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Impact of dyeing industry effluent on germination and growth of pea (*Pisum sativum*)

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Abstract

Dye industry effluent was analyzed for physico-chemical characteristics and its impact on germination and growth behaviour of Pea (*Pisum sativum*). The 100% effluent showed high pH (10.3) and TDS (1088 mg l^{-1}). The germination parameters included percent germination, delay index, speed of germination, peak value and germination period while growth parameters comprised of root and shoot length, root and shoot weight, root-shoot ratio and number of stipules. The study showed the maximum values of positive germination parameters viz. speed of germination (7.85), peak value (3.28), germination index (123.87) and all growth parameters at 20% effluent concentration while the values of negative germination parameters viz. delay index (-0.14) and percent inhibition (-8.34) were found to be minimum at 20% effluent concentration. The study demonstrated that at lower concentrations the dyeing industry effluent caused a positive impact on germination and growth of *Pisum sativum*.

Key words

Dye industry, Effluent, Germination, *Pisum sativum*

Introduction

Indian dyeing and dyestuff industry has grown over 50% during the last decade. India is now the second largest producer of dyes and dye intermediates in Asia after China. Today there are about 50 units in the organized sector and 1000 units in the small scale, with a total annual production of 1,30,000 tones per annum or about 7% of the world production. Dyeing industries are usually categorized under the small-scale industries in India. The small-scale industries in India generate about 3900 million litre of wastewater per day; about 12% of this is contributed by dyeing and textile units.

The dyeing effluents are dark in colour, having very high BOD and COD content and are low in suspended solids and nutrients e.g. nitrogen and phosphorus. Colour varies in intensity and hue with blue and red dominant colours. Besides these, other chemicals are also present in untreated dyeing effluents e.g. acetic acid, caustic soda and sodium hydrosulphate, mordants, reducing agents, soap and heavy metals. These effluents cause colouration of water when released untreated into the water bodies and cause severe problems to aquatic life (Hai *et al*., 2007).

The use of dyeing effluents for irrigation may be an alternative method for recycling if used rationally and in appropriate concentrations (Kumawat *et al*., 2001). Although dyeing effluents contain many constituents which are phytotoxic at higher concentrations (Kaushik *et al*., 2005), many of these constituents can be helpful for plant growth at low concentrations (Swaminathan and Vaidheeswaran, 1991). The effect of dyeing industry effluent on different plants has been investigated by several workers (Dayama, 1987; Sujatha *et al*., 1992; Himabindu and Reddy, 2005). In the present study, an attempt has been made to assess the impact of dyeing industry effluent released from a local dyeing industry on the germination and growth parameters of pea (*Pisum sativum*).

Materials and Methods

In the present study, seeds of *Pisum sativum* L. var. Arkel, certified for purity and quality, by Seed Certification Wing, Department of Agriculture, Jammu Division (Jammu, India) were used. The garden soil was collected from the Department of Arboriculture, University of Jammu, Jammu (India). The soil was sun dried, sieved and farmyard manure was added to the soil in the ratio of 3:1 and mixed properly. The untreated dyeing effluent was collected from M/s Vinayak Synthetic Industry Ltd., Jammu (India) at regular intervals and analyzed for physico-chemical characteristics e.g., pH, electrical conductivity (EC), total dissolved solids (TDS) ect. The untreated dyeing effluent was collected from M/s Vinayak Synthetic Industry Ltd., Jammu (India) at regular intervals and analyzed for physico-chemical characteristics e.g., pH, electrical conductivity, total dissolved solids (TDS) etc. using portable analyzers (APHA, 2005).

The earthen pots were filled with equal quantity (2.0 kg) of prepared soil. These pots were then transferred to the experimental site and arranged in accordance with the experimental design. Out of six treatment sets, set was taken as control (tap water irrigation) and in remaining five sets, different concentrations of the effluent (20, 40, 60, 80 and 100%) were used for irrigation. The experiment was conducted during 2^{nd} fortnight of November to I^{st} fortnight of December (total duration- 30 days; mean maximum temperature- 27.9 °C and mean minimum temperature- 12.2 °C).

In each pot, twelve seeds were sown with proper spacing and nutrients availability. Out of these seeds, two seeds were tagged for growth parameter studies and remaining ten seeds were considered for germination experiment. Observations were made regularly following every 2 days after sowing upto 1 month. Germination started after 8 days of sowing. A seed was considered grown when its root length exceeded 5 mm. For length less than 5 mm, the root length was taken equal to zero and seed was not considered grown. Number of seedlings emerged in each replicate was noted and various indices were calculated. Germination index was calculated by the formula of Zucconi *et al.* (1981). Delay index (delay in germination time over control) was calculated to compare the performance of plant under various treatments (Modified after Kaushik *et al*., 2005). Other parameters e.g., percent inhibition (percent germination of treatment over control), germination period (subtraction of germination day on which first reading was taken from day on which maximum germination was obtained), peak value (cumulative percent germination divided by number of days since initial imbibition), germination value (peak value*percent germination), speed of germination (rate of seed germination over time) were estimated by formulae of Rao *et al*. (1979) and Czabator (1962). Root and shoot length and weight were also measured.

Results and Discussion

The dyeing effluent used for the study was dark brown in colour and had petrol like smell. Values of various parameters for different concentrations of the effluent are given in Table 1, which showed an increasing trend of EC (electrical conductivity), OP and TDS with increasing concentrations of the effluent. Minimum values of EC, OP and TDS were observed for 20% effluent concentration. Maximum values, on the other hand were observed for 100% effluent concentration. There was no variation in values of pH at different effluent concentrations.

Table 2 shows the values of various positive germination parameters (speed of germination, germination index, germination value etc.), which were maximum for 20% concentration of effluent and then decreased gradually with increase in the concentration of the effluent. Similarly, for negative germination parameter (delay index), the value was minimum at 20% effluent concentration. This may be due to the optimum levels of micro and macro nutrients present in the effluent that may serve as potential fertilizer. The values of germination parameters of control were lesser than the treatment set (20%). This shows availability of more nutrients in the effluent as compared to tap water (Singh *et al*., 2002). Overall, the percent germination showed following trend: 20% > C > 40% > 60% > 80% > 100%. Earlier study has clearly shown that there exists a specific correlation between effluent concentration and germination parameters (Malaviya and Sharma, 2011). The reason for reduction in germination parameters at higher concentration could be attributed to the excessive quantities of inorganic salts and consequently its higher EC (1.7 mS cm^{-1} at 100% effluent) value. With increase in concentration of the effluent, the EC and OP also increased. (Table 2).The increased OP of the effluent made imbibition more difficult and retarded germination (Malaviya and Sharma, 2011).

Values of delay index were found to be greater at high effluent concentrations and thus followed the similar trend as obtained by Kaushik *et al*. (2005). The seeds take up water during germination in order to hydrolyse the stored food material and to activate their enzymatic systems. As absorption takes place by osmosis, the salt content outside the seeds may act as a limiting factor, which might be responsible for the delay in germination (Garg and Kaushik, 2006). Our findings are also in accordance with the outcome obtained by Himabindu and Reddy (2005) in

Table- 1: Physico-chemical characteristics of different concentrations of dyeing effluent

Effluent (%)	pH	EC	TDS	OP
20	10.3	0.6	384	0.216
40	10.3	1.0	640	0.360
60	10.3	1.2	768	0.432
80	10.3	1.4	896	0.504
100	10.3	1.7	1088	0.612

EC=Electrical conductivity (mS cm^{-1}); TDS=Total dissolved solids (mg l^{-1}); OP=Osmotic pressure (atmospheres)

Table- 2: Effect of dying industry effluent on various germination parameters of *Pisum sativum*

	Effluent treatments (%)					
Parameters	**Control**	**20**	**40**	**60**	**80**	**100**
Delay index	-	-0.14	0	0	0.42	1.14
Speed of germination	6.46	7.85	5.87	5.59	4.38	3.67
Peak value	2.28	3.28	2.35	2.08	1.68	1.48
Germination index (%)	-	123.87	88.94	81.70	63.37	52.33
Percent inhibition	-	-8.34	2.77	5.55	16.66	19.44
Germination period (d)	20	14	18	20	20	22
Germination value	145.64	236.88	143.60	121.3	79.32	63.77
Cumulative germination (%)	63.88	72.22	61.11	58.33	47.22	44.44

Control (Tap water irrigation)

Table- 3: Effect of different concentrations of effluent on various growth parameters of *Pisum sativum* after 1 month of sowing

Effluent treatment (%)	Root length (cm)	Shoot length (cm)	Root/Shoot ratio	Root weight (g f. wt.)	Shoot weight (g f. wt.)	Root/Shoot ratio	Plant biomass (g f. wt.)	Number of stipules
C	8.56 ±0.20	8.44 ±1.53	1.01	2.48 ±0.39	5.62 ±1.44	0.44	8.10	10.72 ±0.52
20	9.38 ±0.53	9.22 ±1.81	1.01	3.90 ±0.43	6.88 ±1.95	0.56	10.78	10.83 ±1.06
40	7.96 ±2.85	7.98 ±0.45	0.99	2.32 ±0.52	4.19 ±0.13	0.55	6.51	10.00 ±0.65
60	7.66 ±1.15	7.78 ±0.26	0.98	2.00 ±1.30	3.95 ±2.39	0.50	5.95	9.11 ±0.66
80	7.34 ±0.28	7.55 ±0.25	0.97	1.60 ± 0.32	3.81 ±1.57	0.41	5.41	9.09 ±0.89
100	6.44 ±0.70	6.81 ±0.62	0.94	0.99 ±0.76	2.52 ±1.41	0.39	3.51	8.86 ±0.52

Value are mean of three replicates ± SD except for plant biomass

their study on the effect of dyeing effluent on the seed germination, seedling growth and chlorophyll content of *Withania somnifera*. They observed that the increasing concentration of the effluent induced gradual reduction in the germination percentage and seedling growth.

Table 3 shows the effect of effluent on root-shoot ratio in terms of length and fresh weight which showed a decreasing trend with the increase in effluent concentration. A similar trend was also observed in case of number of stipules. All the growth parameters increased at 20% effluent concentration and decreased at 100% effluent concentration. At 100% effluent concentration nutrients were raised too high to become toxic resulting in retarded root and shoot length (Dutta and Boissya, 1996). Mohammad and Khan (1985) also found no adverse effect of textile industry effluent at lower concentrations (<50% effluent concentration), which is in conformity with the present results (effective concentration 20% effluent). Similar observations were also noticed by Malaviya and Sharma (2011).

It can be concluded from the present study that dyeing effluent as such inhibits the growth whereas with dilution it promotes the germination and growth parameters of pea.

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