

# Effects of Textile Effluent Fertilization on Germination, Growth and Metabolites of Chilli (*Capsicum annum*) Cultivars

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## Research Article

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1 **Title: Effects of Textile Effluent Fertilization on Germination, Growth**  
2 **and Metabolites of Chilli (*Capsicum annum*) Cultivars**

3 **Running Title: Effects of Textile Effluent on Chilli**

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17 **Effects of Textile Effluent Fertilization on Germination, Growth and Metabolites of**  
18 **Chilli (*Capsicum annum*) Cultivars**

19

20 **Abstract**

21 Nutrients deficiency in soil suppresses crop growth, yield and nutritional value of the  
22 products. Textile effluent, a rich source of several essential minerals (Ca, Mg, Cu, Fe, Zn,  
23 Mn, etc.) required for the plant growth, could be a vital option to supplement minerals to  
24 accomplish the nutrient availability of soil. Although presence of some toxic metals and  
25 organic compound restrict its use as irrigation water, its controlled use as fertilizer was  
26 not studied so far. This study was undertaken to assess the eco-friendly utilization  
27 method of textile industry effluent by applying the same into chilli (*Capsicum annum* L.)  
28 cropping system for its suitability and potentiality as macro and micronutrient  
29 supplement. Result of the experiment showed no inhibitory effect of textile effluent on  
30 seed germination, while its fertilization as soil drench worked as nutrient supplement for  
31 growth in chilli cultivars. Textile effluent fertilization enhances plant biomass up to  
32 124.47% and 110.85% in chilli cultivar GVC-101 and GVC-121, respectively. Total  
33 carbohydrate and foliar protein was also favoured by effluent fertilization. Lower RSR  
34 and least proline accumulation suggested reduced stress due to textile effluent  
35 fertilization. Study concluded that the lower dose of textile effluent fertilization can  
36 function as nutrient supplement with chilli cultivars and 20% (v/v) dilution provide most  
37 favourable results.

38 **Keywords** Textile effluent; *Capsicum annum*; Mineral nutrients; Germination index;  
39 Metabolites

40

41 **Article Highlight:**

- 42 1. Management of hazardous textile effluent is a global issue. Application of  
43 textile effluent to agricultural field could be a viable option.
- 44 2. Application of textile effluent enhances germination of chilli cultivars.
- 45 3. Lower dose of textile effluent fertilization provided nutrients to the chilli plants  
46 and increases growth.

47

48 **Introduction**

49 Textile industry is one of known water intensive industries, consuming large quantity  
50 of water for various processes and discharge equally large volumes of waste water  
51 containing a variety of pollutants. Unimpeded disposal of textile effluent not only poses  
52 risks to human, animal and plant health but also possess serious threats to soil and water  
53 body and disrupt ecology of affected areas. Textile effluent can induce mutations, causes  
54 genotoxicity and oxidative damage, root growth retardation, mito-depression, and  
55 induction of chromosomal abnormalities in root meristematic cells (Hemachandra and  
56 Pathiratne 2016; Akhtar et al. 2016).

57 On the other hand, micronutrients deficiency in soil and plants is a global nutritional  
58 problem and is prevalent in many countries with different magnitude of severity.  
59 Micronutrient deficiencies in soil have been identified as one of the main factors  
60 affecting crop yield and food quality, which resulted in reduced nutrient in diet (Cakmak  
61 2002). The industrial effluent contains several macro and micronutrients in the form,  
62 which plants can take for their growth. Application of such effluent in agricultural fields  
63 may be a viable option to dispose industrial effluent, and would sustain agriculture in  
64 non-irrigated areas where the availability of fresh water is scarce (Kumar and Chopra  
65 2013). Moreover, waste water can provide important nutrients, especially nitrogen and

66 phosphorus and some micro-nutrients, which can increase soil fertility and enhance plant  
67 growth, crop production and quality of produce. It also reduces the requirements for  
68 commercial chemical fertilizers and thus increases farmer's economic benefits  
69 (Papadopoulos and Savvides 2003). Fertilization by effluent provided dual benefit to the  
70 environment as it reduces the requirement of chemical fertilizer besides resolving the  
71 problem of effluent disposal.

72 Composite effluent from textile industries consist high concentration of heavy metals  
73 and organic compounds. Some metals, necessary for plant metabolism as enzyme  
74 activators or regulators e.g. Fe, Cu, Mn, Mo, are present in textile effluent, but may cause  
75 toxicity if supplied in excess (Kaushik et al. 2005). Use of wastewater reduces fertilizer  
76 and irrigation cost as it is available without paying any cost (Papadopoulos and Savvides  
77 2003). Earlier researches with lower dose of distillery effluent as irrigation provided  
78 positive results on seed germination, total sugars, starch, reducing sugars, and  
79 chlorophyll (Ramana et al. 2002).

80 The studies conducted so far on the utilization of textile effluent in agriculture were  
81 focused on nutrient utilization during irrigation. However, presence of high salinity and  
82 significant amount of trace metal can harm the crop and soil by its continuous application  
83 as irrigation. So far, no study was seen for application of limited amount of textile  
84 effluent as fertilizer dose to harvest the nutrient potential of the textile effluent. The  
85 present study aimed eco-friendly disposal of textile industry effluent and supplement the  
86 micronutrient during cultivation of chilli (*Capsicum annum* L. cv.GVC-101 and GVC-  
87 121) by fertilization with different concentration of effluent and assess the agro-  
88 potentiality and suitability of the optimum effluent concentration.

89

90 **Materials and methods**

91 ***Effluent collection and characterization***

92 Textile effluent originating from the Mangalam textile industry was collected from a  
93 Green Environment CETP located in Vatwa (Singh and Rathore 2020) before treatment  
94 process. Collected effluents were stored in refrigerator (4 °C) to avoid changes in its  
95 characteristics during storage. As the textile effluent used in the present study was same  
96 of our previous studies (Singh and Rathore 2018, 2020), physico-chemical  
97 characterisation, analysed using standard methods described in APHA (2012), was also  
98 similar (Table S1) and reported before in Singh and Rathore (2018, 2020).

99 ***Germination experiment***

100 Wet cotton method was applied for germination experiment. Cotton was moistened  
101 with 10 ml water for control and with the same quantity of different concentrations of  
102 textile effluent dilution (10%, 20%, 40% and 60% v/v) in water and kept in a petri dish. 8  
103 seeds of both cultivars were placed in these petri dish. Petri dishes were incubated at 30  
104 ±1°C temperature. Germination was recorded every 5 days from the date of sowing for  
105 15 days at 11 am, and the emergence of the radicle was taken as a criterion of  
106 germination. All the experiments were carried out in three replication (3 petri dishes for  
107 each treatment) and the result was averaged.

108 Seed germination under different effluent concentration was recorded and computed  
109 for germination percent. Speed of germination was analysed using the following  
110 formulae-

111 
$$\text{Speed of germination} = \frac{\text{No. of seeds germinated}}{\text{days of the first count}} + \dots + \dots + \frac{\text{No. of seeds germinated}}{\text{days of the final count}} \quad (1)$$

112 Peak value and germination value was calculated using formulae explained by  
113 Kaushik et al. (2005).

114 Peak value =  $\frac{\text{Cumulative percent germination on each day}}{\text{No.of days elapsed since initial imbibition}}$ . (2)

115 Germination value = Peak Value  $\times$  germination percent. (3)

116 Seed Vigor index and delay index was obtained using following formulae explained  
117 in Abdul-Baki and Anderson (1973):

118 Vigor index= Germination percent  $\times$  mean of seedling length (root + shoot) at the  
119 end of incubation period. (4)

120 Delay Index=  $\frac{\text{Delay in germination time over control}}{\text{Germination time for control}}$ . (5)

### 121 ***Pot experiment material and design***

122 Two cultivars of chilli (*Capsicum annum*) i.e. GVC-101 and GVC-121 obtained from  
123 Anand Agricultural University, Anand, Gujarat. Both cultivars are Kharif-Rabi season  
124 variety, but different in their morphology, biochemical characteristics, nutritional  
125 composition and yield potential (<http://www.aau.in>; Litoriya et al., 2014). Genetically  
126 uniformed seeds of chilli were sown in pots of 19cm (diameter)  $\times$  18cm (height) size. Pots  
127 were filled with equal amounts of slightly alkaline (pH 7.8 and EC 0.53  $\mu\text{Scm}^{-1}$ ) sandy  
128 loam soil of medium fertility (NPK value of used soil is 236.31, 78.63, 118.54 kg ha<sup>-1</sup>,  
129 respectively). Twelve seeds of chilli cultivars were sown in each pot. Four dilution of  
130 textile effluent (10%, 20%, 40% and 60% v/v i.e. T1, T2 T3 and T4 respectively) was  
131 applied in soil as the basal fertilizer dose for micronutrient supplementation (Table S2).  
132 Fertilization with textile effluent have applied only once during the whole experiment. A  
133 control set (without textile effluent fertilization), were also maintained for comparison.  
134 Ground water was applied for irrigation purpose in all treatments. After germination  
135 seeds were thinned to six seedlings per pot in all the pots, which were further thinned at

136 each sampling period. Experiment was conducted under completely randomized designed  
137 and replicated by three times.

### 138 ***Plant growth analysis***

139 Plants were randomly sampled in triplicate from all treatment at 30, 60, 90 and 120  
140 days after sowing (DAS). After carefully washing with distilled water, plants were  
141 separated into roots, stem and leaves. Plant height (roots and shoot length) was measured  
142 by meter scale and leaf area was measured by graphical method and presented as cm<sup>2</sup>  
143 plant<sup>-1</sup>. To determine biomass, plant parts were oven-dried at 80°C till a constant weight  
144 was achieved. After drying, the plant parts were weighed by weighing balance. Root to  
145 shoot ratio (RSR) was calculated according to Hunt and Burnett (1973).

### 146 ***Photosynthetic pigments***

147 For chlorophyll and carotenoid determinations, 0.1 g leaf sample was placed in 10 ml  
148 of 80% acetone in a test tube and kept it overnight in a refrigerator at 4°C. It was then  
149 homogenized and centrifuged at 6000×g for 15 minutes. The optical densities of the  
150 supernatant were measured at 480, 510, 645 and 663 nm. The contents of chlorophyll *a*, *b*  
151 and carotenoid were calculated by using the formulae described by Machlachlan and  
152 Zalik (1963) and Duxbury and Yentsh (1956), respectively. Total chlorophyll was  
153 obtained by adding the value of chlorophyll *a* and chlorophyll *b*.

### 154 ***Metabolites and proline content***

155 For carbohydrate, 1 gm of fresh leaf sample was crushed with chilled 70% ethanol  
156 and centrifuge at 4000 rpm for 10 min. After centrifugation, 1 ml of obtained supernatant  
157 was added with freshly prepared 4ml of Anthrone reagent and mixture was allowed to

158 stand in warm water for 8-10 min than cooled rapidly and absorbance was read to  
159 estimate total carbohydrate content as described by Yemm and Willis (1954).

160 Protein was estimated by leaf extraction in 0.2 M phosphate buffer of pH 7 following  
161 the method of Lowry et al. (1951). Amount of protein present in the samples was  
162 expressed with the bovine serum albumin (BSA) as standard in  $\mu\text{g/ml}$ .

163 Proline content was estimated by extracting the leaf sample in 10 ml sulfosalicylic  
164 acids and supernatant was used for acid-ninhydrin test (Bates et al. 1973) and expressed  
165 as  $\mu\text{mol proline g}^{-1}\text{FW}$ .

#### 166 *Statistical analysis*

167 The data for different treatment were presented as mean value of three replicate.  
168 Average of three replications and their standard errors were calculated. The significance  
169 of the data was analysed using two ways ANOVA, growth stage and treatments were  
170 considered as two factors. Statistical analyses were performed using the SPSS program  
171 (version 17.0) to compare the effect of textile effluent fertilization and plant age. Plant  
172 photosynthetic pigment content, biochemical characterisation, and biomass assay were  
173 compared by analysis of variance and multiple comparison tests. In case of significant  
174 changes, heterogeneous groups were distinguished on the basis of Duncan test multiple  
175 range test at  $p < 0.05$ .

#### 176 **Results**

##### 177 *Effluent characteristics*

178 Used textile effluent is brownish in colour, deficit in dissolved oxygen, rich in total  
179 solids, total alkalinity, high biological oxygen demand (BOD) and chemical oxygen  
180 demand (COD) with considerable amounts of total nitrogen, phosphate, chlorides,

181 sulphate, sodium, calcium, zinc, manganese, copper, nickel, ferrous, lead and cadmium  
182 (Singh and Rathore 2018). Concentration of total suspended solid (TSS), BOD, COD,  
183 and Total dissolved solid (TDS) content of studied effluent exceeded the prescribed limit  
184 of Indian irrigation standard (BIS 1991).

### 185 ***Germination experiment***

186 Textile effluent dilution favoured well for both chilli cultivars in germination  
187 experiment. Both the cultivars showed increase in percentage germination by all the  
188 dilution of textile effluent except a slight decrease at T4 dilution in GVC-101.  
189 Germination percent was also higher than control in both the cultivars after dilution of  
190 textile effluent (Table 1).

191 Peak value (PV), germination value (GV) and seed vigor index (SVI) was also  
192 increased by addition of textile effluent in both the cultivars with highest increase at T1  
193 treatment except SVI of GVC-121 which was found highest at T2 treatment. Delay index  
194 was nil at T1 and T2 treatment for GVC-101 and at T1 treatment for GVC 121.

### 195 ***Plant growth***

196 Application of textile effluent showed positive response for shoot height and root  
197 length in both the chilli cultivars (Fig. 1a) at all the ages. For shoot height, most suited  
198 fertilization dose of textile effluent was T2 at all the ages except 30 DAS in GVC-101.  
199 Highest shoot length of cultivars GVC-101 and GVC-121, were 31.17% and 39.25%,  
200 respectively at 120 DAS in T2 treatment while, root length was highest in T3 treatment at  
201 120 DAS (31.56% and 18.91% for GVC-101 and GVC-121, respectively).

202 Two factor analyses showed significant variation for all the factors in both cultivars  
203 except interaction of age × treatment for GVC-101 of root length (Table S3).

204 Similar to plant height, leaf area was also increased by textile effluent fertilization in  
205 both the studied cultivars and best result was seen with T2 treatment (Fig. 1b). Increase  
206 in leaf area was significant by both the factors i.e. plant age and fertilization dose and its  
207 interaction for both experimental cultivars (Table S3). Highest leaf area was found at 60  
208 DAS with T2 treatment *i.e.* 26.59 and 21.46 cm<sup>2</sup> plant<sup>-1</sup> for cv. GVC-101 and GVC-121,  
209 respectively.

210 Plant biomass was significantly increased at successive growth stages in all the  
211 textile effluent fertilization regimes except at 30 DAS in T1 and T3 treatment for GVC-  
212 121 (Fig. 1c). Increase was highest at 120 DAS. Application of textile effluent  
213 fertilization with 20% (T2) dilution was found most suited for total biomass  
214 accumulation in both the cultivars. Highest increase of total dry biomass was recorded  
215 with T2 treatment at 120 DAS for both the chilli cultivars *i.e.* 43.78% and 42.19% for  
216 GVC-101 and GVC-121, respectively against their respective controls. .

### 217 ***Photosynthetic pigments and plant metabolites***

218 Chlorophyll 'a' accelerated significantly from 30 to 120 days in both the cultivars at  
219 all the textile effluent fertilization regime except at 120 DAS for GVC-121 (Fig. 2a).  
220 Increase in chlorophyll 'a' was found maximum at 120 DAS (45.25% and 32.66% for  
221 GVC101 and GVC-121 respectively) with T2 treatment than their respective controls.  
222 Similar to Chl 'a', Chl 'b' was also increased in the similar trend (Fig. 2b). Plant  
223 fertilized by 40% (T3 treatment) textile effluent exhibited maximum content of total  
224 chlorophyll (46.32 and 35.07% respectively for cultivar GVC-101 and GVC-121)) than  
225 control at 120 DAS (Fig. 2c).

226 Carotenoids content recorded an increase with successive plant age (Fig. 2d). Textile  
227 effluent fertilization further enhances carotenoids synthesis in both experimental plant

228 cultivars. Enhancement was higher with higher dose of textile effluent fertilization.  
229 Highest carotenoid in both the cultivars was present at 90 DAS with T3 treatment.  
230 Statistically, effect of age, treatment and its interaction was highly significant with both  
231 the cultivars (Table S3).

232 Total carbohydrate content was affected positively by textile effluent fertilization in  
233 both chilli cultivars (Fig. 3a). Increase in carbohydrate was higher for T1 and T2  
234 treatments. Highest increase in total carbohydrate content was seen in T2 treatment at 90  
235 DAS for GVC-101 (78%) and in T2 treatment at 120 DAS for GVC-121 (83%). Similar  
236 to total carbohydrate, protein content was also increased significantly under textile  
237 effluent application at all ages with all the treatments in both the tested cultivars (Fig.  
238 3b). Protein content observed maximum in GVC-101 (72.92%) at T2 after 120 DAS.  
239 Order of the increase was T2>T1>T3>T4 in both cultivars compare to their respective  
240 control. Variation in total carbohydrate and total protein was highly significant by both  
241 the factors viz. age and textile effluent fertilization and their interactions (Table S3).

242 Contrary to carbohydrate and protein, proline accumulation was reduced at  
243 successive ages by textile effluent fertilization in respect to their control except at 30  
244 DAS, where it was found higher in control (Fig. 3c). Proline accumulation was least with  
245 T2 fertilization in both cultivars. Analysis of variance showed highly significant effect of  
246 factor age and fertilization, although factor interaction was non-significant (Table S3).

## 247 **Discussion**

248 Textile effluent plays a major role in producing large amounts of water pollution by  
249 characteristic toxicity of its effluent i.e. higher total hardness, TDS, BOD, COD, SO<sub>4</sub>, Ca  
250 Mg, Pb, Cd etc. However, appreciable amount of mineral nutrients such as Ca, Fe, Mg,  
251 Zn, Cu, and Mn are also present in the textile effluent (Kaushik et al. 2005; Singh et al.

252 2015) making its a possible source of fertilizer. The fertilization property of textile  
253 effluent is well discussed in our earlier published report (Singh and Rathore 2018).  
254 Panda et al. (2016) in his experiment with *Oryza sativa* demonstrated that the lower  
255 concentrations of industrial effluents promote seed germination, seedling growth and dry  
256 matter accumulation. Textile effluent used for present study was having appreciable  
257 amount of plant mineral nutrient which increases the possibility of using this waste as a  
258 source of plant nutrient in agricultural soil. Although, high COD, total solid, total  
259 dissolve solid, soaring alkalinity with higher value of chloride and sulphate can make soil  
260 alkaline and reduce availability of micronutrients. Results of the present study indicate  
261 the fertilization of textile effluent in lower dilution increasing the germination property,  
262 growth and metabolites of chilli cultivars.

263 The present experiment showed positive response of textile effluent on germination.  
264 Earlier researchers (Kaushik et al. 2005; Khan et al. 2011) observed increase in  
265 germination of wheat, pea, lentil and gram with low dilution of textile effluent while a  
266 decrease in seed germination with increase in the concentration of the effluent. Result  
267 showed higher seed germination as compare to control in all the used dilution of textile  
268 effluent (up to 60% dilution) in cultivar GVC-101 however, germination of cultivar  
269 GVC-121 was increased up to 40% dilution and reduced with 60% dilution as compare to  
270 control. Industrial effluent with high osmotic pressure can cause reduction in germination  
271 (Kaushik et al. 2005; Khan et al. 2011). However, germination percent was varies with  
272 the cultivars of same species as seen in this experiment. The maximum promoting effect  
273 on germination percent was observed with 10% dilution of textile effluent in both the  
274 cultivar.

275 In the present study, germination speed, peak value and germination value also  
276 followed the same trend as seed germination. Speed of germination is maximum in 10 %

277 dilution and reduced with increase in textile effluent concentration. Ajouri et al. (2004)  
278 suggested that the minimum speed of germination is in control (without treatment) may  
279 be due to nutrient unavailability as well as nutrient deficiency in soil. The reason for the  
280 germination inhibition in the higher concentration of textile effluent can be explained as  
281 the toxic effect of heavy metals and persistent organic compound present in the  
282 composite textile effluent (Singh and Rathore, 2019). Delay index calculated in present  
283 experiment also showed delayed germination due to higher dose of textile effluent while  
284 vigor index showed vigorous characteristic of used seed with moderate dose of textile  
285 effluent. This result is consistent with Ramana et al. (2002) in some vegetable crops  
286 (tomato, cucumber, bottle gourd etc.) under distillery effluent.

287 Plant height and leaf area of chilli cultivars (GVC-101 and GVC-121) under textile  
288 effluent fertilization were also increased over control plants. However, fertilization of  
289 lower dose textile effluent provided more persistent results as compare to high dose.  
290 Deficiency of nutrient in the soil suppress the growth of plant while accumulation of salts  
291 such as Cd that could interfere with the uptake of various nutrient elements, decrease root  
292 respiration and inhibit root production (Bhuiyan et al. 2016). Contrary to the results  
293 obtained in the present study, Marwari and Khan (2012) reported reduction in root and  
294 shoot length by textile effluent.

295 Deficiency of Zn causes strong chlorosis and decreases leaf production besides the  
296 reduction of crop growth. Increase in leaf area can be correlated with increase in  
297 photosynthetic activity and higher production. Faster development of leaf size and  
298 increase in total photosynthetic rate could lead to a general increase of carbon  
299 assimilation as evident in the present experiment by increased plant biomass. Similar  
300 result also obtained by Kaushik et al. (2005) on growth and biomass of wheat cultivars  
301 with textile effluent and by Araújo et al. (2007) on growth and development of soybean

302 and cowpea with textile sludge. However, increase in root:shoot ratio (RSR) during  
303 fertilization with higher concentration of textile effluent suggested increased stress due to  
304 higher salinity or by trace elements present in the effluent.

305 Chlorophyll estimation is one of the important plant parameters which are used as an  
306 index of production capacity of the plant and carotenoids act as an accessory pigment in  
307 photosynthesis. Increase in chlorophyll could be due to addition of nutrient by textile  
308 effluent fertilization while high concentration of micronutrient showed synergistic effect  
309 on either chlorophyll synthesis pathways or on enzymes used for synthesis. Srivastava  
310 and Sahai (1988) supported the view that the increase in carotenoid content at low  
311 concentrations of the effluent treatment may be due to the beneficial effect of nitrogen  
312 and other inorganic elements present in the textile effluent.

313 Total carbohydrate and protein content showed similar trend as chlorophyll and  
314 increased with age and textile effluent fertilization. Increase in carbohydrate with age  
315 may be expected, as starch is converted to carbohydrate as the plants mature (Badoni et  
316 al. 2016). Although, suppression of carbohydrate content by high concentration of  
317 composite textile effluent can be explained as by presence of high amount of metals (Zn,  
318 Mn, Cu etc.) and role of carbohydrate in the enzymatic reactions related to the cycles of  
319 carbohydrate catabolism during reactive oxygen species (ROS) generation. Similar to our  
320 result, Badoni et al. (2016) also reported an increased accumulation of carbohydrate with  
321 increasing concentration of Zn as compared to the control in *Jatropha curcas*. Amino  
322 acid is the basic precursors for the protein that take part in photosynthesis and  
323 photosynthetic pigments and leaf protein content may positively correlated with biomass  
324 and total chlorophyll content of plant (Ayyasamy et al. 2008).

325 Increase in protein under textile effluent fertilization was corresponding to  
326 carbohydrate. However, gradual decrease of protein content at higher concentration

327 (above 20% to 60%) suggested the breakdown of protein in amino acid due to stress  
328 generated in the presence of the toxic concentration of heavy metals in the textile  
329 effluent. However, as explained by Rehman and Bhatti (2009) the enhancement in leaf  
330 protein exposed to the lower concentration of textile effluent by synthesis of stress  
331 protein gradually from 30 DAS up to 120 DAS.

332 Proline is a stress amino acid synthesized according to the defensive capability of  
333 plants. The accumulation of proline in plant tissue increase due to stress generated during  
334 the growth phase (age of the plant) or in different environmental conditions i.e. heavy  
335 metals, UV light, drought, air pollution etc (Agrawal et al., 2004; Rathore and  
336 Chaudhary, 2019, Singh and Rathore, 2019). In presented study, proline accumulation  
337 increased in T4 due to the heavy metals and salt stress. Stress generated from nutrient  
338 deficiency in soil can also cause proline accumulation in plant (Arias-Baldrich et al.  
339 2015) which can be seen in high concentration of proline in control plants (without  
340 textile effluent fertilization).

#### 341 **Conclusion**

342 Textile effluent is rich in nutrients for plants all together unwanted and surplus  
343 trace elements and high salt content. Positive response of lower dose (with 20% dilution)  
344 of textile effluent fertilization on germination, growth and metabolites of chilli cultivars  
345 represented mineral utilization from the effluent. Mineral deficiency or excess mineral  
346 developed stress symptoms in plants which can be evident by higher proline  
347 accumulation or high RSR as seen in present study with no fertilization or higher textile  
348 effluent fertilization. Lower dose of textile effluent fertilization accumulated least proline  
349 proved a most suited condition for chilli growth. Intra-specific variation among the chilli  
350 cultivars GVC-101 and GVC-121 to textile effluent was not much evident. Although,  
351 slightly higher efficiency was seen in cultivar GVC-101 as compare to cultivar GVC-121

352 for nutrient utilization from textile effluent. Study concluded that the lower dose of  
353 textile effluent can be applied as mineral nutrition supplement for plant growth.  
354 However, at this point variable nutrient use efficiency among the cultivars from textile  
355 effluent cannot be concluded.

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362 **Authors' contributions:**

363 RS carried out the experiment, recorded the data, interpreted the result, and wrote the  
364 final manuscript. DR designed and supervised the experiment, made suitable changes in  
365 the manuscript. Both author's read and approved the final manuscript.

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**Tables**

471

472 Table 1. Effects of textile effluent on Germination percent (GP), Speed of germination (SOG), peak value (PV), germination value (GV), seed  
 473 vigor index (SVI) and delay index (DI) of chilli (*Capsicum annum*) cultivars GVC-101 and GVC-121\*.

Parameters	GVC-101					GVC-121				
	C	T1	T2	T3	T4	C	T1	T2	T3	T4
<b>GP</b>	56.67±0.04 <sup>a</sup>	85.78±1.03 <sup>b</sup>	77.89±0.11 <sup>ab</sup>	74.11±0.05 <sup>ab</sup>	62.00±0.04 <sup>ab</sup>	68.33±1.33 <sup>a</sup>	88.00±0.01 <sup>a</sup>	82.22±0.15 <sup>a</sup>	69.00±0.02 <sup>a</sup>	65.11±0.17 <sup>a</sup>
<b>SOG</b>	21.81±1.42 <sup>b</sup>	30.35±1.09 <sup>e</sup>	26.73±0.01 <sup>d</sup>	25.27±0.08 <sup>c</sup>	21.17±0.03 <sup>a</sup>	22.21±1.27 <sup>b</sup>	31.33±0.31 <sup>c</sup>	28.54±0.33 <sup>bc</sup>	24.84±1.24 <sup>ab</sup>	22.29±0.42 <sup>a</sup>
<b>PV</b>	11.33±0.07 <sup>a</sup>	17.16±0.01 <sup>e</sup>	15.58±0.06 <sup>d</sup>	14.82±0.03 <sup>c</sup>	12.40±0.04 <sup>b</sup>	13.67±0.01 <sup>a</sup>	17.60±0.04 <sup>b</sup>	16.45±0.11 <sup>b</sup>	13.80±0.14 <sup>a</sup>	13.02±0.08 <sup>a</sup>
<b>GV</b>	642.2±0.1 <sup>a</sup>	1471.6±0.3 <sup>e</sup>	1212.7±0.1 <sup>d</sup>	1098.6±0.2 <sup>c</sup>	768.8±0.1 <sup>b</sup>	933.9±0.2 <sup>b</sup>	1548.8±0.3 <sup>d</sup>	1352.1±0.4 <sup>c</sup>	952.2±0.2 <sup>b</sup>	847.90±0.1 <sup>a</sup>
<b>SVI</b>	75.75±0.1 <sup>a</sup>	227.06±0.2 <sup>d</sup>	218.88±0.06 <sup>d</sup>	161.14±0.11 <sup>c</sup>	109.81±0.3 <sup>b</sup>	22.13±0.23 <sup>a</sup>	209.44±0.07 <sup>d</sup>	210.84±0.13 <sup>e</sup>	150.22±0.02 <sup>c</sup>	110.05±0.14 <sup>b</sup>
<b>DI</b>	-	0±0.00 <sup>a</sup>	0±0.00 <sup>a</sup>	0.5±0.002 <sup>c</sup>	1±0.001 <sup>b</sup>	-	0±0.00 <sup>a</sup>	0.2±0.001 <sup>ab</sup>	0.5±0.001 <sup>c</sup>	1.5±0.001 <sup>b</sup>

474 \*Within columns, means not followed by the same letter are different at the 0.05 level analysis of variance with Duncan's correction.

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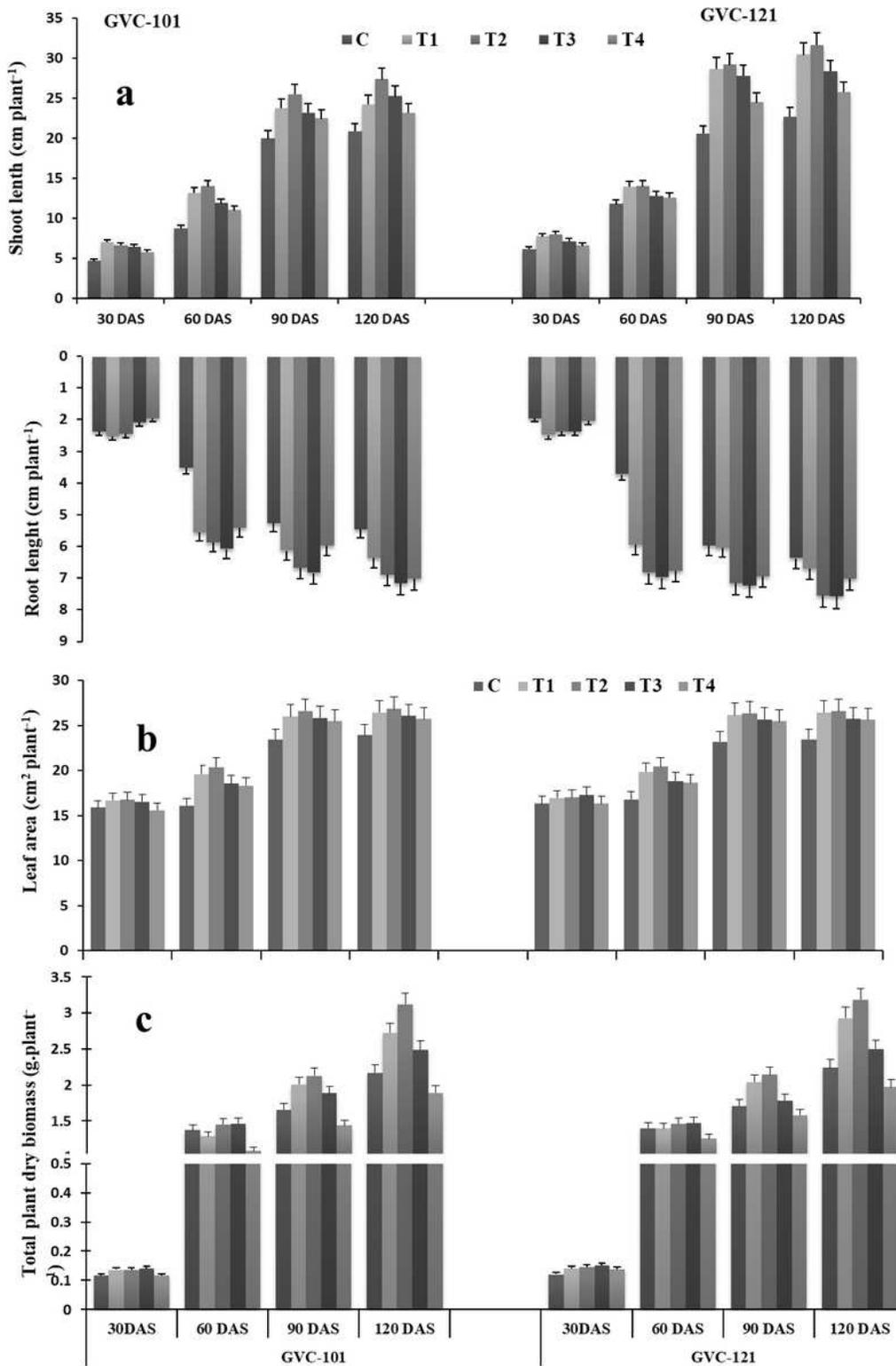
**Figure captions**

478 Fig. 1. a) Root length and shoot height b) Leaf area and c) Total dry biomass of chilli  
479 (*Capsicum annum*) cultivars (GVC-101 and GVC-121) under different treatment (v/v %) of textile effluent fertilization.

481 Fig. 2. a) chlorophyll 'a', b) chlorophyll 'b', c) total chlorophyll and d) carotenoid  
482 content in leaves of chilli (*Capsicum annum*) cultivars (GVC-101 and GVC-121) 30, 60,  
483 90 and 120 DAS under different treatment (v/v %) of textile effluent fertilization.

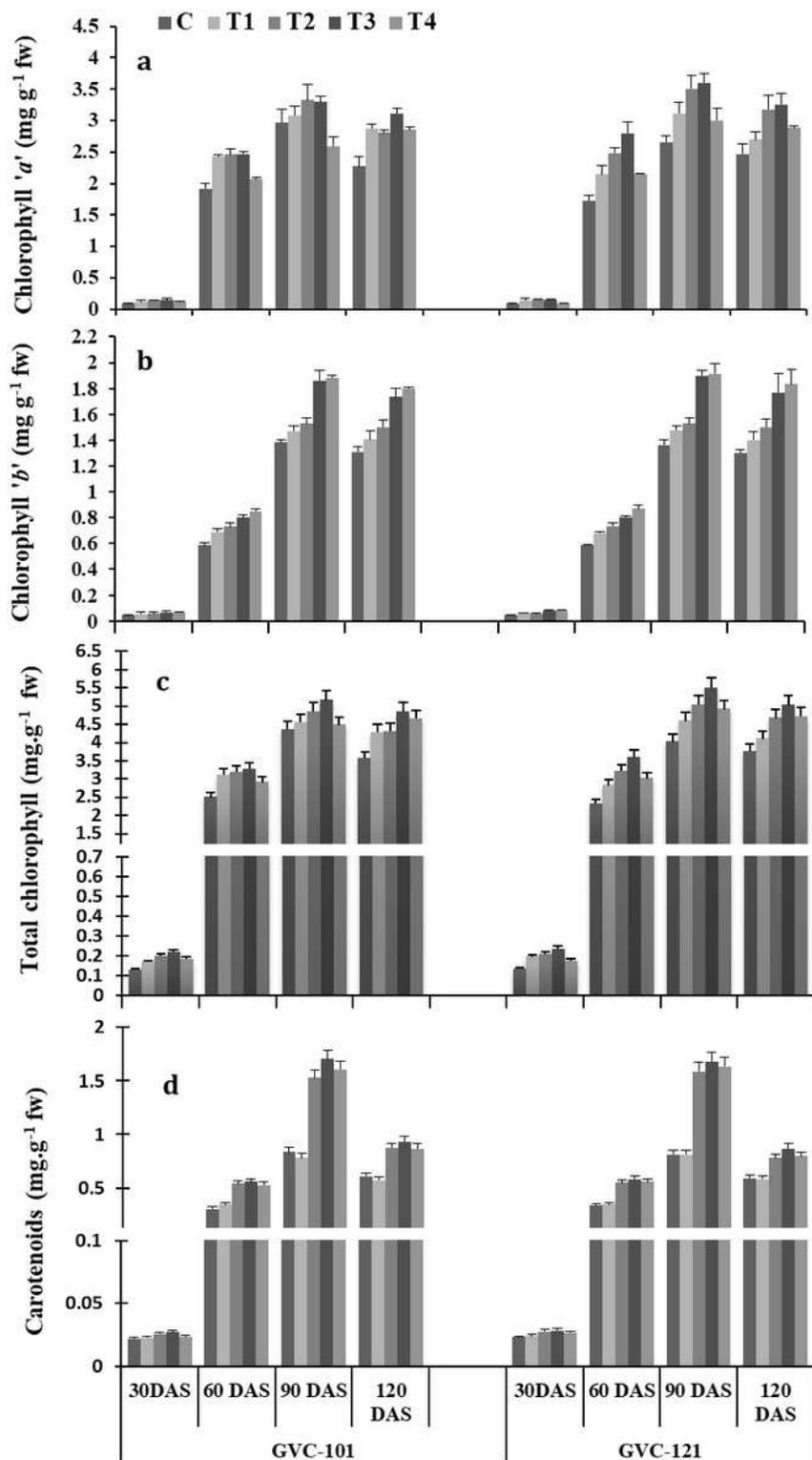
484 Fig. 3. a) Carbohydrate content, b) protein content and c) proline accumulation in leaves  
485 of chilli (*Capsicum annum*) cultivars (GVC-101 and GVC-121) 30, 60, 90 and 120 DAS  
486 under different treatment (v/v %) of textile effluent fertilization.

# Figures



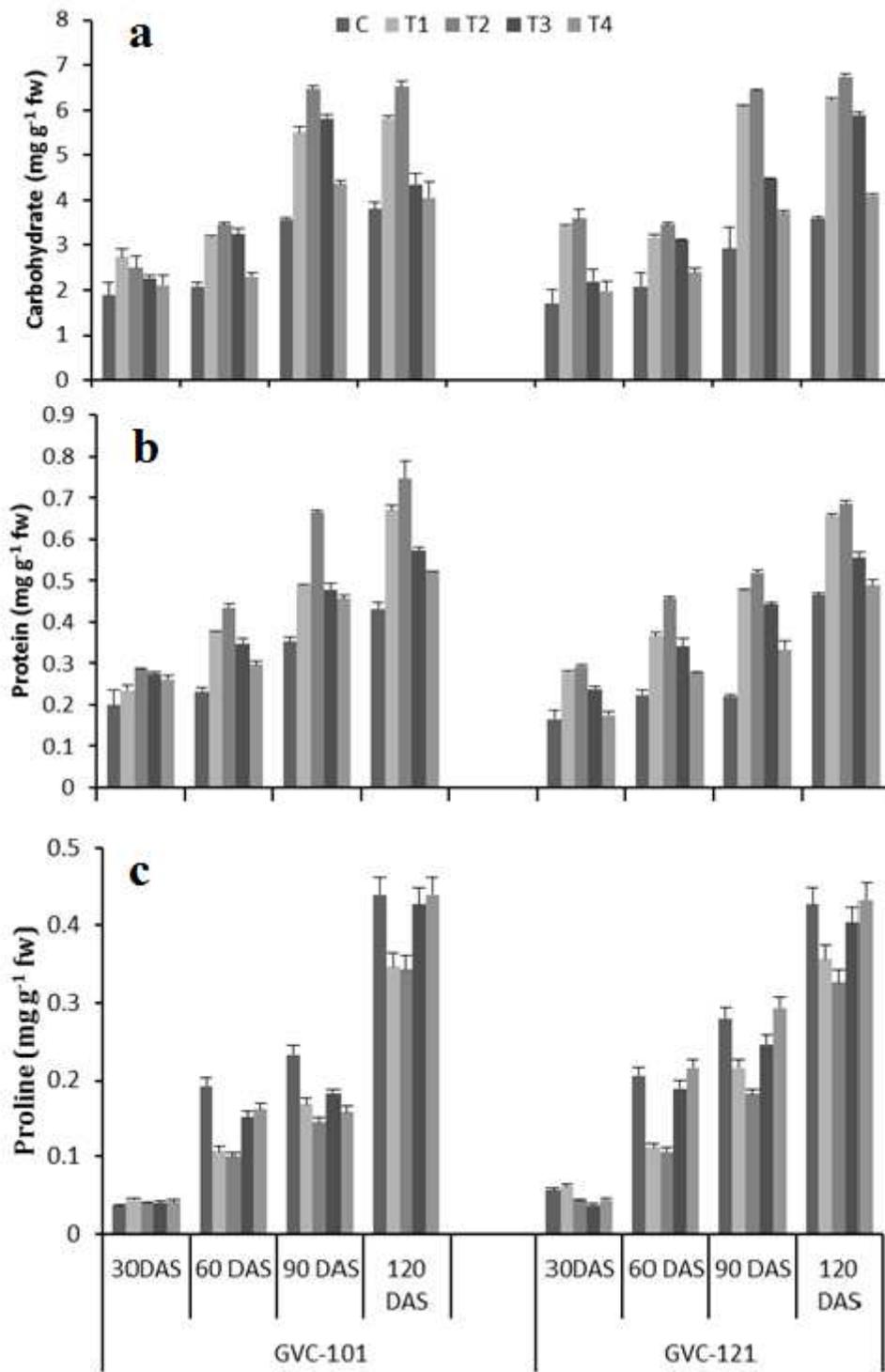
**Figure 1**

a) Root length and shoot height b) Leaf area and c) Total dry biomass of chilli (*Capsicum annum*) cultivars (GVC-101 and GVC-121) under different treatment (v/v %) of textile effluent fertilization.



**Figure 2**

a) chlorophyll 'a', b) chlorophyll 'b', c) total chlorophyll and d) carotenoid content in leaves of chilli (*Capsicum annum*) cultivars (GVC-101 and GVC-121) 30, 60, 90 and 120 DAS under different treatment (v/v %) of textile effluent fertilization.



**Figure 3**

a) Carbohydrate content, b) protein content and c) proline accumulation in leaves of chilli (*Capsicum annuum*) cultivars (GVC-101 and GVC-121) 30, 60, 90 and 120 DAS under different treatment (v/v %) of textile effluent fertilization.

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