International Journal of Bio-resource and Stress Management 2014, 5(3):356-362
DOI:10.5958/0976-4038.2014.00580.6
Full Research Article

Influence of Biomethanated Spentwash and Chemical Fertilizers on Productivity and Quality of Soybean-Wheat Cropping Sequence

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Article History

Manuscript No. AR695
Received in 26th March, 2014
Received in revised form 29th August, 2014
Accepted in final form 2nd September, 2014

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Keywords

Primary treated biomethanated spentwash, quality, yield, soybean, wheat

Abstract

A field experiment was conducted on effect of one time controlled application of primary treated biomethanated spentwash (PBSW) and chemical fertilizers on yield and quality of soybean -wheat cropping sequence on Inceptisol. The field experiment was though initiated during 2007-08 observations were recorded during third (2009-10) and fourth years (2010-11) of experimentation. The experiment was laid out in a RBD with five treatments viz., recommended dose (RD)-NPK, 100% RD of N through PBSW without P chemical fertilizer, 100% RD of N through PBSW+remaining P through chemical fertilizer, 50% RD of N through PBSW+remaining N and P through chemical fertilizers and 25% RD of N through PBSW+remaining N and P through chemical fertilizers with four replications. The higher oil and protein yield of soybean was observed in 100% RD-NPK and 25% RD of N through PBSW+remaining N and P through chemical fertilizers, respectively. Lower doses of PBSW @ 25% RD of N through PBSW+remaining N and P through chemical fertilizers improved the lysine, methionine and tryptophan content of soybean and protein, dry gluten, carbohydrate and net protein utilization of wheat. Application of 25% RD N-through PBSW well before sowing for soybean and wheat+remaining N and P through chemical fertilizers was increased grain yield and improved the quality parameters of soybean and wheat.

1. Introduction

India is the sixth largest producer of ethanol in the world and the second largest in Asia (Anonymous, 2012). Most of the Indian distilleries use sugarcane molasses as raw material. Spentwash generated from distillation process from molasses has very high pollution potential (Joshi, 1999). As the spentwash contains considerable amount of organic matter and plant nutrients, particularly potassium and sulphur (K 1.03%; Sulphates 2421 mg L^{-1}), this can be applied to crops (50,000 L ha^{-1}) as a source of plant nutrients and has been reported to increase the yield of the pearlmillet (Deshpande et al., 2009). Thus, application of spentwash as a source of plant nutrients offers a promising alternative for its safe disposal. Many farmers in the vicinity of sugar factories in Northern and Western India apply spentwash and spentwash containing products in their field as manure. The only problem with spentwash is excessive biological and chemical oxygen demand and electrical conductivity (Joshi, 1999). These problems could be overcome by the application of spentwash well before the planting of the crop (40 to 60 days before planting) to give sufficient time for the natural oxidation of organic matter. The present study was undertaken to study the effect of one time controlled application of PBSW and chemical fertilizers on productivity and quality of crops in a soybean and wheat cropping sequence.

2. Material and Methods

The field experiment was initiated during 2007-08, however, third (2009-10) and fourth years (2010-11) of experiment were undertaken for long term research study. It was conducted on calcareous soil belonging to Sawargaon series of isohyperthermic family of *Vertic haplustepts* at Post Graduate Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra. The experimental soil was alkaline (pH 8.42) in nature with EC of 0.37 dS m^{-1} and clayey in texture. The soil N (alkaline $KMnO_4$), P_2O_5 (Olsen P) and K_2O (NH_4OAc) contents were 194, 19.12 and 702 kg ha^{-1}, respectively. The experiment was laid out in a RBD and replicated four times with five treatments viz., T_1-Recommended dose (RD)-NPK, T_2-100% RD of N through post biomethanated spentwash (PBSW) without P chemical fertilizer, T_3-100% RD of N through PBSW+remaining P through chemical fertilizer T_4-50% RD of N through PBSW+remaining N and P through chemical fertilizers and T_5-25% RD of N through PBSW+remaining N and P through chemical fertilizers Application of PBSW was done on fifty days before sowing of soybean and wheat. The sowing date of soybean was 07-07-2009 and 08-07-2010 in *kharif* season and for *rabi* wheat was 08-12-2009 and 06-12-2010. The basal dose of recommended dose fertilizer (RDF) was applied for soybean (50:75 N:P_20_5 kg ha^{-1}) as per the treatments. The RDF for wheat was 120:60:40 (N: P_20_5:K_20 kg ha^{-1}), out of which half dose of N (60 kg ha^{-1}) and full dose of 60 kg P_20_5 ha^{-1} and 40 kg K_20 ha^{-1} in treatment T_1 as basal dose. In treatment T_2 and T_3-100% and in T_4-50% dose of N and in T_5-25% N dose was applied through PBSW before sowing. In T_5-25% dose of N at sowing was supported through chemical fertilizer and remaining ½ dose of N was applied after 21 days of sowing in $T_{1,}$ T_4 and T_5 .The standard agronomic packages of practices were adopted in both the crops. The four irrigation for soybean and six irrigation for wheat were given during crop growth period and class was C_1S_1. The crop spacing was 30×10 cm^2 for soybean and 22.5 cm (row) for wheat. The PBSW was obtained from the distillery of Shri Baburaoji Tanpure co-operative sugar factory, Rahuri (MS) which was having characters viz., pH 7.40-7.48, EC 36.48-37.20 dS m^{-1}, BOD 5286-5443 and COD 24133-24874 mg L^{-1}, K^+ 0.99-1.03%, Ca^{2+}, Mg^{2+}, Na^+, SO_4^{2-} and Cl^- were 3422-3467, 2923-3080, 2390-2390, 2421-2643 and 2255-2418 mg L^{-1}, respectively. The grain and straw yield of soybean and wheat were recorded and grain samples of soybean and wheat were analyzed for total N by microkjeldahl method in H_2SO_4:H_2O_2 (1:1) digestion (A.O.A.C., 2005) and the crude protein was estimated by N% multiplying 5.71 for soybean and 5.83 for wheat (Thimmaiah,2006). The oil content was estimated using soxhlet apparatus (A.O.A.C., 2005) and quality parameters of soybean and wheat were analysed by using NIR Spectrophotometer (Osborne, 2007 and Cozzlino et al., 2006).

3. Results and Discussion

3.1. Yield of soybean and wheat

3.1.1. Grain and straw yield of soybean

The grain yield of soybean was significantly influenced by various treatments in both the years (2009-10 and 2010-11), whereas pooled grain yield of soybean was non-significant (Table 1). Higher pooled grain yield of soybean (7.12 q ha^{-1}) was recorded in treatment T_5 whereas straw yield (21.39 q ha^{-1}) was significantly higher in treatment T_1 (RD-NPK). These results suggested that an integration of PBSW with inorganic source was better in harnessing higher grain yield. When PBSW at lower doses along with chemical fertilizers of N and P applied together, nitrogen will be released first by inorganic source and subsequently from the PBSW (Kalaiselvi and Mahimairaja, 2010 and Saha et al., 2013).

The treatment T_1 (RD-NPK) recorded the higher grain yield (3.52 q ha^{-1}) and it was at par with the treatments T_4 (2.91 q ha^{-1}) and T_5 (3.03 q ha^{-1}) i.e. 50% and 25% N-PBSW+remaining N and P through chemical fertilizers during 2009-10. On the contrary, significantly higher grain yield of soybean (11.20 q ha^{-1}) was recorded in treatment T_5 and it was at par with treatment T_1 (10.41 q ha^{-1}) during the year 2010-2011. Similar trend was observed in straw yield of soybean during both the years of experimentation. The pooled means of straw yield also differ significantly from each other (Table 1). The treatment T_1 (21.39 q ha^{-1}) was giving highest pooled straw yield which was at par with T_5 (20.70 q ha^{-1}). Significantly lowest pooled straw yield of soybean was observed in T_2 (13.65 q ha^{-1}) which was statistically at par with T_3 (14.35 q ha^{-1}). The NPK was at par with 25% RD of N through PBSW+remaining N and P-chemical fertilizers for grain and straw yield of soybean in both the years of experimentation (2009-10 and 2010-11). It clearly indicated that 25% N fertilizer could be saved by application of PBSW. This might be due to mineralization of organic matter of PBSW and during the mineralization process more availability of nutrients including micronutrients to soybean. Similar observations were recorded by Suganya and Rajannan (2009) and Rath et al., (2011).

3.1.2. Grain and straw yield of wheat

Significantly the higher pooled grain yield of wheat was recorded in treatment T_1 (36.04 q ha^{-1}) over the rest of other treatments (Table 2). The straw yield of wheat was statistically

Table 1: Effect of one time application of PBSW on grain and straw yield of soybean

Treat-ment	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})		
	2009-10	2010-11	Pooled mean	2009-10	2010-11	Pooled mean
T_1	3.52[a]	10.41[ab]	6.97	19.21[a]	23.56[a]	21.39[a]
T_2	1.78[b]	6.11[c]	3.95	11.47[b]	15.82[c]	13.65[c]
T_3	1.76[b]	6.57[c]	4.17	11.75[b]	16.95[bc]	14.35[c]
T_4	2.91[a]	8.28[bc]	5.60	15.77[a]	21.90[ab]	18.84[b]
T_5	3.03[a]	11.20[a]	7.12	17.97[a]	23.42[a]	20.70[a]
SEm±	0.35	0.79	0.65	1.12	1.70	0.42
CD (p=0.05)	0.94	2.43	NS	3.47	5.26	1.40

influenced by various treatments during 2010-11 and also on pooled data basis except straw yield in 2009-10. The treatments T_1 and T_4 and T_5 were at par with each other for pooled grain and straw yield of wheat. This might be due to PBSW contains essential plant nutrients which were made available to the plant as well as mineralization of organic material, from PBSW was rather fast as compare to other PBSW treatments due to comparatively less quantity of PBSW and high amount of chemical fertilizer N, which hastens the mineralization of PBSW, thus resulting in better growth, development and yield of the crop (Kalaiselvi and Mahimairaja, 2010 and Saha et al., 2013).

The higher grain yield of wheat was observed in treatment T_1 (32.99 and 39.08 q ha^{-1}) during both the years. However the treatment T_1 was significantly superior to all other treatments during 2009-10 and at par with treatments T_4 (35.47 q ha^{-1}) and T_5 (37.53 q ha^{-1}) during the year 2010-11(Table 2). The similar trend as per grain yield was observed in straw yield of wheat during the both the years of experimentation. Among all the treatments, the treatment T_5 was recorded significantly higher straw yield of wheat (65.63 q ha^{-1}) during the year 2010-11 and in pooled means (54.76 q ha^{-1}), however T_5 was statistically at par with T_4 and T_1 during 2010-11 and in pooled straw means (62.33, 52.17 and 64.85, 54.74 q ha^{-1}, respectively). The treatment T_2 was recorded significantly lowest pooled straw yield (32.51 q ha^{-1}) and it was followed by the treatment T_3 (41.27 q ha^{-1}).The reduction in grain and straw yield of wheat recorded in 100% N-PBSW treatments might be due to toxic effect from excessive quantities of soluble salt and high amount of organic matter which resulted in immobilization of nutrients and thereby reduction in uptake of nutrients, ultimately affected growth and yield of wheat. The increasing grain and straw yield of wheat were noticed in treatments 25 and 50% N through PBSW and remaining N and P through chemical fertilizers. This might be due to comparatively small amount of PBSW in 25 and 50% N-PBSW as compare to 100%N-PBSW treatments due to high amount of chemical N through fertilizers, which was helpful for increasing soil available nitrogen rather than immobilization as seen in 100% N-PBSW treatments. Similar observations were noticed by Sukanya et al., (2004) and Deshpande et al., (2009). The salt load added through 25 or 50% N-PBSW treatments was also low as compare to 100% N-PBSW, which was tolerated by the wheat, due to its well known tolerance nature against salt.

3.2. Oil content and oil yield of soybean

The oil content and oil yield of soybean was significantly influenced by various treatments except for oil content during the year 2010-11. Significantly higher pooled oil content (20.30%) and oil yield (142.20 kg ha^{-1}) of soybean was observed in treatment T_1 over the rest of other treatments, whereas the lower oil content (17.72%) and oil yield (70.73 kg ha^{-1}) of soybean was observed in treatment T_2. The treatments T_2 and T_3 were at par with each other for pooled oil content and oil yield of soybean (Table 3). The treatment of RD-NPK (T_1) was statistically at par with treatment of 25% N-PBSW+remaining N and P through chemical fertilizers (T_5) with respect to the pooled oil yield (142.20 and 138.65 kg ha^{-1}, respectively). Increased levels of PBSW decreased pooled oil content and oil yield of soybean.

Significantly higher oil yield of soybean was observed in treatment T_1 and T_5 during the 2009-10, however, during 2010-11, it was at par with that of T_5 (Table 3). The decrease in oil content and oil yield of soybean due to increase in PBSW application was observed which might be due to immobilization of nutrients due to high BOD and COD of PBSW and high salt concentrations, which affected yield and thereby oil yield of soybean. Taamalli et al., (2004) also reported that salt at high concentration reduces the transport of stored lipids as well as their content and composition of *Helianthus annus*. Application of 25 or 50% RD of N through PBSW along with remaining N and P through chemical fertilizers helped in easy availability

Table 2: Effect of one time application of PBSW on grain and straw yield of wheat

Treatment	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})		
	2009-10	2010-11	Pooled mean	2009-10	2010-11	Pooled mean
T_1	32.99^a	39.08^a	36.04^a	44.62	64.85^a	54.74^a
T_2	13.41^c	26.32^b	19.87^b	19.06	45.95^c	32.51^c
T_3	13.08^c	27.98^b	20.53^b	32.67	49.87^{bc}	41.27^b
T_4	28.21^b	35.47^a	31.84^a	42.00	62.33^{ab}	52.17^a
T_5	30.17^b	37.53^a	33.85^a	43.88	65.63^a	54.76^a
SEm±	0.80	1.89	2.41	6.03	4.37	2.18
CD (p=0.05)	2.46	5.81	7.22	NS	13.46	6.52

Table 3: Effect of one time application of PBSW on oil content and oil yield of soybean

Treatment	Oil content (%)		Pooled mean	Oil yield (kg ha^{-1})		Pooled mean
	2009-10	2010-11		2009-10	2010-11	
T_1	20.07^a	20.53	20.30^a	70.64^a	213.75^a	142.20^a
T_2	17.34^b	18.10	17.72^d	30.86^c	110.59^c	70.73^c
T_3	17.73^b	18.01	17.87^d	31.21^c	118.31^c	74.76^{bc}
T_4	18.00^b	18.93	18.47^c	52.38^b	156.77^b	104.58^b
T_5	19.32^a	19.53	19.43^b	58.53^b	218.77^a	138.65^a
SEm±	0.41	0.72	0.09	0.96	5.86	10.18
CD (p=0.05)	1.27	NS	0.28	6.72	18.07	31.38

of nutrients and thus helped in increasing the oil content and oil yield. Similar results were also reported by Bharagava et al., (2008) and De et al., (2013).

3.2.2. Protein content and protein yield of soybean

The protein content and protein yield of soybean was significantly influenced by various treatments in both the years and pooled means (Table 4). Significantly higher pooled protein content in soybean was found in treatment T_5 over the rest of other treatments except treatment T_4. Significantly lower protein content of soybean was noticed in treatment T_2 in both the years and pooled means. It clearly indicated that the application of PBSW without P chemical fertilizer decreased protein content of soybean.

The higher pooled protein yield of soybean was observed in treatment T_5 over the rest of other treatments and it was at par with treatments T_1 and T_4. The higher protein yield of soybean was observed in treatments T_1 and T_5 during the year 2009-10 and 2010-11, respectively (Table 4). The treatments T_1, T_4 and T_5 significantly differed with each other in both the years and the order of protein yield was T_1>T_5>T_4 during 2009-10 and T_5>T_1>T_4 during 2010-11. This might be due to lower levels of PBSW applied along with chemical fertilizer and also yield of soybean. The 25% N-PBSW+remaining N and P-chemical fertilizers was significantly superior over RD-NPK for protein concentration and protein yield, indicated superiority of small quantity of PBSW along with other N and P fertilizers over mere chemical fertilizer in improving protein content and protein yield of soybean. Similar results were reported by Sukanya and Meli (2004).

3.2.3. Protein content and protein yield of wheat

The protein content and protein yield of wheat was significantly influenced by various treatments in both the years of experimentation (Table 5). Higher protein content of wheat was noticed in treatment T_5 and was found to be significantly superior to rest of other treatments except that it was at par with treatment T_1. The treatment RD-NPK was at par with 50% N-PBSW+remaining N and P chemical fertilizers and T_5. Similar trend was observed as per pooled protein content in both the years of experimentation.

The higher protein yield of wheat was observed in treatment T_1 over the rest of other treatments and it was at par with T_5 in both the years. The wheat protein yield was increased in treatments T_1, T_4 and T_5 as compared to T_2 and T_3 during both the years of study Application of PBSW along with N and P chemical fertilizers increased protein content and protein yield of wheat at lower levels as compared to higher levels of PBSW. Similar observations were reported by Sukanya and Meli (2004).

3.2.4. Ash, lysine, crude fibre, methionine and tryptophan content of soybean

The quality parameters viz., ash and lysine were statistically significant and crude fibre, methionine and tryptophan were non significant in both the years of experimentation and pooled means (Table 6).

The higher pooled ash content (4.70%) was observed in treatment RD-NPK as compare to rest of other treatments and treatments T_4 and T_5 were at par with each other. The pooled lysine content of soybean was significantly higher in T_5 (6.19 g 16 g N^{-1}) which was at par with T_4 (6.17g 16 g N^{-1}) and T_1 (6.12g 16 g N^{-1}). This might be due to increased protein content in soybean due to combination organic (PBSW)+inorganic fertilizer (N and P chemical fertilizers). Lower doses of PBSW @ 25 and 50% N through PBSW+N and P chemical fertilizer improved the quality of soybean. The lowest pooled lysine and ash content of soybean was recorded in T_2 and T_3. The quality of soybean was decreased with higher levels of PBSW application. Similar results were reported by Soundarajan et

Table 4: Effect of one time application of PBSW on protein content and protein yield of soybean

Treatment	Protein content (%) 2009-10	Protein content (%) 2010-11	Pooled mean	Protein yield (kg ha^{-1}) 2009-10	Protein yield (kg ha^{-1}) 2010-11	Pooled mean
T_1	30.21^{bc}	30.78^{b}	30.50^{bc}	106.32^{a}	320.39^{b}	213.36^{a}
T_2	30.08^{c}	26.18^{c}	28.13^{d}	53.54^{d}	159.96^{d}	106.75^{b}
T_3	30.75^{abc}	26.58^{c}	28.67^{cd}	54.12^{d}	174.63^{d}	114.38^{b}
T_4	33.26^{ab}	31.12^{ab}	32.19^{ab}	96.79^{c}	257.67^{c}	177.23^{a}
T_5	33.55^{a}	33.55^{a}	33.55^{a}	101.65^{b}	375.72^{a}	238.69^{a}
SEm±	0.56	0.83	0.63	1.22	6.93	20.01
CD (p=0.05)	3.06	2.55	1.94	3.77	21.36	61.68

Table 5: Effect of one time application of PBSW on protein content and protein yield of wheat

Treatment	Protein content (%) 2009-10	Protein content (%) 2010-11	Pooled mean	Protein yield (kg ha^{-1}) 2009-10	Protein yield (kg ha^{-1}) 2010-11	Pooled mean
T_1	10.22^{a}	11.98^{ab}	11.10^{ab}	337.06^{a}	468.20^{a}	402.63^{a}
T_2	7.96^{b}	8.98^{c}	8.47^{c}	106.72^{c}	236.31^{c}	171.52^{c}
T_3	8.03^{b}	9.42^{c}	8.73^{c}	105.04^{c}	263.44^{c}	184.24^{c}
T_4	10.38^{a}	10.81^{bc}	10.60^{b}	292.75^{b}	383.60^{b}	338.18^{b}
T_5	10.49^{a}	12.45^{a}	11.47^{a}	316.60^{ab}	467.14^{a}	391.87^{a}
SEm±	0.33	0.62	0.18	8.53	19.91	7.56
CD (p=0.05)	0.74	1.91	0.54	26.29	61.38	23.30

al., (2007).

3.2.5. Quality parameters of wheat

The quality parameters of wheat *viz;* pooled biological value, carbohydrate, dry gluten, net protein utilization, riboflavin and thiamine were significantly influenced by application of PBSW along with or without chemical fertilizers and non-significant effect was observed in crude fibre, lysine and niacin (Table 7 and 8).

The treatment T_5 showed significantly higher pooled biological value (54.86) which was at par with T_4 (54.63) and T_1 (53.95). The treatment T_2 (52.56) showed significantly lower biological value of wheat which was at par with T_3 (52.92). The pooled carbohydrate content in wheat was recorded significantly higher in T_1 and the treatments T_2, T_3 and T_4, T_5 were statistically at par with each other. The pooled dry gluten in wheat was statistically higher in T_5 (8.28%) which was at par with T_4 and T_1 (8.27 and 8.16, respectively) followed by T_3 and T_2 (7.60 and 7.67, respectively) and both T_3 and T_2 treatments were statistically at par with each other. Significantly higher pooled net protein utilization was observed in T_5 (52.71%) which were at par with T_4 (52.24%). The higher values of pooled riboflavin and thiamine were observed in T_5 (0.097 and 0.487mg 100g^{-1}, respectively) and T_5 was statistically at par with T_4 for riboflavin and thiamine. In general, application of PBSW before sowing @ 25 or 50% RD of N through PBSW and remaining recommended N and P through chemical fertilizers, helped in improving wheat grain quality than that of 100% N through PBSW with or without P chemical fertilizer. This might be due to balanced availability of nutrients from PBSW and fertilizers and higher uptake of nutrients as well as protein content. These results were close in conformity with Sukanya and Meli (2004)

3.3. Economics of soybean and wheat

The highest gross returns, net returns and B:C ratio of soybean and wheat was recorded in treatment T_1 (₹ 59075 ha^{-1}, ₹ 21852 ha^{-1} and 1.59) and followed by treatment T_5 during the year 2009-10 (Table 9). In the second year of experimentation during the 2010-11, the highest net returns and B: C ratio of soybean and wheat was recorded in treatment T_5 (₹ 43311 ha^{-1} and 2.18) and followed by treatment T_1. The highest mean of gross returns and net returns of soybean and wheat was recorded in treatment T_1 (₹ 69716 ha^{-1} and ₹ 31596 ha^{-1}) and B:C ratio in treatment T_5. However, the lowest mean of gross returns, net returns and B:C ratio of soybean and wheat was recorded in treatments T_2 and T_3 due to application of PBSW. The higher mean of B:C ratio of soybean and wheat

Table 6: Effect of one time application of PBSW on quality parameters of soybean

Treat-ment	Ash (%)			Crude fibre (%)			Lysine (g 16 g N^{-1})			Methionine (g 16 g N^{-1})			Tryptophan (g 16 g N^{-1})		
	2009-10	2010-11	Pooled Mean	2009-10	2010-11	Pooled Mean	2009-10	2010-11	Pooled Mean	2009-10	2010-11	Pooled Mean	2009-10	2010-11	Pooled Mean
T_1	4.65^{a}	4.74^{a}	4.70^{a}	4.63	4.97	4.80	6.18^{a}	6.06^{ab}	6.12^{ab}	1.46	1.51	1.49	1.45	1.45	1.45
T_2	4.17^{c}	4.26^{b}	4.22^{c}	4.73	4.54	4.64	6.04^{b}	5.64^{c}	5.84^{c}	1.42	1.42	1.42	1.43	1.41	1.42
T_3	4.31^{bc}	4.35^{b}	4.33^{b}	4.78	5.22	5.00	6.02^{b}	5.72^{bc}	5.87^{c}	1.42	1.41	1.42	1.44	1.45	1.45
T_4	4.57^{ab}	4.42^{b}	4.50^{b}	4.57	4.69	4.63	6.21^{a}	6.12^{ab}	6.17^{ab}	1.49	1.50	1.50	1.46	1.46	1.46
T_5	4.58^{ab}	4.41^{b}	4.50^{b}	4.46	5.16	4.81	6.18^{a}	6.20^{a}	6.19^{a}	1.51	1.46	1.49	1.51	1.46	1.49
SEm±	0.10	0.09	0.06	0.20	0.187	0.10	0.03	0.14	0.05	0.03	0.05	0.03	0.02	0.01	0.02
CD (p=0.05)	0.31	0.28	0.17	NS	NS	NS	0.10	0.44	0.15	NS	NS	NS	NS	NS	NS

Table 7: Effect of one time application of PBSW on quality parameters of wheat

Treat ment	Biological value			Carbohydrate (%)			Fibre (%)			Lysine (g 16 g N^{-1})			Dry gluten (%)		
	2009-10	2010-11	Pooled Mean	2009-10	2010-11	Pooled Mean	2009-10	2010-11	Pooled Mean	2009-10	2010-11	Pooled Mean	2009-10	2010-11	Pooled Mean
T_1	53.60^{ab}	54.30	53.95^{b}	84.90^{a}	82.00^{a}	83.45^{a}	1.13	1.13	1.13	2.21	2.22	2.22	8.30^{a}	8.01^{ab}	8.16^{a}
T_2	51.65^{c}	53.46	52.56^{c}	81.75^{b}	78.70^{c}	80.23^{c}	1.10	1.12	1.11	2.20	2.14	2.17	7.41^{b}	7.78^{b}	7.60^{b}
T_3	52.73^{bc}	53.10	52.92^{c}	81.66^{b}	79.35^{bc}	80.51^{c}	1.10	1.01	1.06	2.28	2.21	2.25	7.53^{b}	7.80^{b}	7.67^{b}
T_4	54.17^{ab}	55.09	54.63^{ab}	82.84^{b}	80.98^{ab}	81.91^{b}	1.13	1.14	1.14	2.21	2.28	2.25	8.28^{a}	8.25^{a}	8.27^{a}
T_5	55.17^{a}	54.54	54.86^{a}	83.05^{ab}	81.62^{a}	82.34^{b}	1.12	1.15	1.14	2.24	2.30	2.27	8.25^{a}	8.30^{a}	8.28^{a}
SEm±	0.63	0.81	0.26	0.67	0.65	0.20	0.017	0.04	0.03	0.03	0.04	0.05	0.22	0.134	0.08
CD (p=0.05)	1.94	NS	0.79	2.06	2.01	0.61	NS	NS	NS	NS	NS	NS	0.40	0.413	0.26

Table 8: Effect of one time application of PBSW on quality parameters of wheat

Treatment	Net protein utilisation (%)			Niacin (mg 100 g^{-1})			Riboflavin (mg 100 g^{-1})			Thiamine (mg 100 g^{-1})		
	2009-10	2010-11	Pooled Mean	2009-10	2010-11	Pooled Mean	2009-10	2010-11	Pooled Mean	2009-10	2010-11	Pooled Mean
T_1	52.75^a	51.34^{bc}	52.05^b	3.97^c	4.25^a	4.11	0.085^{bc}	0.095	0.090^b	0.434^c	0.471	0.453^b
T_2	51.92^{bc}	50.77^c	51.35^c	4.35^a	3.90^c	4.13	0.080^c	0.087	0.084^c	0.443^c	0.463	0.453^b
T_3	51.71^c	50.82^c	51.27^c	4.29^a	4.10^{bc}	4.20	0.092^{ab}	0.089	0.091^b	0.468^b	0.489	0.479^a
T_4	52.33^{ab}	52.15^{ab}	52.24^{ab}	4.21^b	4.24^{ab}	4.23	0.094^a	0.100	0.097^a	0.486^{ab}	0.496	0.491^a
T_5	52.68^a	52.73^a	52.71^a	4.05^b	4.21^{ab}	4.13	0.097^a	0.097	0.097^a	0.495^a	0.479	0.487^a
SEm±	0.19	0.34	0.18	0.023	0.050	0.08	0.002	0.005	0.002	0.008	0.011	0.006
CD (p=0.05)	0.60	1.04	0.56	0.069	0.143	NS	0.007	NS	0.005	0.024	NS	0.017

Table 9: Effect of one time application of PBSW on economics of soybean and wheat

Treatment	Gross returns (₹ ha^{-1})			Net returns (₹ ha^{-1})			B:C ratio		
	2009-10	2010-11	Mean	2009-10	2010-11	Mean	2009-10	2010-11	Mean
T_1	59075	80357	69716	21852	41340	31596	1.59	2.06	1.83
T_2	25068	51983	38526	-2333	22788	10228	0.91	1.78	1.36
T_3	24537	55472	40005	-6527	22613	8043	0.79	1.69	1.25
T_4	50250	70197	60224	16607	34761	25684	1.49	1.98	1.74
T_5	53581	80036	66809	18650	43311	30981	1.53	2.18	1.86

was observed in treatment T_5 and followed by T_1. This might be due to higher grain yield of soybean and wheat crop was obtained in these treatments as compared to other treatments. The similar results were observed by Selvamurugan et al., (2013) also noticed that the net returns and benefit cost ratio of sugarcane were also as high as ₹ 19,612 ha^{-1} and 1.90 for the treatment that received pre-sown application of biomethanated distillery spentwash @100 m^3 ha^{-1} along with recommended NP as compared to control of ₹ 19,612 ha^{-1} and 1.38, respectively. The lower mean B: C ratio of soybean and wheat was observed in treatments T_2 and T_3 .

4. Conclusion

One time of application of 25% N-recommended dose PBSW well before sowing for soybean and wheat+remaining N and P through chemical fertilizers increased grain yield and improved the quality parameters of soybean and wheat. As the PBSW contain high amount of K, potassium fertilizers should need not be added separately. Hence, the PBSW can be conveniently and judiciously used as a source of plant nutrients for soybean and wheat crop.

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