Maintenance and Improvement of Organic Matter Status of Punjab Soils by Growing Sesbania in Standing Wheat Crop and Economics of Sesbania Green Manuring

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Background:

According to soil testing conducted during the past twelve years, soils are significantly deficient in organic matter. Due to this primary aspect, our chemical fertilizer use efficiency has dropped, resulting in a poor benefit-to-cost ratio. According to soil fertility scientists, organic matter addresses all soil ailments. Its improvement in soil has been shown to be the single most important factor for increased yields as well as improved soil fertility. Thus, over the past many years, farmers' fields have been researched to incorporate Jantar (Sesbania) sowing into intensive cropping systems in a way that is practical, feasible, increases soil organic matter, and reduces chemical fertilizer use without yield compromising. Green manure includes sesbania, cowpeas, guar, etc. However, including green manures between crops is difficult since they need time to grow and degrade. To save sesbania's growing period, Soil Fertility Research Institute Lahore has experimented with seeding sesbania in standing wheat crop at last irrigation. Improvements in both yield and soil organic matter was remarkably successful. After conducting extensive field trials on farmer's fields, SFRI has, Alhamdulillah, been able to discover an outstanding technique for achieving the goal.

Abstract

Majority of the farmers of our country are poor having low budget for different agricultural inputs such as fertilizers. They spend money on nitrogenous fertilizers as compared to Phosphatic and potassium fertilizers. It is the dire need of today to include green manuring alongwith synthetic

fertilizers in order to reduce the cost of fertilizers as well as to increase soil organic matter and to enhance the soil fertility on sustainable basis. This study was conducted with the objectives to evaluate the impact of Sesbania as green manure on soil organic matter, soil fertility status of soil as well as its impact in reducing the cost of synthetic fertilizers. Results revealed that the organic matter contents increased from 0.78% to 1.66% and 1.69% in T2 (Jantar + Full Fertilizer) and T3 (Jantar + Half Fertilizer). As for as economics of green manuring is concerned it increased net profit from 108892 and 124403 per hectare/ annum in T2 and 72621 to 83584 per hectare per annum in T3 during the said two series of experiments. So, it is clear from the results that using Sesbania as a green manure in standing wheat crops is a practical technology because it is the most cost-effective and eco-friendly. Hence, it is advised to spread 8 kg of Jantar seed after the last irrigation of wheat in the middle of March if the farmer has a few weeks of free time. Apply irrigation once the wheat has been harvested, then scatter 8 kg of Jantar seed again. However, the amount of fertilizer used for kharif crops may be lowered by 25–50% the next year, depending on how well green manuring works.

Keywords: Sesbania, improvement, green manure, economics

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Introduction

Rice-wheat cropping system occupy about twenty six million hectares of arable lands of Asia (Chauhan et al., 2012). In our country (i.e Pakistan) it covers about 2.2 million hectares (Timsina et al., 2010). No doubt the use of synthetic fertilizers helped in increasing the yield of various crops, however it lead to deterioration of soil structure and increased environment pollution issues, further fertilizers are very expensive (Islam et al., 2014). The Green manuring, is the technique in which fresh (i.e undecomposed plant material) is mixed in the soil in order to obtain organic matter and essential plant nutrients that are considered as a appropriate option having positive impact on soil physic-chemical as well as biological parameters of soil (Fageria 2007). Green Manuring crops are sown in between the major crops as they protect the soil from erosion, restore soil productivity of the exhausted soil and act as a best substitute of synthetic fertilizers (Xie et al. 2016

The use of synthetic fertilizers can be reduced by having appropriate knowledge about the composition and proper application rate of green manuring crops, (Saria et al. 2018). Green manuring technique is therefore promising methods for improving agriculture's sustainability on long term basis and with nearly no environmental health hazards (Kumar et al. 2014). Sesbania aculeata L. is one of the most significant green manuring crops and when it is incorporated in soil it adds 60–80 kg per hectare nitrogen. In order to enhance soil fertility, and to promote nutrient cycling and to bring crop nutrients up from lower soil profile and to reduce external nutrient inputs, the use of green manuring is inevitable (Yadav et al. 2019). In past prior to the advent of synthetic fertilizers, the green manuring was supposed to be a an indispensable tool for various crops such as like rice, wheat, sugarcane, potato etc. (Mandal et al., 2003). Total dependence on chemical fertilizers has been proved to be very harmful for health and is polluting the environment.

Organic matter is the most important constituent of soil and play key role in various chemical, physical and biochemical reactions going on in the soils. Increasing soil OM content through green manuring is the best way to maintain sustainability in agriculture by improving soil quality and reclaiming degraded soil (Chimouriya et al. 2018). This method is environment friendly, non-polluting and safe for soil, water, and the air (Yang et al. 2018). Green Manuring with higher concentration of nutrients and with low C/N ratio are very valuable as being organic fertilizers (Talgre et al. 2012). According to earlier studies (Chimouriya et al. 2018), the addition of green manure to soil may increase the availability of P to subsequent crops by a number of mechanisms, including: Green manure converts unavailable P to the forms that become available to subsequent crops; (2). Continued breakdown of some green manures (alfalfa, lupine, sweet clover etc) raise the amount of available P in the soil (Braum and Helmke 1995). According to Sarwar et al. (2017), the addition of Sesbania (dhaincha) into the soil not only increased the organic matter contents of the soil but also increased nitrogen in the soil. They reported 1.582 to 2.133% before addition of sesbania and 1.995 to 2.271 after incorporation.

Taking into consideration the aforementioned facts, the current study was conducted with the aim of increasing soil organic matter contents and soil fertility through Sesbania green manuring.

Material and methods

The experiment was conducted at farmers fields at various locations in Rice and Central zones of Punjab for evaluating the response of green manuring on soil organic matter in standing wheat crop. Soil samples were collected from the experimental area in a zig zag way to in order to make

composite soil samples from each site for soil fertility evaluation. Samples were properly prepared and analyzed in the laboratory. The determination of soil organic matter was done through the method given by Walkley-Black. while, available Phosphorus was assessed through Olsen's method by using sodium bicarbonate (NaHCO3) as extracting agent. Potassium (K) was measured using Flame photometer and its extraction was performed by ammonium acetate.

At each site, 3-replications were made by using Randomized Complete Block design (RCBD) layout. All Phosphorus and potash were applied at sowing time. The application of nitrogen was done in two splits (i.e half at sowing and remaining half at 1st irrigation). On soils without salt or sodicity, rice-wheat crop rotation trials were undertaken in Lahore, Gujranwala, Faisalabad, and Multan divisions from 2012–13 to 2020–21. Each year, wheat was cultivated with a prescribed dose of 160–114–60 kg ha-1 of N-P2O5-K2O. After the final irrigation, Sesbania aculeata (Jantar) seed was sown in standing wheat at the mid of March. Wheat was harvested at the end of April. If the Jantar population in the field was low, a few kg of Jantar seed were reapplied after the wheat harvest. After the wheat harvest, about two additional irrigations were done to sesbania. In mid-June, prior to blossoming, the sesbania was mixed into the soil by a disc plough or rotovator. In the regions of Kasur and Gujranwala, the first series of experiments were conducted between 2013–14 and 2016–17. From 2018 to 2021–22, a second series of experiments was also conducted in Gujranwala and Kasur at new sites. Following treatments were applied.

T1= No jantar+ Full Fertilizer

T2= jantar+ Full Fertilizer

T3= jantar+ Half Fertilizer

The statistical analysis of the data was done by using suitable statistical techniques (Steel RD, Torrie 1997). For treatments means comparison, LSD test was used.

Result and Discussion

As seen in Table 1, the yield increased from 2013–14 to 2016–17 as a result of green manuring. Full doses of fertilizer with Jantar as green manure provided the highest net benefit. Nonetheless, the net benefit with half the recommended dose of fertilizer was still greater than the control with no Jantar (Table 1). After four years of green manuring in a particular field with a permanent layout, the organic matter content of the soil grew from 0.78 percent to 1.66 percent (Iqbal et al. 2020).

During the second series of studies (from 2017–18 to 2021–22) in Kasur and Gujranwala, results were nearly the same. The highest overall yield of wheat and rice grains was attained with Jantar as

green manure and the recommended fertilizer (Table 3). It was also observed that Jantaralong with half of fertilizer yielded higher than recommended fertilizer without Jantar which shows saving of about half of fertilizer. The results of (Dubey et al., 2015) are in line with our findings as they reported about 6.7 to 11.8 % increase in the Organic carbon by the use of Sesbania green manure than control.

Economic analysis of both the series of experiments shows that growing of Jantar as green manure with recommended fertilizer increased the profit ranging between Rs 1,08,892 and Rs 1,24,403per hectare annually during these two series of experiments. Moreover, if half of recommended fertilizer is used for rice crop, Jantar green manuring is still profitable with profit ranging between Rs 72,621 and 83,584 per hectare annually.

In nutshell, the growing of sesbania as green manure in standing wheat crop is feasible technically and economically. Therefore, wherever a farmer finds few weeks of time available after wheat crop, it is recommended to spread 8 kg ofJantar seed after last irrigation to wheat in mid of March.After harvesting of wheat, apply irrigation and spread 8 kg of Jantar seed again. This helps improving sesbania population.

Table 1: Economics of green manuring of sesbania in rice zone (2013-14 to 2016-17)

Treatments	Fertilizer Cost Rice only (Rs kg/ha)	Total Variable Cost (Rs/ha) Rice+Jantar	Rice yield (Kg/ha)	Value of paddy produce (Rs ha-1)	Net benefit from paddy (Rs/ha)	Additional benefit from paddy (Rs/ha)	Wheat Yield (kg/ha)	Value of wheat produce (Rs ha^{-1})	Additional Benefit from Wheat (Rs ha^{-1})	Net annual additional benefit (Kg/ha)
No jantar+ Full Fertilizer	79190	79190	3979	387953	308763	0	4002	300150	0	0
Jantar +Full Fertilizer	79190	104690	4798	467805	363115	54353	4936	370200	70050	124403
Jantar+Half Fertilizer	39595	65095	4343	423467	358372	49609	4455	334125	33975	83584

Prices used	Per bag price		Per kg price
Urea=2440	2440	N price/kg	106
DAP=11450	11450	P price/kg	456
MOP=11900	11900	K price/kg	397
Paddy price Rs 3900 per 40 kg = Rs97.5kg, Wheat price Rs 3000/40kg = Rs 75/kg, Variable costs include: Jantar seed Rs 100/kg, Seed rate 12kg/acre, Cost for 3 irrigations = 5000/acre, Cost for disc, plough/disc plough = 4000/acre			

Table 2: Soil characteristics (0-15 cm) of experimental site after five crops and green manuring (2013-14 to 2016-17)

	Soil analysis after experiment				
Treatments	**ECe (µS /cm)**	**pH**	**O.M. (%)**	**Av P (mg kg^{-1})**	**Ex K (mg kg^{-1})**
No jantar+ Full Fertilizer	1330	8.1	0.79b	11.20	153
Jantar +Full Fertilizer	1170	7.9	1.67a	11.00	145
Jantar+Half Fertilizer	1500	8.0	1.69a	12.39	153
Lsd	**ns**	**ns**	**0.09**	**ns**	**Ns**

With the application of Jantar green manuring, the level of organic matter in the soil increased significantly.

Table 3: Economics of green manuring of sesbania in rice zone (2018 to 2021-22)

Treatments	**Fertilizer Cost Rice only (Rs kg/ha)**	**Total Variable Cost (Rs/ha) Rice+ Jantar**	**Rice yield (Kg/ha)**	**Value of paddy produce (Rs ha^{-1})**	**Net benefit from paddy (Rs/ha)**	**Additional benefit from paddy (Rs/ha)**	**Wheat Yield (kg/ha)**	**Value of wheat produce (Rs ha^{-1})**	**Additional Benefit from Wheat (Rs ha-1)**	**Net annual additional benefit (Kg/ha)**
No jantar+ Full Fertilizer	79190	79190	4320	421220	342030	0	4059	304440	0	
Jantar +Full Fertilizer	79190	104690	5120	499151	394461	52432	4812	360900	56460	108892
Jantar+Half Fertilizer	39595	65095	4506	439335	374240	32211	4598	344850	40410	72621

SESBANIA TECHNOLOGY AS A GREEN MANURE FOR STANDING WHEAT CROP

1. Apply the last irrigation to the wheat crop in mid-March and spread 8 kg of Jantar seed in the standing wheat crop immediately after irrigation. Jantar seed will start germinating.
2. Harvest the wheat crop by hand or with a combine harvester. Most of the sesbania growth is damaged or cut due to harvesting, but this is not worrisome; it will sprout again.
3. Apply irrigation and spread 8 kg of Jantar seed again after harvesting and removing straw from the field. Seeding twice boosts Sesbania populations and yields good biomass at integration.
4. Let Jantar grow and irrigate the field as needed.
5. Use a disc plough and rotavator to incorporate Jantar into the field before it flowers.
6. Jantar will be decomposed in the soil in a few weeks. Add 15-20 kg of urea (for rapid decomposition of Jantar residues) at the time of applying the rotavator particularly if the time to sow the next crop is approaching and it is believed that the sowing of the next crop may be delayed. Grow the next crop with usual agronomic practices.
7. After green manuring, any kharif crop may be sown, like rice or maize, etc. The sowing of Basmati rice varieties after adding sesbania green manure has been proven effective.
8. Green manuring, every year, improves soil health. During the first two years of green manuring, apply full fertilizer to crops after Jantar. However, depending on the effectiveness of green manuring practices, fertilizer for kharif crops may be reduced by 25-50% in subsequent years.

All other agronomic practices to the crops will remain the same

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