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# *Sesbania* – An Important aspect of INM for sustainable productivity of rice: A review

**Ramyajit Mondal and Saumi Goswami**

**Abstract**
Population explosion is now a days a major factor that affects the food production in our country and thus quality food grain production in sufficient quantity without damaging the soil quality, productivity and fertility is one of the biggest challenges in the present agriculture scenario. Huge amount of chemical fertilizers, pesticides are very common and traditional solution for higher production of crop and for pest management purpose. But, due to lack of judicious application of such chemicals soil fertility is declining very rapidly and that is linked up directly and indirectly with poor nutrition and health of human being. This situation is severe in case of cereal production especially in case of rice where, chemical use is much more. In this context, practice of green manuring is the spark in dark to a great extent. Leguminous Green manure crops can meet a substantial portion of N requirement of rice and provide organic matter to the soil to maintain soil fertility. *Sesbania aculeata* (Dhaincha) can be useful alternatives to resource poor rice farmers if applied as green manure**.** Being a leguminous green manure crop it has several advantages over chemical fertilizers like it improves soil physical, chemical and biological health, promote microbial activity in soil, maintain nutrient balance, enrich the soil with organic matter etc. By addition of huge biomass Dhaincha increases rice yield besides improving soil quality. The highest rice yield was obtained when rice and Dhaincha were grown at 2:1 ratio in 20 cm wide rows. Effect of green manuring with Dhaincha on growth and yield of direct sown and transplanted rice have also been studied by different scientists.

**Keywords:** Green manure, Dhaincha, soil fertility, rice, yield

## Introduction
Among the cereals, rice (*Oryza sativa* L.) is the major source of calories for 40% of the world population. In India, rice is cultivated on 44 million ha and contributing 104.32 million tonnes grain production with productivity of 2.37 t $ha^{-1}$. Cultivation of high yielding dwarf varieties responsive to fertilizer and excess use of inorganic fertilizers has depleted the inherent soil fertility. The decline or stagnation in yield has been attributed to nutrient mining and reduced use of organics (John *et al.* 2001) [17]. Several long-term experiments conducted all over India indicated a decrease in rice productivity due to continuous use of chemical fertilizers. Integrated nutrient management (INM) aims to improve soil health and sustain high level of productivity and production (Prasad *et al*, 1995) [29]. He combined use of organic and inorganic fertilizers has been reported not only to meet the nutrients need of the crop but also has been fund to sustain large scale productivity goals (Yadav and Meena 2014) [36]. Integrated Nutrient Management (INM) promotes the use of balanced and judicious use of chemical fertilizers in conjunction with manures like compost, farm yard manure, vermicomposting, green manures and use of fertilizers fortified with micro-nutrients, use of bio-fertilizers (e.g. phosphate solubilizing bacteria, Azospirillum, Azotobacter, Rhizobium, and Potash mobilizing bio-fertilizers) that can supplement a part of NPK fertilizers (Herbert 1998) [13]. India has changed from a region of food scarcity to food sufficiency by increased fertilizer use with subsidized prices, but use of organic manures including green manure, declined substantially. Inorganic fertilizers are becoming more expensive; therefore, sustainability of soil productivity has become a question. Hence, alternate sources to supplement inorganic fertilizers are thought on the other hand, in any type of farming systems, lots of works are required and much time goes on the production of a basket of compost and carrying it into the field. Green manures are a method of replacing that basket of compost with a handful of seed. In this method, the plants that grow from the handful of seed are ploughed back into the soil. After a while in the soil,

the plants rot down to become compost. Green manuring are low cost and effective technology in minimizing cost of fertilizers and safeguarding productivity.

**Fig 1:** Incorporation of Green manure crop

**Green manuring**

Owing to the intensely hot summers, the available humus in the soil is burnt up quickly. A periodical application of OM is, therefore, essential to replenish the loss of humus, which is necessary for keeping the soil in good condition by enhancing the supply of N and by promoting the growth of microorganisms. Green-manuring is, thus, a very useful soil-improving practice for building up soil fertility. First, it increases the soil fertility by the direct addition of N to the soil. Second, it improves the soil texture by the addition of humus or organic matter, which is essential for making the soil more productive. Green manuring may be defined as a practice of ploughing or turning into the soil undecomposed green plants or their residue for the purpose of improving physical structure and fertility of a soil. There are various types of green manures in India like dhaincha, glyricidia other leguminous crops etc. non leguminous crops Buck wheat, wheat, maize, sun flower etc. leguminous crops containing different microorganisms which can fix nitrogen to improve the soil fertility and hence plant growth.

**Advantages of green manuring:** There are various advantages of green manuring in relation to soil fertility which are as follows: –

- Green manure crops modify soil physical chemical and biological environments (Fig 2). Green manures not only supply N to rice but also improve physical and chemical properties of soils (Buresh and De Datta, 1991[7], Becker *et. al*., 1995 [3]). In fact, this stimulates the activity of soil micro-organisms.
- The green manure crops help for returning the different plant nutrients to the surface soil layer from the sub-surface soil layer.
- It improves the soil structure, aeration status, and permeability and infiltration capacity of soil. – It reduces the soil loss caused by run-off and erosion. An effective technology in economizing the agricultural production system ensuring productive capacity of soil without causing environmental problem (Bana and Pant, 2000) [2].

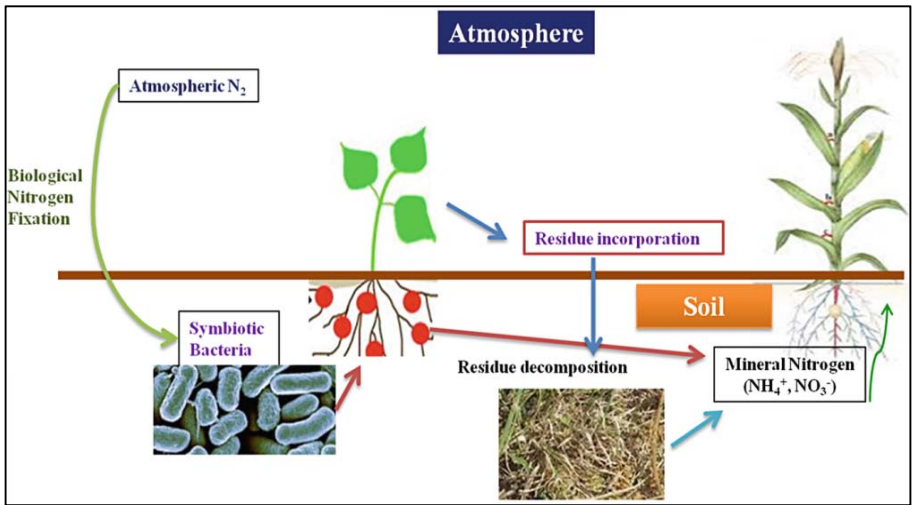


**Fig 2:** Nitrogen cycle

- Due to green manuring the nutrient regimes can be improved and restored otherwise be lost by leaching. In waterlogged soils, green manures increased the availability of P through the mechanism of reduction, chelation and favourable changes in soil pH (Hundal *et al*, 1987) [14]. Better utilization of P and K to an extent of 10 to 12 per cent was observed due to green manure incorporation (Lekha, Sreekantan and Palaniappan, 1990) [21].
- It increases the organic matter regime of the soil. S. *aculeata* application recorded higher availability of soil organic carbon and it also has some residual effect in relation to supply of different plant nutrient and thereby it helps for the better growth to the next crop.

**Characteristics desirable in legume green manure crops**

For lowland ecosystem Dhaincha is a premier green manure crop since it fulfills the traits of an ideal green manure which is further supported by FAO (1977) [9]; IRRI (1988) [15] and Ladha *et al.* (1988) [20] described below.

- Early establishment and high seedling vigour
- Tolerance to flooding and drying
- Early onset of N fixation and efficient sustenance over varied climatic and edaphic conditions.
- Fast growth with an ability to accumulate large biomass and N within four to six weeks of growth.
- Quick decomposability.

**Types of green manuring**

The practice of green manuring is performed in different ways according to suitable soil and climatic conditions of a particular area. Broadly the practice of green manuring in India can be divided into two types:

**1. Green manuring in- situ:** In this system, green manure crops are grown and buried in the same field, which is to be green manured, either as pure crop or an intercrop with the main crop. This system is followed in the northern India. Plants suitable for green manuring in the field or in- situ: An ideal in-situ green manure crop should possess the following desired characteristics

1. It should be a legume with good nodular growth habit indicative of rapid N fixation under even unfavorable soil conditions.
2. It should have little water requirements for its own growth and should be capable of making a good stand on poor and exhausted soils.
3. It should have a deep root system, which can be open the sub-soil and tap lower regions for plant nutrients.
4. The plant should be of a leafy habit capable of producing heavy tender growth early in its lifecycle.
5. It should contain large quantities of non-fibrous tissues of rapid decomposability containing fair percent of moisture and nitrogen.

**Suitable green manure crops:** Sunn- hemp (*Crotalaria juncea*), Dhaincha (*Sesbania aculeata* and *S. rostrata*), Wild indigo or kolingi (*Tephrosia purpurea*). Among the green manures, *S. aculeata* and S. speciosa exhibited higher organic carbon content with wider C-N ratio than *S. rostrata* (Ndoye and Dreyfus, 1988) [25].

**2. Green leaf manuring**: Green leaf manuring refers to turning into the soil green leaves and tender green twigs collected from shrubs and trees grown on bunds, wastelands and nearby forest areas. This system is generally followed in the central and eastern India.

Gliricidia (*Gliricidia maculata*), Subabul (*Leucaena leucocephala*), Cassia (*Cassia auriculata*).

**Techniques of green manuring in the field:**

The maximum benefit from the green manure crop cannot be obtained without knowing the

i) When it should be grown.
ii) When it should be buried into the soil.
iii) How much time should be given between the burying of the green manure crop and the sowing of the next crop.

**Time of sowing of the green manure crop:** Normally the green manure crop should be grown immediately after the monsoon rains. As far as cultivation practice involved, no special care is needed in the preparation of the seedbed. Soil must have sufficient moisture for the quick germination and rapid early growth. Phosphatic fertilizers, if applied, should be evenly broadcast. Usually the seed of the green manure crop is broadcast preferably with higher seed rate.

**Stage of burying of the green manure crop**: From the results of the several experiments, it is observed that best results of the green manuring are obtained if it is buried at the flowering stage. The seed also broadcasting at the time of rice transplanting and grow it when 30 to 35 days age then the dhaincha crop can be incorporated and mixed properly in the field. Incorporation of young green manure ensures adequate mineralisation of N (Bhuiya and Zaman, 1996). Dhaincha (*Sesbania aculeate)* recorded maximum biomass between 40 and 50 DAS suggesting it to be the ideal time for incorporation into the soil (Kalidurai, 1998) [19].

**Time interval between burial of green manure crop and the sowing of the next crop**:

The time interval should be allowed for complete decomposition of the turned in green manure crop before planning of the next crop and that time should depend upon the following factors:

1. Weather conditions
2. Nature of the buried green material

In areas, receiving rainfall >50 inches, humid conditions favours decomposition. If the green manure crop is succulent, then there is no harm in transplanting the paddy immediately after turning in the green manure crop. However, in case of the woody, then sufficient time should be allowed for its proper decomposition before planting the paddy e.g. when succulent green manure crop of around 8 weeks was buried then paddy can be planted without having any adverse effect on the yield. But when dhaincha become woody (12 weeks), it was necessary to bury it about 4 to 8 weeks first for its decomposition before planting paddy. In areas receiving 25 to 50 inches' rainfall, green manure crop required about 6 to 8 weeks to decompose. It is only because of lesser moisture conditions. When green manure crop was intercropped in between the rows of the main crops like paddy, cotton, sugarcane etc. then it is buried in the succulent stage for its rapid decomposition. Classic experiments repeated five times between 1955 and 1958 at Central Rice Research Institute (CRRI), Cuttack showed that an eight-week-old S. *aculeata* could be incorporated and rice planted on the same day obviating the need for allowing a decomposition period (Vachhani and Murthy 1964) [35]. Green manuring has greater manorial potential when rice is planted immediately after burying the green manure (Dargan *et al.,* 1975) [8]. Incorporation of green manure one day before transplanting (DBT) without fertiliser N gave a significantly higher grain yield of rice (by 1.2 - 3.8 t $ha^{-1}$) which was equivalent to 120 kg N $ha^{-1}$ urea than its incorporation 7 and 14 DBT (Beri *et al.,* 1989b) [4].

**Dhaincha:**

Sesbania is a legume commonly used as a green manure crop to add nitrogen and organic matter to the soil. The name Sesbania is taken from its Arabic name "Siesaban". It is known by many common names, including danchi, dunchi, dhaincha, canicha, prickly sesban, "Jantar" or spiny sesbania. The most common species of sesbania used in Asia are *Sesbania cannabina* (former name acculeata), *S. rostrata* and *S. cannabina* (which produces nitrogen-fixing nodules in its roots). *Sesbania rostrata* (produces nitrogen-fixing nodules in both roots and stems) and is commonly found in Africa.

**Sesbania: A brief classification**

***Sesbania cannabina (aculeata)-*** The legume *Sesbania cannabina*, also known as *Sesbania aculeata* is a small tree in the genus *Sesbania*. It is an annual shrub, quick growing and succulent which can grow to seven metres in height but usually only reaches one to two metres (Fig 3). It sends out fibrous, pithy stems with long leaves and bears purple-spotted yellow flowers. It produces pods which contain light brown beans. It is native to Asia and North Africa, is most common in tropical Africa where it grows as a common noxious weed, and has been introduced to the Americas. It can grow on saline soil. S. cannabina is adapted to wet, heavy soil but apparently adapts easily to drought-prone or sandy regions. It is cultivated widely in India. The plant has a great number of uses, including as green manure that can be incorporated at 8-

10 weeks after sowing. Other usable parts are straw, wood and fodder. It can be used like industrial hemp for rope, fish nets, sackcloth and sailcloth. Its fibers are similar to those of birch trees and show promise as a source of paper fiber. The foliage makes a good fodder for livestock and the beans can be fed to fowl. The plant has been also used as a famine food by people. Natural gum from the plant is useful as a thickening agent. Like other legumes, it can be planted to improve the soil via nitrogen fixation. It makes good firewood. It has several culinary uses like the yellow flowers of S. cannabina (aculeate) are eaten as a vegetable in Southeast Asia. They are much smaller than the more popular white flowers of Sesbania grandiflora, but similar in shape. Still, they are appreciated as food in Thai and Vietnamese cuisine also. S. cannabina can be grown even under adverse conditions of drought, water logging, salinity etc. Recommended seed rate is 20-25 kg/ha. The green matter yield is 10-20 t/ha. Quantity of nitrogen fixed is 75-80 kg/ha.

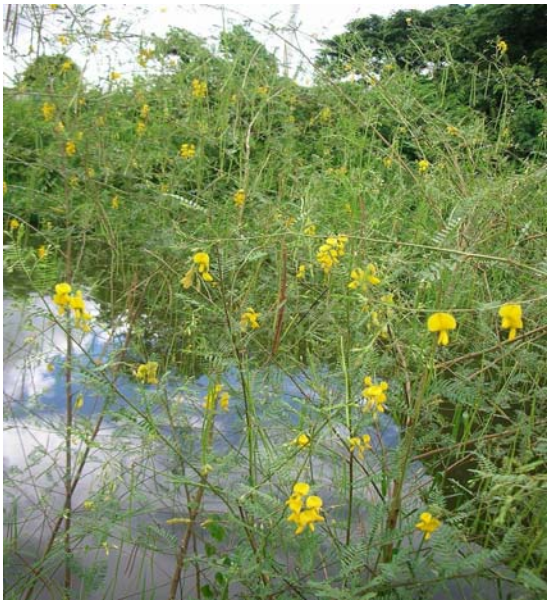

**Fig 3:** *Sesbania cannabina* (*acculeata*)

***Sesbania rostrata*** – It is one of the few legumes that forms nodules on both stems and roots. It thrives well under waterlogged condition. Seed rate of 30-40 kg/ha is optimum. For early and uniform germination, seeds are treated with concentrated sulfuric acid for 15 minutes and then washed thoroughly with fresh water and sown immediately. Within a period of 8-10 weeks, 15-20 t/ha of green mass yield can be obtained. Besides these, the stem nodules of *S.rostrata* can fix a huge amount of N in the soil. The stem nodules are formed by Azorhizobium caulinodans and are induced following crack-entry infection at the base of dormant root primordia, which are present in rows along the length of the stem. Direct intercellular infection is followed by very active multiplication of the bacteria, forming wide intercellular spaces filled with azorhizobium. These azorhizobium-filled spaces then extend inward as narrow, branched, intercellular infection threads which spread into the meristematic zone induced in the cortex. The subsequent release of bacteria into the cytoplasm of newly induced meristematic cells leads eventually to the development of a determinate nodule. It has been reported that infection occurs by means of infection threads through root hairs during root nodulation of S. rostrata, although other symbiotic steps were not addressed in that study.

**Sesbania in Rice Cultivation**

The organic matter and nitrogen produced by Sesbania help improve the soil and subsequent crop growth. Under some circumstances, growing green manures is a cheaper and renewable source of N, especially when inadequate infrastructure and transport mean that other sources of nutrients are expensive or not delivered on time.


Besides that, dhaincha reclaimed soil sodicity faster than FYM and paddy straw. Green manuring with S. *rostrata* increased both availability in soil and accumulation in plant of Fe, Mn and Cu due to the development of intense reducing condition, complex formation and greater nutrient binding capacity (Bhattacharyya and Mandal, 1996) [5]. Along with these, the effectiveness of dhaincha in smothering weeds was reported when grown as intercrop in rice (Angadi, 1997) [1]. Intercropping dhaincha in between two rows of rice in additive series and incorporating 35 DAS proved superior to sole rice (Joseph, 1998) [18].

**How do you manage Sesbania in rice?**

Sesbania can produce up to 80-100 kg N/ha (equivalent to 4 - 5 t dry biomass of Sesbania per ha) in around 40 days during the long-day season and in 50-60 days during the short-day season.

When to plant:

Sesbania is planted before or after rice, when the land is vacant. Sesbania is highly photoperiod sensitive, flowering in about 35 days during the long-day season and in 125 days during short-day season. But, there is not much scope of growing dhaincha as rainfed crop during the summer (March–April) before rice on residual soil moisture, because of the extremely hot and dry weather which is not congenial. One alternative is to grow rice and dhaincha simultaneously during the 1–2 months of pre-monsoon period (May– June) and recycle the green manure at an appropriate stage after water accumulates in the field from July onward. Mixed cropping of rice and dhaincha simultaneously and incorporating of dhaincha with the *beushaning* operation has been recommended for improving the productivity and supplementing the rice N requirement (Manna *et al*., 1988 [24]; Panda *et al*., 1988) [28]

**Temperature requirements**:

Sesbania grows best at temperatures above 25ºC.

**Land preparation:**

While Sesbania can be grown with little tillage, more thorough land preparation (e.g., one ploughing and two or three harrowings) gives better crop establishment.

**Seed rate:**
Where weed populations are low, sesbania seeds can be broadcast at a rate of 30 to 40 kg per ha before the onset of the rains. With land preparation and irrigation, the seeding rate can be reduced to 16 kg per ha. Seed usually weighs from14 to 18 g per 1000 seed. To improve germination (up to 65%) and emergence, seeds can be immersed in water at 100ºC for three seconds. Some farmers scarify the seeds (i.e., slightly split the seed coat) by simply pounding the sacks containing the seed.

**Irrigation:**
The crop does not need to have standing water, but irrigation water should be applied as necessary (e.g., if soil is cracking and sesbania leaves are being shed).

**Incorporation:**
After about 45-60 days, and before it becomes woody, incorporate the Sesbania in one of several ways: e.g., chop the crop for easier ploughing. A faster, and more efficient way is tok- nock over the standing crop of sesbania using for example an animal-drawn wooden plank, and then plough along the direction of the lodged crop.
A hydro tiller used for tillage in deep mud, incorporates bulky biomass effectively. The high-speed cage wheel, with short triangular teeth, cuts the biomass into pieces before burying it into the puddled soil. If using the hydro tiller, the field should be water soaked for at least 48 h before the biomass is incorporated. For large-scale production, a four-wheel tractor fitted with a roto tiller is the most efficient method.

**Seed production:**
Sesbania seeds can be produced by growing when the day lengths are shorter than 11hrs. During these periods, Sesbania flowers in 30 to 35 days and bears seed 30 days later. Seeds harvested during the rainy season are often of lower quality as they are often infested with pod borers. Seeds can also be produced on marginal lands, dikes or paddy bunds to reduce costs.

**Brown manuring**
Brown manuring is a technique to grow Sesbania in standing rice crop and kill them with the help of herbicide for manuring. After killing the color of the sesbania residue become brown so it called brown manuring. Brown manuring practice introduced where *Sesbania* crop @ 20 kg/ha is broadcasted three days after rice sowing and allowed to grow for 30 days and was dried by spraying 2,4-D ethyl easter which supplied up to 35 kg/ha N, control of broad leaf weeds, higher yield by 4 -5 q/ha due to addition of organic matter in low fertile soils.

**Dhaincha as Green Manure and Rice Yield:**
Dhaincha (*S. aculeata*) being a member of leguminous green manure crop, enhance rice yield significantly by means of addition of green biomass into the soil and also helps to meet the rice N requirement to a certain extent. These are in conformity with the findings of many scientists.
The benefit of intercropping dhaincha was reported when 30 days old seedlings were transplanted about 30 days after transplanting rice (Lizhi, 1988) [23].
Interplanting one row of S. *aculeata* seedlings at a spacing of every 3 m between rice rows with 20 x 15 cm spacing gave more profitable yield than sale crop of rice (Jha *et al*., 1989) [15].
*Sesbania aculeata* broadcast at 40 kg seed $ha^{-1}$ increased the germination of rice by 24 per cent in the encrusted lateritic soils and with its incorporation, the yield of rice was enhanced in upland conditions (Hati, 1987) [12].
The highest rice yield was obtained when rice and dhaincha were grown at 2:1 ratio in 20 cm wide rows. The yield was, however, at par with the treatments where rice and dhaincha were grown in alternate rows at 15 cm spacing (Sharma and Das, 1994) [30].
Intercropping *Sesbania* with suitable row (4-6 m) and plant (24-30 cm with 3-4 seedlings per hill) spacings will not affect the associate rice yield (Liu Chungchu, 1988) [22].
Intercropping *S.rostrata* did not cause any *adverse* effect on the yield of transplanted rice. (Padmavathy, 1992) [26] and wet seeded rice (Urkurkar *et. al.*, 1994) [34].
Green manuring of rice with leguminous annual crops, such as dhaincha (*Sesbania aculeata*), sunnhemp (*Crotalaria juncea*) and cowpea (*Vigna unguiculata*) or with twigs and leaves of perennial trees, such as *Glyricidia sepium* and *Leucaena leucocephala* has been recommended to improve soil fertility and crop productivity, besides saving costly chemical fertilizers, particularly N (Singh *et al*., 1991) [31].
Sharma and Das (1994) [30] have studied the effect of green manuring with Dhaincha on growth and yield of direct sown and transplanted rice under intermediate deep water condition (0-50 cm). They reported highest yield when rice and Dhaincha were grown at a 2:1 ratio in 20 cm wide rows. Increase in yield under green manuring was due to greater panicle weight, which was probably due to a continuous supply of N following decomposition of organic matter added through Dhaincha. They concluded that green manuring of direct sown rice with Dhaincha was beneficial for higher crop productivity under excess water condition.

**Conclusion:**
Green manuring is the ray of hope for the production of quality food in sufficient quantity and also for maintaining soil health. More specifically, Dhanicha, a leguminous green manure is used in rice cultivation for its several beneficial effects. It improves soil health and yield of rice by addition of green matter in soil in huge quantity. Thus practice of green manuring with Dhaincha in the rice field is an indication of sustainable production system in an ecologically sound environment.

**References**

1. Angadi VV, Umapathy PN. Integrated weed management through smother intercrops in rainfed lowland rice. Int Rice Res Notes. 1997; 22:47-48.
2. Bana APS, Pant AK. Indian Farmer's Digest. 2000; 33:19-20.
3. Becker M, Ladha JK, Ottow JCG. Nitrogen losses and lowland rice yield as affected by residue nitrogen release. Soil Science Society of America Journal. 1994; 58(6):1660-1665.
4. Beri V, OP Meelu, CS Khind. Studies on Sesbania aculeata Pers. As green manure for N accumulation and substitution of fertilizer N in wetland rice. Tropical Agriculture. 1989b; 66:209-212.
5. Bhattacharyya K, Mandal SR. Effect of green manuring on changes of micronutrients in soil and plant systems of rainfed rice. Indian Agriculture. 1996; 40:199-208.
6. Bhuiyan NI, Zaman SK. *In:* Biological Nitrogen Fixation Associated with Rice Production Kluwer Academic Publishers. Dordrecht, The Netherlands, 1999, 51-64.

7. Buresh RJ, De Datta SK. Nitrogen dynamics and management in rice-legume cropping systems. In Advances in Agronomy. 1991; 45:1-59. Academic Press.
8. Dargan KS, Chhillar RK, Bhardwaj KKR. In alkali soils: green manuring for more paddy. Indian farming, 1975.
9. FAO. Recycling of organic waste in agriculture. *In:* Report on FAO/UNDP tour to the Republic China, 1977, 28.
10. FAO. soils bulletin. Food and Agricultural Organisation of United Nations. Rome, 1988.
11. Grace TM. J. Maharashtra Agric. Univ. 1999; 23:261-264.
12. Hati N. IRRN. 1987; 12:44-45.
13. Herbert SJ. Deptt. Of Plant and Soil Sci. Univ. of Massachusetts Amherst Crops, Dairy, Livestock News. 1998; 3:1.
14. Hundal HS, Biswas CR, Vig AC. The utilization of phosphorus by rice from 32P labeled green manure. Biol. Wastes. 1987; 22:97-105.
15. IRRI. Annual report for 1987. Manila, Philippines, 1988.
16. Jha KP, Manna GB, Mishra AP. Feasibility of augmenting green-manure seed production by rice (Oryza sativa)-dhaincha (Sesbania cannabina) intercropping during rainy season. Indian J. Agric. Sci. 1989; 59:207-210.
17. John PS, George M, Jacob RZ. Nutrient mining in agro-climatic zones of Kerala, Fertilizer News. 2001; 46:(45-52)(55-57).
18. Joseph. M.Sc. (Ag.) Thesis, Tamil Nadu Agric. Univ. Coimbatore, 1998.
19. Kalidurai M. Nitrogen fixation and mineralization of Sesbania rostrata in rice soil ecosystem. Ann. Agric. Res. 1998; 19(4):365-369.
20. Ladha JK. In*:* Symp. on Sustainable Agriculture in Rice Res. Inst., Philippines: Green manure in rice farming, 1988, 25-29.
21. Lekha Sreekantan, Palaniappan SP. J. Agron. Crop. Sci. 1990; 165:14-18.
22. Liu Chung Chu. *In:* Symp. on Sustainable Agriculture. The role of green manures in Rice farming. Fujian Acad. Agric. Sci., Fuzhou, China, 1988, 319-331. ISBN97: 104-189.
23. Lizhi C. *In:* Symp. on Sustainable Agriculture: Int. Rice Res., IRRI. Philippines. Green manuring in Rice farming. 1988, 63-70.
24. Manna GB, Jha KP, Rao KS. Potentiality of green manuring practice in the current rice production strategy. Biological Nitrogen Fixation Associated with Rice Production, 1988, 329-335.
25. Ndoye I, Dreyfus B. N2 fixation by Sesbania rostrata and Sesbania sesban estimated using 15N and total N difference methods. Soil Biology and Biochemistry. 1988; 20(2):209-213.
26. Padmavathy VK. M.Sc. (Ag.) Thesis, Tamil Nadu Agric. Univ. Coimbatore, 1992.
27. Palaniappan SP, Siddeswaran K. Bioresources Technology for Sustainable Agriculture. Associated Publishing Company, New Delhi, 1999, 41-55.
28. Panda D, Samantaray RN, Mohanty SK, Patnaik S. Green manuring with Sesbania aculeata–its role in nitrogen nutrition and yield of rice. Biological Nitrogen Fixation Associated with Rice Production, 1988, 305-313.
29. Prasad B, Prasad J, Prasad. Nutrient management for sustained rice and wheat production in calcareous soil amended with green manures, organic manure and zinc. Fertilizers News. 1995; 40(3):39-41.
30. Sharma AR, Das KC. Effect of green manuring with dhaincha (Sesbania aculeata) on growth and yield of direct-sown and transplanted rice under intermediate deepwater conditions (0–50 cm). The Journal of Agricultural Science. 1994; 122(3):359-364.
31. Singh Y, Khind CS, Singh B. Efficient management of leguminous green manures in wetland rice. In Advances in Agronomy. 1991; 45:135-189. Academic Press.
32. Sreekantan L, Palaniappan SP. Radio Tracer Studies on P Use Efficiency in a Rice Based Cropping System. Journal of Agronomy and Crop Science. 1990; 165(1):14-18.
33. Sreeramachandrasekaran MV. Oryza. 1996; 33:126-131.
34. Urkurkar JS. *In:* Nat. Symp. on Integrated Input Management for Efficient Crop Production 22-251994, Tamil Nadu Agric.Univ., Coimbatore, 1994, 72.
35. Vachhani MB, Murthy KS. Green Manuring for Rice. ICAR Res. Report. Ser. No.17. ICAR, New Delhi, 1964, 50.
36. Yadav L, Meena N. Performance of aromatic rice (*Oriza sitiva*) genotype as influenced by integrated nitrogen management. Indian Journal of Agronomy. 2014; 59(2):51-255.