

# Growth and Yield Response of Carrot (*Daucus carota* L.) to Different Soil Amendments

## ABSTRACT

Carrot (*Daucus carota* L.) is an important vegetable that is ranked tenth among the succulent vegetables in the world. It is easy to cultivate and requires a moderate amount of nutrients in comparison to other vegetables. However, carrot production in Liberia is almost negligible, as farmers are not aware of its requirements, its cultivation, and the unsuitable environmental conditions. The objective of this study was to assess the growth and yield performance of carrot under different soil amendments. The experiment was done at the Cuttington University research and demonstration site in a randomized complete block design (RCBD) with three replications. The treatments were: 10 t ha<sup>-1</sup>, 15 t ha<sup>-1</sup>, and 20 t ha<sup>-1</sup> compost; 300 t ha<sup>-1</sup> NPK (15:15:15); and control (0 t ha<sup>-1</sup>). The distance between plots and between blocks was 0.5 m and 1 m, respectively. Results indicated that The highest recorded plant root length (11.10 cm) occurred in the 20 t ha<sup>-1</sup> compost application, while the lowest (6.84 cm) was observed in the control treatment. The highest root diameter (22.89 mm) was recorded in the treatment with 20 t ha<sup>-1</sup> while the lowest (17.59 mm) was recorded in the control treatment. Results showed that the maximum root weight (31.73 g) occurred in the 20 t ha<sup>-1</sup> compost treatment, while the minimum (12.33 g) was observed in the control. These variations are likely attributed to nutrient levels, which play a vital role in promoting root length, diameter, and overall yield in the plant. That means the lowest values in all the parameters might be due to the low rate of compost applied to the soil. In conclusion, the highest overall growth and yield performance among carrot plants were observed in the 20 t ha<sup>-1</sup> compost treatment, followed by 15 t ha<sup>-1</sup>, 300 t ha<sup>-1</sup> NPK (15:15:15), 10 t ha<sup>-1</sup>, and the control. It is therefore recommended that farmers apply 20 t ha<sup>-1</sup> of compost for maximum growth and yield performance in carrot production.

*Keywords: Carrot; compost; soil amendment; yield response, Liberia*

## 1. INTRODUCTION

Carrot (*Daucus carota* L.) is a highly valued vegetable that ranks tenth among the succulent vegetables and is renowned for its vibrant orange color and remarkable nutritional value (Nagraj et al., 2020). This important root vegetable, which is a member of the *Umbelliferae* family (Ismail et al., 2023), is eaten both raw and cooked. Carrot is prized for having a high beta-carotene content (Ebadollahi-Natanzi and Arab-Rahmatipour, 2020; Nagraj et al., 2020), which is a precursor to vitamin A and is known to protect against infections and some cancers (Key, 2011; Zaini et al., 2012; Xu et al., 2019) and improve vision (Krinsky and Johnson, 2005). It is also an essential part of the diet since it is high in riboflavin B2, vitamin C, and thiamin B1 (Mbatha et al., 2014).

Carrot responds favorably to a variety of inorganic and organic fertilizers (Kushwah et al., 2019). However, excessive use of inorganic fertilizers leads to adverse consequences such

24 as soil acidification, increased greenhouse gas emissions, and increased eutrophication of  
25 water bodies (Kumar et al., 2019; Rashimi et al., 2020; Tiyagi et al., 2022). These negative  
26 consequences deteriorate the nutritional value of crops in addition to compromising crop  
27 productivity. On the other hand, excessive organic matter in the soil can induce forking in  
28 the carrot, which reduces its marketability and profitability (Adelaide, 2011; Akologo et al.,  
29 2023).

30 A sustainable option to improve carrot quality and yield while addressing the environmental  
31 issues caused by inorganic fertilizers is soil amendment with compost (Habteweld et al.,  
32 2018; Bender et al., 2020). Poor soil and inadequate crop management techniques,  
33 particularly in sub-Saharan Africa, have been identified as important contributors to low crop  
34 yields and decreased nutritional value (Biramo, 2018). These difficulties are exacerbated by  
35 the limited availability of resources and production knowledge, such as high-quality seeds  
36 and fertilizers (Yasoda et al., 2018).

37 Despite being considered a medium feeder, carrots still demand fertile soil for optimal growth  
38 (Thapa et al., 2023). Improper organic fertilizers can cause carrot roots to become  
39 excessively coarse, gritty, and twisted (Dickinson, 2021). Other variables, such as  
40 temperature, poor soil structure, high nitrogen fertilizer rates, high clay content, and varying  
41 soil moisture levels, can contribute to these root deformities (Achakzai and Panizai, 2007).  
42 Furthermore, in soils in wet locations with acidity and leaching properties, high fertilizer may  
43 be required to improve the soil structure (Osman and Osman, 2018; Snr et al., 2020). Timing  
44 of organic fertilizer application, along with soil temperature and pH, also plays a crucial role  
45 in nutrient availability and uptake (Rahman et al., 2018).

46 In Liberia, where carrot production is currently almost nonexistent due to soil management  
47 challenges, this study was aimed at assessing the yield response of carrot (*Daucus carota*  
48 *L.*) to different soil amendments and evaluating the impact of varying amendment rates on its  
49 growth. Enhancing carrot production through sustainable soil management practices can  
50 contribute significantly to improving the livelihoods of local farmers and increasing the  
51 availability of this nutritious vegetable in the market.

## 52 2. MATERIAL AND METHODS

53

### 54 2.1 Study site

55 The study was conducted at the Cuttington University research and demonstration site in  
56 Suakoko, Bong County, Liberia. The experimental site lies at an altitude of 270 m above sea  
57 level and is located at 7.0451° latitude and -9.5508° longitude. Climatic variables such as  
58 temperature and rainfall pattern are largely tropical, with an annual average temperature of  
59 25 °C and an annual average rainfall of 2013 mm distributed from May to October. The main  
60 soil types in the district include *latosols*, *lithosols*, *regosols*, and *alluvial* or swamp soils.

### 61 2.1 Experimental design and treatments application

62 The experimental area was slashed, ploughed, and harrowed to a fine tilth. The debris was  
63 raked off the field, and the area was demarcated into three blocks. A block had 5 plots, each  
64 measuring 1 m long, 1 m wide, and 0.25 m high. The experiment was done in a randomized  
65 complete block design (RCBD) with three replications. Following the methods by Srn (2020),  
66 the treatments (soil amendments) considered in the study were: 10 t ha<sup>-1</sup>, 15 t ha<sup>-1</sup>, and 20 t  
67 ha<sup>-1</sup> compost; 0.33 t ha<sup>-1</sup> NPK (15:15:15); and control. The distance between plots and  
68 between blocks was 0.5 m and 1 m, respectively. The various rates of compost were

69 incorporated into the soil during the preparation of the beds, while the NPK fertilizer granules  
70 were applied thirty days after the germination of the carrot seeds by side dressing.

71 According to Bolkunov (2019), the seeds were drilled to a depth of 1-2 cm. Before watering,  
72 gardens were mulched by covering them with palm fronds. After seeding, the palm fronds  
73 were cut off fourteen days later, and the seedlings were spaced out to a maximum of five  
74 centimeters between each plant. To maintain the soil's moisture content during the growth  
75 season, daily irrigation was conducted. Twice a week, the areas between the rows of carrot  
76 plants were turned over with a hand fork to get rid of weeds and soften the soil for better  
77 aeration and infiltration. In order to keep the root shoulders from turning green, they were  
78 covered with soil.

## 79 2.2 Sample size determination

80 From a total population of 2,565 plants, the required sample size was determined following  
81 Ismail (2022):

$$82 \quad N/1+N(e^2)$$

83 Where: N is the total population; e is the margin sampling error.

84 However, during the germination period of the seeds, torrential rainfall came and caused  
85 damage to the newly emerged seedlings. Therefore, data was collected from the available  
86 plants: 9 samples from 10 t ha<sup>-1</sup>, NPK, and control; 27 samples from 20 t ha<sup>-1</sup>; and 18  
87 samples from 15 t ha<sup>-1</sup>, totaling 72 sampling plants, were collected.

## 88 2.3 Data collection procedures

89 Data was collected on root length, root weight, and root diameter from 72 plants, which were  
90 randomly selected. Root length was measured from one end to the tip of the other end.  
91 Veneer calipers were used to measure the root diameter at a distance of around 1 cm from  
92 the root shoulder following the procedures by Md Saleh (2022). We used a digital balance to  
93 find the root weight.

## 94 2.4 Statistical analysis

95 Data on plant growth performance and yield of carrots was summarized using descriptive  
96 statistics such as mean and standard errors. An analysis of variance (ANOVA) was  
97 performed to see if there were any significant differences among the selected treatments.  
98 Pearson correlation analysis was also done to see if there was any relationship between the  
99 parameters. Mean comparisons were made using the Tukey Honest Significant Difference  
100 (TSD) at 0.05 significant levels. The IBM SPSS 25 package was used to perform all the  
101 statistical analyses.

102

# 103 3. RESULTS AND DISCUSSION

104

## 105 3.1 Root length

106 The length of the root is a crucial parameter affecting the yield of root vegetables. In our  
107 study, we observed that the measured root length of carrot plants was significantly  
108 influenced by the application of different rates of compost and NPK fertilizer (Table 1). There  
109 was a noticeable increase in plant root length as the amount of compost increased. The  
110 longest plant root length recorded was 11.10 cm in the 20 t ha<sup>-1</sup> compost application, while  
111 the lowest root length, 6.84 cm, was measured in the control treatment. This difference in

112 root length can likely be attributed to the low nutrient levels in the control treatment, which  
113 may have constrained root growth and development.

114 Our findings align with the research of Yasoda et al. (2018), who reported that carrot root  
115 length tends to perform best in soils with a high compost content. Dry soils can cause  
116 cracking in carrot roots (Eshkurbanovich et al., 2022), leading to an increased percentage of  
117 rotten roots and a subsequent decrease in plant yield (Villeneuve and Geoffriau, 2020). In  
118 contrast, favorable soil conditions with a high compost level promote the development of  
119 longer roots and enhance overall yield.

120 Similarly, our results are consistent with the findings of Rahman et al. (2018), who noted a  
121 significant improvement in carrot growth and yield with the application of compost compared  
122 to the control. Specifically, compost application at rates between 15 to 20 t ha<sup>-1</sup> led to a  
123 substantial enhancement in carrot plant performance.

### 124 3.2 Root diameter

125 The root diameter of carrot plants was significantly influenced by different levels of compost  
126 and NPK applications in our study. The mean values of root diameter exhibited a consistent  
127 increase as the rate of compost application increased. The highest root diameter, measuring  
128 22.89 mm, was observed in the treatment with 20 t ha<sup>-1</sup> compost, while the lowest mean root  
129 diameter, 17.59 mm, was recorded in the control treatment with no compost (0 t ha<sup>-1</sup>) (Table  
130 1). These findings are consistent with the results reported by Fikadu and Refisa (2019), who  
131 noted the significant impact of compost application on carrot root diameter.

132 Our study clearly demonstrates that as the rate of compost application increases, the root  
133 diameter of carrot plants also increases. A similar investigation conducted by Achakzai and  
134 Panizai (2007) focused on the effect of compost on carrot yield. They found that the highest  
135 root fresh weight, 160.70 g, was achieved with a 15 t ha<sup>-1</sup> compost application. Likewise, Snr  
136 et al. (2020) reported that the maximum root fresh weight, 146.50 g, was obtained with a 25 t  
137 ha<sup>-1</sup> compost application, while the lowest (123.96 g) was observed in the control treatment.  
138 Dawuda et al. (2011) also found that the application of bio-slurry manure at 7.8 t ha<sup>-1</sup> led to a  
139 23.5% increase in carrot yield compared to the control.

140 The enhanced response in root fresh weight is likely attributable to the improved soil fertility  
141 status resulting from the increasing levels of compost. This aligns with the findings of Kiran  
142 et al. (2016), who emphasized the effectiveness of compost in enhancing soil fertility,  
143 particularly for growing vegetable crops. Similarly, Adelaide (2011) highlighted compost as a  
144 valuable fertilizing material capable of maintaining soil fertility and improving crop production.  
145 These results are consistent with the observations made by Asante et al. (2019), who  
146 reported significant variations in carrot root diameter with the application of both chemical  
147 fertilizers and organic manures.

### 148 3.3 Root weight

149 Root weight stands as a critical parameter influencing the yield of root vegetables. In our  
150 study, significant differences ( $p < 0.001$ ) were observed among the five different treatments.  
151 Notably, the average root weight of carrot plants exhibited a consistent increase with higher  
152 levels of compost, resulting in substantially greater root weight in the NPK treatment  
153 compared to the 10 t ha<sup>-1</sup> and control treatments. Specifically, the highest root weight,  
154 measuring 31.73 g, was recorded at the 20 t ha<sup>-1</sup> compost rate, while the lowest, 12.33 g,  
155 was observed in the control treatment. This discrepancy in root weight may be attributed to  
156 the relatively low compost application rate in the control treatment, potentially limiting

157 nutrient availability in the soil. This finding aligns with the research by Mbatha et al. (2014),  
 158 which suggests a direct correlation between carrot yield and the quantity of compost applied  
 159 to the soil.

160 Our results corroborate the findings of Yasoda et al. (2018), who highlighted the nutrient-rich  
 161 nature of compost. They reported that consistent compost applications not only supply  
 162 essential plant nutrients but also enhance soil fertility. Similarly, Rahman et al. (2018)  
 163 demonstrated that compost leads to increased nitrogen uptake and improved carrot yield.  
 164 However, it's important to note that nutrient availability in the soil can vary significantly based  
 165 on the nutrient source.

166 Furthermore, Kiran et al. (2016) observed a significant boost in plant growth and carrot yield  
 167 with higher doses of compost compared to lower doses, supporting our findings. Additionally,  
 168 Achakzai and Panizai (2007) reported an increase in carrot yield upon the addition of 40 t ha<sup>-1</sup>  
 169 of compost.

170 **Table 1. Root length, root diameter, and root weight comparisons among the selected**  
 171 **treatments**

Treatment	Root length (cm)	Root diameter (mm)	Root weight (g)
10 t ha <sup>-1</sup> compost	(7.67 ± 1.08) <sup>bc</sup>	(18.45 ± 1.63) <sup>ab</sup>	(16.90 ± 2.37) <sup>b</sup>
15 t ha <sup>-1</sup> compost	(10.52 ± 0.55) <sup>ab</sup>	(19.96 ± 1.00) <sup>ab</sup>	(22.93 ± 2.92) <sup>ab</sup>
20 t ha <sup>-1</sup> compost	(11.10 ± 0.52) <sup>a</sup>	(22.89 ± 0.72) <sup>a</sup>	(31.73 ± 2.46) <sup>a</sup>
control	(6.84 ± 0.73) <sup>c</sup>	(17.59 ± 1.30) <sup>b</sup>	(12.33 ± 1.38) <sup>b</sup>
0.33 t ha <sup>-1</sup> NPK (15:15:15)	(8.22 ± 1.20) <sup>abc</sup>	(22.82 ± 1.63) <sup>ab</sup>	(20.19 ± 4.47) <sup>ab</sup>

172 *\*Means followed by the same letter are not significantly different at P ≤ 0.05 as determined*  
 173 *by Tukey Honest Significant Difference (HSD) test. Values are expressed as mean ±*  
 174 *standard error.*

175 Correlation analysis revealed strong positive correlations among root length, root diameter,  
 176 and root weight (Table 2). The Pearson correlation coefficient indicated a robust relationship  
 177 between root length and root weight ( $r = 0.698$ ), as well as between root diameter and root  
 178 weight ( $r = 0.736$ ). Although the correlation between root length and root diameter was  
 179 slightly lower ( $r = 0.492$ ), it still provides valuable insight into the relationship between these  
 180 two variables.

181 **Table 2. The correlation matrix of the root length, root weight, and root diameter**

	Root length (cm)	Root weight (g)	Root diameter (mm)
Root length (cm)	1	0.698	0.492
Root weight (g)	0.698	1	0.736
Root diameter (mm)	0.492	0.736	1

182

#### 183 4. CONCLUSION

184 The present study has yielded vital insights on the notable effects of NPK fertilizer and  
 185 compost on root weight, root diameter, and root length in carrot plants. According to the  
 186 study, the amount of compost that is added to the soil has a significant impact on the length  
 187 of carrot roots. The application of 20 t ha<sup>-1</sup> of compost resulted in the longest roots among  
 188 carrot plants, suggesting a favorable correlation between compost levels and root length.

189 The study also demonstrated the positive link that exists between root length, root diameter,  
190 and root weight, highlighting the interdependent nature of these factors in affecting the  
191 growth and yield of carrot plants. The relevance of these parameters in influencing overall  
192 root vegetable output is highlighted by the substantial correlations found between root  
193 diameter and weight and between root length and weight. This study highlights how crucial it  
194 is to maintain soil properly, using compost, in order to optimize root characteristics and  
195 eventually increase the yield of root crops like carrots.

196 In conclusion, this study's findings advance our knowledge of the significant effects that NPK  
197 fertilizer treatments and compost can have on the length, width, and weight of carrot plants'  
198 roots. Farmers and other agricultural professionals who want to increase the yield of root  
199 vegetables by using efficient soil nutrient management techniques may find these ideas to  
200 be helpful. This research highlights the possibility for greater agricultural production and food  
201 security in areas where root vegetables are important for dietary diversity and nutrition by  
202 highlighting the significance of soil fertility and nutrient levels.

### 203 **COMPETING INTERESTS**

204 Authors have declared that no competing interests exist.

### 206 **AUTHORS' CONTRIBUTIONS**

207 All authors involved in the design of the study, performed the statistical analysis, wrote the  
208 protocol, and wrote the manuscript. All authors read and approved the final manuscript.

### 211 **REFERENCES**

- 212 Achakzai, A. K. K., & Panizai, M. K. (2007). Effect of Row Spacing on Growth , Yield and  
213 Yield Components of Mashbean. *Journal of Horticulture*, 23(1), 149–155.
- 214 Adelaide, M. (2011). Influence of temperature on yield and quality of carrots (*Daucus carota*  
215 *var. sativa*). *November*, 1–84.
- 216 Akologo, L. A., Dapaah, H. K., & Yirzagla, J. (2023). Recommended Carrot Production and  
217 Handling Practices. *Emerging Issues in Agricultural Sciences*, 132.
- 218 Asante, K., Manu-Aduening, J., & Essilfie, M. E. (2019). Nutritional Quality Response of  
219 Carrot (*Daucus carota*) to Different Rates of Inorganic Fertilizer and Biochar. *Asian*  
220 *Journal of Soil Science and Plant Nutrition*, 5(2), 1–14.
- 221 Bender, I., Edesi, L., Hiiesalu, I., Ingver, A., Kaart, T., Kaldmäe, H., Talve, T., & Luik, A.  
222 (2020). Organic carrot (*Daucus carota* L.) production has an advantage over  
223 conventional in quantity as well as in quality. *Agronomy*, 10(9), 1420.
- 224 Biramo, G. (2018). The role of integrated nutrient management system for improving crop  
225 yield and enhancing soil fertility under Small holder farmers in Sub-Saharan Africa: A  
226 review article. *Mod. Concepts Dev. Agron*, 2, 1-9.
- 227 Bolkunov, A. I., Postnova, M. V., & Sroslova, G. A. (2019, October). Features of the  
228 cultivation technology of carrot hybrids in dry steppes of the Lower Volga region on drip  
229 irrigation. In *IOP Conference Series: Earth and Environmental Science* (Vol. 341, No.  
230 1, p. 012001). IOP Publishing.
- 231 Dawuda, M., Boateng, P., Hemeng, O., & Nyarko, G. (2011). Growth and yield response of  
232 carrot (*Daucus carota* L.) to different rates of soil amendments and spacing. *Journal of*  
233 *Science and Technology (Ghana)*, 31(2), 11–20.
- 234 Dickinson, B. (2021). Gardening to Eat: Connecting People and Plants. *Gardening to Eat*, 1-  
235 152.
- 236 Ebadollahi-Natanzi, A., & Arab-Rahmatipour, G. (2020). A study on chlorophyll, total  
237 carotenoid and beta-carotene contents in carrot and the effect of climate on  
238

239 them. *Journal of Medicinal Plants*, 19(75), 254-265.

240 Eshkurbanovich, A. I., Asadullaevich, R. E., Jumaevich, C. A., & Rustamovna, X. M. (2022).

241 EVALUATION OF VARIETIES AND HYBRIDS OF TABLE CARROT (*DAUCUS*

242 *CAROTA L.*) GROWN IN CONDITIONS OF DESERT SOIL-CLIMATE ZONE OF

243 SURKHANDARYA REGION. *Open Access Repository*, 8(12), 295-299.

244 Fikadu, L., & Refisa J., (2019). The Effect of Different Rates of Cow Dung Application on

245 Growth and Yield of Carrot (*Daucus carota L.*). *International Journal of Agriculture &*

246 *Agribusiness*, 6(1), 21–27.

247 Habteweld, A. W., Brainard, D., Kravchenko, A., Grewal, P. S., & Melakeberhan, H. (2018).

248 Effects of plant and animal waste-based compost amendments on the soil food web,

249 soil properties, and yield and quality of fresh market and processing carrot

250 cultivars. *Nematology*, 20(2), 147-168.

251 Ismail, I. A., Pernadi, N. L., & Febriyanti, A. (2022). How To Grab And Determine The Size

252 Of The Sample For Research. *International Journal of Academic and Applied Research*

253 (*IJAAR*), 6(9), 88-92.

254 Ismail, J., Shebawy, W. N., Daher, J., Boulos, J. C., Taleb, R., Daher, C. F., & Mroueh, M.

255 (2023). The Wild Carrot (*Daucus carota*): A Phytochemical and Pharmacological

256 Review. *Plants*, 13(1), 93.

257 Key, T. J. (2011). Fruit and vegetables and cancer risk. *British journal of cancer*, 104(1), 6-

258 11.

259 Kiran, M., Jilani, M. S., Waseem, K., & Marwat, S. K. (2016). Response of Carrot (*Daucus*

260 *carota L.*) Growth and Yields to Organic Manure and Inorganic Fertilizers. *American-*

261 *Eurasian J. Agric. & Environ. Sci*, 16(6), 1211–1218.

262 Krinsky, N. I., & Johnson, E. J. (2005). Carotenoid actions and their relation to health and

263 disease. *Molecular aspects of medicine*, 26(6), 459-516.

264 Kumar, R., Kumar, R., & Prakash, O. (2019). Chapter-5 the impact of chemical fertilizers on

265 our environment and ecosystem. *Chief Ed*, 35, 69.

266 Kushwah, G., Sharma, R. K., Kushwah, S. S., & Mishra, S. N. (2019). Effect of organic

267 manures, inorganic fertilizers and varieties on growth, yield and quality of tropical

268 carrot. *Indian Journal of Horticulture*, 76(3), 451-456.

269 Mbatha, A. N., Ceronio, G. M., & Coetzer, G. M. (2014). Response of carrot (*Daucus carota*

270 *L.*) yield and quality to organic fertiliser. *South African Journal of Plant and Soil*, 31(1),

271 1–6.

272 Md Saleh, R., Kulig, B., Arefi, A., Hensel, O., & Sturm, B. (2022). Prediction of total

273 carotenoids, color, and moisture content of carrot slices during hot air drying using

274 non-invasive hyperspectral imaging technique. *Journal of Food Processing and*

275 *Preservation*, 46(9), e16460.

276 Nagraj, G. S., Jaiswal, S., Harper, N., & Jaiswal, A. K. (2020). Carrot. *Nutritional*

277 *Composition and Antioxidant Properties of Fruits and Vegetables*, 323-337.

278 Osman, K. T., & Osman, K. T. (2018). Acid soils and acid sulfate soils. *Management of Soil*

279 Rahman, M., Islam, M., Mamun, M., Rahman, M., & Ashraf, M. (2018). Yield and Quality

280 Performance of Carrot under Different Organic and Inorganic Nutrient Sources with

281 Mulching Options. *Asian Journal of Agricultural and Horticultural Research*, 1(4), 1–8.

282 Rashmi, I., Roy, T., Kartika, K. S., Pal, R., Coumar, V., Kala, S., & Shinoji, K. C. (2020).

283 Organic and inorganic fertilizer contaminants in agriculture: Impact on soil and water

284 resources. *Contaminants in Agriculture: Sources, Impacts and Management*, 3-41.

285 Snr, P. A. P., Addo, J. S., Logah, V., & Kyere, C. G. (2020). Effect of Different Soil

286 Amendments and Variety on the Growth and Yield of Carrot (*Daucus carota L.*).

287 *International Journal of Plant & Soil Science*, 32(10), 16–25.

288 Thapa, A., Garhwal, B. T. T., Srivastava, U. A., Shrestha, A. K., & Giri, H. N., (2023). Effect

289 of Different Levels of Potassium and Boron on Growth, Yield and Quality of Carrot

290 (*Daucus carota cv. New Kuroda*) in Nawalparasi, Nepal. *International Journal of*

291 *Innovative Science and Research Technology*, 8(2), 1640-1647.

292 Tyagi, J., Ahmad, S., & Malik, M. (2022). Nitrogenous fertilizers: Impact on environment  
293 sustainability, mitigation strategies, and challenges. *International Journal of*  
294 *Environmental Science and Technology*, 19(11), 11649-11672.

295 Villeneuve, F., & Geoffriau, E. (2020). Carrot physiological disorders and crop adaptation to  
296 stress. In *Carrots and related Apiaceae crops* (pp. 156-170). Wallingford UK: CABI.

297 Xu, H., Jiang, H., Yang, W., Song, F., Yan, S., Wang, C., Fu, W., Li, H., Lyu, C., & Lu, Z.  
298 (2019). Is carrot consumption associated with a decreased risk of lung cancer? A meta-  
299 analysis of observational studies. *British Journal of Nutrition*, 122(5), 488-498.

300 Yasoda, P. G. C., Pradheeban, L., Nishanthan, K., & Sivachandiran, S. (2018). Effect of  
301 Different Shade Levels on Growth and Yield Performances of Cauliflower. *International*  
302 *Journal of Environment, Agriculture and Biotechnology*, 3(3), 948–955.

303 Zaini, R., Brandt, K., R Clench, M., & L Le Maitre, C. (2012). Effects of bioactive compounds  
304 from carrots (*Daucus carota* L.), polyacetylenes, beta-carotene and lutein on human  
305 lymphoid leukaemia cells. *Anti-Cancer Agents in Medicinal Chemistry (Formerly*  
306 *Current Medicinal Chemistry-Anti-Cancer Agents)*, 12(6), 640-652.

307