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LONG-TERM EFFECT OF SPENTWASH APPLICATION ON GROWTH, YIELD AND NUTRIENT UPTAKE BY MAIZE UNDER VERTISOLS OF NORTHERN TRANSITION ZONE OF KARNATAKA

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Abtract: A field experiment was conducted in the long-term trial on distillery spentwash application established since 2003 at the Main Agricultural Research Station, UAS, Dharwad. The study was carried out during kharif 2012 to know the response of maize to long-term biomethanated spentwash application under Vertisols of Northern transition zone of Karnataka. Experiment consisted of seven treatments and 3 replications. Results revealed that application of 1½ recommended nitrogen through spentwash was superior with respect to the growth parameters like plant height, chlorophyll content and dry matter production and yield parameters like cob length, cob circumference, cob weight, number of rows per cob, number of seeds per row, number of seeds per cob and test weight. Both growth and yield parameters complemented each other in realising higher grain and stover yield. Spentwash application had also increased the nutrient uptake of the maize.

Key words: Long-term spentwash application, Nutrient uptake, Maize yield

INTRODUCTION

Distillery industries produce liquid effluent called spentwash which could be used for crop cultivation. Total waste water produced per litre of alcohol production is around 8-12 litres (Anon, 2012). In India, there are around 400 distilleries with a production capacity of about 3800 million liters of alcohol generating 40 billion liters of waste water annually. Generally spentwash is discharged into the water bodies. It has high BOD and COD and contains high organic compounds like phenols, lignin, oil and grease which deteriote the surrounding ecosystem quality. As the effluent is mainly a plant extract, rich in organic matter and plant nutrients like potassium, nitrogen, sulphur and calcium, there is a scope for using it advantageously as a ferti-irrigation source to agricultural crops without any adverse effect on soil fertility and productivity. In order to suppress the impact of BOD, COD and salinity, biomethanation process is recommended where in the raw spentwash is subjected to anaerobic decomposition process yielding methane, a fuel and thereby the BOD level is brought down. This is called post methanated distillery spentwash. Biomethanated spentwash has 0.1–0.15 per cent N, 0.8-1.2 per cent K_2O and appreciable quantities of Ca, Mg, S and micronutrients. On an average 1 m^3 of spentwash supplies 1.0 kg N, 0.2 kg P_2O_5 and 10 kg K_2O (Anon, 2006). However, this treated spent wash could not be directly applied to the growing crops because of higher BOD and COD than the permissible limits. So, it should be applied well before crop planting or diluted with normal water and then applied to the growing crops or as one time controlled land application applied before one month of the planting. This waste water is considered safer to use for crop production as a source of nutrients and growth stimulator. With an objective to assess response of maize to long-term application of spentwash, a field experiment was conducted during *kharif* 2012 and the results obtained are discussed in this paper.

MATERIALS AND METHODS

The experiment was being conducted in the Main Agricultural Research Station, Dharwad under Vertisols since 2003 with permanent plots. The present study had field observations on maize crop during *kharif* 2012. The soil of the experimental site is Typic Chromustert. Initial properties of the experimental soil are presented in Table 1 and 2. The experiment was laid out in a randomized complete block design with three replications. The details of the treatments were; T1- 1 N through spentwash (60,000 litre ha^{-1}+

Table 1. Initial soil properties as influenced by previous spentwash application

Treatment	Soil pH (1:2.5)		ECe (dS m^{-1})		Organic C (g kg^{-1})		Available N (kg ha^{-1})		Available P_2O_5		Available K_2O	
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
	cm											
T_1- 1N through spentwash	7.23	7.14	1.45	1.03	5.57	5.10	315	256	19.8	16.2	1393	1047
T_2-1 ½ N through spentwash	7.40	7.35	2.18	0.97	6.60	5.80	354	295	21.8	17.5	1587	1327
T_3-1N through fertilizer	6.93	6.84	0.91	0.84	4.97	4.80	198	217	13.7	11.6	740	653
T_4-1 ½ N through fertilizer	6.65	6.63	0.8	0.86	4.03	3.60	217	198	12.5	10.4	726	673
T_5- ½ N through fertilizer + ½ N spentwash	6.98	6.95	1.31	0.84	5.23	5.00	276	236	16.5	12.2	940	893
T_6- ½ N through spentwash + ½ N through fertilizer	7.09	7.03	1.40	0.88	5.33	5.00	277	276	17.3	13.0	953	940
T_7-Farmers practice	6.58	6.70	0.8	0.94	5.00	4.20	159	180	13.7	11.6	653	600
S. Em ±	0.12	0.12	0.0	0.09	0.15	0.48	18.27	19.53	0.32	0.43	18.34	25.7
C.D. (0.05)	0.36	0.37	0.10	NS	0.45	NS	55.4	59.3	0.9	1.3	55.6	77.9

Table 2. Initial DTPA extractable micronutrients as influenced by previous spentwash application (mg kg^{-1})

Treatment	Zinc		Iron		Manganese		Copper	
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
	cm							
T_1- 1N through spentwash	1.73	1.50	21.00	16.02	40.03	42.15	2.82	2.83
T_2-1 ½ N through	1.96	2.29	21.20	19.40	48.72	46.81	2.87	2.87
T_3-1N through fertilizer	1.38	1.22	12.48	13.43	27.05	30.90	2.75	2.58
T_4-1 ½ N through fertilizer	1.34	1.19	11.20	13.21	20.80	29.78	2.74	2.56
T_5- ½ N through fertilizer + ½ N spentwash	1.65	1.17	14.10	14.58	29.27	35.99	2.79	2.69
T_6- ½ N through spentwash + ½ N through fertilizer	1.73	1.17	14.50	15.59	39.67	36.33	2.80	2.76
T_7-Farmers practice	1.16	1.18	9.73	12.51	18.35	22.13	2.63	2.58
S. Em ±	0.16	0.12	0.77	0.46	2.40	2.52	0.03	0.03
C.D. (0.05)	0.48	0.37	2.33	1.40	7.28	7.63	0.09	0.09

balanced P through SSP); T2 – 1 ½ N through spentwash (90,000 litre ha^{-1} + balanced P through SSP); T3 – 1 N through recommended dose of fertilizer (150:75:37.5 kg NPK ha^{-1}); T4 – 1 ½ N through recommended dose of fertilizer (225:75:37.5 kg NPK ha^{-1}); T5 – ½ N through fertilizer + ½ N through spentwash; T6 – ½ N through spentwash + ½ N through fertilizer and T7 – Farmer's practice (2 bags DAP + 1 bag urea= 41:46:0 NPK kg ha^{-1}). Required quantity of spentwash was calculated as per the nitrogen levels in the treatments. Sixty per cent of the spentwash was applied uniformly 15 days before sowing the crop and 40 per cent was applied at tasseling stage. Phosphorus was applied in the form of SSP in treatments with spentwash and DAP in fertilizer treatments. In treatments without spentwash, nitrogen was applied in the form of urea and DAP and potassium through Muriate of potash. The maize seeds were sown on July 1st 2012 in the recommended spacing of 60 cm between rows and 30 cm between plants.

The growth parameters like plant height, chlorophyll content and drymatter production were recorded during crop growth. The crop was harvested when it attained maturity. The cobs of maize in the net plots were threshed to separate grains and the yield and yield parameters were recorded. Stover yield was recorded after sun drying. Uptake of nutrients at harvest was worked out after determining concentration of nutrients in maize plant tissue by adopting standard analytical procedures.

RESULTS AND DISCUSSION

Growth parameters

The data (Table 3) indicated that plant height of maize at 30 DAS was not significantly influenced by long-term spentwash application. At 60 DAS, the highest plant height (197.37 cm) was recorded in the treatment that was applied with 1½ N through fertilizers. Plant height was significantly higher in the treatments with increased dose of nitrogen (1½ N) through chemical fertilizers. This was due to quick releasing nature of the chemical fertilizers. Plant height at 90 DAS was significantly influenced by long-term spentwash fertigation. The highest plant height (207.6 cm) was recorded in the treatment that was supplied with 1½ N through spentwash.

At flowering stage, all the treatments except that with 1 N spentwash application (151.0 g plant^{-1}) showed significantly higher drymatter production compared with farmers' practice (150.7 g plant^{-1}). Spentwash applied treatments (1N and 1½ N) recorded significantly lower dry matter accumulation compared to equivalent fertilizer dose application. The highest drymatter production (209.0 g plant^{-1}) was recorded in the treatment that was supplied with 1½ N through fertilizer. While at harvest, the drymatter production was significantly higher in treatment receiving 1½ N through spentwash (284.8 g plant^{-1}). However, this was on par with the treatments that received 1½ N through fertilizer and ½ N through spentwash and remaining ½ N through fertilizer. Treatment receiving farmers' practice of fertilizer dose recorded the lowest drymatter production both at flowering stage (150.7 g plant^{-1}) and at harvest (253.3 g plant^{-1}). Spentwash had undergone slow mineralisation and there was constant supply of nutrients even at the later stages of crop growth. Hence at harvest, crop that received higher doses of spentwash recorded higher plant height and dry matter production.

The SPAD meter readings at tasseling stage of maize showed that significant differences existed between different treatments with respect to chlorophyll content. Chlorophyll content increased wherever nitrogen was supplied through spentwash. Increase in the level of nitrogen supply also increased the

Table 3. Effect of long-term spentwash fertigation on plant height, dry-matter production and leaf chlorophyll content of maize

Treatments	Plant height (cm)			Dry matter production of whole plant (g plant^{-1})		Chlorophyll content (SPAD) at tasseling
	30 DAS	60 DAS	At harvest	At flowering	At harvest	
T_1- 1N through spentwash	34.5	183.8	196.2	151	276.6	38.5
T_2-1 ½ N through spentwash	39.2	185.8	207.6	185.3	284.8	49.3
T_3-1N through fertilizer	38.3	185.6	194.4	198	264.4	38.2
T_4-1 ½ N through fertilizer	39.2	198.4	201.5	209	282.6	46.8
T_5- ½ N through fertilizer + ½ N through spentwash	38.1	161.1	195.5	182.7	276.4	42.2
T_6- ½ N through spentwash + ½ N through fertilizer	31.0	167.9	197.0	168	282.4	40.8
T_7-Farmers practice	29.2	151.4	188.3	150.7	253.3	30.4
S. Em ±	4.60	3.40	1.78	1.79	2.18	0.80
C.D. (0.05)	NS	10.31	5.39	5.42	6.60	2.42

chlorophyll content. The highest chlorophyll content (49.3) was recorded in the treatment receiving 1½ N through spentwash. The lowest chlorophyll content (30.4) was recorded in the treatment receiving farmers' practice. There was no significant difference in chlorophyll content between the treatments that was supplied with 1 N through spentwash (38.5) and 1 N through fertilizers (38.2). Similarly, the treatments with 1½ N through spentwash and 1½ N through fertilizers did not differ significantly in terms of chlorophyll content. Long-term spentwash application either alone or in combination with the fertilizers, improved the available status of N, P, K and micronutrients as evident by soil analysis. This facilitated better growth, dry matter accumulation and chlorophyll content of maize plants under spentwash compared to only fertilizer applied plots. These results corroborate with the findings of Suganya and Rajannan (2009), who also reported that the growth attributes of maize like plant height, leaf length, leaf breadth, number of leaves per plant and leaf area index were higher in distillery effluent irrigated treatments compared to control. Rath *et al.* (2011) also observed maximum growth and chlorophyll content of maize in 50 per cent distillery spentwash as compared to two different types of fertilizers. The maximum growth performance of the fenugreek plants was observed at 50% effluent concentration by Kumar and Chopra (2010).

Yield parameters and yield

The various parameters of yield such as cob length, cob circumference, number of rows per cob, number of seeds per row, number of seeds per cob, cob weight, 100 seed weight etc., were higher in the treatments that had 1½ times recommended N through spentwash supply (Table 4). The distillery spentwash is essentially a plant extract and contains high levels of plant nutrients which were made available to the plants by mineralization thus, resulting in better growth, development and yield of the crop. This was possible due to the sustained supply of nutrients throughout the crop growth period by mineralization as indicated by higher enzymatic activities in spentwash applied plots. The cob length, single cob weight, 100 grain weight and grain yield increased in maize due to the application of spentwash at 150 kL ha^{-1} (Mallika, 2001). Similarly, Sridharan (2007) concluded that one time land application of post methanated distillery spentwash at 60 m^3 ha^{-1} increased the yield of rainfed maize.

Spentwash application in combination with chemical fertilizers produced higher cob length, cob weight and 100 seeds weight compared to treatments with fertilizers alone. This may be due the immediate supply of nutrients through fertilizers in the initial stages of crop growth and slow and steady supply of nutrients over an

Table 4. Effect of long-term spentwash fertigation on yield parameters and yield of maize

Treatments	Cob length (cm)	Cob circumference (cm)	Cob weight (g)	No. of rows per cob	No. of seeds per row	No. of seeds per cob	100 seeds weight (g)	Grain yield (q ha^{-1})	Stover yield (t ha^{-1})
T_1- 1N through spentwash	15.2	14.3	94.6	15	25	365	27.3	49.1	13.9
T_2- 1 ½ N through spentwash	18.7	17.8	120.9	16	31	495	32.1	56.0	17.5
T_3-1N through fertilizer	15.4	15.3	86.1	15	24	346	26.3	48.4	13.8
T_4-1 ½ N through fertilizers	15.6	16.0	94.1	15	29	445	28.0	54.5	15.4
T_5- ½ N through fertilizer + ½ N through spentwash	16.7	15.7	106.0	15	26	419	30.2	42.9	13.2
T_6- ½ N through spentwash + ½ N through fertilizer	16.3	14.9	113.3	15	28	426	29.6	45.3	13.1
T_7-Farmers practice	14.3	13.7	82.7	14	23	349	26.0	41.3	12.9
S. Em ±	0.19	0.12	4.26	0.53	1.47	3.13	1.08	1.43	0.83
C.D. (0.05)	0.59	0.36	12.92	NS	4.46	9.48	3.24	4.32	2.51

extended period of crop growth through spentwash.

Both growth and yield parameters complemented each other in producing higher grain and stover yield in spentwash applied plots. The highest grain yield (56.0 q ha^{-1}) and stover yield (17.5 t ha^{-1}) were obtained in the treatment that received 1.5 times recommended nitrogen through spentwash. This was in agreement with the study conducted by Kavitha *et al.* (2008), wherein 1.5 times N through spentwash along with 1.5 times P and 1.5 times N through spentwash along with balanced P through SSP gave superior yield in sunflower. Similarly, significant increase in yield of sugarcane with graded doses of distillery effluent was reported by Subash Chandra Bose *et al.* (2002).

The treatment in which 50 per cent of recommended nitrogen through spentwash before sowing and another 50 per cent through fertilizer at tasseling stage produced higher grain yield compared to the treatment with fertilizer applied first and then spentwash. Spentwash when applied first will get sufficient time to undergo decomposition and mineralization. There will be continuous supply of nutrients in all the crop stages. The field experiment conducted by Pradeep (2007) also revealed that yield and growth of maize and chick pea were superior in the treatment that received 50 per cent RDN through urea and 50 per cent through biomethanated spentwash.

Nutrient uptake

Maize crop is nitro positive and responded to higher rates of nitrogen application. Uptake of nitrogen was the highest (196.0 kg ha^{-1}) in the treatment that received 1½ times recommended nitrogen through spentwash and was significantly higher when compared to that of chemical fertilizers (Table 5). Long-term application of spentwash increased the availability of nitrogen to the crop and provided greater opportunity for the crop to remove more nitrogen for an extended period of time. Chemical fertilizers were more prone to nutrient losses. Patil et al. (2000) noticed significant increase in the N uptake (3.24 g/pot) by the addition of spentwash at 50 m^3 ha^{-1} over control (0.29 g/pot). Application of spentwash along with fertilizer also showed good uptake of nitrogen.

Application of spentwash to supplement different levels of nitrogen along with balanced application of phosphorus through DAP increased the phosphorus uptake. Uptake of phosphorus increased in the treatment with 1½ N through spentwash (46.8 kg ha^{-1}) compared with 1 N through spentwash (Table 5). Patil *et al.* (2000) noticed significant increase in P uptake (2.18 g/pot) by the application of spentwash @ 50 $m^3 ha^{-1}$ over control (0.66 g/pot). Increase in available P led to greater

Table 5. Effect of long-term spentwash fertigation on nutrient uptake by maize at harvest

Treatments	Major nutrient uptake (kg ha^{-1})			Micronutrient uptake (g ha^{-1})			
	Nitrogen	Phosphorus	Potassium	Iron	Manganese	Copper	Zinc
T_1- 1N through spentwash	182	40.6	170	415	125.4	159.0	206
T_2-1 ½ N through spentwash	196	46.8	245	530	138.8	161.7	229
T_3-1N through fertilizer	144	34.0	125	336	109.9	86.6	189
T_4-1 ½ N through fertilizers	177	32.3	115	356	105.4	117.3	198
T_5- ½ N through fertilizer + ½ N through spentwash	155	38.7	140	368	125.5	86.1	204
T_6- ½ N through spentwash + ½ N through fertilizer	160	40.4	147	427	126.4	102.2	209
T_7-Farmers practice	131	31.9	117	331	97.4	65.2	177
S. Em ±	2.81	0.59	1.74	11.72	2.56	9.3	1.91
C.D. (0.05)	8.53	1.78	5.27	35.55	7.77	28.21	5.8

uptake by maize. Patil (2002) also observed higher uptake of P by cabbage due to combined application *i.e.* 50 per cent RDN (urea) + 50 per cent RDN (DYS) which was on par with 100 per cent RDN (urea).

Spentwash applied as a substitute for nitrogenous fertilizer acted as a good source of potassium for the crop. Spentwash treated plots showed higher uptake of potassium by maize crop (Table 5). The highest potassium uptake (245 kg ha^{-1}) was recorded in the treatment receiving 1½ N through spentwash. There was an increase of about 44 per cent in potassium uptake when the quantity of spentwash increased (1 N to 1½ N through spentwash). Higher content of potassium in the spentwash had increased the uptake of potassium. The result was similar to that of Bhukya (2006) and Goudar (2006).

Application of 1½ recommended nitrogen through spentwash had increased the uptake of all the micronutrient cations (Table 5). Spentwash served as a source of carbon for microbes and might have enhanced the reduction and chelation reactions leading to increased availability of these cations. The reduced forms of micronutrient cations are labile and could be easily taken up by crops. This was in partial agreement with the findings of Sukanya and Meli (2004) who reported maximum uptake of major and micronutrients by wheat in treatment with 50 per cent N substitution through solid effluent and 50 per cent through inorganic sources. An upsurge in nutrients uptake by paddy (N, P, K, Ca, Mg, Zn, Cu, Fe and Mn) with increasing effluent concentration was reported by Das *et al*. (2010).

CONCLUSION

Spentwash, a distillery by product, is a plant extract and microbial residue, rich in plant nutrients could be utilized in agriculture as a liquid manure after biomethanation. Application of treated spentwash was superior with respect to the growth parameters like plant height, chlorophyll content and dry matter production. This was on par with the treatment that received 1½ N through fertilizers. The yield parameters (cob length, cob circumference, cob weight, number of rows per cob, number of seeds per row, number of seeds per cob and test weight) and yield (grain and stover) were the highest in the treatment that was applied with 1½ recommended N through spentwash. However, long term use of treated spentwash to the soil is not advisable because of buildup of salinity ie., ECe of soil which may affect both physical and shemical properties of the soilultimately affecting the crop yield.

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