Sesbania aculeata a Cost Effective Alternative to Enhance the Soil Health and Productivity of Rice-Wheat System

Akhilesh Sah

ABSTRACT

Background: Cereal based cropping systems are predominantly followed in south Asia because of higher productivity and profitability and ensuring food security. Rice is grown once a year in rotation mainly with wheat. Continuous cultivation of rice results in the formation of a hard pan below the ploughing layer, which may act as a barrier to normal root growth of the subsequent wheat crop. Consequently, soil bulk density is increased and hydraulic conductivity is reduced thus leading to non-conducive soil physical characteristics for the subsequent wheat crop. To reduce these ill effects, FYM is used as organic source. But live stock population is not increasing in the ratio as it is required to meet the FYM demand. Organic source requirement cannot meet through use of FYM in rice-wheat system, which is vital for food security point of view. There is need of alternate cost effective source of FYM which could enhance the soil health as well as productivity of rice-wheat system. The present study aimed to see the efficacy of growing green manure crop (Sesbania aculeata) as an alternative of FYM in the rice-wheat rotation.

Methods: In this experiment conducted during kharif and rabi seasons of 2014-15 and 2015-16 in on-going long term permanent manorial trial since 1984 at research farm (Bihar Agricultural University, Sabour, Bihar, India), twelve treatments were taken under RBD in four replications. Observations and analysis were carried out by following the standard procedures.

Result: The present investigation showed that combination of inorganic fertilizer and Sesbania aculeata helped in increasing yield as well as improving soil health. Sesbania aculeata can be used as a viable and cost effective alternative through partial substitution of inorganic fertilizers to enhance the soil health and productivity of rice-wheat system.

Key words: Economics, Rice-wheat system, Sesbania aculeata, Soil properties, Yield.

INTRODUCTION

Cereal based cropping systems are predominantly followed in south Asia because of higher productivity and profitability and ensuring food security. Rice is grown once a year in rotation mainly with wheat. Continuous cultivation of rice results in the formation of a hard pan below the ploughing layer, which may act as a barrier to normal root growth of the subsequent wheat crop. Consequently, soil bulk density is increased and hydraulic conductivity is reduced thus leading to non-conducive soil physical characteristics for the subsequent wheat crop (Gangola et al., 2012). To reduce these ill effects, FYM is used as organic source. But live stock population is not increasing in the ratio as it is required to meet the FYM demand. During 19th Live Stock Census (2012), total live stock population (512.06 million) was 3.5% lesser in comparison to 2007 (529.70 million). Thus, organic source requirement cannot meet through use of FYM in rice-wheat system, which is vital for food security point of view. There is need of alternate cost effective source of FYM which could enhance the soil health as well as productivity of rice-wheat system. The present study was, therefore, undertaken to see the efficacy of growing green manure crop (Sesbania aculeata) as an alternative of FYM in the rice-wheat rotation.

MATERIALS AND METHODS

A field experiment was conducted during kharif and rabi seasons of two consecutive years, 2014-15 and 2015-16 in on-going long term permanent manorial trial since 1984 at research farm (Bihar Agricultural University, Sabour, Bihar, India). The experiment was laid under RBD in four replications. Net plot size was 7.5 m x 4.35 m for rice and 7.5 m x 4.15 m for wheat. FYM and wheat straw were used in the experiment. For green manuring 50 days old succulent crop of Sesbania aculeata (Dhaincha) was used from which available N 194 (kg/ha), P 23 (kg/ha) and K 155 (kg/ha) helped in increasing yield as well as improving soil health. Sesbania aculeata can be used as a viable and cost effective alternative through partial substitution of inorganic fertilizers to enhance the soil health and productivity of rice-wheat system.

Background: Cereal based cropping systems are predominantly followed in south Asia because of higher productivity and profitability and ensuring food security. Rice is grown once a year in rotation mainly with wheat. Continuous cultivation of rice results in the formation of a hard pan below the ploughing layer, which may act as a barrier to normal root growth of the subsequent wheat crop. Consequently, soil bulk density is increased and hydraulic conductivity is reduced thus leading to non-conducive soil physical characteristics for the subsequent wheat crop. To reduce these ill effects, FYM is used as organic source. But live stock population is not increasing in the ratio as it is required to meet the FYM demand. Organic source requirement cannot meet through use of FYM in rice-wheat system, which is vital for food security point of view. There is need of alternate cost effective source of FYM which could enhance the soil health as well as productivity of rice-wheat system. The present study aimed to see the efficacy of growing green manure crop (Sesbania aculeata) as an alternative of FYM in the rice-wheat rotation.

Methods: In this experiment conducted during kharif and rabi seasons of 2014-15 and 2015-16 in on-going long term permanent manorial trial since 1984 at research farm (Bihar Agricultural University, Sabour, Bihar, India), twelve treatments were taken under RBD in four replications. Observations and analysis were carried out by following the standard procedures.

Result: The present investigation showed that combination of inorganic fertilizer and Sesbania aculeata helped in increasing yield as well as improving soil health. Sesbania aculeata can be used as a viable and cost effective alternative through partial substitution of inorganic fertilizers to enhance the soil health and productivity of rice-wheat system.

Key words: Economics, Rice-wheat system, Sesbania aculeata, Soil properties, Yield.

INTRODUCTION

Cereal based cropping systems are predominantly followed in south Asia because of higher productivity and profitability and ensuring food security. Rice is grown once a year in rotation mainly with wheat. Continuous cultivation of rice results in the formation of a hard pan below the ploughing layer, which may act as a barrier to normal root growth of the subsequent wheat crop. Consequently, soil bulk density is increased and hydraulic conductivity is reduced thus leading to non-conducive soil physical characteristics for the subsequent wheat crop. To reduce these ill effects, FYM is used as organic source. But live stock population is not increasing in the ratio as it is required to meet the FYM demand. Organic source requirement cannot meet through use of FYM in rice-wheat system, which is vital for food security point of view. There is need of alternate cost effective source of FYM which could enhance the soil health as well as productivity of rice-wheat system. The present study aimed to see the efficacy of growing green manure crop (Sesbania aculeata) as an alternative of FYM in the rice-wheat rotation.

Methods: In this experiment conducted during kharif and rabi seasons of 2014-15 and 2015-16 in on-going long term permanent manorial trial since 1984 at research farm (Bihar Agricultural University, Sabour, Bihar, India), twelve treatments were taken under RBD in four replications. Observations and analysis were carried out by following the standard procedures.

Result: The present investigation showed that combination of inorganic fertilizer and Sesbania aculeata helped in increasing yield as well as improving soil health. Sesbania aculeata can be used as a viable and cost effective alternative through partial substitution of inorganic fertilizers to enhance the soil health and productivity of rice-wheat system.

Key words: Economics, Rice-wheat system, Sesbania aculeata, Soil properties, Yield.
**Table 1: Effect of Sesbania aculeata practice on yield.**

| Treatments | Rice | Grain yield (kg ha⁻¹) | REY (kg ha⁻¹) |
|------------|------|----------------------|---------------|
|            |      | Wheat                |               |
|            |      | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| T₁         | N₀P₀K₀ | N₀P₀K₀ | 935  | 906  | 920  | 771  | 751  | 761  | 2112.00 | 2033.00 | 2072 |
| T₂         | 50% RDF | N₀P₀K₀ | 2759 | 2702 | 2730 | 1976 | 1952 | 1964 | 5774.00 | 5629.00 | 5701 |
| T₃         | 50% RDF | N₀P₀K₀ | 2782 | 2743 | 2762 | 3719 | 3585 | 3638 | 8458.00 | 8081.00 | 8269 |
| T₄         | 75% RDF | N₀P₀K₀ | 3601 | 3542 | 3571 | 3028 | 2932 | 2986 | 8233.00 | 7939.00 | 8086 |
| T₅         | 100% RDF | N₀P₀K₀ | 4912 | 4875 | 4893 | 3904 | 3855 | 3879 | 10870.00 | 10658.00 | 10764 |
| T₆         | 50% N through FYM + 50% RDF | N₀P₀K₀ | 5510 | 5615 | 5562 | 4345 | 4410 | 4377 | 12142.00 | 12229.00 | 12185 |
| T₇         | 25% N through FYM + 75% RDF | N₀P₀K₀ | 5046 | 5210 | 5128 | 3976 | 4000 | 3988 | 11114.00 | 11210.00 | 11162 |
| T₈         | 50% N through WS + 50% RDF | N₀P₀K₀ | 5280 | 5442 | 5361 | 4080 | 4096 | 4088 | 11507.00 | 11586.00 | 11546 |
| T₉         | 25% N through WS + 75% RDF | N₀P₀K₀ | 4985 | 4927 | 4946 | 3896 | 3928 | 3912 | 10911.00 | 10818.00 | 10864 |
| T₁₀        | 50% N through GM + 50% RDF | N₀P₀K₀ | 5479 | 5506 | 5492 | 4289 | 4305 | 4297 | 12025.00 | 11964.00 | 11994 |
| T₁₁        | 25% N through GM + 75% RDF | N₀P₀K₀ | 5027 | 5185 | 5106 | 3968 | 3976 | 3972 | 11083.00 | 11149.00 | 11116 |
| T₁₂        | FP (N₀P₀K₀) | FP (N₀P₀K₀) | 3272 | 3248 | 3260 | 2651 | 2522 | 2586 | 7318.00 | 7031.00 | 7174 |

| Treatments | Wheat | SEm(s) | CD at 5% |
|------------|-------|--------|---------|
| T₁         |       | 201.82 | 591.87 |
| T₂         |       | 209.61 | 614.71 |
| T₃         |       | 373.32 | 737.32 |
| T₄         |       | 564.87 | 1064.87 |
| T₅         |       | 524.09 | 924.09 |
| T₆         |       | 355.87 | 655.87 |
| T₇         |       | 472.09 | 947.20 |
| T₈         |       | 429.09 | 852.90 |
| T₉         |       | 437.09 | 873.79 |
| T₁₀        |       | 429.09 | 852.90 |
| T₁₁        |       | 429.09 | 852.90 |
| T₁₂        |       | 429.09 | 852.90 |

RDF: Recommended dose of fertilizer, WS: Wheat straw GM: Green manure, FP: Farmers’ practice, REY: Rice equivalent yield.

**RESULTS AND DISCUSSION**

Data revealed that level of application of inorganic fertilizers and organic sources applied in kharif crop, significantly influenced grain yield of the system. The highest rice equivalent yield (12185 kg ha⁻¹) was recorded in T₄ getting 100% RDF (in plot of 50% N through FYM and 50% RDF through inorganic fertilizers during kharif) and was statistically at par with T₈ (11546 kg ha⁻¹) and T₁₀ (11994 kg ha⁻¹) and significantly superior to T₁, T₂, T₃, T₅, T₆, T₇, T₈, T₉, T₄ and T₁₂ (Table 1).

The data showed that the maximum net return and B:C ratio was recorded in the treatment having Sesbania aculeata (Rs. 84379/- ha⁻¹ and 1.27), which was significantly to all other treatments (Table 2).

Critical examination of the data revealed significant effect of treatments on soil organic carbon content of soil. Initial soil organic carbon content (SOC), pH and EC at the start of the experiment during 1984-85 was 0.46%, 7.40 and 0.29 (dSm⁻¹), respectively. Integrated use of organics along with chemical fertilizers resulted in increase in SOC of soil (up to 0.79) and decreased in pH and EC (Table 3).

Initial available N, P and K of soil at the start of the experiment in 1984-85 was 194.00, 23.0 and 155.0 kg ha⁻¹, respectively. Continuous cropping of rice-wheat revealed that in control (T₁) as well as T₂, T₃, T₄, T₅ and T₁₀, there was decline in available N content of soil from its initial value (194.00 kg ha⁻¹). However, treatments receiving either 25% or 50% N substitution through organic source resulted a higher built up of available N, P and K content in soil. The maximum available N, P and K (228.45, 49.54 and 168.40 kg ha⁻¹), respectively, were noticed in treatment 50% N through FYM in rice followed by Sesbania aculeata (226.10, 48.55 and 170.20 kg ha⁻¹), respectively which was statistically at par with each other (Table 3).

*SES**bac**a** aculeata a Cost Effective Alternative to Enhance the Soil Health and Productivity of Rice-Wheat System*
Perusal of the data (Table 4) revealed significant effect of treatments on microbial population (bacteria, fungi and actinomycetes). Soil microbial density as envisaged through the population of bacteria, fungi and actinomycetes observed in the experimental plots. It was revealed from the observation that the microbial count was found in the plots received organic sources. Treatment having FYM and Sesbania aculeata was significantly superior to rest of the treatments and both were statistically at par with each other. Among the three groups of microorganisms, the population of bacteria and actinomycetes were higher as compared to the fungal population.

Organic sources viz. FYM, wheat straw and Sesbania aculeata (green manure crop) used to substitute 50% of recommended N dose in rice were effective in bringing about marked improvement in chemical and biological properties of soils over the years. The quantity of biomass added to the soil through different organic sources and the quantity of end product of decomposition of the organic matter capable of imparting binding effect on soil particles might have been responsible to improve soil health.

Addition of organic matter through green manuring with Sesbania was helpful in improving status of organic carbon, available N, P and K in soil over the years of experimentation. Even during the course of present investigation, an increasing trend was observed. Organic carbon content which was 0.46% during the initial year (1984) reached to 0.78% in Sesbania aculeata and 0.79% in FYM plot during the year 2015-16. The control and plots receiving 50% RDF through inorganic fertilizers in both the crops exhibited drop in organic carbon. Incorporation of organic amendments induced an increasing effect on organic carbon status might due to improvement of physical and biological properties of the soil (Satish et al., 2011, Wallia et al., 2010).

Table 2: Effect of Sesbania aculeata practice on economics of rice-wheat system (Pooled).

| Treatments                          | Rice | Wheat | Cost of cultivation (Rs. ha\(^{-1}\)) | Gross return (Rs. ha\(^{-1}\)) | Net return (Rs. ha\(^{-1}\)) | B : C ratio |
|-------------------------------------|------|-------|---------------------------------------|--------------------------------|-------------------------------|-------------|
| T\(_1\)                             | N\(_P\)K\(_0\) | N\(_P\)K\(_0\) | 55397                                  | 26492                          | -28905                        | 0.52        |
| T\(_2\)                             | 50% RDF    | 50% RDF    | 59264                                  | 72580                          | 33161                        | 0.22        |
| T\(_3\)                             | 50% RDF    | 100% RDF    | 61505                                  | 103715                         | 42210                        | 0.68        |
| T\(_4\)                             | 75% RDF    | 75% RDF    | 61198                                  | 101896                         | 40698                        | 0.66        |
| T\(_5\)                             | 100% RDF    | 100% RDF    | 63131                                  | 135180                         | 72049                        | 1.14        |
| T\(_6\)                             | 50% N through FYM + 50% RDF | 100% RDF | 79231                                  | 153117                         | 73886                        | 0.93        |
| T\(_7\)                             | 25% N through FYM + 75% RDF | 75% RDF | 70061                                  | 140288                         | 70227                        | 1.01        |
| T\(_8\)                             | 50% N through WS + 50% RDF | 100% RDF | 66595                                  | 145186                         | 78591                        | 1.18        |
| T\(_9\)                             | 25% N through WS + 75% RDF | 75% RDF | 63743                                  | 136543                         | 72800                        | 1.14        |
| T\(_10\)                            | 50% N through GM + 50% RDF    | 100% RDF | 66154                                  | 150533                         | 84379                        | 1.27        |
| T\(_11\)                            | 25% N through GM + 75% RDF    | 75% RDF | 62929                                  | 139857                         | 76928                        | 1.22        |
| T\(_12\)                            | FP (N\(_{30}\)P\(_{30}\)K\(_{15}\)) | FP (N\(_{30}\)P\(_{30}\)K\(_{15}\)) | 60150                                  | 90850                          | 30700                        | 0.51        |
| SD(±)                               | 0±4466      | 0±1906      |                                      |                                |                              |             |
| CD at 5%                            | 0±12657     | 0±5401      |                                      |                                |                              |             |

RDF: Recommended dose of fertilizer, WS: Wheat straw GM: Green manure, FP: Farmers’ practice.

Table 3: Effect of Sesbania aculeata practice on Chemical properties of soil.

| Treatments                          | Rice | Wheat | pH (dSm\(^{-1}\)) | EC (dSm\(^{-1}\)) | OC (%) | N (kg ha\(^{-1}\)) | P (kg ha\(^{-1}\)) | K (kg ha\(^{-1}\)) |
|-------------------------------------|------|-------|-------------------|-------------------|--------|--------------------|-------------------|-------------------|
| T\(_1\)                             | N\(_P\)K\(_0\) | N\(_P\)K\(_0\) | 7.37              | 0.28              | 0.34   | 115.60             | 13.80             | 105.20            |
| T\(_2\)                             | 50% RDF    | 50% RDF    | 7.34              | 0.28              | 0.39   | 142.10             | 19.40             | 111.35            |
| T\(_3\)                             | 50% RDF    | 100% RDF    | 7.32              | 0.28              | 0.45   | 154.45             | 32.55             | 118.45            |
| T\(_4\)                             | 75% RDF    | 75% RDF    | 7.30              | 0.28              | 0.48   | 161.45             | 36.65             | 121.30            |
| T\(_5\)                             | 100% RDF    | 100% RDF    | 7.28              | 0.28              | 0.54   | 168.55             | 40.60             | 128.90            |
| T\(_6\)                             | 50% N through FYM+50% RDF | 100% RDF | 7.21              | 0.25              | 0.79   | 232.85             | 50.60             | 176.50            |
| T\(_7\)                             | 25% N through FYM+75% RDF | 75% RDF | 7.25              | 0.28              | 0.74   | 214.50             | 44.80             | 160.70            |
| T\(_8\)                             | 50% N through WS+50% RDF | 100% RDF | 7.22              | 0.27              | 0.77   | 226.20             | 48.60             | 197.00            |
| T\(_9\)                             | 25% N through WS+75% RDF | 75% RDF | 7.27              | 0.26              | 0.72   | 207.95             | 43.15             | 177.75            |
| T\(_10\)                            | 50% N through GM+50% RDF | 100% RDF | 7.24              | 0.28              | 0.78   | 230.60             | 49.10             | 172.15            |
| T\(_11\)                            | 25% N through GM+75% RDF | 75% RDF | 7.27              | 0.26              | 0.73   | 214.00             | 45.05             | 162.15            |
| T\(_12\)                            | FP (N\(_{30}\)P\(_{30}\)K\(_{15}\)) | FP (N\(_{30}\)P\(_{30}\)K\(_{15}\)) | 7.36              | 0.27              | 0.46   | 140.80             | 26.45             | 116.65            |
| SD(±)                               | 0±0.10       | 0±0.01       | 0±0.01             | 0±0.01             | 0±0.01 | 0±0.01             | 0±0.01             | 0±0.01             |
| CD at 5%                            | 0±0.28       | 0±0.02       | 0±0.03             | 0±0.03             | 0±0.03 | 0±0.03             | 0±0.03             | 0±0.03             |
| Initial value (1984-85)             | 7.40              | 0.29          | 0.46               | 194.00             | 23.00  | 155.00             |                   |                  |

RDF: Recommended dose of fertilizer, WS: Wheat straw GM: Green manure, FP: Farmers’ practice.

Volume 54 Issue (2020)
Increase in available P\(_4\)O\(_5\) in organo – inorganic combinations might be due to the mineralization of organic matter accompanied by the release of appreciable quantities of CO\(_2\) which when dissolved in water, forms carbonic acid which is capable of decomposing certain primary minerals which might increase availability of P\(_4\)O\(_5\). Higher potassium content in wheat straw than other sources might have been the possible reason for higher residual K in the soil. At the current level of productivity, the K uptake has been much higher than its application, but still the charges in available K\(_2\)O after continuous rice-wheat cropping was of smaller magnitude probably because the crop requirement of K was largely met with non-exchangeable pool of soil (Sepehya et al., 2012). Similar results was reported in different types of soils of India by Maurya et al. (2014).

*Sesbania aculeata* was helpful in getting the highest net returns as well as B: C ratio. The requirement of *Sesbania aculeata* can be met with seed production of *Sesbania aculeata*. Soil biologia as envisaged through the population of bacteria, actinomycetes and fungi in experimental plot showed that substitution of inorganic fertilizers through organic manure in the proportion of 50% were instrumental in raising the microbial density significantly over the years. Pronounced effects of *Sesbania aculeata* on all the microbes may be explained in the light of the fact that both the amendments were of low C:N ratio, which induced a positive effect on microbial community. The availability of higher organic carbon and available N under the influence of these amendments might have enhanced the count of bacteria, actinomycetes and fungi whereas the effect of wheat straw was not so notable due to its higher C:N ratio. Application of balanced NPK or integrated nutrient management practices in rice had a stimulating influence on the microbial population as well as soil respiration due to proliferation of root exudates and addition of root biomass which increased carbon substrate for microbial growth. These results were in conformity with the findings of Singh et al. (2015).

### CONCLUSION

It may be summarized as *Sesbania aculeata* can be used as a viable and cost effective alternative through partial substitution of inorganic fertilizers to enhance the soil health and productivity of rice-wheat system.

### REFERENCES

Gangola, P., Singh, R., Bhardwaj, A.K. and Gautam, P. (2012). Effect of moongstraw on soil properties under INM in long-term rice-wheat cropping system in a Mollisol. International Journal of Agriculture, Environment and Biotechnology. 5(3): 281-286.

Maurya, B.M., Dhakad, S.S. and Tarwariya, M.K. (2014). Long term effect of NPK in rice-wheat cropping system under irrigated conditions of Madhya Pradesh. International Journal of Agricultural Sciences. 10(2): 541-545.

Rangaswami, G. and Bagyaraj, D.J. (1993). Agricultural Microbiology 2nd Ed. PHI Learning Private Ltd. New Delhi. pp - 422.

Satish, A., Hugar, A.Y., Kusagur, N. and Chanrappa, H. (2011). Effect of integrated nutrient management on soil fertility status and productivity of rice-maize sequence under permanent plot experiment. Indian Journal of Agricultural Research. 45(4):320-325.

Sepehya, S., Subehia, S.K., Rana, S.S. and Negi, S.C. (2012). Effect of integrated nutrient management on rice-wheat yield and soil properties in a north western Himalayan region. Indian Journal of Soil Conservation. 40(2): 135-140.

Singh, G., Kumar, D. and Sharma, P. (2015). Effect of organics, biofertilizers and crop residue application on soil microbial activity in rice-wheat and rice-wheat-mungbean cropping systems in the Indo-Gangetic plains. Cogent Geoscience. 1: 1085296.

Wallia, M.K., Wallia, S.S. and Dhaliwal, S.S. (2010). Long term effect of integrated nutrient management of properties of Typic Ustochrept after 23 cycles of an irrigated rice-wheat system. Journal of Sustainable Agriculture. 34: 724-743.