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Energy Studies of Soybean-Wheat Cropping Sequence under Organic Sources

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ABSTRACT

The present investigation was conducted for kharif and rabi season on soybean – wheat cropping system for two consecutive years (2010-11 and 2011-12) in a clayey in texture soil at the Agronomy Department Research Farm, Dr. PDKV, Akola (Maharashtra) India. To evaluate the energy studies of soybean-wheat cropping sequence under organic sources .The results revealed that significant enhancement in the energy output (155271 and 148563 Mj ha^{-1}), energy balance (139322 and 132656 Mj ha^{-1}), energy balance per unit input (8.74 and 8.34 Mj ha^{-1}) and energy output per unit input ratio (9.74 and 9.34 Mj ha^{-1}) of the soybean-wheat cropping system with the application of 100 % recommended dose of nitrogen through vermicompost + jeevamrut followed by 100 % recommended dose of nitrogen through vermicompost during the period of study. Thus ,use of organic sources vermicompost + jeevamrut and vermicompost alone significantly improved the Energy output, energy balance per unit input and energy output per unit input ratio of the soybean-wheat cropping system.

Key words: *Soybean-wheat cropping system, Energy output, Energy balance, Energy balance per unit input, Energy output per unit input ratio*

INTRODUCTION

Rotation of soybean-wheat is one of the most dominant cropping systems practiced on 4.5 million hectare on the Vertisols of central India and proved beneficial for long term productivity and sustainability. Soybean is a well known oilseed as well as pulse crop, rich and cheapest source of protein and fat, having vast multiplicity and uses as food, being rightly called as 'wonder crop' or the 'Miracle / Golden Bean'. Soybean contains 20 per cent oil, 40 to 42 per cent proteins, 20 to 30 per cent carbohydrates, vitamin A, B, C, D, E and K. Similarly, wheat is a rich source of protein, minerals and vitamins amongst all cereals.

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It contributes about 60 per cent of daily protein and 20 per cent of calories requirement of human diet. In India during 2012-13, soybean is grown on 12.2 M ha area with production of 11.8 M tons while wheat is second most important food crop, with an area of 29.8 million hectares and production of 93.90 million tons during 2012- 13[1]. The soybean-wheat cropping sequence has the highest nutrient requirement; however, it is most attractive system in terms of economics returns and energy efficiency[13].

In India, after the green revolution, intensive agriculture involving exhaustive high yielding varieties has lead to heavy withdrawal of nutrients from the soil. The imbalanced use of chemical fertilizers by farmers has deteriorated soil health. The organic sources of nutrients helps in improving and maintaining soil health for enhancing and sustaining agricultural production[8]. Regular use of a reasonable dose of organic manure, along with crop residue recycling, is known to cater the nutrient requirements of a low to medium intensity rice-wheat cropping system[3]. A field experiment at Dharwad, Karnataka by Shwetha *et al.*[12] observed that grain yield of soybean (16.98 q ha^{-1}) and wheat (15.92 q ha^{-1}) were significantly increased under combined use of organic manure + fermented organics (compost + green leaf manure + beejamrut + jeevamruth and panchagavya) over compost + VC + green leaf manure. To meet the basic food needs of our expanding human population, a productive sustainable agriculture system must be a major priority[4].

In India, agriculture not only provides food for all, but also employment to 70% of the population, which generates 40% of the national income and consumes about 10% of the commercial forms of energy. Energy is a critical aspect of a national development process it is also expended in agricultural operations. Crop cultivation requires application of both animal and inanimate forms of energy at different stages. Nutrients are provided through organic manure, chemical fertilizer or both. Seed, manures, labour and draft animal can be termed as renewable indirect source of energy as they can be replenished in due course of time. Vyas and Khandwe[13] revealed that application of soybean residue + FYM 5 ton ha^{-1} + Zn 5 kg ha^{-1} recorded highest energy input and gross energy output ratio followed by application of FYM 5 ton ha^{-1}, soybean residue 5 ton ha^{-1} and control. However, maximum net energy output, highest energy use efficiency and energy productivity were recorded in the sole application of FYM 5 ton ha^{-1}.

Nutrients are one of the most important inputs, required by the plants for their growth and yield. The organic manures is considered as the promising renewable source of energy, nutrient rich source and can be served as a substitute to cut down the cost of fertilizer input and to increase the productivity in addition to maintain soil productivity, improve the eco-system and ultimately resulting in improved soil-plant-health in a sustainable agricultural eco-system. Keeping this in view, the present investigation was taken up to study the effect of organic nutrient management on soybean – wheat cropping system and its energy balance since limited information is available pertaining to this.

MATERIAL AND METHODS

A field experiment was conducted during two consecutive years (2010-11 and 2011-12) at Agronomy Department Research Farm, Dr. PDKV, Akola (Maharashtra), located at between 22º42'N latitude and 77°02'E longitude with an altitude of 307.41 m above mean sea level. During the investigation cumulative rainfall was 1057.4 mm (2010-11) and 515.8 mm (2011-12) while mean maximum and minimum temperature of 43.2ºC and 10.6ºC respectively. The soil of the experimental site was clayey in texture and slightly alkaline in reaction (pH 7.8), low in available nitrogen (204 kg ha^{-1}), organic carbon (0.40%), available phosphorus (17.0 kg ha^{-1}) and marginally high in available potassium (328 kg ha^{-1}). The treatments having different organic nutrient sources were tested in randomized block design replicated thrice. The same set of treatments, on nitrogen equivalent basis, were applied to both *kharif* and *rabi* crops , *i.e.* recommended nitrogen dose of soybean (30 kg N ha^{-1}) and wheat (80 kg N ha^{-1}) was applied through organic sources only. The treatments consisted of control (T_1), in situ incorporation of 100% RDN through FYM (T_2), 100% RDN through vermicompost (T_3), 100% RDN through compost (T_4), 100% RDN through FYM + jeevamrut (T_5), 100% RDN through vermicompost + jeevamrut (T_6), 100% RDN through compost + jeevamrut (T_7), Cotton residue @ 5 ton ha^{-1}+ jeevamrut (T_8), Wheat residue @ 5 ton ha^{-1}+ jeevamrut (T_9) and Soybean residue @ 5 ton ha^{-1}+ jeevamrut (T_{10}). Organic manures and crop residues were applied and incorporated in the experimental plot one month before sowing and application of jeevamrut was done @ 500 l ha^{-1} at 30 and 45 DAS. The soybean(variety JS-335) and wheat (variety AKW-1071) was planted using a seed rate of 75 and 100 kg ha^{-1} respectively by drilling method , seeds were sown at a spacing of 45x5 cm(soybean) and row spacing of 22 cm apart (wheat), The required quantity of soybean and wheat seed, were treated with trichoderma viridi culture @ 4.0 g/kg of seed and also with biofertilizers rhizobum japonicum, phosphate solubilising bacteria (PSB) @ 20.0 g/kg of seed for soybean .Similarly azotobacter, phosphate solubilising bacteria (PSB) were applied in wheat by same method of seed inoculation before sowing. Standard procedures were adopted for recording the data on various growth and yield parameters. Data collected were statistically analyzed by using Fisher's analysis of variance technique.

The energy input, energy output, energy balance per unit inputs and energy input output ratio (Mj ha^{-1}) of the system were worked out. The energy input was worked out by using the item wise energy values for each treatment and expressed as Mj ha^{-1}. The energy output from grain and straw of respective crop was worked out by multiplying yields (grain and straw) with their energy values for respective crop *i.e.*, soybean and wheat and expressed as Mj ha^{-1}. The energy balance was worked out by deducting the energy input from the energy output for each treatment and expressed as Mj ha^{-1}. Energy balance per unit input (Mj ha^{-1}) was calculated as -

$$\text{Energy balance per unit input} = \frac{\text{Energy balance}}{\text{Energy input}}$$

The energy output per unit input ratio (Mj ha^{-1}) was estimated by dividing energy output values with input values.

RESULTS AND DISCUSSION

Productivity: Yield

The data on grain and straw yield of soybean and wheat at harvest as influenced by different treatments are presented in Table 1. Application of 100 per cent N through vermicompost + Jeevamrut (T_6) produced higher grain yield of soybean and wheat (17.77 & 26.20 q ha^{-1}, respectively) which was comparable to application of 100 per cent N through vermicompost (16.92 & 25.30 q ha^{-1} respectively) (T_3). Similarly, in terms of stover and straw yield of soybean and wheat also, treatment (T_6) application of 100 per cent N through vermicompost + Jeevamrut (27.91 & 40.94 q ha^{-1}, respectively) proved significantly better than rest of the treatments. However, it was on par with treatment (T_3) application of 100 per cent N through Vermicompost (26.36 & 39.32 q ha^{-1}, respectively) proved significantly superior over rest of the treatments.

Biological yield were also significantly higher with these treatments. Jeevan Rao and Rama Laxshmi[5]obtained significantly higher yields of soybean with substitution of 25 per cent of the recommended N by vermicompost, during both the years of study .Similaly Singh *et al*[11] inferred that number of effective tillers, grains per spike, grain, straw and biological yields of wheat were increased significantly with the graded levels of vermicompost and FYM . The enhancement in grain yield could be attributed to cumulative effect of better growth, more dry matter accumulation with better partitioning of photosynthates towards sink, ultimately resulting in increased grain yield Sandeep Navrang and Tomar[9].

Energy Study:

Energy output

The data on energy output, energy input and energy balance in soybean - wheat cropping system as influenced by different treatments are presented in Table 2. The mean energy output of the system was 115503 and 107936 MJ ha^{-1} during 2010-11 and 2011-12, respectively and when pooled over the years, it was 111720 MJ ha^{-1}. Energy output of the system was significantly influenced by the nutrient management treatments during both the years which was reflected in pooled analysis also. Among the different treatments, application of 100 per cent N through vermicompost + Jeevamrut (T_6) was at par with application of 100 per cent N through vermicompost (T_3) and recorded significantly higher energy output over rest of the treatments. It was followed by treatments T_5, T_7, T_2 and T_4 which were on par with each other during both the years. Mandal *et al*.[7]revealed that highest total bioenergy output of the crop production system was observed in soybean - wheat crop sequence (131277 MJ ha^{-1}) followed by soybean - mustard (101661 MJ ha^{-1}) and soybean - chickpea (92658 MJ ha^{-1}).

In pooled results, application of 100 per cent N through vermicompost + Jeevamrut (T_6) recorded significantly higher energy output as compared to rest of the treatments. The next best treatment was application of 100 per cent N through vermicompost (T_3). The lowest energy output was observed under control during both the years and in pooled results as well.

Energy balance

Mean energy balance of the system during 2010-11, 2011-12 and in pooled analysis was 57035, 49468 and 53252 MJ ha^{-1}, respectively. Nutrient management in soybean-wheat cropping system exhibited significant differences in respect of energy balance of the system during both the years of investigation and in pooled results also. The energy balance was significantly higher with the application of 100 per cent N through vermicompost + Jeevamrut (T_6) and application of 100 per cent N through vermicompost (T_3) being on par with each other. The next best treatments were T_5, T_7, T_2 and T_4 which were on par amongst themselves during both the years. In pooled results, application of 100 per cent N through vermicompost + Jeevamrut (T_6) recorded significantly higher energy balance as compared to the rest of treatments. The next best treatment was application of 100 per cent N through vermicompost (T_3). Lowest energy balance was observed under application of 100 per cent N through cotton crop residue + Jeevamrut treatment (T_8) during both the years and in pooled results as well. Similar results were also reported by Joshi and Billore[6] that energy output, energy balance, energy balance per unit input and energy output per input ratio of cropping sequence were at higher magnitude due to conjunctive use of organic manures and biofertilizers.

As energy value of crop residues is more compared to organic manures and due to lower yield per hectare obtained under crop residue treatments (T_8 to T_{10}), it resulted in negative energy balance and lower energy output values.

Energy balance per unit input and energy output per unit input ratio

The data on energy balance per unit input and energy output per unit input ratio of in soybean - wheat cropping system as influenced by different treatments are presented in Table 3.The mean energy balance per unit input during 2010-11, 2011-12 and in pooled results was 4.82, 4.48 and 4.63 MJ ha^{-1}, respectively and the corresponding output per unit input ratio was 5.82, 5.43 and 5.63, respectively.

Energy balance per unit input of the system produced significant differences due to various nutrient management treatments. During both the years and in pooled analysis, application of 100 per cent N through vermicompost + Jeevamrut (T_6) recorded significantly higher energy balance per unit input of system as compared to other treatments. The next best treatment was application of 100 per cent N through vermicompsot (T_3). Vyas and Khandwe[13] also showed that application of soybean residue +

FYM 5 ton ha^{-1} + Zn 5 kg ha^{-1} recorded highest energy input and gross energy output ratio in soybean-wheat cropping system. Lower energy balance per unit input of the system was noticed under treatment application of cotton crop residue + Jeevamrut (T_8).

Due to lesser energy balance values and higher energy input values under crop residue treatments (T_8 to T_{10}) the energy balance per unit input values were negative. Similar research trend was evident in respect of energy output per unit input ratio during both the years and in pooled results also

The energy evaluation studies in respect of energy output, energy balance, energy balance per unit input and energy output per unit input ratio showed that these parameters were significantly increased with successive increase in yield level. The values of these energy parameters were of lower magnitude during second year as compared to that of first year due to reduction in the yields of during second year.

Among the cropping system soybean-wheat found to be most productive remunerative, energy efficient and energy productive than soybean-chickpea and soybean-mustard cropping system. Majority of cultivators perceived that soybean-wheat cultivation as a major factor for their socio-economic development Behere[2].

Table 1: Yield (q ha^{-1}) of Soybean and Wheat as influenced by different treatments during 2010-11 and 2011-12

Treatments	Soybean						Wheat					
	Grain yield (q ha^{-1})			Stover yield (q ha^{-1})			Grain yield(q ha^{-1})			Straw yield(q ha^{-1})		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T_1	8.85	8.04	8.44	11.60	11.09	11.34	11.09	10.24	10.68	16.17	15.35	15.76
T_2	13.80	12.45	13.13	21.32	19.10	20.21	22.23	20.78	21.51	34.25	31.81	33.03
T_3	17.16	16.69	16.92	26.78	25.93	26.36	26.01	24.59	25.30	40.53	38.10	39.32
T_4	13.34	12.02	12.68	20.56	18.40	19.48	21.85	20.21	21.03	33.60	30.86	32.23
T_5	15.12	14.53	14.82	23.40	22.38	22.89	23.00	21.48	22.24	35.54	33.02	34.28
T_6	18.08	17.46	17.77	28.47	27.35	27.91	26.97	25.42	26.20	42.25	39.63	40.94
T_7	14.30	13.75	14.03	22.09	21.06	21.57	22.53	20.81	21.67	34.79	31.88	33.33
T_8	10.24	9.52	9.88	15.53	14.35	14.94	13.04	12.28	12.66	19.70	18.47	19.08
T_9	11.14	10.32	10.73	16.95	15.63	16.29	14.30	13.69	14.00	21.66	20.66	21.16
T_{10}	12.14	11.18	11.66	18.64	16.86	17.75	15.70	15.01	15.36	24.03	22.81	23.42
SE (m)$\pm$	0.85	0.82	0.54	1.39	1.20	0.82	1.26	1.07	0.49	1.89	1.63	0.80
CD(P=0.05)	2.54	2.43	1.60	4.12	3.56	2.45	3.76	3.18	1.47	5.63	4.84	2.37
GM	13.43	12.60	13.01	20.53	19.21	19.87	19.67	18.45	19.06	30.25	28.26	29.26

Table 2: Energy output, Energy input and Energy balance (MJ ha^{-1}) in soybean – wheat cropping system as influenced by different treatments during 2010-11 and 2011-12

Treatments	Energy output			Energy input			Energy balance		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T_1	65780	59604	62692	11011	11011	11011	54769	48593	51681
T_2	127480	116226	121853	16527	16527	16527	110953	99699	105326
T_3	152134	144991	148563	15907	15907	15907	136227	129084	132656
T_4	123238	112444	117841	16527	16527	16527	106711	95917	101314
T_5	133695	125879	129787	16569	16569	16569	117126	109310	113218
T_6	159361	151181	155271	15949	15949	15949	143412	135232	139322
T_7	127981	120412	124196	16569	16569	16569	111412	103843	107627
T_8	80415	75088	77752	191039	191039	191039	-110624	-115951	-113287
T_9	88038	82929	85484	148539	148539	148539	-60501	-65610	-63055
T_{10}	96906	90606	93756	136039	136039	136039	-39133	-45433	-42283
SE (m) $\pm$	4082	5153	2004	--	--	--	4082	5153	2004
CD(P= 0.05)	12126	15310	5955	--	--	--	12126	15310	5955
GM	115503	107936	111720	58468	58468	58468	57035	49468	53252

Table 3: Energy balance per unit input (MJ ha^{-1}) and Energy output per unit input ratio in soybean - wheat cropping system as influenced by different treatments during 2010-11 and 2011-12

Treatments	Energy balance per unit input			Energy output per unit input ratio		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T_1	4.97	4.41	4.69	5.97	5.41	5.69
T_2	6.71	6.03	6.37	7.71	7.03	7.37
T_3	8.56	8.11	8.34	9.56	9.11	9.34
T_4	6.46	5.80	6.13	7.46	6.80	7.13
T_5	7.07	6.60	6.83	8.07	7.60	7.84
T_6	8.99	8.48	8.74	9.99	9.48	9.74
T_7	6.72	6.27	6.49	7.72	7.27	7.49
T_8	-0.58	-0.61	-0.59	0.42	0.39	0.41
T_9	-0.41	-0.44	-0.42	0.59	0.56	0.58
T_{10}	-0.29	-0.33	-0.31	0.71	0.67	0.69
SE (m) $\pm$	0.19	0.27	0.09	0.19	0.27	0.09
CD (P= 0.05)	0.57	0.81	0.28	0.57	0.81	0.28
GM	4.82	4.43	4.63	5.82	5.43	5.63

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