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Assessment of *Sesbania aculeata* as green manure in rice-wheat cropping system

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Abstract

Field studies were conducted in permanent layout in Rice-Wheat cropping system in Punjab Pakistan from 2012-13 to 2016-17 to assess the inclusion of Sesbania aculeata (locally called *jantar*) in crop rotation as green manure. Soil was alkaline with pH of 7.9-8.0 and loam in texture. Sesbania was broadcasted in standing wheat crop in mid of March followed by last irrigation to wheat crop. Wheat was harvested in mid of April followed by irrigation to standing sesbania. Sesbania was incorporated into soil by disc plough or rotavator near flowering. During summer season, the plot was divided into half; in first half recommended dose of fertilizer (N-P_2O_5-K_2O @135-90-60 kg/ha) was applied whereas in other half fertilizer was applied at half recommended dose to rice. These two practices were compared with common practice of fallow between wheat and rice. Rice was followed by wheat crop with uniform fertilizer dose. Experimental results indicated that green manuring of sesbania increased paddy and wheat yield of following crop. Both in Rice and Wheat, plot with half of fertilizer out yielded recommended dose when jantar was incorporated. Chemical analysis of soils of experimental sites indicated that organic matter increased in sesbania incorporated plots.

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Introduction

Rice-wheat cropping pattern covers about 26 million hectares of land of Asia (Balasubramanian *et al.*, 2012; Chauhan *et al.*, 2012) and 2.2 million ha area of Pakistan (Timsina *et al.*, 2010). About 97% of total edible grain production is from rice-wheat system (Hossain and Teixeira da Silva, 2013a,b). With expanding population, it is expected that there may be 75-100% increase in food and other commodities demand by 2050 global scale (Keating *et al.*, 2010; Tilman *et al.*, 2011). Increasing demand for food may be met through substantial increase in the production of all cereal crops especially wheat, rice and maize. Under these circumstances, crop intensification program through efficient use of resources may play key role in increasing crop production (Ladha *et al.*, 2009; Dore *et al.*, 2011; Hochman *et al.*, 2013).

Practice of rice-wheat mono-cropping system rotation results in depletion of essential nutrients and loss in organic matter year by year, this loss of soil organic matter results in low soil fertility causing lower production of crops (Timsina and Connor, 2001, Shah *at el.*, 2017). Addition of inorganic fertilizers can meet the nutritional requirement of plants but their availability and cost is not according to the farmer demands. Use of inorganic fertilizers increase the yield of crops but there are also some disadvantages associated with the extensive use of these chemicals such as deterioration of soil structure and groundwater pollution. Another disadvantage of chemical fertilizers is their expensiveness and timely unavailability to farmers (Islam *et al.*, 2014).

In such a scenario use of organic amendments in combination with inorganic fertilizers is the most beneficial practice for todays' farmer. Use of green manure crops can be an excellent source of organic matter and restoration of soil fertility. Process of green manuring involves growing leguminous crops and after reaching vegetative stage ploughing them in soil. Upon decomposition it replenishes soil fertility status and organic matter content of soil. Along with this it also improves physical and chemical properties of soil including aeration, soil structure water holding capacity and nutrient retention capacity of soil (Kumar *at el.*, 2015, Hossain *et al.* 2016).

There are many leguminous crops used as green manuring crops. *Sesbania aculeata* locally called *jantar* is also a leguminous crop used as green manure crop having a good capacity of nitrogen fixation. Green manuring with *sesbania* not only meet the nitrogen requirement of following crop but also recycle the pool of sulfur and phosphorus for the next season crops. Intercropping of *Sesbania aculeata* as green manure along with recommended dose of inorganic fertilizer can supply sufficient amount of nutrients particularly nitrogen to the rice for whole growing period resulting in increased yield (Hossain *et al.*, 2016). Green manuring has also been found economical by Sajjad *et al.*, 2019. The present studies were conducted to assess the incorporation of *Sesbania aculeata* pre-rice green manure in improving production of the following rice crop in particular and next season grown wheat in general in rice-wheat cropping system.

Material and methods

Field study was conducted on permanent layout from 2012-13 to 2016-17 in rice-wheat cropping system in district Kasur, Punjab, Pakistan. The site was free from salinity or sodicity. During winter each year, wheat was grown with recommended dose of 160-114-60 of N-P_2O_5-K_2O kg ha^{-1}. Recommended dose of phosphorus and potassium and half of the recommended dose of nitrogen was applied at sowing. Remaining half dose of nitrogen was applied at first irrigation. During summer, main plot was subdivided into three subplots and basmati rice was grown. The treatments to rice during summer are as follows: T_1=Recommended dose of N-P_2O_5-K_2O (135-90-60 kg ha^{-1}) without Sesbania; T_2= Recommended dose of N-P_2O_5-K_2O+ Sesbania (RNPK) as green manure and T_3=Half recommended dose (67.5-45-30) of fertilizer+sesbania as green manure. In treatments #2 and 3, seed of Sesbania aculeata (*Jantar*) was spread in standing wheat in mid of March and last irrigation was given to wheat crop. Wheat was harvested in end of April. After harvesting of wheat two more irrigations were applied to sesbania. In the mid of June, at start of flowering, Sesbania was incorporated into soil by disc plough or rotavotor. Same cropping sequence was followed throughout the experiment and yield data of rice and wheat was collected.

Soil analysis

Soil samples were taken to laboratory for analysis. Soil organic matter (SOM) was determined using Walkley Black procedure using potassium dichromate as oxidizing agent (Nelson&Sommers, 1996). Available phosphorus was extracted through 0.5 M sodium bicarbonate and transmittance was measured through spectrophotometer at 880 nm by Olsen and Sommers (1982). Extractable potash was determined using 1N ammonium acetate through flamephotometer.

Statistical analysis

Yield data of both crops was recorded and analyzed statistically by using appropriate statistical design (Steel *et al.*, 1997) using MSTATC software. Year wise and pooled data analysis was also done. Single degree of freedom contrast analysis was also carried out to do comparison of sesbania and fertilizer groups.

Simple cost and benefit was also calculated using existing prices of fertilizer and other commodities.

Results and discussion

Soil was loam in texture with saturation percentage of 43 and free from any salinity or sodicity problem with normal of electrical conductivity and pH (Table 1).

Table 1. Soil characteristics (0-15 cm) of experimental site after five crops and green manuring.

Soil analysis after experiment					
Treatment No	ECe (dS m^{-1})	pH	O.M. (%)	Av P (mg kg^{-1})	Ex K (mg kg^{-1})
1	1.33	8.1	0.78b	11.3	154
2	1.17	7.9	1.66a	11.0	144
3	1.50	8.0	1.69a	12.3	153
Lsd	ns	ns	0.09	ns	ns

Soil analysis results at the end of experiment showed significant increase in organic matter contents of soil with sesbania green manuring. However, other soil chemical parameters remained unchanged. Soil organic matter contents were 0.78 percent in T_1 where there was no intervention. However, both in T_2 and T_3 where sesbania was incorporated, organic matter contents increased to 1.63 and 1.69 percent respectively. Similar results were obtained by Salahin *et al.* (2013) where he observed increased soil organic matter and nitrogen contents after green manuring of Sesbania Aculeata.

Table 2. Effect of green manuring and fertilizer dose on paddy yield (kg ha^{-1}).

Sr No	Treatments to Rice	2013	2014	2015	2016	Average
1	Without Sesbania +Recommended NPK	3764b	4700c	3880b	3573c	3979c
2	With Sesbania+Recommended NPK	4826a	5315a	4381a	4670a	4798a
3	With Sesbania+Recommended NPK	4022b	5003b	3957b	4391b	4343b
	$Lsd_{0.05}$	331	284	319	278	116

Experimental results (Table 2) showed that the incorporation of *Sesbania aculeata* as green manure in rice-wheat crop rotation significantly enhanced the production of following rice crop every year. Incorporation of sesbania with recommended dose of fertilizer (T2) increased paddy yield over control by 28, 13, 13 and 31 percent respectively from years 2013 to 2016 with an overall average of 21 percent (Table 2). Table 2also indicated that paddy yield in T_3 (Sesbania+half RNPK) was also slightly higher than T_1 during all the years and was statistically significant at 0.05 percent.

Table 3. Effect of green manuring and fertilizer dose on wheat grain yield (kg ha^{-1}).

Sr No	Treatments to Rice	2012-13	2013-14	2014-15	2015-16	2016-17	Average (2013-17)
1	Without Sesbania+Full NPK to Rice	4609	4262c	4609c	4363c	2811c	4002c
2	Sesbania+ Full NPK to Rice	4528	5031a	5102a	5491a	4120a	4936a
3	Sesbania+Half NPK to Rice	4532	4664b	4978b	4927b	3251b	4455b
	$Lsd_{0.05}$	ns	289	82	138	237	77

Fertilizer dose to wheat @160-114-60 kg ha^{-1}.

On an average, during these years the paddy yield was increased from 3979 to 4798 kg ha^{-1} with application of sesbania as green manure. Similarly, paddy yield from T_3 equalled to T_1during two years out of four years as compared to control. However, on overall basis of four years, yield increased from 3979 to 4343 kg ha^{-1} with sesbania with saving of half of fertilizer. Increase in rice yield by green manuring with *Sesbania aculeata* may be attributed to benefits of increased organic matter contents of soil (Table 1) and increased availability of nitrogen due to nitrogen fixation ability of the leguminous crop (*Sesbania aculeata*) and other beneficial effects of green manure (Islam *et al.*, 2014).

Table 4. Single degree of freedom contrast analysis.

Sr No	Group comparison	Crop	P value	F significance
1	Sesbania T1 vs (T2+T3)	Rice	0.00	s
2		Wheat	0.00	s
3	Fertilizer (T1+T2) vs T3	Rice	0.64	ns
4		Wheat	0.90	ns

s=Significant, ns=Non Significant.

Table 3 showed that there was no significant difference in grain yield of wheat when crop was harvested after first seeding of sesbania. However, application of green manure (*Sesbania aculeata*) resulted in causing significant increase in the production of wheat in successive years. Table 3 shows that green manuring before rice crop also had significant effect on yield of following wheat crop despite the fact that uniform dose of NPK fertilizer was added to wheat crop.

Table 5. Cost analysis of green manuring practice.

			Cost (Rs ha^{-1})		
Sr #	Sesbania seed	Irrigation	Sesbania incorporation	Fertilizer to rice	Total cost (Rice +Sesbania)
T_1	0	0	0	29535	29535
T_2	2400	3750	5000	29535	40685
T_3	2400	3750	5000	14767	25917

On an average, grain yield of wheat was increased by 23 percent viz. 4002 to 4936 kg ha^{-1}with T_2 (Sesbania+ RNPK)over control (T_1) during four years from 2013-14 to 2016-17. Maximum increase was observed during last year which was 47% i.e. from 2811 to 4120 kg ha^{-1} which was last year. Grain yield of wheat in T_3 (4455 kg ha^{-1}), where half dose of fertilizer was applied to rice, was also higher than T_1

(4002 kg ha^{-1}). This indicated that through reduction of fertilizer use in rice resulted in lowering of wheat yield in T_3 versus T_2. However, wheat yield still increased as compared to control (no sesbania). Enhanced wheat yield observed in the treatments, where *Sesbania aculeata* was incorporated in the soil as green manure, may be due to benefits of increased organic matter. The slow release of mineral elements, increased efficiency of inorganic fertilizer and improved organic matter of soil may ultimately improve soil properties and productivity of soil (Sultani *et al.*, (2007).

Table 6. Simple cost-benefit of green manuring practice in rice-wheat system.

Sr #	Total Cost (Rice +Sesbania)	Value of paddy produce (Rs ha^{-1})	Value of paddy minus variable cost (Rs ha^{-1}) (C-B)	Additional benefit from paddy over T_1 (Rs ha^{-1})	Value of wheat grain (Rs ha^{-1})	Additional benefit from Wheat (Rs ha^{-1})	Total annual additional benefit (Rs ha^{-1}) (E+G)
A	B	C	D	E	F	G	H
T_1	29535	198950	169415	-	135067	-	-
T_2	40685	239900	199215	29800	166590	31522	61322
T_3	25917	217163	191246	21831	150356	15288	37119

Prices: N@Rs 89 kg^{-1}, P_2O_5@Rs 128 kg^{-1}, K_2O@Rs 100 kg^{-1}, Paddy price @Rs 2000 per 40kg, wheat grain price @Rs 1350 per 40kg.

Single degree of freedom contrast analysis showed sesbania group (T_1 vs T_2+T_3) to be significant (Table 4). However, fertilizer group (T_1+T_2 vs T_3) was non-significant.

This indicated that sesbania green manuring was equally effective at both the fertilizer levels. It also indicated that sesbania also modified fertilizer response to the extent that fertilizer contrast became non-significant. This indicated the effectiveness of sesbania green manuring intervention.

Simple cost and benefit analysis of inputs and outputs (Table 5, 6) indicated that green manuring of sesbania proved economical. Additional cost occurred due to *jantar* seed price, irrigations, incorporation cost. Treatment T_2 *viz.* sesbania alongwith recommended dose of fertilizer to rice gave maximum return of Rs61322 and as compared to T_1 which yield a return of Rs 37119 per hectare. With extra cost of Rs 11150 (excluding fertilizer), T_2 provided Rs 61322 per hectare in return with earning ratio of 5.49.However, if fertilizer cost is also included earning ration becomes 1.51. T_3 also provided return of Rs 37119 per hectare but it was lower than T_1. However, all expenses due to green manuring including fertilizer in T_3 were lower by Rs 3617 per hectare as compared to T_1due to half fertilizer saving (Table 4). Therefore, T_3 may be recommended for farmers with lower budgets.

Similar results were obtained by Sajjad *et al.* (2019) when they found green manuring as having positive economic value most of the time. Similar results have been achieved for green manuring by Sher *et al.* (2013) and it was found economical rice-wheat system despite all costs. He used berseem as green manure.

Conclusion

Results of all field experiments including five wheat and four rice trials conducted during 2012-13 to 2016-17 at different sites indicated that practice of wheat-sesbania-rice crop rotation gives better production of both cereal crops and the beneficial effect is not limited to following rice crop only. Though extra expenditure is incurred on sesbania seed, irrigation and incorporation, however, the technology is still economical. Additional advantage is the improvement of soil health through increased organic matter.

The increase in yield might be due to long term effect of slow release of nutrients, nitrogen fixation and decomposing organic matter added by the leguminous crop. In the present study, it was concluded and suggested that intercropping of leguminous crops as green manure in rice-wheat crop rotation gives a sustainable production system for maintaining the soil fertility and getting better crop yields.

References

Balasubramanian V, Adhya TK, Ladha JK. 2012. Enhancing eco-efficiency in the intensive cereal-based systems of the Indo-Gangetic Plains. In: Issues in Tropical Agriculture Eco-Efficiency: From Vision to Reality. CIAT Publication, Cali, CO, 1-17.

Chauhan BS, Mahajan G, Sardana V, Timsina J, Jat ML. 2012. Productivity and sustainability of the rice–wheat cropping system in the Indo-Gangetic Plains of the Indian subcontinent: problems, opportunities, and strategies. Advances in Agronomy **117**, 316-355.
https://doi.org/10.1016/B978-0-12-3942784.00006-4

Dhiraj K, Purakayastha TJ, Shivay YS. 2015. Long-term effect of organic manures and biofertilizers on physical and chemical properties of soil and productivity of rice-wheat system. International Journal of Bioresources and Stress Management **6(2),** 176-181.
(https://doi.org/10.5958/0976-4038.2015.00030.5)

Dore T, Makowski D, Malezieux E, Munier-Jolain N, Tchamitchian M, Tittonell P. 2011. Facing up to the paradigm of ecological intensification in agronomy: revisiting methods, concepts and knowledge. European Journal of Agronomy **34(4),** 197-210.
https://doi.org/10.1016/j.eja.2011.02.006

Hochman Z, Carberry PS, Robertson MJ, Gaydon DS, Bell LW, McIntosh PC. 2013. Prospects for ecological intensification of Australian agriculture. European Journal of Agronomy **44,** 109-123.
https://doi.org/10.1016/j.eja.2011.11.003

Hossain A, Teixeira da Silva JA. 2013a. Wheat production in Bangladesh: its future in the light of global warming. AoB Plants **5,** 0-42.

Hossain A, Teixeira da Silva JA. 2013b. Wheat and rice: the epicenter of food security in Bangladesh. Songklanakarin Journal of Science and Technology **35 (3)**, 261-274.

Hossain MS, Hossain A, M.A.R. Sarkar MAR, Jahiruddin M, Teixeira da Silva JA, Hossain MI. 2016. Productivity and soil fertility of the rice–wheat system in the high Ganges river floodplain of Bangladesh is influenced by the inclusion of legumes and manure. Agriculture, Ecosystems and Environment **218**, 40-52.
https://doi.org/10.1016/j.agee.2015.11.017

Salahin N, Alam K, Islam M, Naher L, Majid MN. 2013. Effects of green manure crops and tillage practice on maize and rice yields and soil properties. Australian Journal of Crop Science **7(12),** 1901-1911.

Shah IA, Sharma BC, Samanta A, Nandan B, Verma A, Banotra, Kumar MR. 2017. Soil aggregation, carbon and nitrogen stabilization in relation to application of different soil organic amendments in aerobically grown basmati rice and their residual effect on the productivity of wheat in rice– wheat system under Shiwalik foothills of Jammu and Kashmir, India. International Journal of Current Microbiology and Applied Sciences **6(10),** 349-357.
https://doi.org/10.20546/ijcmas.2017.610.043

Keating BA, Carberry PS, Bindraban PS, Asseng S, Meinke H, Dixon J. 2010. Eco-efficient agriculture: Concepts, challenges and opportunities. Crop Science **50 (1)**, 109-119.
https://doi.org/10.2135/cropsci2009.10.0594

Ladha, JK, Kumar V, Alam MM, Sharma S, Gathala M, Chandana P, Saharawat YS, Balasubramanian V. 2009. Integrating crop and resource management technologies for enhanced productivity, profitability and sustainability of the rice-wheat system in South Asia. In: Ladha JK, Singh Y, Erenstein O, Hardy B. (Eds.), Integrated Crop and Resource Management in the Rice-Wheat System of South Asia. International Rice Research Institute, Los Banos, Philippines, 69-108.

Islam MR, Hossain MB, Siddique AB, Rahman MT, Malika M. 2014.Contribution of green manure incorporation in combination with nitrogen fertilizer in rice production. SAARC Journal of Agriculture **12(2),** 134-142.
https://doi.org/10.3329/sja.v12i2.21925

Olsen SR, Sommers LE. 1982. Phosphorus. In Page AL, Miller RH, Keeney DR (eds.), Methods of Soil Analysis-Chemical and Microbiological Properties. Part-2. American Society of Agronomy No **9**, Madison, Wisconsin, USA, 403-430.

Nelson DW, Sommers LE. 1996. Total carbon, organic carbon and organic matter. In: Sparks DL (ed.), Methods of Soil Analysis-Chemical Methods. Part-3. ASA, Madison, Wisconsin, USA, 961-1010.

Sajjad MR, Rafique R, Bibi R, Umair A, Afzal A, Ali A, Rafique T. 2019. Performance of green manuring for soil health and crop yield improvement. Pure Applied Biology, **8(2),** 1543-1553.
http://dx.doi.org/10.19045/bspab.2019.80095

Sher F, Bashir A, Hussain M, Baig MMQ, Ali MA. 2013. Economic comparison of different cropping systems in agro-ecological conditions of Gujranwala zone. Journal of Agricultural Research, **51(4),** 411-418.

Steel RD, Torrie JH, Dickey TA. 1997. Principles and Practice of Statistics. A Biomedical Approach, McGraw-Hill, New York.

Sultani MI, Gill MA, Anwar MM, Athar M. 2007. Evaluation of soil physical properties as influenced by various green manuring legumes and phosphorus fertilization under rain fed conditions. International Journal of Environmental Science and Technology **4 (1)**, 109-118.

Tilman D, Baizer C, Hill J, Befort BL. 2011. Global food demand and the sustainable intensification of agriculture. Proceedings of National Academy of Sciences U.S.A. **108**, 20260-20264.

Timsina J, Connor DJ. 2001. Productivity and management of rice–wheat cropping systems- Issues and challenges. Field Crops Research **69**, 93–132.
https://doi.org/10.1016/S0378-4290(00)00143-X

Timsina J, Jat ML, Majumdar K. 2010. Rice–maize systems of South Asia: Current status, future prospects and research priorities for nutrient management. Plant and Soil **335,** 65–82.
https://doi.org/10.1007/s11104-010-0418-y