Indian Journal of Agronomy **56** (2): 138–144 (June 2011)

Effect of phosphorus enriched vermicompost on juice quality, ethanol yield and nutrient balance in sweet sorghum (*Sorghum bicolor*)

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Received: June, 2010

ABSTARCT

The work on enrichment of rock phosphate with vermi-compost and use of VAM is limited. Therefore, an experiment was conducted during 2008 and 2009 in sandy clay loam soil at Kathalagere, Karnataka to study the effect of phosphorus enriched vermin-compost on juice quality, ethanol yield and nutrients balance in soil after harvest of sweet sorghum [*Sorghum bicolor* (L.) Moench]. Results revealed that, application of 125 kg N + 50 kg K + vermi-compost enriched (VCE) with rock phosphate (RP), phosphorus solubilizing bacteria (PSB) and vescular arbuscolor mycorrhiza (VAM) resulted significantly higher grain (1.78 and 1.72 t/ha), millable stalk (30.7 and 29.6 t/ha), juice (10,472 and 9,934 l/ha), ethanol yield (492.2 and 465.2 l/ha), net returns (23,844/ha and 22,461/ha) and B:C ratio (2.59 and 2.5) during 2008 and 2009, respectively and which was on par with the application of 125 kg N + 50 kg K + VCE with RP and PSB. Whereas, application of 50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Azatobacter* recorded significantly lower grain, millable stalk, juice, ethanol yield, net returns and B:C ratio. The uptake of nitrogen, phosphorus and potassium by crop was significantly higher with the application of 125 kg N + 50 kg K + VCE with RP, PSB and VAM during both the years of experimentation.

Key words: Ethanol yield, Nutrient uptake, Nutrient balance, Sweet sorghum

Sweet sorghum is special crop with a sugar-rich stalk, similar to sugarcane. It has rapid growth, high sugar accumulation, and biomass production potential, besides, wider adaptability. Given that water availability is poised to become a major constraint to agricultural production in coming years and cultivation of sugarcane becomes difficult. Sweet sorghum would be a logical crop option in lieu of sugarcane in such situations. It can be grown with less irrigation and rainfall and purchased inputs when compared with sugarcane. The sugar content in the juice extracted from sweet sorghum varies from 16 to 23% brix. It has a great potential for jaggery, syrup and most importantly fuel alcohol production (Ratnavathi *et al.*, 2003). There are many factors that influence the growth and yield of sweet sorghum, among them, nutrient supply is the prime factor. Reports on nitrogen requirement of the sweet sorghum crop revealed that inadequate supply of nitrogen results in lower stalk yield and sugar per unit area, while excessive application results in poor juice quality. Similar to nitrogen, potassium is also fundamental to sweet sorghum for synthesis and translocation of protein and carbohydrates and thus accumulation of sucrose rather than reducing sugars but work on potassium requirement in sweet sorghum is limited. Deficiency of phosphorus (P) may adversely affect the plants in obtaining full supply of nitrogen. Phosphorus is essential for the formation of chlorophyll and protoplasm which are essential part of life. Demand for phosphatic fertilizer is increasing in the recent years, particularly for diammonium phosphate (DAP) and its price depends on the phosphoric acid, a chief raw material which is imported from foreign countries. The rise in the prices of phosphoric acid escalates the price of DAP. Besides, adequate quantity is not supplied to the farmers in time. So that search of alternative sources for phosphatic fertilizer is needed. Rock Phosphate (RP) is locally available and cheaper source but appropriate management practices to effectiveness of RP are remained. Enriching organic manure with RP is one of them. Among the sources of available organic manures, vermicompost is a potential source due to the presence of readily available plant nutrients, growth enhancing substances and number of beneficial microorganisms like N-fixing, P-solubalizing and cellulose decomposing organisms. But work on enrichment of vermicompost with RP and use of biofertilizers (VAM) is also meager. Therefore, efforts are made in the current study to determine proper balance and efficient use of nitrogen and potassium with enriched vermicompost as alternative to phosphorus fertilizer in sweet sorghum production.

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MATERIALS AND METHODS

A fixed plot experiment was conducted during 2008 and 2009 at Agriculture Research Station, Kathalagere, Davanagere Dist, Karnataka (India). The soil of the experimental site was sandy clay loam in texture (coarse sand 20.36%, fine sand 22.11%, silt 20.6% and clay 36.93%) with a bulk density of 1.59 Mg/m^3. The soil pH was slightly acidic (5.5) with an electrical conductivity (EC) of 0.08 dS/m. The organic carbon content was 0.5 %. The soil was medium in available nitrogen (284.6 kg/ha), available phosphorus (23.3 kg/ha) and available potassium (198.5 kg/ha). The experiment was laid out in Randomized complete Block Design replicated thrice. The investigation consists of ten treatments *viz*., T_1: 125 kg N + 50 kg K + VCE with RP and PSB, T_2: 125 kg N + 50 kg K + VCE with RP, PSB and VAM, T_3: 100 kg N + 40 kg K + VCE with RP and PSB, T_4: 100 kg N + 40 kg K + VCE with RP, PSB and VAM, T_5: 75 kg N + 30 kg K + VCE with RP, PSB, VAM and *Gluconobacter,* T_6: 75 kg N + 30 kg K + VCE with RP, PSB, VAM and *Azatobacter,* T_7: 50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Gluconobacter,* T_8: 50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Azatobacter,* T_9: 100 kg N + 40 kg K + PSB + VAM and T_{10}: 100+75+40 kg of NPK/ha Recommended dose of fertilizer (RDF). 5 t/ha of farmyard manure (FYM) and 2 t/ha of phosphorus enriched vermicompost (VC) were applied for all the treatments, except T_{10}. RP was added for enrichment of VC according to P_2O_5 requirement of sorghum, 2 kg of PSB, VAM, *Azatobacter* and *Gluconobacter* were used per ton of VC for enrichment. The nutrient content of VC was 1.8:1.28:1.57 % $N:P_2O_5:K_2O$ whereas enriched vermi-compost was 1.95:3.73:1.66 % $N:P_2O_5:K_2O$. FYM used in the experiment contained 0.53:0.32:0.45 % $N:P_2O_5:K_2O$. The experiment was taken during *rabi* with the cultivar 'RSSV-9'. The seeds were sown with the spacing of 45 cm X 15 cm. The crop was sown on 20 September 2008 and 30 October, 2009 was harvested on 17 January 2009 and 20 February 2010, respectively. Fertilizers were applied as per the treatments. Half the dose of N and full dose of P or EVC and P was applied at the sowing as urea (N), single super phosphate (P_2O_5) and muriate of potash (K_2O), respectively. Remaining N was applied at 30 days after sowing to all the treatments. Sweet sorghum was supported by supplemental irrigation based on soil moisture status at establishment stage only and later continued with rainfall. The rainfall received during 2008 and 2009 was 970 and 960 mm, respectively. Homogenous mixture of juice samples were drawn from all the treatments and analyzed for various quality parameters of juice *viz.,* pol per cent was estimated by Horne's dry lead acetate clarification method using polarimeter (Ishwaran, 1981). Juice brix values were recorded by using hand Refractometer (0-30^0) and values were expressed in degrees. Calculated sugar yield/ha was worked out by using the formula and expressed in terms of kg/ha. Calculated sugar yield (kg/ha) = [S-0.4(B-S)] X F X Y/100. Where, B and S = Brix and Pol per cent, respectively of the juice sample extracted. F = value of the factor dependent on the fibre per cent of the sample. Y = weight of the stripped stalk (t/ha). Millable stalk yield was calculated by recording of fresh weight of stalk without leaves and ear head in each net plot using spring balance expressed in t/ha. Juice yield was calculated by using formula and expressed in l/ha. [Juice yield (l/ha) = extractability (ml/kg) X millable stalk yield (t/ha)]. Ethanol yield was calculated from the respective juice values of each treatment according to Manke and Kapoor (2004).

RESULTS AND DISCUSSION

Grain and stover yield

Grain yield is polygenic complex character and is determined by the interaction of a number of characters among themselves and with the environment. Application of enriched vermicompost along with varied levels of nitrogen and potassium caused significant variations in the yield and yield components of sweet sorghum. In the present investigation, application of 125 kg N + 50 kg K + VCE with RP, PSB and VAM and application of 125 kg N + 50 kg K + VCE with RP and PSB recorded significantly higher grain and stover yield when compared with other treatments. The extent of increase in grain yield in these treatments was 5.42 and 8.49%, respectively over the treatment received recommended dose of fertilizer (100:75:40 kg N:P:K/ha). Higher grain and stover yield might be attributed to rapid mineralization of N and K from inorganic fertilizers and steady supply of these nutrients from enriched vermi-compost and FYM, which might have met the nutrient requirement of crop at the critical stages. The findings of this study are in conformity with Kagne *et al.* (2008). Significantly lower grain and stover yield was noticed with the application of 50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Azotobacter,* and 50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Gluconobacter* when compared with other treatments (Table 2). This might be due to lower uptake of nutrients.

Millable stalk and green biomass yield

Application of 125 kg N + 50 kg K + VCE with RP, PSB and VAM 125 kg N + 50 kg K + VCE with RP and PSB recorded significantly higher millable stalk yield when compared with other treatments. The extent of increase in millable stalk yield in these treatments was 13.1 and 7.49 %, respectively over the treatment which received RDF

Table 1. Growth, yield and quality of sweet sorghum as influenced by enriched vermicompost under different N and K fertility levels.

Treatment	Millable stalk yield (t/ha)		Juice yield (l/ha)		Ethanol yield (l/ha)		Brix (%)		Pol (%)		Calculated sugar yield (kg/ha)	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
125 kg N + 50 kg K + VCE with RP and PSB	29.4	27.9	10,472	9,934	492.2	465.2	13.5	13.3	8.3	8.2	135.3	127.2
125 kg N + 50 kg K + VCE with RP, PSB and VAM	30.7	29.6	8,656	8,072	380.9	353.3	13.5	13.3	7.9	7.9	128.6	125.7
100 kg N + 40 kg K + VCE with RP and PSB	27.4	25.8	9,260	8,472	416.7	379.0	14.0	13.8	8.3	8.2	122.1	113.8
100 kg N + 40 kg K + VCE with RP, PSB and VAM	28.1	26.0	8,067	7,481	349.6	321.9	14.0	13.8	8.2	8.1	122.3	112.0
75 kg N + 30 kg K + VCE with RP, PSB, VAM and *Gluconobacter*	25.9	24.6	7,506	6,937	315.3	289.0	14.5	14.3	8.4	8.3	114.2	107.4
75 kg N + 30 kg K + VCE with RP, PSB, VAM and *Azatobacter*	24.4	22.9	6,472	5,902	239.5	217.2	14.7	14.5	8.6	8.6	111.2	105.7
50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Gluconobacter*	21.9	20.3	6,174	5,614	226.4	204.5	14.8	14.7	8.5	8.5	96.9	90.4
50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Azatobacter*	21.4	20.0	6,860	6,311	260.7	238.1	15.5	15.3	8.9	8.9	99.1	93.8
100 kg N + 40 kg K + PSB + VAM	22.4	21.4	8,998	8,291	397.8	367.8	14.0	13.8	8.2	8.1	97.5	92.2
100+75+40 kg of NPK/ha	27.6	25.9	9,817	9,180	458.1	426.6	14.0	13.8	8.4	8.3	125.8	116.9
SEm±	0.77	1.11	237.2	354	14.57	17.07	0.50	0.08	0.2	0.1	4.12	5.96
CD (P=0.05)	2.31	3.32	711.0	1,062	43.69	51.19	1.49	0.24	0.5	0.3	13.09	18.58

Table 2. Yield and economics of sweet sorghum as influenced by enriched vermicompost under different N and K fertility levels

Treatment	Grain yield (t/ha)		Stover yield (t/ha)		Cost of Cultivation	Gross returns (₹/ha)		Net returns (₹/ha)		B:C ratio	
	2008	2009	2008	2009	(Rs/ha)	2008	2009	2008	2009	2008	2009
125 kg N + 50 kg K + VCE with RP and PSB	1.70	1.62	32.1	31.7	14,985	36,662	34,807	21,677	19,822	2.45	2.32
125 kg N + 50 kg K + VCE with RP, PSB and VAM	1.78	1.72	34.8	34.3	14,985	38,829	37,446	23,844	22,461	2.59	2.50
100 kg N + 40 kg K + VCE with RP and PSB	1.53	1.50	30.6	30.2	14,656	32,422	31,342	17,766	16,686	2.21	2.14
100 kg N + 40 kg K + VCE with RP, PSB and VAM	1.61	1.51	31.4	30.8	14,656	34,400	32,255	19,744	17,599	2.35	2.20
75 kg N + 30 kg K + VCE with RP, PSB, VAM and *Gluconobacter*	1.45	1.41	29.1	29.0	14,327	30,520	29,268	16,193	14,941	2.13	2.04
75 kg N + 30 kg K + VCE with RP, PSB, VAM and *Azatobacter*	1.38	1.36	27.6	27.2	14,327	28,589	27,679	14,262	13,352	2.00	1.93
50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Gluconobacter*	1.22	1.20	26.2	26.0	13,998	24,629	23,744	10,631	9,746	1.76	1.70
50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Azatobacter*	1.21	1.18	25.2	24.9	13,998	24,045	23,106	10,047	9,108	1.72	1.65
100 kg N + 40 kg K + PSB + VAM	1.29	1.27	26.5	26.3	14,656	26,008	25,174	11,352	10,518	1.77	1.72
100+75+40 kg of NPK/ha	1.55	1.50	31.0	30.5	14,656	31,656	30,520	17,000	15,864	2.16	2.08
SEm±	0.05	0.06	1.02	1.04	-	-	-	863	969	0.05	0.06
CD (P=0.05)	0.15	0.20	3.18	3.38	NA	NA	NA	2,537	2,981	0.17	0.20

NA: Not Analyzed Grain: ₹12000/t Stover: ₹1500/t Ethanol: ₹25/lit

Note: Cost of cultivation was same for both the years

(100:75:40 kg N:P:K/ha). The increase in millable stalk yield was a result of increase in plant height. Application of 50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Azatobacter* and 50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Gluconobacter* recorded significantly lower millable stalk yield as compared to other treatments. Decrease in millable stalk yield might be due to decrease in millable stalk length, stem girth and plant height (Table 1). These results are on par with the findings of Sanjeev Raddi (2006).

Juice and ethanol yield

Application of 125 kg N + 50 kg K + VCE with RP, PSB, VAM and 125 kg N + 50 kg K + VCE with RP and PSB recorded significantly higher juice yield as compared to other treatments. The extent of increase in juice yield in these treatments was 19.4 and 11.1 %, respectively over the treatment received RDF (100:75:40 kg NPK/ha). The increase in juice yield might be due to increase in millable stalk yield, extractability and extraction %. These results are in agreement with those of Sanjeev Raddi (2006) and Latha (2007). Application of 50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Azatobacter* produced significantly lower juice yield (Table 1). The ethanol yield of sweet sorghum differed significantly. Application of 125 kg N + 50 kg K + VCE with RP, PSB and VAM recorded significantly higher ethanol yield followed by 125 kg N + 50 kg K + VCE with RP and PSB (442.8 l/ha) when compared with other treatments (Table 1). The extent of increase in ethanol yield in these treatments was 26.5 and 16.8 %, respectively over the treatment received RDF (100:75:40 kg NPK/ha). This might be due to significantly higher pol, brix and green biomass yield. These results are in conformity with the findings of Bennet (1982). Application of 50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Azatobacter* produced significantly lower ethanol yield which was on par with the application 50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Gluconobacter*.

Table 3. Nitrogen balance (kg/ha^{-1}) in soil after harvest of sweet sorghum as influenced by enriched vermicompost under different N and K fertility levels.

Treatment	2008				2009					
	N through fertilizer and manures	Total N	Crop uptake	Actual** balance	N through fertilizer and manures	Total N	Crop uptake	Expected balance (f-g)	Actual balance	Net gain (+) or Net loss (-)
	(a)	(b=a+*)	(c)	(d)	(e)	(f=d+e)	(g)	(h)	(i)	(j=i) (h)
125 kg N + 50 kg K + VCE with RP and PSB	190.5	475.1	107.8	261.7	190.5	452.2	104.4	347.8	244.2	-103.6
125 kg N + 50 kg K + VCE with RP, PSB and VAM	190.5	475.1	113.0	260.5	190.5	451.0	110.4	340.6	242.9	-97.7
100 kg N + 40 kg K + VCE with RP and PSB	165.5	450.1	91.9	266.2	165.5	431.7	90.5	341.2	251.4	-89.8
100 kg N + 40 kg K + VCE with RP, PSB and VAM	165.5	450.1	94.2	265.8	165.5	431.3	90.5	340.8	250.1	-90.7
75 kg N + 30 kg K + VCE with RP, PSB, VAM and *Gluconobacter*	140.5	425.1	83.1	273.4	140.5	413.9	81.7	332.2	254.7	-77.5
75 kg N + 30 kg K + VCE with RP, PSB, VAM and *Azatobacter*	140.5	425.1	76.0	275.3	140.5	415.8	75.0	340.8	255.3	-85.5
50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Gluconobacter*	115.5	400.1	64.8	280.4	115.5	395.9	64.0	331.9	263.1	-68.8
50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Azatobacter*	115.5	400.1	62.0	282.5	115.5	398.0	61.0	337.0	264.5	-72.5
100 kg N + 40 kg K + PSB + VAM	165.5	450.1	77.2	278.5	165.5	444.0	76.3	367.7	257.3	-110.4
100+75+40 kg of NPK/ha	165.5	450.1	97.6	279.4	165.5	444.9	96.3	348.6	259.8	-88.8

Initial status: 284.6 kg/ha (2008)* **Initial status for 2009

Juice quality parameters

Significantly higher brix and pol per cent were observed with the application of 50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Azatobacter*. Application of 125 kg N + 50 kg K + VCE with RP, PSB and VAM recorded significantly lower brix and pol per cent as compared to rest of the treatments (Table 1). Reverse trend in juice quality parameters might be due to vigorous vegetative growth and succulent nature of plant at higher level of nitrogen (Balasubramanian and Ramamoorthy, 1998; and Silli *et al.,* 2001).

Nutrient uptake and balance

The data pertaining to NPK uptake by sweet sorghum is presented in Tables 3 to 5. The NPK uptake by sweet sorghum varied due to varied levels of N and K with enriched vermicompost application in both the years. Higher uptake of NPK was recorded with the application of 125 kg N + 50 kg K + VCE with RP, PSB and VAM. It may be due to higher availability of nutrients by synergistic effect of combined application of organic sources like vermicompost and FYM with inorganic fertilizer. Krishnamoorthy (1995) observed higher N, P and K uptake due to addition of vermicompost in conjunction with *Azospirillum*. The *Azospirillum* produce photo-hormones which can stimulate root growth and induce changes in root morphology and increases the surface area as a result of root proliferation, which inturn could increase assimilation of nutrients. Lower uptake of nitrogen, phosphorus and potassium were recorded with the application of 50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Azatobacter* when compared with other treatments. The lower N, P and K uptake during both the years was due to lower grain and stover yield may be due to lower availability of nutrients (Negalur, 2000).

Higher available NPK in soil after harvest of the crop was recorded with the application of 50 kg N + 20 kg K + VCE with RP, PSB, *VAM and Azatobacter*. This might be due to lower uptake of NPK. Whereas, lower available NPK was recorded with the application of 125 kg N + 50

Table 4. Phosphorus balance (kg P_2O_5/ha) in soil after harvest of sweet sorghum as influenced by rock phosphate enriched vermicompost under different N and K fertility levels

Treatment	2008				2009					
	P through fertilizer and manures	Total P	Crop uptake	Actual** balance	P through fertilizer and manures	Total P	Crop uptake	Expected balance (f-g)	Actual balance	Net gain (+) or Net loss (-) (i-h)
	(a)	(b=a+*)	(c)	(d)	(e)	(f=d+e)	(g)	(h)	(i)	(j=i) (h)
125 kg N + 50 kg K + VCE with RP and PSB	90.4	113.7	36.8	26.8	90.4	117.2	35.8	81.4	27.8	-53.6
125 kg N + 50 kg K + VCE with RP, PSB and VAM	90.4	113.7	37.7	24.5	90.4	114.9	36.9	78.0	26.5	-51.5
100 kg N + 40 kg K + VCE with RP and PSB	90.4	113.7	31.9	27.9	90.4	118.3	31.4	86.9	30.2	-56.7
100 kg N + 40 kg K + VCE with RP, PSB and VAM	90.4	113.7	31.6	27.2	90.4	117.6	30.5	87.1	29.3	-57.8
75 kg N + 30 kg K + VCE with RP, PSB, VAM and *Gluconobacter*	90.4	113.7	29.4	29.5	90.4	119.9	28.9	91.0	32.5	-58.5
75 kg N + 30 kg K + VCE with RP, PSB, VAM and *Azatobacter*	90.4	113.7	29.2	30.2	90.4	120.6	28.8	91.8	33.9	-57.9
50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Gluconobacter*	90.4	113.7	28.5	37.2	90.4	127.6	28.1	99.5	39.3	-60.2
50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Azatobacter*	90.4	113.7	26.0	38.3	90.4	128.7	25.5	103.2	40.5	-62.7
100 kg N + 40 kg K + PSB + VAM	90.4	113.7	29.2	33.6	90.4	124	28.8	95.2	35.7	-59.5
100+75+40 kg of NPK/ha	90.4	113.7	33.5	32.5	90.4	122.9	33.1	89.8	34.5	-55.3

Initial status: 23.3 kg/ha (2008)* ** Initial status for 2009 kg K + VCE with RP, PSB and VAM (Tables 3 to 5). This might be due to higher NPK uptake as influenced by interactive behavior of VAM and PSB in enriched vermicompost which increased the mobilization of NPK in the soil along with external supply of N and N through inorganic sources. Further, increased microbial activity in soil due to conjunctive use of FYM, enriched vermicompost along with inorganic fertilizer also contributed NPK to the available pool which ultimately reflected in the grain and stover yields. These results are in accordance with the studies of Bagyaraj (2004).

There was a negative balance of nitrogen observed in all the treatments during both the years. Application of 100 kg N + 40 kg K + PSB + VAM recorded higher negative balance of nitrogen. The negative balance of nitrogen after harvest of crop might be ascribed to the fact that loss of nitrogen. Similarly, negative balance of phosphorus observed in all the treatments. Application of 50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Azatobacter* recorded higher negative balance of phosphorus. This might be due to the fixation of available phosphorus in soils ultimately resulted in net loss of available phosphorus. However, negative balance of potassium was also observed in all the treatments except T_{10}. The negative balance in potassium (K) was probably due to high potassium demand by sweet sorghum crop for vegetative growth and grain formation. There was a positive balance of potassium observed with the application of 100+75+40 kg NPK/ha (Tables 3 to 5). This might be due to the fact that the fixed potassium might have been made available to the sweet sorghum and enriched the soil, resulting in a positive balance of potassium observed in these treatments, which is unique in nature. These results are in accordance with the studies of Gajanana *et al.* (2000) Bagyaraj (2004).

Economics

Economics is the main parameter which finally decides the adoption of any recommended practices or technology at farming situations by the farmers. It should be technically and economically viable. Application of 125 kg N +

Table 5. Potassium balance (kg K_2O ha^{-1}) in soil after harvest of sweet sorghum as influenced by enriched vermicompost under different N and K fertility levels.

Treatment	2008				2009					
	K through fertilizer and manures	Total K	Crop uptake	Actual** balance	K through fertilizer and manures	Total K	Crop uptake	Expected balance (f-g)	Actual balance	Net gain (+) or Net loss (-) (i-h)
	(a)	(b=a+*)	(c)	(d)	(e)	(f=d+e)	(g)	(h)	(i)	(j=i) (h)
125 kg N + 50 kg K + VCE with RP and PSB	105.7	304.2	110.7	171.3	105.7	277.0	108.9	168.1	160.1	-8.0
125 kg N + 50 kg K + VCE with RP, PSB and VAM	105.7	304.2	118.2	170.5	105.7	276.2	116.3	159.9	158.3	-1.6
100 kg N + 40 kg K + VCE with RP and PSB	95.7	294.2	100.4	175.6	95.7	271.3	99.0	172.3	165.4	-6.9
100 kg N + 40 kg K + VCE with RP, PSB and VAM	95.7	294.2	102.3	174.2	95.7	269.9	100.0	169.9	163.2	-6.7
75 kg N + 30 kg K + VCE with RP, PSB, VAM and *Gluconobacter*	85.7	284.2	92.4	178.5	85.7	264.2	91.7	172.5	171.1	-1.4
75 kg N + 30 kg K + VCE with RP, PSB, VAM and *Azatobacter*	85.7	284.2	86.2	179.3	85.7	265.0	85.0	180.0	173.2	-6.8
50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Gluconobacter*	75.7	274.2	78.0	187.4	75.7	263.1	77.4	185.7	183.5	-2.2
50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Azatobacter*	75.7	274.2	74.3	188.5	75.7	264.2	73.3	190.9	185.3	-5.6
100 kg N + 40 kg K + PSB + VAM	95.7	294.2	86.7	182.3	95.7	278.0	86.1	191.9	176.5	-15.4
100+75+40 kg of NPK/ha	95.7	294.2	107.5	180.4	95.7	276.1	106.7	169.4	175.2	5.8

Initial status: 198.5 kg/ha (2008)* ** Initial status for 2009

50 kg K + VCE with RP, PSB and VAM recorded higher gross returns, net returns and B:C ratio. It was comparable with the application of 125 kg N + 50 kg K + VCE with RP and PSB (Table 2). This might be due to higher grain, stover and ethanol yield. Application of 50 kg N + 20 kg K + VCE with RP, PSB, VAM and *Azotobacter* recorded lower gross returns, net returns and B:C ratio. This might be due to lower grain and ethanol yield. These results are in conformity with findings of Sanjeev Raddi (2006) and Latha (2007).

Application of 125 kg N + 50 kg K + VCE with RP, PSB and VAM, and application of 125 kg N + 50 kg K + VCE with RP and PSB maximized the grain, stover and ethanol yield and recorded higher net returns and B:C ratio.

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