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EXPLORING THE IMPACT OF DISTILLERY EFFLUENTS ON THE INITIAL GROWTH OF SOYBEAN CULTIVARS

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ABSTRACT

This study examined the effects of different levels of distillery effluents (referred to as RSW, BSW, and LS) on two varieties of soybean (*Glycine max*) called Punjab-1 and Alankar collected from Shamli Distillery and Chemical Works at Shamli (U.P.). In the study, concentrations ranged between 0.5% to 55% were used. Standard tap water was used as a control. Workers conducted germination tests on seeds of both soybean varieties with various levels of effluent treatments. The results showed that at lesser concentrations, there was a noticeable increment in both the proportion of germination and the germination rate index. However, if the concentration exceeded 5% for RSW and 10% for BSW and LS effluents, it hindered seed germination. These trends remained similar pertaining to the growth and biochemical aspects of plants from the two cultivars.

KEY WORDS: Biomethanated spent wash, Chlorophyll, Distillery effluent, Germination, Lagoon sludge, Raw spent wash.

INTRODUCTION

Soybean (*Glycine max* L.; Family- Fabaceae) is an incredibly versatile crop which contains an abundance of oil (20%), protein (40% with 5% lysine) and minerals, salts, vitamins such as thiamine and riboflavin. Its sprouting grains even contain considerable amounts of vitamin C. Soybean is also the most cost effective source of high quality protein and oil, making it the largest contributor to the world's oil pool. 49% linolenic unsaturated fatty acid (18: 3) makes soybean suitable for both edible and industrial purposes. It not only provides economic benefits but also improves fertility of soil through fixing atmospheric nitrogen via root nodules or leaf fall on the ground at maturity. For these reasons, soybean has earned its reputation as a 'wonder crop'.

Industrial effluents discharged into fresh water bodies can damage the quality of water, as they are known to contain excessive nutrients and toxins. India is witnessing a growing number of operational distilleries, numbering over 300, making it one of the largest agro-based polluting industries (Khan *et. al.*, 2019 and Khalkar, 2021). To address this problem, most of the distilleries have installed Effluent Treatment Plants (ETPs) with raw distillery effluents (RSW), being treated anaerobically using methanogens to generate biomethanated spent wash (BSW). The BSW is then treated aerobically by means of aerated lagoons or activated sludge processes, creating lagoon sludge (LS) as the final product. This study looks into how RSW, BSW and LS from above said distillery affects the germination rates, growth and biochemical parameters in soybean cultivars.

MATERIALS AND METHODS

Two cultivars of soybean (*Glycine max*) - cv. Punjab-1 and Alankar were utilized in this study as test crops. Three different distillery effluents (RSW, BSW and LS) were used in diluted forms at 0.5%, 1.0%, 2.0%, 5%, 10%, 25%, 35%, 45% and 55%. Tap water was used as control. Alternate days saw irrigation of research plots or pots with the various effluent concentrations. At 8 DAS, the seed germination percentage and germination rate index was recorded. To observe the long term effects on *Glycine max* cv. Punjab-1 and Alankar, data for different growth and biochemical parameters up to 25 days from sowing was recorded and statistically analysed by using t-test. Proper agronomical practices were used during the investigations.

RESULTS AND DISCUSSION

As shown in Table 1, distillery effluents (RSW, BSW and LS) influenced seed germination percentages and germination rate index of 8 days old seedlings.

Seed Germination Percentage

Up to 5% concentrations of RSW and up to 10% concentrations of BSW and LS, both cultivars of *Glycine max* showed 100% seed germination. The seed germination percentage in Punjab-1 was reduced to 46.39, 38.14 and 35.05%, respectively by 55% concentration of RSW, BSW and LS. For cv. Alankar, the reductions were 38.77, 34.69 and 30.61%.

Germination Ṛate Index

In cv. Punjab-1, germination rate index increased to 8.02% at 5% RSW concentration and 12.77 and 9.30% at 10% BSW and LS concentration, respectively. A similar pattern of increment was also observed for cv. Alankar where the increment percentages were 6.00, 10.24 and 7.95% under 5% of RSW, 10% of BSW and LS concentration. Under 55% of RSW, BSW and LS, the reduction percentages in cv. Punjab-1 were 23.72, 21.16 and 19.52%, respectively. Similar pattern was also observed for cv. Alankar.

Growth Parameters

Table 2 shows the results of exposure to different concentrations of distillery effluents (RSW, BSW and LS) on both cultivars' growth parameters. Root length was increased by 18.08% with RSW at 5% concentrations and by 20.79 and 20.67%, respectively at 10% concentrations of BSW and LS. In Punjab-1 (25 days old plants), the reduction percentages were 37.67, 35.82 and 34.44%, respectively in RSW, BSW and LS at 55% concentration. The same pattern was also observed for Alankar cultivar.

Shoot length of both cultivars was found to be significantly increased when exposed to concentrations of 5% RSW, 10% BSW and 10% LS. For cv. Punjab-1, the increment was of 17.16%, 20.17% and 19.60% while for cv. Alankar this was 17.59%, 21.12% and 19.83%, respectively. After 25 days of being exposed to a 55% concentration of RSW, BSW and LS shoot lengths decreased substantially for both cultivars; for Punjab-1 it was 33.81%, 32.04% and 31.18%; whereas in cv. Alankar those values were 29.76%, 28.93% and 28.17%, respectively. The biomass production of both cultivars changed in a similar manner with root and shoot length of 25 days old plants. For cv. Punjab-1, phytomass increased up to 18.30% at 5% RSW and

Table 1. Effect of different concentrations of distillery effluents on seed germination percentage and germination rate index of 8 days old seedlings of two cultivars of *Glycine max*.

Cultivar	Parameters	Treatments									
		RSW concentration (%)									
		Control	0.5	1.0	2.0	5.0	10	25	35	45	55
Punjab-1	Seed germination percentage	97	98	100	100	100	93	82	69	64	52
	Germination Rate index	548	552	560	572	592	510	486	468	442	418
Alankar	Seed germination percentage	98	99	100	100	100	95	85	76	68	60
	Germination Rate index	566	568	572	588	600	532	502	485	456	434
		BSW concentration (%)									
Punjab-1	Seed germination percentage	97	100	100	100	100	100	80	73	68	60
	Germination Rate index	548	560	568	586	602	618	516	494	474	432
Alankar	Seed germination percentage	98	100	100	100	100	100	88	81	73	64
	Germination Rate index	566	568	577	590	608	624	530	508	486	452
		LS concentration (%)									
Punjab-1	Seed germination percentage	97	98	99	99	100	100	89	78	70	63
	Germination Rate index	548	551	556	568	588	599	521	499	480	451
Alankar	Seed germination percentage	98	99	99	100	100	100	89	82	75	68
	Germination Rate index	566	566	568	586	595	611	538	518	497	463

Table 2. Effect of different concentrations of distillery effluents on different growth parameters of 25 days old plants of two cultivars of *Glycine max*.

Cultivar	Parameters	Treatments									
		RSW concentration (%)									
		Control	0.5	1.0	2.0	5.0	10	25	35	45	55
Punjab-1	Root length (cm)	17.36±1.24	17.54±1.12†	18.06±0.82†	19.28±1.44*	20.50±1.22**	17.14±1.08†	15.58±1.76*	13.74±0.98**	12.40±0.78**	10.82±0.94**
	Shoot length (cm)	34.54±1.80	35.28±2.18†	36.34±2.32†	38.26±1.98*	40.47±1.74**	33.87±2.44†	30.26±2.19*	28.47±1.63**	25.67±1.82**	22.86±2.53**
	Biomass production(g)	3.06±0.88	3.15±0.71†	3.31±0.54†	3.43±0.57*	3.62±0.63*	2.99±0.59†	2.80±0.47*	2.58±0.61**	2.35±0.45**	2.19±0.39**
	NPP (g/plant/day)	0.122	0.126	0.132	0.137	0.144	0.119	0.112	0.103	0.094	0.087
		BSW concentration (%)									
	Root length (cm)	17.36±1.24	17.72±1.24†	18.34±1.18*	19.57±1.34*	20.54±1.57**	20.97±1.45**	15.87±1.24†	14.18±1.07**	12.86±0.86**	11.14±1.29**
	Shoot length (cm)	34.54±1.80	35.80±1.63†	37.08±1.77*	38.69±1.82*	41.28±2.19**	41.51±2.52**	31.74±2.43†	29.62±2.16*	26.53±1.75**	23.47±1.68**
	Biomass production(g)	3.06±0.88	3.19±0.67†	3.42±0.48*	3.57±0.51*	3.70±0.56**	3.83±0.44**	2.91±0.38†	2.72±0.40*	2.44±0.36**	2.28±0.29**
	NPP (g/plant/day)	0.122	0.127	0.136	0.142	0.148	0.153	0.116	0.108	0.97	0.091
		LS concentration (%)									
	Root length (cm)	17.36±1.24	17.48±1.12†	18.01±1.31†	19.12±1.22*	20.41±1.27**	20.95±1.34**	16.12±0.82†	14.32±0.96**	13.18±0.74**	11.38±0.79**
	Shoot length (cm)	34.54±1.80	35.54±1.64†	36.50±1.70†	38.02±1.82*	39.88±1.68**	41.31±1.37**	31.87±1.58†	29.90±1.37*	26.76±1.65**	23.77±1.80**
	Biomass production(g)	3.06±0.88	3.12±0.73†	3.26±0.58†	3.38±0.47*	3.56±0.80**	3.71±0.36**	2.95±0.49†	2.78±0.33*	2.49±0.43**	2.32±0.37**
	NPP (g/plant/day)	0.122	0.124	0.130	0.135	0.142	0.148	0.118	0.111	0.099	0.092
		RSW concentration (%)									
Alankar	Root length (cm)	15.80±1.36	16.02±1.18†	16.64±1.22†	17.76±0.98*	18.99±1.28**	15.61±1.06†	14.06±0.92*	12.73±0.82**	11.86±0.74**	10.43±0.80**
	Shoot length (cm)	32.62±1.92	33.48±1.67†	34.87±1.52†	36.10±1.48*	38.36±1.53**	32.39±1.42†	29.65±1.25*	27.46±1.37**	25.14±1.31**	22.91±1.22**
	Biomass production(g)	3.22±0.76	3.34±0.58†	3.55±0.63†	3.71±0.48*	3.89±0.38**	3.16±0.27†	2.99±0.31*	2.82±0.25**	2.60±0.33**	2.35±0.24**
	NPP (g/plant/day)	0.128	0.133	0.142	0.148	0.155	0.126	0.119	0.112	0.104	0.094
		BSW concentration (%)									
	Root length (cm)	15.80±1.36	16.03±1.26†	16.78±1.18*	17.61±1.12*	19.09±1.27**	19.31±1.09**	14.71±1.13†	13.34±0.94**	12.97±0.88**	10.71±0.91**
	Shoot length (cm)	32.62±1.92	33.90±1.83†	33.08±1.65*	36.83±1.78*	37.29±1.58**	39.51±1.73**	31.78±1.84†	29.62±1.64*	26.17±1.76**	23.18±1.66**
	Biomass production(g)	3.22±0.76	3.40±0.67†	3.68±0.72*	3.75±0.63*	3.91±0.69**	4.05±0.61**	3.15±0.52†	2.94±0.59*	2.72±0.62**	2.47±0.47**
	NPP (g/plant/day)	0.128	0.136	0.147	0.150	0.156	0.161	0.126	0.117	0.108	0.098
		LS concentration (%)									
	Root length (cm)	15.80±1.36	16.00±1.44†	16.56±1.40†	17.54±1.52*	18.41±1.38**	19.02±1.63**	14.22±1.12†	12.93±1.22**	12.24±1.04**	11.16±1.13**
	Shoot length (cm)	32.62±1.92	33.24±1.87†	34.45±1.63†	35.56±1.81*	37.74±1.77**	39.09±1.62**	31.92±1.85†	30.52±1.93*	27.12±1.46**	23.43±1.97**
	Biomass production(g)	3.22±0.76	3.29±0.64†	3.47±0.72†	3.65±0.83*	3.82±0.62**	3.97±0.78**	3.16±0.53†	2.98±0.58*	2.79±0.47**	2.53±0.51**
	NPP (g/plant/day)	0.128	0.131	0.138	0.146	0.152	0.156	0.126	0.119	0.111	0.101

Values are in mean ± standard deviation.
Significance of difference from control; P* < 0.05; P** < 0.01 and † non-significant

25.16 and 21.24% at 10% BSW and LS concentration but decreased by 28.43, 25.49 and 24.18% when treated with 55% of RSW, BSW and LS treatments, respectively. While the accumulation in cv. Alankar was increased by 20.88% with a 5% RSW treatment, 25.77 and 23.29% at 10% BSW and LS concentration but declined to 27.01, 23.29 and 21.42%, correspondingly after the treatment with 55% concentration. The decrease in total dry weight eventually impacted the net primary productivity of these plants negatively.

Biochemical Parameters

Chlorophyll Content

Noteworthy changes in chlorophyll a and b levels of leaves were recorded for the different RSW, BSW and LS concentrations. For instance, chlorophyll a and b spiked by 18.22 and 16.16% with 5% RSW, respectively. Moreover, 24.02, 22.75% and 20.10, 16.46% increments were witnessed with 10% BSW and LS concentrations after 25 days for Punjab-1 cultivar plants. Conversely, at 55% concentration, chlorophyll a and b decreased up to 35.09, 32.63, 30.15, 28.14, 28.10 and 23.05% in RSW, BSW and LS treatments, respectively (Figure 1 and 3). Comparably similar trends were also observed for Alankar cultivar, albeit it was better than the Punjab-1 (Figure 2 and 4). In general, reductions in chlorophyll a levels tended to be greater than those of chlorophyll b content.

Results of germination parameters indicate that the effect of distillery effluents (RSW, BSW and LS) can differ depending on both cultivar and concentrations used. Seed germination percentage and germination rate index are known to improve when RSW is used at a concentration of up to 5% and BSW or LS at 10%. This is due to an increase in the availability of optimum concentrations of

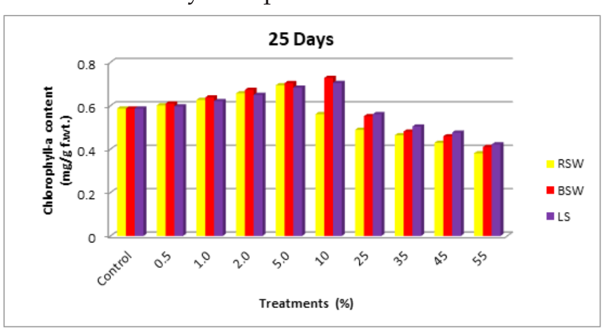

Fig. 1. Effect of different concentrations of distillery effluents on chlorophyll-a content (mg/g fresh weight) of 25 days old plants of *Glycine max* cv. Panjab-1.

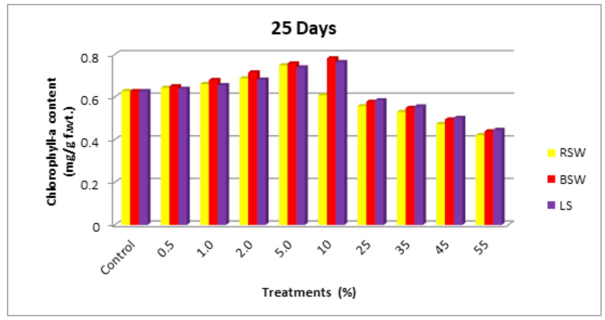

Fig. 2. Effect of different concentrations of distillery effluents on chlorophyll-a content (mg/g fresh weight) of 25 days old plants of *Glycine max* cv. Alankar.

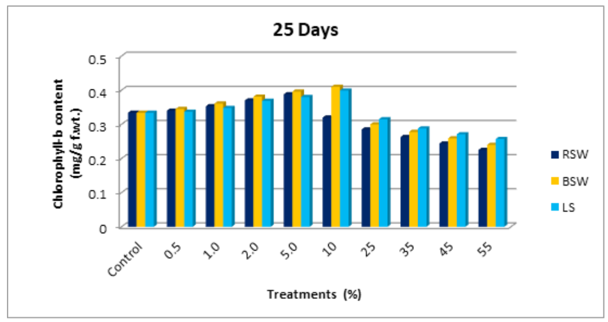

Fig. 3. Effect of different concentrations of distillery effluents on chlorophyll-b content (mg/g fresh weight) of 25 days old plants of *Glycine max* cv. Panjab-1.

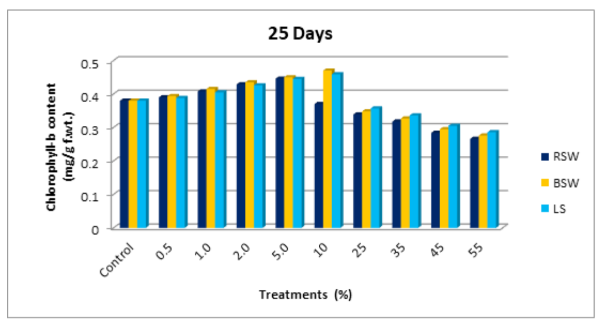

Fig. 4. Effect of different concentrations of distillery effluents on chlorophyll-b content (mg/g fresh weight) of 25 days old plants of *Glycine max* cv. Alankar.

nutrients (Sharma *et al.*, 2002). However, higher concentrations cause a decrease in seedling growth such as root and shoot length, biomass production and net primary productivity. Similar findings were also observed by Kalaiselvi, 2009; Rath *et al.*, 2010. A decrease in chlorophyll content limits photosynthesis, which ultimately affects the growth and productivity of a plant. Distillery effluents have been found to reduce the photosynthetic rate in plants at higher concentrations. Similar observations have also been reported by various earlier workers including Bharti *et al*., 2014; Kumar, 2014; Goli and Sahu, 2014; Chandraju *et al*., 2015; Qureshi *et al*., 2015; Reddy *et al*., 2015; Jacob *et al*., 2016; Sharma and Malaviya, 2016; Mishra and Gupta, 2017; Snehlata *et al*., 2018; Kapil and Mathur, 2020; Jakhrani *et al*., 2021; Umair *et al*., 2021; Khalkar, 2021; Bartkowiak *et al*., 2022 and Choudhary and Tejasvi, 2023.

CONCLUSION

This research indicates that a distinct pattern of behaviour was observed in treated plants depending on the concentrations of effluents. Notably, with concentrations greater than 5% for RSW and 10% for both BSW and LS, negative outcomes were seen. Therefore, when considering higher amounts of distillery effluents for irrigation, caution is advised. The situation showed significant improvement when the concentrations of effluent were reduced. This resulted in positive responses from the treated plants, particularly regarding their early growth parameters. Evidently, these lower concentrations of distillery effluents had a stimulating effect during the initial stages of the plant's growth. This is an affirming and heartening result, indicating that with proper management and dilution, distillery effluents could be used as effective liquid fertilizer for farming.

As a result, the study emphasizes the importance of finding the right balance when utilizing distillery effluents for irrigation. By repurposing these effluents as a resource for enhancing plant growth, provided they are appropriately diluted and treated, this knowledge could pave the way for more sustainable agricultural practices.

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