seeds in polythene bags under shade net in Nalgonda district, nursery in Warangal district and planting of *Gliricidia*

of <20 cm is recommended for better soil erosion control. *Gliricidia* plants from stem cuttings grow faster than those grown from seeds (Figure 3).

Harvesting green leaf manure

One year after planting, harvesting can be started by lopping the plants at 75 cm to 1 m above the ground. For good management, plants should be pruned at appropriate time. Pruning should be done at least thrice during the year; i.e., in June (before sowing of the rainy season crop), in November (before sowing of the post rainy season crop), and in March (before sowing of the summer crop). After pruning the loppings, they are made into smaller pieces and can be transported to nearby fields. Leaf material is applied on the surface of ploughed soil and mixed into soil before crop planting (Figure 4, 5 & 6). Values reported for *Gliricidia* annual leaf dry matter production generally range from about 2 t ha^{-1} yr^{1} (Wong and Sharudin, 1986) to 20 t ha^{-1} yr^{1} (Sriskandarajah, 1987).

Extending *Gliricidia* green leaf manuring in farmers fields

The *Gliricidia* green leaf manuring technology was promoted in light soils of rainfed tribal and backward districts of Andhra Pradesh and All India Coordinated Research Project on Dryland Agriculture (AICRPDA) and ORP villages in different regions across the

Figure 4: Pruning of Gliricidia lopping

Figure 5 : Steps in *Gliricidia* lopping and transporting the leaf material

Figure 6 : Field application of chopped *Gliricidia*

country. Initially about 120 farmers were trained in on-farm generation of *Gliricidia* leaf manuring in terms of selecting good seed material, soaking, filling of polythene bags with soil and vermicompost, sowing the seed, planting of seedlings. In some of villages community nursery of *gliricidia* was taken under shade net facility provided under NAIP project led by CRIDA, Hyderabad (Figure 3). Training was also given on propagation through stem cuttings. Planting was taken up on the field boundaries, common lands, around water harvesting ponds and also as live fencing. Some of pictures (Figure 7 to 10) show the *gliricidia* plantations on the field boundaries of cotton-pigeonpea (Adilabad, Andhra Pradesh), fingermillet (Bengaluru, Karnataka), groundnut and chickpea (Anantapur, Andhra Pradesh) and castor and pearlmillet (Sardhar Krushi Nagar, Gujarat)

Benefits of *Gliricidia*

Nutrient additions

Amount of *Gliricidia* leaf manure application depends upon the growth of boundary plantations. Usually, about 1 to 2 t ha^{-1} leaf manures can be applied. Application of 1 t ha^{-1} *gliricidia* leaf manure provides 21 kg N, 2.5 kg P, 18 kg K, 85 g Zn, 164 g Mn, 365 g Cu, 728 g Fe besides considerable quantities of S, Ca, Mg, B, Mo etc. While, double amount of these nutrients

Figure 7: ***Gliricidia*** **on the boundaries of cotton-pigeonpea intercropped field in Adilabad district of Andhra Pradesh**

Figure 8 : ***Gliricidia*** **on the field bunds at Bengaluru (Karnataka) in fingermillet based systems**

Figure 9 : Plantations on the boundary of groundnut and chickpea fields at Anantapur (Andhra Pradesh)

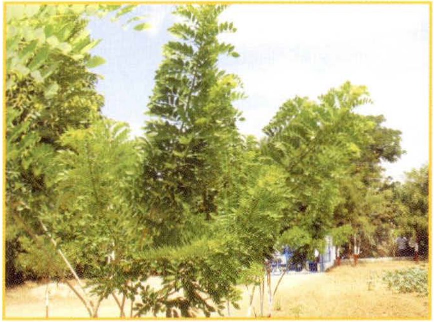

Figure10: *Gliricidia* on the boundaries of castor and pearlmillet at Sardhar Krushi Nagar (Gujarat)

was added / supplied when applied 2 t ha^{-1} (Figure 11 & 12). It improves mobilization of native soil nutrients in the soil due to production of carbon dioxide and organic acids during decomposition of the plant material, adds valuable nutrients such as N, P, K, Ca, and Mg to the soil. *Gliricidia* plants grown on 700-m long bunds can provide about 30 kg N ha^{-1} yr^{-1} under rainfed systems with 700-800 mm annual rainfall.

In a laboratory study on surface applied *Gliricidia* leaves in ICRISAT, Nagavallemma (2000) observed a consistency increasing mineral N from 7.00 mg N kg^{-1} soil at 5 days after ibcubation to 121 mg kg^{-1} soil at 150 days after incubations, they thereby incating in addition to supplying nutrients on a regular and balanced supply of nutrients with use of *Gliricidia* loopings. Moreover significantly lower amounts of CO_2 (1434 mg g^{-1} soil) are released with *Gliricidia* leaves when incorporated into the soil as compared to other crops like pigeonpea leaves (Vineela et al., 2008).

The major requirement of rainfed crop nutrient needs can be met through 2 t *gliricidia* leaf manuring, if properly added. Remaining nutrient needs of

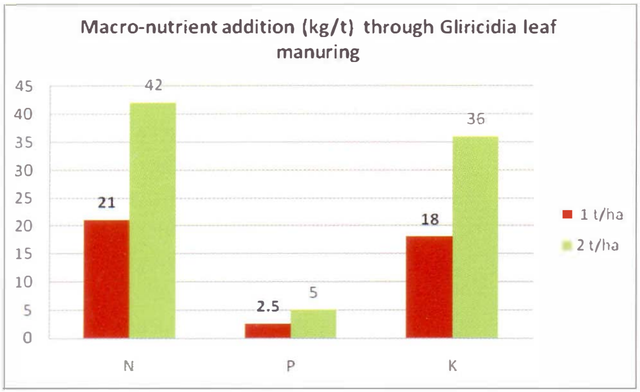

Figure 11: Macro nutrient addition through *Gliricidia* leaf manuring at different levels of manure application

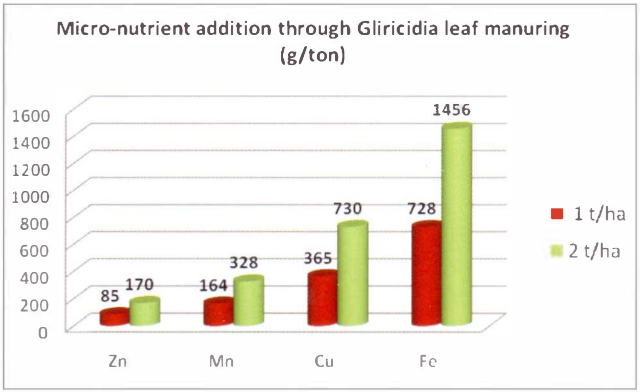

Figure 12: Micro-nutrient addition through *Gliricidia* leaf manuring at different levels of manuring

crops can be supplied through chemical fertilizers. Legume crops like chickpea, soybean, groundnut, blackgram, greengram, pigeonpea do not need any additional N application, if 2 t *gliricidia* leaf manure per ha applied. Similarly, P and K needs in most of the dryland crops like sorghum, pearlmillet, upland rice, chickpea groundnut, soybean, sunflower and cotton can be supplied if crops are grown in soils with medium to high soil fertility (Table 1). Micronutrient requirement is mostly met through addition of 2 t *gliricidia* ha^{-1} for major rainfed crops (Table 2).

Table 1: Nutrient requirement per tonne of production in important rainfed crops

Crop	kg nutrient/tonne produce		
	N	P_2O_5	K_2O
Sorghum	22.4	13.3	34.0
Pearl millet	42.3	22.6	90.8
Rice	20.1	11.2	30.0
Chickpea	46.3	8.41	49.6
Groundnut	58.1	9.6	30.1
Soybean	66.8	17.7	44.4
Sunflower	56.8	25.9	105.0
Cotton	44.5	28.3	74.7

Table 2: Average uptake of micronutrients by some rainfed crops grown in Andhra Pradesh

Crop	Economic yield (t ha^{-1})	Total uptake (g ha^{-1})					
		Zn	Fe	Mn	Cu	B	Mo
Maize	1.0	130	1200	320	130	--	--
Sorghum	1.0	72	720	54	6	54	2
Pearlmillet	1.0	40	170	20	8	--	--
Chickpea	1.5	57	1302	105	17	--	--
Pigeonpea	1.2	38	1440	128	31	--	--
Soybean	2.5	192	866	208	74	--	--
Groundnut	1.9	208	4340	176	68	--	--
Sunflower	0.6	28	645	109	23	--	--
Seasmum	1.2	202	952	138	140	--	--
Linseed	1.6	73	1062	283	48	--	--

Soil health improvement

Gliricidia leaf manuring improves organic matter content in the soil., improves soil physical properties like, allows the water to infiltrate into the soil more quickly rather than run off the surface, increases water-holding capacity of the soil, reduces soil erosion, restores and improves the soil quality, increases crop yields. Use of *Gliricidia* as green manure minimizes the usage of chemical fertilizers that are very expensive and also environmentally unfriendly, acts as a barrier and filter to the rainwater running down the surface of a slope. *Gliricidia* roots stabilize lands with high slopes. *Gliricidia* root rhizosphere soil samples showed improved organic carbon content in different depths of soil profiles (Figure 13). Similarly biological health of soil improved considerably in terms of population of fungi, bacteria, actinomycetes, total microbial count, microbial biomass carbon and nitrogen (Figure 14). Improvement of soil environment in the *Gliricidia* rhizosphere in the field bund soil could be due to improvement of organic carbon and root activity and rhizodeposition. (Srinivasarao et al. 2011a).

Relative Soil Quality Index (RSQI) was found to be highest with 3 t *Gliricidia* ha^{-1} and 25% RDF + 1.5 t *Gliricidia* ha^{-1} in cotton + blackgram (1:1) and greengram – *Rabi* sorghum system on Vertisols of

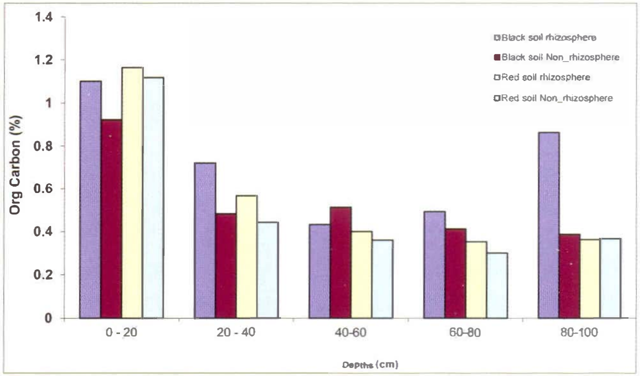

Figure 13: Organic carbon content in the soil from *Gliricidia* root rhizosphere in black and red soils

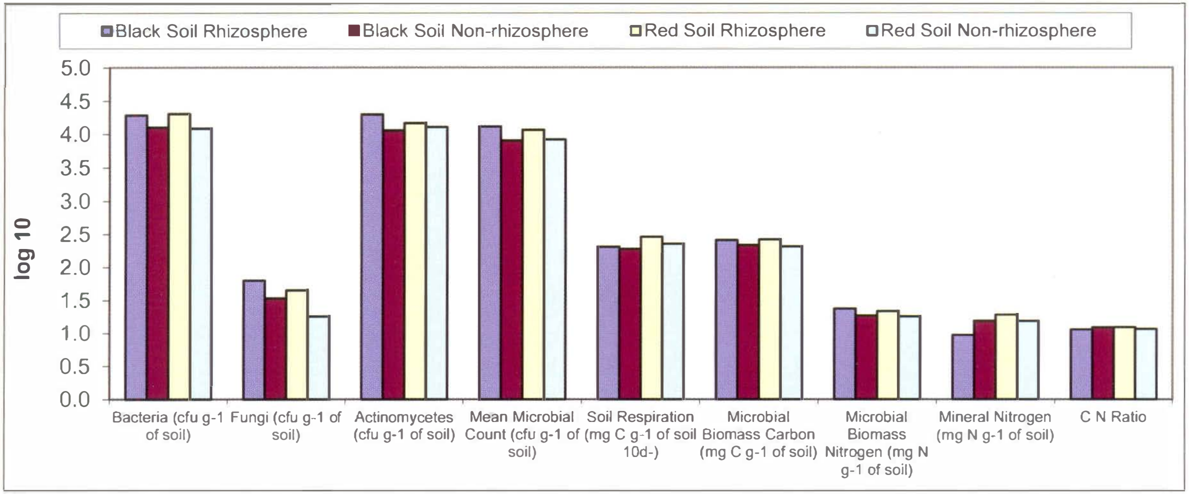

Figure 14: Comparative analysis of microbial, biological para-meters of soil samples collected from the bunds of rhizosphere and non-rhizosphere of *Gliricidia* in Vertisols and Alfisols

Parbhani (CRIDA 2007-08). Mulch cum manure is a practice adopted to improve the fertility and productivity of the soil under rainfed conditions. The biomass obtained from this plantation can be utilized as mulch in between crop rows raised during *kharif*. This practice facilitates in reducing the impact of rain on the soil, minimizing the nutrient and soil losses and controlling the weeds effectively. Annual runoff was drastically reduced from 33.90 mm (control) to 14.90 mm (FYM+NPK+*gliricidia*). Corresponding soil loss was reduced from 0.58 t ha^{-1} to 0.16 t ha^{-1}. Besides improving the yields, this system improves soil quality (Table 3) (Subba Reddy, 2008).

Additional uses

Plants are grown as live fence (hedge), stems are used as fuel wood, plants serve as support for other plant species, mixture of ground leaves or bark and cooked seeds of *Gliricidia* is used as poisonous bait for rats, leaves are used as insecticide and insect repellent.

Improved crop yields

Enhancement of soil productivity and increase in crop yields were found with the addition of *gliricidia* leaf manuring in several rainfed crops. Yields of different rainfed crops due to *gliricidia* leaf manuring improved significantly in many regions

Table 3: Impact of mulch-cum-manuring with *gliricidia* on the productivity of sorghum + pigeonpea-castor system at Nallavelli village in Andhra Pradesh (1999-2000)

Treatments	Castor equivalent (kg ha^{-1})	Net income (Rs. ha^{-1})	Annual run off (mm)	Total soil loss (t ha^{-1})
T1: No FYM and no fertilizer	328	2035	33.90	0.58
T2: FYM@ 5t ha^{-1} + 40:30:0 kg NPK ha^{-1}	691	5493	24.70	0.22
T3: T2 + *gliricidia*	984	8307	14.90	0.16

Figure 15: *Gliricidia* plants grown as hedge or vegetative barrier (after pruning)

like fingermillet in red soils of Karnataka, groundnut in red soils of Andhra Pradesh, pearlmillet in light textured soils of Gujarat, sorghum in medium to deep black soils of Maharashtra. At Bhubaneswar, in acid red and lateritic soils, maize yield improved from 17.0 to 21.0 q ha^{-1} due to *gliricidia* leaf manure equivalent to 20 kg N ha^{-1} (AICRPDA Reports). In long term manurial experiment on Alfisols of CRIDA farm near Hyderabad, sorghum and green gram yields were significantly higher with the addition of 1 to 2 t gliricidia along with 10-20 kg N ha^{-1} .

Sharma et al. (2004), reported that the two INM treatments, 2t *gliricidia* loppings + 20 kg N and 4 t compost + 20 kg N were found to be most effective in increasing the sorghum grain yield by 84.6 and 77.7 per cent over control, respectively. However, the highest amount of organic carbon content (0.74%) was recorded in 100% organic treatment (4 t compost + 2 t *gliricidia* loppings). Some of these options of managing nutrients by using farm based organics can form a potential component of organic farming.

While conducting the long-term experiment, Sharma et al. (2002) reported that the conjunctive use of urea and organics such as loppings of *leucaena* and *gliricidia* (1:1 ratio on N equivalent) had considerable effects on raising the sorghum grain yield to the levels of 16.9 and 17.2 q ha^{-1} respectively and thus revealed that a minimum of 50% N requirement of

Figure 16: Impact of *Gliricidia* leaf manuring on different crops (tomato, maize, chilli and cotton)

Figure 17: Field exposure of farmers to soil health experimences and *Gliricidia* field bunds

sorghum can be easily met from farm based organic sources. This information can be used to supplement fertilizer nitrogen upto 50% by using green loppings of *Gliricidia maculata* and *Leucaena leucocephala* and will be useful while planning for raising organic produce. Organic carbon in the soil was significantly increased by application of crop residues such as sorghum stover and *gliricidia* @ 2 t ha^{-1} under minimum and conventional tillages in sorghum-castor rotation in rainfed Alfisols. Further, they reported that increase in nitrogen levels from 0 to 90 kg N ha^{-1} also helped in significantly improving the organic carbon status in these soils over a period of 8 years.

Benefits to environment

Application of *gliricidia* imparts resilience to soil against moisture stress, improves soil quality, reduces soil erosion and pollution besides helping to minimize use of chemical fertilizers. It reduces the nitrogen oxide (N_2O) and CO_2 emissions into atmosphere and contributes overall reduction green house gases (GHGs) and has far reaching benefits in the climate change scenario.

Benefits to national economy

Sustainable agricultural productivity, reduced reliance on fossil fuels for producing fertilizers, increased carbon sequestration are some of the significant benefits if *gliricidia* is promoted on a large scale. For instance, in Seetagondi cluster of Adilabad district about 50 ha of cotton-pigeonpea inter cropping systems have benefited by this *gliricidia* leaf manuring technology. Similarly, in Duphad cluster of Nalgonda district covering 10 villages about 100 ha grown with cotton, groundnut, pigeonpea, greengram, blackgram, vegetables like bhendi, tomato, Palak have *gliricidia* plantations on field bunds. In other clusters also *gliricidia* green leaf manuring technology is practiced by the several farmers for various crops.

Summary

Farmers need to be encouraged to grow Gliricidia on farm bunds, borders of fields and on common lands. Use of *Gliricidia* as green manure in crop production systems provides a sustainable means of maintaining soil fertility along with inorganic sources of nutrients. From these field experiences it is learnt that continuous application of organic residues has significant effects on organic carbon status in soils. One has to think to improve organic carbon and nutrient pools in soil by way of recycling of sparable crop residues and other biomass available in the farm. It has a large scope for improving organic carbon and nutrient pools in soils. However, *gliricidia* needs to be promoted systematically through proper technical guidance at the village level to up scale this technology on large scale.

However, availability of *Gliricidia* seed at village level and lack of awareness on the benefits of *Gliricidia* green leaf manuring among extension workers and line departments are some constraints in the implementation of this technology. If this technology is successfully implemented, input cost on fertilizers will be reduced considerably besides many environmental benefits. This is much more significant in the light of escalation in the cost of almost all the chemical fertilizers today.

Acknowledgement

The partnership of the consortium (CRIDA, SAIRD, MARI, BAIF, KVK, Adilabad, AAKRUTI, ANGRAU, ICRISAT, CWS) in the eight districts in collecting and analyzing the soil samples is gratefully acknowledged. Thanks are also due to the farmers who willingly shared information with the project team during the course of the investigation.

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