

Re-popularization of *Sesbania*

green manuring

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Farmers apply increased rate of N fertilizer to meet the growing demand for food and to compensate for decline in productivity due to continuous use of chemical fertilizers. However, it is not possible to go on increasing fertilizer application rate at the cost of decline in soil and environmental health, increased pest and disease load, increased demand for fertilizer manufacture and import, unbearable burden on Government exchequer for subsidy, and undesired carbon footprint associated with fertilizer manufacture and transport. Green manuring with Sesbania has potential to meet 62.5% of N, 3.9% of P and 28.2% of K requirement of irrigated high yielding variety of paddy in wet season. This may contribute in fulfilling the Government target of reducing urea use to 50% by the year 2022. Certain apprehensions prevail regarding large-scale adoption of the green manuring practice and we visualize that these can be managed. We propose that Government should provide incentive to farmers adopting such eco-friendly plant nutrient management practice at INR 1,324 per ha. This can be easily achieved by diverting the money being spent towards subsidy on chemical fertilizers. This will provide enough monetary benefit to the farmers. Ultimately, it will promote wide use of Sesbania green manuring in rice crop and discourage use of chemical fertilizers.

Keywords: Green manure, Incentive, Re-popularization, Rice, *Sesbania*

THERE is demand for increased food production to feed burgeoning population. The net area under cultivation is decreasing due to diversion of agricultural land for housing and developmental projects. Increasing cropping intensity to produce more from the same piece of land will lead to exhausted soil, if due care is not taken for maintaining soil health. Continuous use of chemical fertilizers has resulted in decreased crop productivity, especially in absence of organic matter supplementation. Depletion in soil nitrogen level is reported due to continuous use of synthetic nitrogenous fertilizers in cereal production system. Farmers have increased the rate of fertilizer application to maintain the productivity level. As an example, in Krishna Godavari delta regions of Andhra Pradesh, economic crop response of *rabi* rice to N fertilizer has increased up to 210 kg N/ha as compared to the recommended rate

of 120 kg N/ha (Dakshina Murthy *et al.*, 2015). These fertilizer rates are very high from the angle of environmental pollution and sustainability risk.

Over-application of N fertilizer causes soil acidification, changes species composition and plant chemistry in natural and managed ecosystems, surface water eutrophication, nitrate accumulation in shallow groundwater, enhanced fine particulate matter with diameter smaller than 2.5 μm , global warming and ozone layer depletion, and increased susceptibility of rice plant to pests and diseases. It is not possible to go on increasing application rate of fertilizers because of the socio-environmental side effects and huge burden on Government exchequer on subsidy. India produced 24.5 Mt urea in 2015-16 which accounted 82% of total N consumption, and the remaining 18% was imported.

Realizing the threats, Government

of India has already taken steps to reduce the use of chemical fertilizers. It has a target to reduce urea consumption by 50% till the end of 2022 to reduce soil and environmental pollution. The policy to use *neem* (*Azadirachta indica*) coated urea in place of prilled urea is implemented. The objective is to reduce the quantum of urea use and associated reactive N loss to the environment. Additionally, the quantity of urea fertilizer per bag is reduced from 50 kg to 45 kg. This may help in reduced use of urea by availing psychological advantage, as many farmers apply fertilizers in terms of bags. Some other means to decrease the industrial production and reduce N losses to environment include reasonable changes in diet habit, enhancing N use efficiency and N recycling. In addition, we propose for re-popularization of green manuring for rice crop to substantially reduce the fertilizer consumption in India considering

high acreage and heavy fertilizer use in this important crop.

ADVANTAGES OF *SESBANIA* GREEN MANURING FOR RICE CROP

Crop suitability

Sesbania as a legume cover-cum-green manure crop, fits into the growing environment preceding wet season rice, especially under medium to lowland situations. It has certain advantages as green manure crop.

- i) Nutrient scavenger: *Sesbania* helps to recycle nutrients released from dry tilled soil (after wetting) by capturing through roots. After the long dry season, good amount of N in oxide form is expected to be added from atmosphere (due to combustion of fossil fuels) with the rainfall (<https://water.usgs.gov/edu/nitrogen.html>). Also, by the physical action of lightening, atmospheric inert N₂ is converted to oxide form. Finally, NO₂ reacts with rain water and reaches as HNO₃. *Sesbania* can harvest these benefits and recycle nutrients for rice crop. Also, *Sesbania* as a legume crop adds biologically fixed N in root nodules. These beneficial and conservation agricultural activities can be completed in the fallow period before rice transplanting during mid to end July.
- ii) Low external input needed as the cultural practices are integrated with routine cultivation practices for rice crop: As a traditional practice, soils are open during summer ploughing for control of weeds and other pests using the principle of soil solarization. Seeds of *Sesbania* can be sown on the cloddy field with the expected pre-monsoon showers or at least after receiving early monsoon rainfall. This provides an opportunity to raise green manure-cum-cover crop *Sesbania in-situ*. It acts as cover crop for about 45 to 60 days depending upon the receipt of rainfall and/or sowing time. The green manure crop can be incorporated using rotavator with cage wheel attachment one week

before transplanting rice crop like a routine practice for transplanted rice.

- iii) Fast accumulator of biomass: High biomass yield of 20 to 30 t/ha on fresh weight basis in a short period of 45 to 60 days is reported for this crop.
- iv) Easy decomposition: *Sesbania* is rich in N content (2.1% N on dry weight basis). Succulent tissues of *Sesbania* are known to have high N, protein, and water soluble constituents; and low fiber, hemicelluloses, cellulose and lignin content. These biochemical properties help in fast decomposition. Decomposition rate is fast after incorporation in wet soil, especially in hot humid climate of tropics.
- v) Tolerance to abiotic and biotic stress: *Sesbania* has tolerance to drought, flood and salinity, of course after the critical phase of stand establishment. The crop is hardly affected by pests and diseases as compared to many other field crops. There is high biotic stress load during May to July and fortunately, *Sesbania* is a resistant crop. It is also least preferred by cattle for grazing.

Energy saving in rice cultivation

Using *Sesbania* green manure under integrated nutrient management (INM) practice for rice cultivation reduces the energy input significantly by 23.5% as compared to the conventional practice of rice cultivation using chemical fertilizers (10.2 GJ/ha). The energy input depends primarily on two factors; the quantum of nutrient added especially in terms of N and the energy equivalent of manufacturing it. Manufacture of N fertilizer (through industrial process of fixing atmospheric N₂) is very energy intensive. Energy need is estimated at 60.6 MJ/kg N manufactured. Such needs are 4.8 MJ/kg P and 5.6 MJ/kg K fertilizer. *Sesbania* cultivation did not require additional energy for land preparation, nor for irrigation. Growing of *Sesbania* this way required energy input of only 317.5 MJ/ha towards seed and sowing while the benefit from manurial value

was 2527.2 MJ/ha, when a modest amount of fresh biomass (9.7 t/ha) was harvested. In another experiment, fresh *Sesbania* biomass of 14.3 t/ha was harvested which provided 58.3 kg N, 4.4 kg P and 16.1 kg K/ha, with corresponding energy value of 3532.8, 21.1 and 90.2 MJ/ha, respectively. Thus, with a total energy supply of 3563.1 MJ/ha (3.563 GJ/ha), *Sesbania* green manuring accounted 34.9% of the energy requirement for rice cultivation using chemical fertilizers.

In addition to quantity of energy saved, quality of energy in terms of renewability is important. Renewable energy input was 26% of the total energy input for rice cultivation with the conventional practice of using chemical fertilizers as source of plant nutrient. For the cultivation practice using INM, renewable energy accounted 38% of the energy input while it was 69% in case of the organic nutrient management. The share of renewable energy was increased due to *Sesbania* green manuring and associated saving in chemical fertilizers. This indicates sustainability of the organic nutrient management or at least the INM practice using *Sesbania* green manure as compared to the use of chemical fertilizers in rice cultivation. The dependence on natural gas for fertilizer production can be reduced by *Sesbania* green manuring.

Economics

Cost of vermicompost N was estimated as INR (Indian rupees) 318.9/kg N as compared to urea N (INR 14.1/kg N as per the prevailing market price with subsidy). However, *Sesbania* green manure N (INR 2.4/kg N) was 5.9 times cheaper than urea N. For six years (2010 to 2012 and 2015 to 2017) study, a mean supply of 50.0 kg N, 3.6 kg P and 13.6 kg K/ha is reported (Rautaray, 2019). This amounts to 62.5% of N, 3.9% of P and 28.2% of K recommendation for irrigated high yielding variety of paddy in wet season. For the base year 2015-16, the cost of 50.0 kg N, 3.6 kg P and 13.6 kg K is INR 1,613/ha if met using urea, di-ammonium phosphate and muriate of potash at subsidized

rate decided by the Government of India. As per the nutrient based subsidy provided by the Government, the amount of subsidy for the saved quantity of nutrient is INR 1,324/ha. Thus, the cost of saved fertilizer would be INR 2,937/ha, had there not been subsidy by the Government. In addition to manurial value, it saved on weeding cost. Thus, incentive of INR 1,324/ha by Government (by diverting the subsidy amount as incentive) would help farmers to grow *Sesbania* and thereby save INR 2,937/ha towards fertilizer cost.

Weed management

Sesbania as green manure-cum-cover crop suppresses weeds due to smothering action during pre-rice period. *Sesbania* seeds germinate fast as compared to many weed species. A rainfall amount of 40 mm within a short span of 48 to 72 hours is enough for early germination and quick stand establishment. The legume crop with inherent N fixing ability has the advantage of growing fast and smothering weeds. However, for availing such benefit, proper sowing time is important to get a healthy stand of the green manure crop, early in the season. The weed problem is less in the early growth period of rice crop possibly due to allelopathic effect. With the decomposition of green manure, plant nutrients are readily available to rice crop. This helps rice plant to close the canopy early and, thereby suppression of late stage weed population is facilitated.

Soil Properties

There was build-up of organic C, available N and P content in soil over the cropping seasons with INM involving *Sesbania* green manure and chemical fertilizers. Such build up was more for the organic nutrient management involving *Sesbania* green manure (59 kg N) and vermicompost (21 kg N).

Reduction in Carbon foot print due to fertilizer saving

In China, coal based urea production results in carbon foot print of 6.53 kg CO₂ equivalents per

kg N manufactured. For natural gas based urea production system, 4.14 kg CO₂ equivalents produced per kg N manufactured (Fertilizer Europe (2016) for the production year 2014). Considering a modest amount of 50 kg N saved due to green manuring in 1 ha, reduction in carbon foot print would be 207 kg CO₂ equivalents towards manufacturing using natural gas. Packaging and transportation from factory to field will further enhance carbon foot print value.

Some apprehensions and realities

In the light of so many advantages, the area under green manuring has declined globally. The area under green manuring is less than 5 M ha, mainly concentrated in Asia and Africa. The main reason for decline in area under green manuring is due to easy availability of chemical fertilizers at subsidized rate. Subsidy on fertilizers was introduced for easy accessibility to farmers with the objective of enhancing food production. In developed economies, fertilizer subsidies have essentially disappeared (Agricultural policy monitoring and evaluation-OECD 2019). However, in developing and underdeveloped countries, it is an instrument for enhancing agricultural production and food security. Small and marginal farmers of Asia and Africa are especially in disadvantageous situation to use fertilizers in response to price hike (FAO 2012).

With the increased price of fertilizer due to partial withdrawal of subsidy in developing and under developed countries and increased awareness about the demerits of chemical fertilizers on soil and environment, farmers are discouraged to use fertilizers. We propose to withdraw subsidy on fertilizers, so that farmers will be encouraged to use locally available cheap source of organic nutrients like *Sesbania*. Instead of subsidy, Government should provide incentive to farmers adopting such eco-friendly plant nutrient management practice. This will promote wide use of *Sesbania* green manuring in rice crop and discourage use of chemical fertilizers.

Rainfed rice growing environment is known for inefficient use of N fertilizer and *Sesbania* N is known for higher N use efficiency.

Some farmers, extension workers and scientists have certain apprehensions regarding the wide adoption of *Sesbania* green manure. We have collected information on reservations raised during interaction with rice farmers and extension personnel and some scientists during review meetings. Apprehensions and our view points are described in the following section.

Apprehension 1: It will be difficult for the farmers to arrange Sesbania seeds.

Response: Farmers face difficulty to arrange seeds of important field crops for which seed chain prevails. In this background, it may be difficult to get seeds of a non-commercial crop like *Sesbania* in formal seed chain. However, *Sesbania* can be grown in waste lands, degraded lands, fallow lands, on field bunds and even can be grown as a hedge crop. So, small and marginal farmers can easily produce seeds for own fields. Some farmers grow it as seed crop and are involved in seed production and marketing at low price, particularly in eastern India.

Apprehension 2: Water availability will be a major constraint for growing Sesbania.

Response: The crop is intended to be grown using pre-monsoon showers. After attaining enough biomass accumulation (15-20 t/ha fresh biomass), it is incorporated into the soil during puddling when about 10 to 20 cm water is ponded on the field. This type of situation is expected in shallow lowlands of areas receiving enough pre-monsoon showers. However, in some years, water availability at times may be a constraint under rainfed situations. In intermediate lowlands to deep water situations, when rice crop is direct seeded, dual cropping is feasible by intercropping *Sesbania* after each 2-3 rows of rice crop. Similarly, upland rice crop grown under direct seeding can accommodate sunhemp or *Sesbania* as intercrop for green manure or brown manure purpose.

In these situations both the rice crop and the green manure crop may face water scarcity in some years and provision of life saving irrigation is desired. Land elevation and rainfall analysis for a place will indicate the method of raising wet season rice and the green manure crop.

Apprehension 3: Green manure crop may fail after germination due to dry spell.

Response: Agroadvisory and weather forecasting for an area will guide in finding the favourable period for growing a green manure crop. The type of green manure crop and the method of raising depends on rainfall pattern and land topography. In coastal Odisha, our analysis for the last ten years indicate that in 60% of years, *Sesbania* can be sown in mid to late May. In 40% years, sowing can be delayed to June first week when there is assured soil moisture content in lowlands. Provision of life saving irrigation is the assured way of raising green manure crop.

Apprehension 4: Even after attaining enough biomass, it is difficult to incorporate green manure in time due to dry spell at that stage.

Response: Puddling is required for transplanted rice and ponded water is the pre-requisite for this cultural operation. Optimum transplanting time is mid July and by that time enough water is usually accumulated on field with normal monsoon activity. *Sesbania* roots act as biopores and good amount of water is conserved into the soil. In few years, delayed onset of monsoon may create

the problem of water availability for incorporating *Sesbania*. So, for such adverse situations provision of critical irrigation from water harvesting farm pond or from groundwater is required. In absence of critical irrigation facility, harvest the green manure plants and compost it in a pit for use by rice crop. Otherwise for *in-situ* use, the plants can be killed using a suitable herbicide for use as brown manure.

Apprehension 5: Woody stubbles create problem in field operations during transplanting and weeding.

Response: Allowing the green manure crop beyond 2 months in fields, may lead to development of woody tissues. Subsequently, these woody stubbles/stems may create inconvenience during field operations. So, to avoid this problem, incorporate it at appropriate stage. Due to dry spell, if it is not possible to incorporate in time, then make compost after harvesting at right stage. In worst case, if the crop was over matured and the stem turned woody, cut the crop and keep in heaps. Within 4-5 days, green leaves fall off and are easily composted for use. Stems can be used as fuel wood or for similar uses like jute stick. During land preparation, the woody stubbles can be collected and composted in separate pit with addition of N fertilizer for fast decomposition.

Apprehension 6: Alternative crop can be grown rather than Sesbania green manure crop with low economic benefit

Response: In May-June with very high temperature, very few crops can

be grown with limited water. The crops are damaged easily with polyphagous insect pest as the insect pest load is very high during this period. Among the diseases, yellow vein mosaic is common in legumes and other vegetable crops. *Sesbania* is free from these insect pests and diseases. It easily smothers out the weeds. So, it is a better alternative to grow *Sesbania* as cover-cum-green manure crop, as commercial field crops are difficult to be grown during this period.

SUMMARY

Farmers are concerned about the net benefit from an agricultural practice. They will adopt a technology, when net benefit from the practice is more than the existing practice. Of course, the technology should be user friendly and the profit margin should be reasonably high. Provision of incentive to *Sesbania* growing farmers at INR 1,324 per ha will help in wide adoption of this eco-friendly practice. Considering potential cultivated area of *Sesbania* as green manure in about 20 M ha in irrigated and rainfed lowland ecologies, about 1 Mt N can be saved which corresponds to 9% of annual urea production in India. This will contribute substantially in fulfilling the Government target of reducing urea consumption by 50% till the end of 2022. Beneficial residual effect on soil due to *Sesbania* green manuring may avoid the need of increasing fertilizer application rate.

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