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Effect of green manuring and nitrogen levels on soil health and yield of rice

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Abstract
A field experiment was conducted at Experimental Farm, Annamalai University to find out the effect of green manuring and nitrogen levels on soil health and yield of rice. The experiment was laid out in a split plot design with twenty five treatment combinations resulting from five age of sesbania as main treatments and five nitrogen levels as sub treatments, replicated thrice. Results of the investigation indicated that green manure help in the reduction processes leading to the change in pH, EC, higher content of organic carbon and available NPK. The microbial count, *Actinomycetes, Azotobacter and Azospirillum* increased in soil when green manuring with *Sesbania aculeata* was incorporated. Maximum grain and straw yield recorded in 60 days old *Sesbania* and 90 kg N ha^{-1} beyond which the use of nitrogen was not economical with respect to nutrient uptake. Green manuring crop of *Sesbania,* if incorporated in soil of an age 45-60 days period have provided more benefits to the rice crop. Maximum uptakes of nutrient were obtained if the rate of application of N was up to 60 kg ha^{-1}. There is improvement in soil organic carbon; available nutrients, microbial population and crop yield due to use of *Sesbania* aculeata along with fertilizer N.

Keywords: Green manuring, microbial population, nutrients uptake, Oryzasativa, rice, *Sesbania aculeata,* soil health

Introduction
Organic materials such as *Sesbania* offer sustainable and ecologically sound alternatives for meeting the N requirement. As a consequence, incorporation of green tender material in soil has been a common practice in several parts of the world to maintain high level of soil organic matter and productivity. *Sesbania* is grown in all the agro-ecological situation of the country where it has been planted for green manure. It can produce enough biomass, and can accumulate up to 100 kg N ha^{-1} in 50 - 55 days besides providing a significant residual effect to the succeeding crops. It helps to reduce soil erosion, add organic matter to soil, and reclaim teachable nutrients, making them available to succeeding crop. In recent years there has been increasing interest in the concept of soil health.

A healthy population of soil green manuring improves the physical and microbial conditions of soil and enhances fertilizer use efficiency when applied in conjunction with mineral fertilizer. (Meelu and Morris 1984) [5]. The nutrient needs of the high yielding crop varieties which are the only means to meet the food supply of ever - growing population are so high that none of the single source could meet the demand due to the lack of their availability, both in terms of quality and quantity.

Materials and Methods
A field experiment was conducted in 2016 at Experimental Farm, Annamalai University. Soil samples were collected from a 15 cm depth at various physiological stages of rice crop from plots under various treatments of the experimental field. The soil of the experimental field was clayey in texture with sand 20.68%, silt 33.98% and Clay 45.34% with low available nitrogen (110 kg ha^{-1}), medium available phosphorus (12.5 kg ha^{-1}) and high in available potassium (279 kg ha^{-1}), but low in organic carbon 0.57%, neutral in soil pH 6.95, EC 0.39 dSm^{-1}at 25°c. The present experiment was laid out in a split plot design. Twenty five treatment combinations resulting from five aged *Sesbania* (S_0-control, S,-30 days, S_2- 45 days, S_3- 60 days, S_4- 75 days) as main treatments and five nitrogen levels N_0 control, N, = 30 kg ha^{-1}, N_2 = 60 kg ha^{-1}, N_3=90 $kgha^{-1}$, N_4 = 120 kg ha^{-1}) as sub treatments were replicated thrice. Plot size :4m 3m and fertilizers application for 50% nitrogen and full dose of phosphorus and potash @ 60 kg ha^{-1}, applied at the time of transplanting and remaining dose of 25% nitrogen at 1 month after transplanting and 25% at panicle initiation stage.

Results and Discussion

Microbial population

The data on colony forming unit (cfu) of *Actinomycetes*, *Azotobacter* and *Azospirillum* as influenced by addition of different age of *Sesbania* and nitrogen levels are presented in (Table 1). Addition of nitrogen @ 120 kg ha^{-1} (N_4) significantly increased the population of micro-organisms over N_0. *Azotobacter* population increase significantly with the addition of *Sesbania* of S_1 and S_2 stages at initial and at harvest stages. The population reduced with the addition of *Sesbania* of stage IV. *Azospirillum* population at initial stage did not differ significantly with the additions of *Sesbania* along with different levels of nitrogen. At harvest stage S, caused significant increase in *Azospirillum* population over S_0. The microbial count viz *Actinomycetes*, *Azospirillum*, phosphate solubilizing bacteria increased in soil, when green manuring with *S. aculeata* and *S. rostrata* were incorporated than fallow Tilak (2004) [6].

Table 1: Effect of different age of *Sesbania* and nitrogen levels on microbial population (CFU)

Main (Sesbania)	At initial levels			At harvest		
	Cfu of *Actinomycetes* (×10^4 g^{-1} of soil)	Cfu of *Azotobacter* (×10^3 g^{-1} of soil)	Cfu of *Azospirillum* (×10^2 g^{-1} of soil)	Cfu of *Actinomycetes* (×10^4 g^{-1} of soil)	Cfu of *Azotobacter* (×10^3 g^{-1} of soil)	Cfu of *Azospirillum* (×10^2 g^{-1} of soil)
S_0 - Control	59.43	57.70	76.62	59.99	72.73	60.34
S, - 30 days	68.44	72.73	69.20	69.16	81.26	63.47
S_2- 45 days	83.47	81.27	65.50	84.13	89.78	71.02
S_3- 60 days	57.42	88.47	71.80	57.95	91.20	63.58
S_4- 75 days	59.55	58.21	74.98	59.88	55.35	60.04
LSD (p=0.05)	5.61	4.42	9.72	5.64	4.07	1.38
Sub (N levels)						
N_0 - Control	63.36	69.15	74.72	63.85	74.42	62.86
N_3 - 30 kg ha^{-1}	65.73	70.99	74.25	66.36	77.66	62.47
N_2- 60 kg ha^{-1}	63.33	70.78	70.30	63.96	80.64	64.17
N_3 - 90 kg ha^{-1}	66.09	74.33	71.33	66.75	79.17	64.16
N_4-120 kg ha^{-1}	69.82	73.12	67.53	70.21	78.42	64.60
LSD (p= 0.05) Main x Sub	5.00	NS	NS	4.62	1.77	1.28
LSD (p= 0.05)	Same S 12.28 Same N 12.56	Same S 10.31 Same N 9.89	Same S 22.30 Same N 21.75	Same S 12.18	8.34	2.90

Grain yield: Result (Table 2) revealed that the most favourable soil conditions including the availability of the nutrients would have been prevailed in plots having treatments S_2 and S_3, and therefore the maximum production of rice grain or straw was recorded from S_3 followed by S_2. With the application of 60 days old *Sesbania rostrata* in rice gave the highest grain yield. Grain yield of rice increased with increasing levels of nitrogen (Chandra, 1998). This may be due to the fact that an increase in level of applied N brought significant improvement in rice grain yield even up to 120 kg ha^{-1} (Paikaray *et al.*, 2000) [7]. However, the actual gain of rice grain yield was not compensating the additional cost of input. Thus, it could be concluded that use of higher level of nitrogen beyond 90 kg ha^{-1} is not much useful. It is also found that by increasing nitrogen dose behind 60 kg ha^{-1} reduces the net benefit of the farmers and may lead to excess nutrient losses through leaching.

Table 2. Effect of age of *Sesbania* and N-levels on yield (kg ha^{-1})

Main (Sesbania)	Grain	Straw	Grain /straw ratio
S_0 - Control	3044	3085	0.987
S, - 30 days	2979	2724	1.095
S_2 - 45 days	3374	3243	1.041
S_3 - 60 days	3376	3394	0.995
S_4- 75 days	3127	3234	0.967
LSD P (0.05)	372	440	NS
Sub : (N-levels)			
N_0 - Control	2572	2770	0.928
N, - 30 kg ha^{-1}	2932	2942	0.996
N_2- 60 kg ha^{-1}	3277	3112	1.053
N_3- 90 kg ha^{-1}	3572	3426	1.042
N_4-120 kg ha^{-1}	3548	3431	1.034
LSD (P = 0.05)	447	316	NS

Table 3: Effect of age of *Sesbania* (GM) and nitrogen levels on nutrient uptake (kg ha)

Main (Sesbania)	Nitrogen			Phosphorus			Potassium		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
S_0 - Control	50.67	17.76	68.43	10.19	7.31	17.50	11.53	41.80	53.33
S_3 - 30 days	45.56	15.72	61.28	10.06	5.29	15.35	10.18	37.40	47.58
S_2 - 45 days	53.16	17.95	71.11	12.89	6.76	19.65	10.85	39.78	50.63
S_3 - 60 days	61.04	20.71	81.75	16.23	9.55	25.78	14.46	42.86	57.32
S_4- 75 days	56.46	21.32	77.78	13.31	6.94	20.25	10.48	44.05	54.53
LSD (P = 0.05)	7.07	NS		1.95	1.61		1.67	NS	
Sub (N-levels)									
N_0 - Control	45.09	16.93	61.02	9.51	5.80	15.31	9.18	37.92	47.10
N_3 - 30 kg ha^{-1}	50.26	18.26	68.52	11.42	7.03	18.45	10.75	40.40	51.15
N_2- 60 kg ha^{-1}	56.01	19.59	75.60	13.18	7.70	20.88	12.23	44.56	56.79
N_3 - 90 kg ha^{-1}	56.72	18.48	75.20	13.56	7.22	20.78	12.54	40.03	52.57
N_4-120 kg ha^{-1}	58.81	20.20	79.01	15.00	8.06	23.06	12.80	42.97	55.77SS
LSD (P = 0.05) Main x Sub	9.52 Same	1.94 NS		2.36 NS	0.816 NS		1.98 NS	4.02 NS	

LSP (P = 0.05)	S-21.28 Same N- 0.29								

Results reported that there is improvement in soil organic matter, microbial population activity and crop yield due to use of chemical fertilizer along with organic manure. Such positive effects of organic inputs can help in maintaining organic matter level and sustain good crop systems over a period of time without deteriorating soil health (Dhull *et al*., 2004) [3]. It was also observed that incorporation of S. *rostrata* resulted higher grain and straw yield thar, incorporation of *A. microphylla*. It was also found that green manuring with *Sesbania aculeata* improved the grain and straw yield, N and P utilization by rice crop, (Baig *et al.*, 2004) [1].

Nutrient uptake: The results (Table 3) clearly indicated that the maximum economical yield as well as the uptake of applied nutrients was obtained up to 60 kg N ha^{-1}. The uptake of most of the nutrients was maximum or close to maximum at this level of N application. Behind to 60 kg N ha^{-1} the magnitude of additional gain in yield was unable to compensate the additional cost of inputs. Therefore, it could be concluded that nitrogen application @ upto 60 kg N ha^{-1} is most economical and optimum. Further increase of nitrogen levels did not contribute to the crop performance. Similarly, the optimum age of green manuring crop could be within the range of 45 - 60 days, as uptake of different nutrients was optimum in S_2 and S_3. This was attributed to the fact that any further increase in age of *Sesbania*, beyond 60 days may resist the microbial decomposition process due to its higher lignin content in plant part.

Conclusion

Therefore, plants of about 45 -60 days age are more appropriate for green manuring. It is observed that 17.8% increase of N and 21.9% of P uptake by green manuring with 60 days old *Sesbania aculeate* (Baig *et al.,* 2004) [1]. Results of the experiments indicated that the maximum uptake of N was obtained up to N_2 level of Nitrogen. The highest N-uptake was recorded in S_3N_2, which clearly reveals that the green manure crop up to 60 days old with medium applications of nitrogen (@ 60 kg ha^{-1}) is more economical and beneficial.

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