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Influence of factory effluent and inorganic fertilizers on yield and nutrient uptake by spinach beet (*Beta vulgaris* var. *bengalensis*) in lateritic soil of Konkan

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Abstract
A field experiment was conducted on "Influence of factory effluent and inorganic fertilizers on yield and nutrient uptake by spinach beet (*Betavulgaris* var. *bengalensis*) in lateritic soil of Konkan" with Randomized Block Design comprising nine treatments replicated thrice. The effect of application of effluent before sowing and after first harvest (cutting) with and without NPK fertilizers @ 100, 50 and 25 per cent of recommended dose on yield and nutrient uptake by spinach were studied.
The application of effluent before sowing with inorganic fertilizers or application of effluent before sowing and after first cutting with inorganic fertilizers significantly increased the yield and uptake of primary and secondary nutrients over recommended dose of NPK fertilizers.

Keywords: Effluent, spinach, yield, lateritic soil

Introduction
Spinach beet is also known as Palak in Hindi. It is most common leafy vegetable in India. Palak belongs to same species in which beet root, sugar beet, swiss chard are included. Since palak was grown earlier in West Bengal, it is known as *(Beta vulgaris* var. *bengalensis).* The use of effluent either in liquid or solid form in agriculture has been practiced in India, since the inception of the industry. Since the conventional methods of waste treatment are uneconomical and especially the difficulty in handling and transporting of large quantities, alternative methods like application of effluents to agricultural land is receiving increasing attention. The increasing cost of fertilizers and most essential nutrients also demand the attention as spent wash contains high amount of nutrients like nitrogen, phosphorus, potassium, calcium and sulphur. The effluents have been recommended for amendment of acidic soils, but their long-term effect happens to be injurious for soil fertility.

Material and Methods
The present field experiment was conducted at Research Farm of Pangari Block, Central Experiment Station, Wakawali, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The selection of site was done on the basis of suitability of land for the cultivation of Spinach. Effluent (composite sample of digester over flow) from the Saf Yeast Company Private Limited, Gane-Khadpoli, Chiplun District-Ratnagiri was collected and applied to the crop. The effluent was analyzed for different chemical parameters (Table 1) using standard methods. Based on the irrigation requirement of the crop per plot quantity of effluent was calculated and applied directly to the plot before sowing and after first cutting of spinach as per the treatments. The research was conducted during *Rabi*, 2013-14 with spinach variety All-Green where nine treatments are replicated thrice in randomize block design in lateritic soil of Konkan. The treatments were T_1 (recommended dose of fertilizers), T_2 (application of effluent before sowing), T_3 (T_2 + 100% RDF), T_4 (T_2 + 50% RDF), T_5 (T_2 + 25% RDF), T_6 (application of effluent before sowing and after 1st cutting), T_7 (T_6 + 100% RDF), T_8 (T_6 + 50% RDF) and T_9 (T_6 + 25% RDF). The nutrient content and uptake was analyzed on the basis of methods of analysis of soils, plants, water and fertilizers Tandon (1993) [14].

Table 1: Chemical and biological properties of effluent

Characteristic	Value
Chemical properties	
pH	8.05
EC (dS m^{-1})	26.55
Organic carbon (%)	1.75
Total Nitrogen (%)	0.50
Total Phosphorus (%)	0.005
Total Potassium (%)	0.43
Calcium (%)	0.72
Magnesium (%)	0.24
Iron (ppm)	90.7
Copper (ppm)	3.74
Zinc (ppm)	0.63
Manganese (ppm)	23.7
Chloride (meq L^{-1})	14
Biological properties	
Bacteria (x 10^6 cfu mL^{-1} of effluent)	9.0
Fungi (x 10^6 cfu mL^{-1} of effluent)	36
Actinomycetes (x 10^6 cfu mL^{-1} of effluent)	2

Result and discussion

Influence of factory effluent and inorganic fertilizers on yield of spinach (t ha^{-1})

Among the various treatments, (application of effluent before sowing + 100 % RDF) treatment T_3 registered the highest total yield (68.90 ton ha^{-1}), which was at par with treatment T_4 (61.10 t ha^{-1}), where application of effluent before sowing + 50 % RDF was applied, but.

Table 2: Influence of factory effluent and inorganic fertilizers on yield of spinach

T. No.	Treatments	Yield (t ha^{-1})
T_1	RDF (100:50:50 kg ha^{-1})	8.35
T_2	Application of effluent before sowing	54.77
T_3	T_2 + 100% RDF	68.90
T_4	T_2 + 50% RDF	57.45
T_5	T_2 + 25% RDF	61.09
T_6	Application of effluent before sowing and after 1st cutting	48.68
T_7	T_6 + 100% RDF	54.93
T_8	T_6 + 50% RDF	46.79
T_9	T_6 + 25% RDF	42.05
S.E.±		3.00
C.D. (P=0.05)		9.00

significantly superior over rest of the treatments (Table 2). Increase in the yield with the application of effluent in lateritic soils of Konkan was also reported by Patil (2012) [9] in rice and Parte (2013) [8] in okra. The factory effluent contains high level of plant nutrients which are made available to the plant, thus resulting in better growth and development of the crop (Suganya and Rajannan, 2009) [12]. A decrease in yield was observed with graded application of RDF in both cases i.e. application of effluent before sowing and application of effluent before sowing and after first cutting. Application of nitrogen generally improved the growth of spinach; this might be explained on the basis that N is an essential element for plant growth (El- Gizaway *et al.* 1992) [5].

Uptake of primary nutrients by spinach (kg ha^{-1})

Nitrogen uptake

At 1st and 2nd cutting significantly highest N uptake (79.85 kg ha^{-1} and 50.19 kg ha^{-1}) was noticed in treatment T_3, At 3rd cutting the treatment T_9 exhibited highest uptake of N (Table 3). The uptake of N by the plant increased due to application of effluent with inorganic fertilizers. This increase in the uptake of nitrogen may be due to both higher nutrient content coupled with higher dry matter production in the treatment. Adewoye *et al.* (2010) [1] observed the higher N uptake by okra plant with the lower concentration of partially treated sewage effluent. Sukanya *et al.* (2002) [13] also reported that dilution level of 1:5 and 1:10 of spent wash and fresh water recorded the highest.

Table 3: Influence of factory effluent and inorganic fertilizers on uptake of N, P and K in plant at various cuttings of spinach

T. No.	Treatments	Nutrient uptake (kg ha^{-1})								
		N			P			K		
		1st cutting	2nd cutting	3rd cutting	1st cutting	2nd cutting	3rd cutting	1st cutting	2nd cutting	3rd cutting
T_1	RDF (100:50:50 kg ha^{-1})	10.67	2.56	--	0.88	0.21	--	5.19	1.04	--
T_2	Application of effluent before sowing	48.27	44.17	7.37	6.19	3.95	0.60	72.47	41.08	6.15
T_3	T_2 + 100% RDF	79.85	50.19	27.45	7.16	3.97	2.30	93.88	45.70	23.22
T_4	T_2 + 50% RDF	59.08	41.02	14.12	6.79	3.98	1.11	89.18	36.38	10.75
T_5	T_2 + 25% RDF	51.19	38.05	15.44	6.72	3.33	1.37	81.34	33.69	12.72

T_6	Application of effluent before sowing and after 1st cutting	54.91	15.37	26.02	6.62	0.97	2.59	76.67	8.95	31.26
T_7	T_6 + 100% RDF	76.68	17.25	26.23	8.15	1.13	2.44	97.17	13.64	31.22
T_8	T_6 + 50% RDF	72.04	12.38	20.79	8.37	0.76	1.85	93.22	7.44	23.22
T_9	T_6 + 25% RDF	44.98	5.13	32.37	6.09	0.34	2.43	71.46	4.29	36.04
S.E.±		7.55	3.14	3.31	0.53	0.45	0.42	6.37	3.53	3.84
C.D. (P=0.05)		22.63	9.41	10.05	1.58	1.33	1.27	19.1	10.58	11.66

uptake of N than the undiluted spent wash and control in maize. This phenomenon may be due to the beneficial effect of nitrogen fertilizer on the vegetative growth and development of crop.

Phophorous uptake

At 1st cutting treatment T_8 (application of effluent before sowing and after 1st cutting + 50 % RDF) recorded significantly higher P uptake over all the treatments, At 2nd cutting treatment T_4 (application of effluent before sowing + 50 % RDF) noticed highest uptake of P. The significantly highest uptake of P was recorded in treatment T_6 (Table 3).

The data indicated that P uptake by spinach was decreased at 2nd cutting which was significantly increased at 3rd cutting from treatment T_6 to T_9. Goyal and Kapoor (1995) [6] revealed that dry matter of mung bean and both P uptake were increased due to application of distillery waste water (upto 169 m^3 ha^{-1}). Vice versa again more quantity of application of distillery waste water decrease in both dry matter production and P uptake.

The increase in the uptake of phosphorous may be due to both higher nutrient content coupled with higher dry matter production in the treatment. Sukanya *et al.* (2002) [13] also reported that dilution level of 1:5 and 1:10 of spent wash and fresh water recorded the highest uptake of P than the undiluted spent wash and control. The results of present investgaion also confirm the findings of Zalawadia *et al.* (1997) [15] in sugarcane.

Potassium uptake

At 1st cutting the significantly higher K uptake by plant was recorded in the treatment T_7 (application of effluent before sowing and after first cutting + 100 % RDF), At 2nd cutting the treatment T_3 (application of effluent before sowing + 100 % RDF) was noticed the highest K uptake, At 3rd cutting the treatment T_9 (application effluent before sowing and after first cutting + 25 % RDF) noticed the highest amount of uptake of K in leaves of spinach (Table 3).

Effluent is a rich source of organics, which may be beneficial to microflora besides acting as a slow nutrient releaser (Kavitha *et al.* 2008) [7]. The increased uptake of K in the present study is in conformity with the findings of Sukanya *et al.* (2002) [13], who reported that dilution levels of 1:5 and 1:10 recorded the highest uptake of K in maize than the undiluted spent wash and control. Similar observations were also made by Zalawadia *et al.* (1997) [15] in case of sugarcane.

Uptake of secondary nutrients by spinach (kg ha^{-1})

Ca and Mg uptake by spinach

The calcium uptake was higher in treatment T_7 (application of effluent before sowing and after first cutting + 100 % RDF), while at 2nd and 3rd cutting treatment T_3 the (application of effluent + 100 % RDF) was recorded the highest uptake of calcium. In lateritic soils of Konkan Patil (2012) [9] noticed that increase in uptake of Ca by rice up to 40 per cent effluent concentration and further, increase in concentration there was graded decrease in uptake of Ca.

At 1st cutting treatment T_6 (application of effluent before sowing and after first cutting) exhibited significantly higher uptake of Mg. At 2nd cutting treatment T_2 (application effluent before sowing) recorded significantly superior over all other treatments. At 3rd cutting the significantly higher uptake of Mg was noticed in treatment T_9 (application of effluent before sowing and after 1st cutting + 25 % RDF) (Table 4). Zalawadia *et al.* (1997) [15] reported that application of 25 per cent spent wash recoded the highest uptake of Ca and Mg than the undiluted spent wash recorded the highest uptake of Mg than the undiluted spent wash and control in sugarcane.

Table 4: Influence of factory effluent and inorganic fertilizers on Ca and Mg uptake in plant at various cuttings of spinach

Tr. No.	Treatments	Nutrient uptake (kg ha^{-1})					
		Ca			Mg		
		1st cutting	2nd cutting	3rd cutting	1st cutting	2st cutting	3rd cutting
T_1	RDF (100:50:50 kg ha^{-1})	3.47	0.84	--	6.06	1.26	--
T_2	Application of effluent before sowing	16.72	14.57	2.51	28.46	37.90	5.64
T_3	T_2 + 100% RDF	31.78	18.67	10.71	30.81	35.56	17.15
T_4	T_2 + 50% RDF	29.34	15.10	5.09	37.24	29.53	8.81
T_5	T_2 + 25% RDF	22.09	13.31	5.77	29.43	30.28	11.09
T_6	Application of effluent before sowing and after 1st cutting	16.03	4.90	7.52	44.56	8.95	11.64
T_7	T_6 + 100% RDF	32.99	9.81	10.12	31.70	11.42	11.09
T_8	T_6 + 50% RDF	20.07	5.25	5.66	38.78	9.39	11.25
T_9	T_6 + 25% RDF	17.30	2.83	8.25	27.57	4.72	18.10
S.E.±		2.37	2.04	0.80	3.39	4.06	1.41
C.D. (P=0.05)		7.10	6.11	2.43	10.16	1.18	4.29

Conclusion

The application of effluent before sowing with inorganic fertilizers or application of effluent before sowing and after 1st cutting with inorganic fertilizers increased the yield, and uptake of N, P, K, Ca and Mg over application of RDF alone.

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