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Review Article

Different Nutrient Management Practices in Rice – Green-Gram Based Cropping Sequence on Productivity and Soil Fertility Status: A Review

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Abstract

Rice-based cropping system is a major food production system in India with rice as the first food crop followed by subsequent cultivation of other crops. The promotion of rice based pulses through various cropping sequence by supplying suitable nutrient management is very necessary. Integrated farming systems seem to be the probable key to the continuous raise of demand for foodstuff and nutrition, income stability and livelihood upliftment particularly for small and minor farmers with small resources. The approach for higher yields in the cropping arrangement should be formulated using the collective application of organics, inorganics and bio fertilizers joined with the inclusion of crops in summer fallows for sustainable yields and conservation of soil health. This review aimed to diversify upland rice through cropping sequence with green gram for improving and stabilizing productivity of rain fed uplands under Jhum field.

Keywords: *Productivity; cropping sequence; nutrient management; jhum field; sustainability.*

Introduction

Rice (*Oryza sativa* L.) is one of the significant staple food crops, which supplies primary source of calories for about 45 per cent of world population, particularly to the people of Asian countries (Bian, *et al*., 2020). Indian economy is mainly agriculture orented and 43.86 million ha of rice is grown here (Balasubramanian, *et al*., 2017). The production level is 104.80 million tones and the productivity is about 2390 kg/ha. It is grown under diverse soil and climatic conditions where the productivity level of rice is low compared to the productivity levels of many countries in the world.

Rice based cropping sequence is the most dominant crop sequence in India (Sravan, *et al*., 2018).Cultivation of rice continuously for a long period with near to the groundlevel of productivity and often with a poor crop management practices, results in loss of soil fertility, decline of soil physical properties, deterioration in factor productivity and crop yields in high productivity areas (Yang, *et al*., 2020; Zhang, *et al*., 2019). Emergence of widespread multi nutrient deficiencies, depletion of native nutrient reserves, imbalanced fertilization is matter of serious concern, causing serious stagnation and declining productivity of various rice ecosystems (Jewel, *et al*., 2019).Therefore, there is generous scope to boost the productivity of rice in the country which would be done byadapted of improved technologies and various interventions (Rahman, *et al*., 2020).

Proper nutrition is essential for satisfactory crop growth production. Presently fertilizer application is based on the nutrient requirement of crops (Buresh, *et al*., 2019). Further, application of inorganic fertilizers

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even in balanced amount cannot sustain the soil fertility and crop productivity under diversified continuous cropping or mono-cropping and as a result of these things agriculture is now facing a lot of stresses (Zhao, *et al*., 2021). Integrated nutrients management involving conjunctive use of organic and inorganic sources of nutrients may improve the soil productivity and moreover, better nutrient management strategies can support the needed future yield increase (Kumar, *et al*., 2019).

Crop diversification through cropping sequence has long been predictable as a kind of biological assurance against risks and unusual rainfall behaviour in dry environment and thereby increases theproductivity, cropping intensity, profitability, optimized utilization of soil, water, nutrients and sunlight (Bowles, *et al*., 2020). Besides increased overall productivity and income, cropping sequence of paddy with legumes helps in nitrogen contents, improving physical properties of soil and building-up of soil fertility(Hossain, *et al*., 2016).Short period legumessuch as green gram/black gram may constitute potential intercrop in upland rice under rainfed condition.(Scalise, *et al*., 2016).Therefore, current review was made to diversify upland rice through cropping sequence with green gram for improving and stabilizing productivity of rainfed uplands under Jhum field.

Nutirent Management on Sustainable Productivity and Soil Fertility

Nutrient management is the method of handling the amount, source, timing, and approachof nutrient use with the goal of optimizing farm productivity while minimizing nutrient losses (Mohanty, *et al*., 2019). Effective nutrient management has played a major role in accomplishing the enormous increase in food production. The major factors on soil fertility status includes nutrient removal through entire crop harvests, uncontrolled soil erosion, low soil organic matter and inherent soil fertility, limited application of appropriate types of fertilizers and inappropriate land management practices (Agegnehu and Amede 2017). Distribution of seasonal rainfall during cropping season, soil fertility status and amount of fertilizer nutrient applied influences the productivity of any rainfed crop.

Moreover, maintaining or improving soil quality is an important part of sustainable crop management. Soil quality refers to the long-term ability of soil to function in order to sustain plant and animal productivity, maintain or enhance water and air quality and support human health and habitation.

Why Use Nutrient Management?

Using soil tests to determine the amount of fertilizer needed for a crop is a basic step of nutrient management. Farmers essentially apply nitrogen (N), phosphorus (P), potassium (K) and other nutrients to attain desired crop growth and yield. However, there possibly negative environmental impacts due to excessive nutrient application. Nutrients that can leach into groundwater and move from agricultural land into surface waters those are not efficiently used by crops or retained in the soil(Buresh, *et al*., 2019). However, excess elements applied to crops can move into surface water with runoff causing nutrient enrichment –eutrophication. Nutrient management consists of several steps:

Analysing the soil samples to determine the nutrient contributing power of the soil,
Testing the recommended quantity of nutrients needed to produce the desired yields,
Accounting for nutrient inputs from other sources, such as legumes,
Analyzing manures, composts, and irrigation water to determine the nutrient content,
Applying manures or composts at recommended rates and based on the critical nutrient (usually either nitrogen or phosphorus),
Applying the additional inorganic nutrients as needed,
Analysing data should be documented, so evaluations and adjustments can be made,

Balanced Fertilization in Agriculture

Use of Imbalanced fertilizer is costly in terms of nutrient loss from soil mining, decline in food supply, loss of soil fertility and land productivity and the resulting decline in food production. Moreover, for successful fertilizer promotion and increased crop production sound soil-test crop response and balanced use of fertilizers based on soil test fertilization is essential(Tian, *et al*., 2020).A strategy for balanced fertilization can be adopted to promote soil building and supporting sustainable land use system which will ensure stable supply of food grains from existing agricultural lands. Moreover, a balanced fertilization is targeted at:

Increasing crop yields and crop quality;
Correction of inherent soil nutrient deficiencies;
Improving soil fertility and productivity;
Avoiding damage to the environment; and
Restoring the soil fertility and productivity of land being degraded by wrong and exploitative activities in the past.

Plant Nutrient Balance System

The continuous recycling of nutrients in to and out of the soil is known as the nutrient balance, which involves complex biological and chemical interactions. The nutrient balance system has two parts: inputs that add plant nutrients to the soil and outputs that export them from the soil largely in the form of agricultural products (Mo, *et al*., 2017).Essential input sources involve inorganic fertilizers; organic fertilizers such as manure, plant residues, and cover crops; nitrogen generated by leguminous plants; and atmospheric nitrogen deposition. Nutrients are exported from the field through harvested crops and crop residues, as well as through leaching, atmospheric volatilization, and erosion. The difference between the volume of inputs and outputs constitutes the nutrient balance (Zhang, *et al*., 2016). Positive nutrient balance in the soils (occurring when nutrient additions to the soil are greater than the nutrients removed from the soil) indicatesthat farming systems are ineffective and in the extreme, that they may be polluting the environment. Negative balance is the indication of soils being mined and that farming systems are unsustainable in the long-term. In case of negative nutrient balance, nutrients have to be replaced to sustain agricultural outputs and to provide soil fertility for future.

However, the most logical way to raise the total production by targeting high yield with a high cropping intensity from the country's limited resources. In intensive farming, neither the chemical fertilizers nor the organic and biological sources alone can attainthe production sustainability as the nutrient turnover in soil plant system is considerably high (Yang, *et al*., 2020b). Even with balanced use of chemical fertilizers high yield level could not be maintained over the years because of deterioration in soil physical and biological environments due to low organic matter content in soils. In this context and as a further response to economic recession, and also to conserve and improve soil fertility the concept of Integrated Nutrient Management (INM) system has been adopted

Concept of Integrated Nutrient Management

The Integrated Nutrient Management (INM) is the maintenance of soil fertility for sustaining increased crop productivity through optimizing all possible sources, organic and inorganic, of plant nutrients required for crop growth and quality in an integrated manner, appropriate to each cropping system and farming situation in its ecological, social and economic possibilities (Kumar, *et al*., 2019).

The basic concept underlying the principles of INM is to integrate all sources of plant nutrients and also all improved crop production technologies into a productive agricultural system. In other words, integrated nutrient management intended to maintain the soil fertility and plant nutrient supply to an optimum level for sustaining the requiredcrop productivity through optimization of the benefits from all possible sources of plant nutrients in an integrated manner (Alagappan, *et al*., 2016). Therefore, it is a holistic approach, where we first know what exactly is required by the plant for an optimum level of production, in what different forms these nutrients should be applied to soil and best possible timings and how best these forms can be integrated to get the highest productive efficiency on the economically acceptable limits and also environment friendly. One characteristic of the INM is that the fertilizer recommendation should take into account the cropping system as a whole rather than individual crop in the system. This aspect is particularly important in case of phosphorous where the percentage utilization by the crop to which it is applied is rather low and where there is residual effect to benefit the following crop (Mohanty, *et al*., 2020).Similarly, the contribution of nitrogen in legume crops on the cropping system will have to be considered. Besides, some crops show selective uptake of some specific elements. Moreover, nutrients supplied from other sources should be accounted for making up the gap between the recommended and actual levels of fertilizer application.

Jhum Cultivation

The word Jhum or Podu means shifting or slash and burn cultivation is a local name for slash and burn agriculture practiced by the tribal groups in India like Arunachal Pradesh, Meghalaya, Mizoram and Nagaland(Bose, 2019). It is one of the oldest practices of agriculture systems which involves clearing a piece of land by setting fire and using the area for growing crops of agricultural importance such as upland rice, vegetables or fruits (Pandey, *et al*., 2020). In this system, a patch of forest land is cleared by cutting trees, shrubs, bushes. During May and June, the entire field is set on fire, allowing the dried trees, shrubs and bushes to burn and the land is ploughed immediately after the first shower. It is believed that doing so improves the soil quality. Grains are sown before the arrival of monsoon. All sort of indigenous seeds, including cereals, pulses, vegetables and oilseeds are just broadcasted and harvested periodically one after another. Interestingly enough, once a patch of land is cultivated, they move to another piece of land in the next year, and the cycle continues.

Cropping Sequence

Sequential cropping is a form of multiple cropping in which paddy is grown in sequence on the same field, with the succeeding crop planted after the harvest of the preceding crop. The choice of crops and cropping sequence is retardate by the movement of soluble nitrogen through the soil profile and ultimately into the groundwater and help to restore the soil fertility(Yang, *et al*., 2020b).Aggressive land uses system with continuous growing of similar crops on the same land largely affect soil physical condition, crop development and had big concerns on long term adverse effects of environmental pollution. The choice of sequence is highly based on agricultural system, finance and environmental condition. Conventional monoculture agricultural systems can decrease the soil organic matter contents and structures. Accumulation of crop residues with frequent addition of pulse crops in a rotation is vital to improve the biochemical and physical properties of the soil via increasing the labile of organic matter. Surface residue of crops is one of the most effective erosion control measures for increasing the soil moisture content(Babu, *et al*., 2020). Different crops have different growth and development periods thus, one crop may provide protection from erosive forces during a period of the year and the other may not. Besides, crop rotation combined with different management practices are essential for improving the physical, chemical, biological properties of the soil and thereby control erosion and to maximize crop yield by maintaining soil moisture and control disease and pests infestation.

Rice-based sequence cropping systems as follows:
Rice-rice (eg; Jhum paddy sown in the onset of monsoon followed by rabi season rice).
Rice-groundnut (eg; Jhum paddy sown in the month of February-March and harvested in the month of July and August followed by cultivation of groundnut.).
Rice-pulses (eg; Jhum rice followed by pulses like green gram, soybean, french bean, beans etc).
Rice-fallow (eg; After Jhum rice cultivation field is kept fallow for 2-3 years).
Rice-vegetables (eg; Jhum rice field followed by leafy vegetables like mustard).
Rice-maize (eg; Jhum rice cultivation followed by local maize).

Mixed Cropping

Growing of two or more crops simultaneously and mixed together without row arrangements, where there is significant amount of intercrop competition. (eg;Growing rice + maize + cucumber + tapioca)

Mono-Cropping System

A system of cultivation in which a paddy (rice-rice) is grown over a large area of land often for several years. (eg;Wet terrace rice cultivation)

Ratooning

One of the important methods of intensive cropping, allowing the stubbles of paddy crop to come out again after harvesting and to raise another crop. Rice ratoon cropping system offer considerable increase in rice production and utilizing seasonally idle land and labour as well as residual moisture in the hilly region(Roge, *et al*., 2016). (eg;Growing of green gram right after harvest of rice field and utilize the stubbles of rice field for residual moisture and nutrient conservation)

Relay Planting

Relay Cropping is done where seeds of pulses singly or in mixtures were broadcasted in standing paddy field 21 days before the harvesting of rice, after draining out of standing water. After the harvesting of main paddy crop, the seeds broadcasted in the standing paddy crop continue to grow till the harvesting by utilizing residual moisture and residual nutrients. The seed of succeeding crops like lentil, gram, pea, etc. is sown broadcast in maturing rice crop. This practice saves time; money (to be spent on land preparation etc.),besides utilizing residual fertility. This practice is common in both upland and lowland rice culture. The second crop is planted into an established stand of a main crop. The second crop develops fully after the main crop is harvested. (eg;Growing of short duration crops like soybean and pea in the standing Jhum rice field)

Intercropping System

Intercropping is the system of simultaneously growing two or more crops on the same land area with a definite row arrangement. However, it is very much important to ensure that component crops do not compete with each other for space, moisture, nutrients, and solar radiation (Ning, *et al*., 2017). Cereals with legume intercropping provides a greater scope for minimizing the adverse impact of moisture and nutrient stress in addition to improving system productivity and soil health. Researchers reported significant improvement of system productivity in intercropping besides supplying diversified food. By improving chemical, biological, and physical environment in the soil, legumes can check the declining productivity of cereal-based cropping system. It is important to identify the best intercrops and to assess appropriate doses of nitrogen (N) for the cereal components in intercropping systems considering the sparing effect of biological nitrogen fixation (BNF) from the leguminous component(Kang, *et al*., 2020).A number of indices such as land equivalent ratio, crop equivalent yield, relative crowding coefficient, competition ratio, actual yield loss, etc. have been recommended to assess the competition between cereal and legume intercrops and advantage of intercropping compared to sole cropping. Although there are some constraints for practicing cereal with legume intercropping systems in large scales like limited availability of good-quality seeds, biofertilizers, and technical and proper scientific knowledge for the complex intercropping system, there is a very good potential to increase the productivity and profitability from resource-poor agricultural systems by adopting this system besides reducing farmers' risks and improving the soil quality in the long term.(eg;Growing of Jhum rice field intercropped with the soybean/beans).

Shifting cultivation (SC) is one of the main forms of crop husbandry in North Eastern Region (NER) of India and it is locally known as *Jhuming* where as the cultivators are known as *Jhumias*. SC in its more traditional and integrated form is ecologically and economically viable system of agriculture as long as the population densities are low and *Jhum* fallow cycles are long enough to maintain soil health including fertility(Pandey, *et al*., 2020). In NER, though total area under SC has been decreasing, yet, the major concern is the shrinking of fallow periods from the earlier practice of 10-15 years to the present one of 2-3 years. In north eastern region of India an estimated 1.47 million hectares of land is under shifting cultivation and about 0.44 million tribal families are dependent on this for their livelihood (Yadav, 2013).

Recently, Babu, *et al*., (2020) studied an alternative cropping system to widely prevalent rice-fallow production system in Himalayan region of India, seven cropping sequences viz., rice - fenugreek (green vegetable) - maize (R-F-M); rice -vegetable pea - maize (R-Vp-M); rice coriander (leaves)-cowpea (R-C-Cp); rice - fenugreek (green vegetable) - baby corn (R-F-Bc); rice - broccoli - Sesbania (green manuring) (R-B-S); rice - buckwheat (R-Bw) and rice - maize (R-M) were assessed for five consecutive years from 2013 to 2018 for their productivity and resource conservation values. Results revealed that the inclusion of legumes in rice-based sequences increased the rice grain yield by 13.4 to 24.6% over R-M (3.13 Mg ha^{-1}) sequence.

Nagaland being an agrarian state with over 71% of its population living in rural areas, they depend primarily on agriculture sector for their livelihood. Majority of the farmers practices shifting cultivation which accounts for about 73% of the net cropped area. This traditional system of farming meets the basic needs for food, fuel and housing materials to make subsistence living. The other system of wet terrace rice cultivation (WTRC) accounts for about 27% of net cropped area only.

Rice is most important crop in *Jhum* field of Longleng district of Nagaland. About 12% of the total geographical area of the district is under *Jhum* rice. Rice cultivation in the region has been predominantly a subsistence occupation with little or no emphasis on commercial approach. Mixed cropping is practiced in *Jhum* farming where rice is predominant crop. Rice productivity in *Jhum* is very low 1.6 t mainly due to poor cultivation practices, no input cultivation, lack of soil and water conservation measures, use of low yielding varieties etc. Rice is cultivated during February-March to July-August leaving rest of the period of the year as fallow. Whereas the rainfall in the region continues up to the end of October and residual moisture remains in the field till December. Thus, there is potential for growing a *pre-rabi* crop for which would increase cropping intensity, per unit productivity and income of the *Jhumias* (National Seminar on Sustaining Hill Agriculture in Changing Climate-2015, Agartala, Tripura).

India is the highest producer as well as consumer of pulses in the world and contributes about25.5% of total global pulse production (GOI, 2013). The pre-rabi crop Green gram (*Vigna radiata* L.) is the third important pulse crop of India grown in nearly 8 per cent of the total pulse area of the country. In Nagaland, green gram is cultivated in an area of 350 ha with a production of 350 MT and productivity of only 1000 kg/ha (Statistical Handbook of Nagaland-2015). It is grown mainly in pre-rabi seasons after harvest of rice. Rice-green gram cropping system is the most important cropping system which could enhance the crop productivity as well as sustain the soil fertility to the optimum level in the subsequent year.

Rice is usually grown in N-deficient soils, and this element must be supplied to the field by commercially available N fertilizers. However, a considerable amount of urea-N or NO_3-N applied as fertilizers is lost through different mechanisms, thus causing environmental pollution problems. Application of biological N-fixation technology can reduce N fertilizer application and reduce environmental risks. This process can contribute as much as 75 kg N ha^{-1} per crop cycle with means of 8 to 30 kg N ha^{-1} (Irissarri and Reinhold-Hurek, 2001). These N-fixing bacteria may be free-living or naturally associated to rice plants.

Singh, *et al*., (2001) reported that increase in rice production in different states of the region was mainly due to improvement in yield rather than area expansion. Among the various factors, availability of irrigation facilities, adoption of high yielding varieties (HYV) of rice, rate of fertilizer used, farm size and credit availability experienced great impact on rice productivity of the region.

Shukla, *et al*., (2004) result revealed that emergence of widespread multi nutrient deficiencies, depletion of native nutrient reserves, imbalanced fertilization are matter of serious concern, causing serious stagnation and declining productivity of various rice ecosystems.

Rathore and Bhatt (2008), An experiment was conducted during 2004-07 to establish integrated farming systems in *jhum* (slash and burn agriculture) field in Peren district of Nagaland to findsuitable combination of crops and livestock for better economic return and employment opportunities. Seven cropping systems were tested and integrated in different farming systems. The rice, vegetable pea and beans cropping system were most suitable under *jhum* land of Nagaland.

Narendra Pandey, *et al*., (2010) field experiment was conducted to study the performance of hybrid rice to scheduling of irrigation and nitrogen level. Nitrogen scheduling of 40+20+30+10 percent at basal, active tillering, panicle initiation and flowering reduced the sterility percentage and increased effective tillers and grain yield of hybrid rice. Irrigation, one day after disappearance of water proved as good as continuous submergence for yield components, grain yield and N content in stem and leaf at early stages, flag leaf, grain and straw. The irrigation schedule of one day after disappearance of pond water required 604 mm less irrigation water than that of maintaining continuous submergence.

Porpavai (2011) reported that the cropping systems were evaluated for their productivity, and to assess their effect on the soil organic carbon content and soil available nitrogen. Incorporation of legumes in the cropping system improved the organic carbon status of the soil. The cropping systems rice (*Oryza sativa*) – rice – blackgram (*Vigna mungo*), onion (*Allium cepa*) – rice – blackgram, groundnut (*Arachis hypogea*)– rice – blackgram and rice – rice – greengram, (*Vigna radiata)*enhancedthe soil organic carbon content and soil available N status. Inclusion of blackgram and greengram in rice based cropping system increased the yield of succeeding crop of rice.

Lakshmi, *et al*., (2012) reported that grain and seed yields of rice and green gram were higher with INM practices, especially when vegetable market waste compost was applied. Production efficiency of rice increased with reduced chemical fertilizer levels and highest production efficiency was recorded with 50 % chemical fertilizers integrated with vermicompost's over 75 % chemical fertilizers integrated with vermicompost's. The nitrogen use efficiency with application of 75 % chemical fertilizers + weed vermicompost @ 2.5 t/ha was better than other combinations closely followed by 50 % RDF + 50 % prathista organics. Lowest production efficiency was recorded with 100 % chemical fertilizers alone. Highest profitable treatment in both the crops and in both fertilizer and without fertilizer effects was 75 % chemical fertilizers + vegetable market waste vermicompost @ 2.5 t/ha.

Ali (2012) results showed that the green manuring and leguminous cropping patterns gave higher paddy yield as compared to commonly practiced rice-wheat cropping pattern. The maximum paddy yield of rice (3.73 t/ha) was obtained from rice-wheat-sesbania cropping pattern where sesbania was sown and incorporated in the soil as green manuring crop just before rice transplanting. This increase in paddy yield was statistically at par with the paddy yields received from rice wheat-mungbean (3.52 t/ha) and rice-berseem (3.52 t/ha) cropping pattern. The yield of succeeding wheat crop was also higher in case of green manuring and leguminous crops (mungbean and cowpeas), yielding 2.81, 2.69 and 2.63 t/ha respectively Krishnakumar and Stephan Haefele (2013) reported that the application of N at 90 kg level as 50% through RSC + 50% N as PM registered higher available N, P and K contents of soil during different growth stages as compared to the other treatment combinations including recommended NPK fertilizers. The growth and yield attributes were also found to be improved by the above treatment resulting in more grain and straw yield.

Yadav (2013) reported that in north eastern region of India an estimated 1.47 million hectares of land is under shifting cultivation and about 0.44 million tribal families are dependent on this for their livelihood.

Sourov, *et al*., (2014) reported that the pooled data revealed that integrated source of nutrients (combination of inorganic and organic sources) applied @125% recommended doses (RD) increased the yield of rice by 32.5%, potato by 81.5% and green gram by 47.3%, over the inorganic source applied @ 75% RD, under Common practice. The maximum uptake of N, P and K by rice (114, 19 and 67.5 kg/ha respectively), potato (174, 18 and 187 kg ha-1, respectively) and green gram (78, 14.8 and 35 kg ha-1, respectively) was observed at 125% RD applied through integrated source. Pooled data over three years showed that conjoint use of chemical fertilizers and FYM has significantly improved the soil organic carbon by 17.07%, and available N, P, K and moisture content by 12.9%, 10.3%, 8.89% and 7.82%, respectively, over the inorganic fertilizer alone. It can be concluded that in this red and lateritic zone NPK should be applied at 125% of RD for each crop; half of this through inorganic fertilizer and the rest amount through FYM for increasing the productivity of the cropping sequence as well as sustaining the soil fertility.

Mohanty, *et al*.,and his co-workerconducteda field experiment to study the residual effect of three rice establishment methods (SRI, drum seeding and conventional transplanting) with three nutrient management practices [RDF (80:40:40 N: P2O5: K2O kg ha-1), 50% R.D.F. + 50% R.D.F. through organic sources (based on nitrogen requirement) i.e. INM and 100% RDF through organic management (OM)] and direct effect of three nutrient management practices viz. RDF (20:40:40 N: P2O5: K2O kg ha-1), 50% RDF + Biofertlizer (BF) and no fertilizer on energetics of green gram in a rice-green gram cropping system during rabi seasons of 2009-10 and 2010–11. The design was split plot in kharif and split-split plot in rabi with treatments replicated thrice. Methods of rice establishment did not influence the yield and energetics of subsequent green gram. Residual effect of sole organic nutrient management being at par with integrated nutrient management came out to be the best in terms of yield and energy indices like energy output, energy productivity and energy ratio. 50% RDF + BF application to green gram recorded the highest seed yield (930 kg ha -1). This treatment also recorded the highest energy output (55.7 MJx103), energy productivity (247.3 Kg/MJ x 103) and energy ratio (14.81).

Alagappan and Venkitaswamy (2015) reported that the organic treatments were compared with the recommended dose of fertilizer (RDF) and integrated nutrient management practice (RDF + Dhaincha @ 6.25 t ha^{-1}). INM imposed treatment performed better followed by TRRI practice. Among the organic treatments, TRRI practice followed by 100% RDN through green manure recorded more number of productive tillers m^{-2}, dry matter production, grain and straw yield of rice. The RDF treatment performed better than all the organic treatments except the TRRI practice in both the years of experimentation.

Mohanty, *et al*., (2015) reported that method of rice establishment did not influence the performance of subsequent green gram. OM in rice being at par with INM exhibited the highest yield (852 kg/ha), net return (Rs. 23554 per ha) and return per Rs invested (2.56). 50% RDF+BF application to green gram increased seed yield (930 kg/ha) by 10.7 and 64.9% over RDF and no fertilizer, respectively. It also recorded the highest nutrient uptake and harvest index, net return (Rs. 26980 per ha) and return per Rs. invested (2.80).

Desai, *et al*., (2016) reported that the ten rice based cropping systems were evaluated for production potential in randomized block design with three replications. In pooled results, treatment T_6 rice - sorghum (G) –sorghum ratoon (G) recorded significantly higher paddy equivalent yield (134886 kg/ha) which was at par with treatment T_3 (13095 kg/ha), T_9 (12463kg /ha), T_7 (12379 kg/ha) and T_2 (12273 kg/ha). The minimum PEY were recorded under T_1: Rice- wheat: fallow in all experimental years as well as in pooled. Highest net return/ha was recorded in treatment T_6 rice-sorghum (G) –ratoon sorghum (G). The BCR value was highest under T_6 (2.38) followed by T_7 (1.95). The highest employment generation (397 men days/year) was recorded in Rice - green gram – groundnut cropping system (T_3).

In the hilly northeast India, shifting cultivation is one of the main forms of crop husbandry and is known to change the physico-chemical properties of soil (Zodinpuii, *et al*., 2016) and it has positive significant effect on soil organic carbon content. Moreover, Zodinpuii, *et al*., reported that comparing to pre- and post-Jhum cultivation, the Two-Way ANOVA indicates significant increase of soil organic carbon ($p<0.05$) in the jhum cultivation intervals between 2013 and 2015. The average of SOC in the surface layer increased from first year to third year by 1.34%. However, significant decreased of SOC content with increased in soil depth ($p<0.001$) was also recorded in both EXPTL and CTRL sites.

Alagappa, *et al*., (2016) reported that the gross return per hectare during 2012- 2013, extended with high rated for the rice-green gram cropping sequence. Higher gross return and net return were associated with the Integrated nutrient management (INM) treatment and it was corresponded to that observed with T5 *viz*., 100% RDN through green manure (T). The INM treatment (T) recorded with the grain yield of 6270 kgha-114 and the higher gross return (1,17,175) and net return (70,690) and which was comparable with 100% RDN through green manure (T) with the grain yield of 5140 kg ha^{-1} and the gross return of 1,15,380 and the net return of 69,340 respectively. The lowest gross return was registered with the absolute control (T) (63,817) and net return (32,385) with the grain yield of 3602 and 3646 kg ha during the cropping sequence 2013-2014.

Mahunta, *et al*., (2017) reported that the residual effect of nutrient management practices of rice significantly influenced the primary branches of greengram. Application of organic sources both as sole and combination produced significantly more no of number of branches in both the years as well as in pooled analysis over RDF and control. As per the pooled data analysis the highest number of nodules per plant was observed in T10 (50% RDN from VC+50% RDN from GLM) i.e. 21.2. As per the pooled data analysis the highest dry matter was observed in T10 i.e. 374 g/m 2 which was significantly differing from other treatments and lowest was observed in T 1 Control (No fertilizer applied) i.e. 222.5 g/m Number of pods per plant was highest for the treatment T10 i.e. 17.5 which was significantly different from other treatments and lowest was observed in T1-Control (No fertilizer applied) i.e. 10. The number of seeds per pods was highest for the treatment T10 i.e. 11.5 which was significantly different from other treatments and lowest was observed in T1-Control (No fertilizer applied) i.e. 8.97.

Lal, *et al*., (2017) result revealed that dry season crops following short duration rice cultivars performed better in terms of grain yield. In the dry season, toria was profitable when sown earlier and if sowing was delayed green gram was suitable. Highest system productivity and profitability under timely sown rice may be due to higher dry matter remobilization from source to sink. A significant correlation was observed between biomass production and grain yield. We infer that late transplanting decrease the tiller occurrence and assimilate remobilization efficiency, which may be responsible for the reduced grain yield.

Future Perspectives

The adoption of any technology in modern agriculture can be acceptable and adoptable by farmers only if it is economically viable. Future research should focus on problems for non-adoption of these technologies by farmers and find out suitable ways for their adoption. Next, the adoption of summer/pre *kharif* crops instead of leaving land fallow, which could be made possible through best suited cultivars, seed availability, reducing production cost and optimizing production technologies is of high interest. Research must be initiated considering farmers' voluntary participation, identifying the farmer's problems and develop the location-specific technologies by finding ways for easy integration. The new varieties or species of green manure/grain legume crops should be developed that has multiple uses such as fodder, feed, fuel, and other commercial products. The interaction between mineral fertilizers, organics and nitrogen fixing organisms needs further study as a way of achieving better integration of the nutrition systems for different crops.

Conclusion

Cereal-based cropping system is the most promising system for about 70% of the global population. It could be concluded that green gram is an viable option for growing in residual soil moisture just after harvesting of jhum rice but also in all the jhum land where similar climate is existing for getting additional income of the farmers and also enhance the soil fertility status which ultimately increase the yield of succeeding rice/green gram crop and also intercropping Jhum rice with the soybean. In facilitating proper management and use of nutrient resources, there is also a need to create strong collective action at national, regional and local levels.The reduction in the use of chemical fertilizers and balanced supply of nutrients in an integrated manner through inorganics, organics and biofertilizers will enhance the yield and soil fertility.

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