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*Full Length Research Paper*

# Improving the production of radish (*Raphanus sativus* L.cv. local black) by Fe- EDDHA and carrots (*Daucus carrota* L. var. sativus cv. nates by indole-3-butyric acid (IBA)

**Caser G. Abdel**

Department of Horticulture, Agriculture College, Dohuk University, Kurdistan Region, Iraq.
E-mail: caserabdel@yahoo.com.

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**Seeds of local black radish cultivar (experiment 1) were sown in plots, then plants were sprayed twice after thinning 2 weeks latter by Fe- EDDHA at rates of 0, 20, 30 or 40 mgL$^{-1}$. Whereas, seeds of nates carrot cultivar (experiment 2) were sown on plots and furrows, then plants were sprayed twice after thinning and once more at the commencement of root swollen after 3 months by indole-3-butyric acid (IBA) at rates of 0, 20, 30 or 40 mgL$^{-1}$. The objective of this investigations were to improve growth, yield and yield quality of radish and carrot irrigated whenever 25% of soil available water capacity (AWC) is depleted to a depth of 25 cm. Radish required 146.25 mm supplementary irrigation besides 254.3 mm rainfall incidences during the growing season. Radish yield was substantially increased, as plants sprayed by Fe-EDDHA especially, with 40 mgL $^{-1}$ rate which gave the highest yield (45.47 kgm$^{-2}$). Yield was linearly responded to iron rates, and yield responses to Fe-EDDHA rates could be estimated from the following equation: yield (kgm$^{-2}$) = [30.0178 + 0.3004 (iron rate)]. Carrots required 175.5 mm supplementary irrigation in addition to 254.3 mm rainfalls. Plot cultivation (11.8 kgm$^{-2}$) substantially exceeded its corresponding furrow cultivation (8.7 kgm $^{-2}$) in term of root marketable yield. Yield was quadratically responded to varying IBA rates and could be estimated by the following equation: yield (kgm$^{-2}$) = [10.0482 – 0.0558358 (IBA rate) + 0.0019168 (IBA rate)$^{**2}$]. The highest marketable yield (12.6 kgm$^{-2}$) was obtained from plot cultivated plants sprayed by IBA rate of 40 mgL$^{-1}$.**

**Key words:** Radish, carrot, IBA, Fe-EDDHA, supplemental watering.

## INTRODUCTION

Radish *Raphanus sativus* is a member of Brassicaceae and include both annual and biennial type. Spring and summer radishes (short season types) are annuals. The winter cultivars require up to two months reaching edible stage and may be annual or biennial (Peirce, 1987). Local black and local red are very familiar and the most consumed radish cultivar in Iraq. Local black had been proved to be highly resistance to heart pithiness even under cool conditions (Abdel, 2007). However, $GA_3$ foliar spray to this cultivar substantially induced internal tissue collapse pithiness (Abdel, 2007a). In contrast local red cultivar was found to be very sensitive to pithiness (Abdel, 2008). Radish production is highly confined to plant populations and thus a compromise between root, leaves ratio should be considered to meet the consumer demand and to introduce reasonable yield. Since higher radish densities produce rootless radish of weak leaves stand and hypocotyls being over soil surface manifesting a coil like shape (Abdel, 2007) . He referred this phenomenon to many environmental factors.

Carrots (*Daucus carrota* L. var. sativus) are of tight rosette leaves arise from the crown after the emergence of characteristics cotyledonary leaves. Two kinds of leaves are formed, the lower leaves are pinnate and linear or lancelet and are fine and lacy in appearance. The upper leaves are smaller and less divided. Leaves in the second year of growth arise from the crown and along the elongated stem (Mills, 2001). FAO (1968) reported

**Table 1.** Physical analysis for upper 30 cm Tran located silty loam soil and clayey underneath native field soil.

| Soil separations ($gkg^{-1}$) | Translocated soil | Field native soil |
|---|---|---|
| Clay particles | 564 | 139 |
| Silt particles | 313 | 564 |
| Sand particles | 123 | 297 |
| Soil bulk density ($gcm^{-3}$) | 1.6 | 1.55 |
| Soil field capacity (%) | 21.8 | 20 |
| Soil wilting point (%) | 12.05 | 11 |

that, each 100 g of edible portion of carrot root contains 88 ml of water, 40 calories, 0.9 g protein, 0.19 fat, 9 g carbohydrate, 1.4 g fiber 35 mg calcium, 38 mg phosphorus, 0.7 mg iron, 540 µg -carotene equivalent, 0.04 mg thiamine, 0.04 mg riboflavin, 0.6 mg niacin and 8 mg ascorbic acid. Nates carrot cultivar was lately introduced to Iraq, but it seems that this cultivar is very suitable for our environments. Since, it was found to possess very small leaves, abrupt root ends, perfect orange colour appearance, and excellent taste (Abdel and Al-Saberi, 2009).

Iron is usually present in the $Fe^{3+}$ (ferric) form and must be converted to $Fe^{2+}$ (ferrous) form before it can be absorbed by plant root. However, if soil pH above 7.2 and interveinal chlorosis is apparent, then foliar application of iron cheated may be beneficial that the application of (181.44 to 272.16 $g.h^{-1}$) actual iron. Application of iron is made during early stages of growth are more beneficial than latter in season. More than one foliar spray is usually required (Minnesota, 2004). Iraqi alkaline soil conditions possess pH greater than 7.5 which can render iron unavailable to plant roots. Therefore, iron plant requirements are usually supplied by foliar spray (Al-Hamadany and Abdel, 2008).

IBA is often more effective than IAA in root initiation making it important in several specie (De Klerk et al., 1999) . Differentiation of both xylem elements and phloem sieve tubes around the wound is limited and controlled by auxins supply (Hopkins, 1999). Abdel (2007b) found that naphthalene-3-acetic acid highly improved the growth and yield of nates carrot cultivar, especially at rates of 30 and 40 $MgL^{-1}$. The objectives of these investigations were to improve yield and yield qualities of local black radish cultivar by Fe-EDDHA and nates carrot cultivar by IBA.

## MATERIALS AND METHODS

Both experiments were carried out during fall and spring radishes growing season at horticulture research field, northern Iraqi province (36°' 42" Latitude) . The objective of first experiment was to investigate the possibility of improving growth, yield and yield quality of local black radish cultivar irrigated whenever 25% of available water capacity is depleted to a soil depth of 25 cm by the aid Fe-EDDHA rates 0, 20, 30 and 40 $mgL^{-1}$. Therefore, seeds of a popular radish cultivar namely local black radish were purchased from vegetable seed shop. In second experiment, thiram treated (Batch 890693) seeds of nates carrot cultivar were obtained from Royal Sulis Seed Company under lot no. 411633 and were tested on 02/2004 with a germination percentage of (81%), to improve the yield and yield quality of this cultivar through indole-3-butyric acid (IBA) foliar application.

A Randomized Complete Block Design (RCBD) was selected for radish to include four treatments, each was replicated five times. A replicate was represented by a plot of 4 $m^2$ of 20 cm inter row space and 5 to 7 cm plants intra space. Subsequently, the experiment contained 20 plots. Regression was made in a computer program "Minitab", and Duncan multiple tests was also used to evaluate IBA treatments. However, split plot within Factorial Randomized Complete Block Design (F-RCBD) was chosen for carrot trail, where the main plot (A) was represented by furrow cultivation ($a_1$) and plot cultivation ($a_2$). Whereas the sub main plot (B) was IBA rates which included the distilled water check ($b_1$), 20 $mgL^{-1}$ ($b_2$), 30 $mgL^{-1}$ ($b_3$) and 40 $mgL^{-1}$ ($b_4$). Therefore, 8 treatments were included in this experiment each was replicated 4 times. A furrow of (0.8 x 5 m) was planted with 4 lines, 2 lines at the lowest thirds close to bottom and the other 2 lines were planted at the upper thirds with plant spaces of 2 to 4 cm after thinning to represent one replicate. A plot of 4 $m^2$ was planted in rows 20 cm apart and 2 to 4 cm intra plant spaces after thinning to represent one plot cultivation replicate.

Soil was analyzed at the soil and water Department Laboratory (Table 1), while meteorological data was obtained from Al-Rashidia meteorological office, Mosul (Table 2). Soil was plowed vertically and once more horizontally, and then dissected to math the chosen design. A gypsum block was settled at a depth of 25 cm in each plot to truck the fluctuations of soil moisture content caused by supplementary irrigations and rainfall incidences, in order to determine the precise time for irrigation (Poincelot, 2004).

Radish seeds were sown on September, 15th in plots of 4 $m^2$ with 20 cm row inter space and 5 to 7 cm intra plant space. Thereafter, on October, 5th plants were thinned to a space of 5 to 7 cm intra plants on each row. Irrigation was ceased for a week to harden plants, induce storage root initiation, and establish plant well in soil. Plants were sprayed with the proposed iron rates after the drought period and repeated after 2 weeks. Weeds were manually controlled during the growing season and Diaminophoshate (DAP) fertilizer was applied twice immediately after the drought period and again after one month at rate of 15 $gm^{-2}$ for each application time. Plants were harvested on February, 1st to 7th. Plant height, leaf numbers were counted. Plant fresh weight, fresh weight of leaves and yield were weighed by the aid of electrical balance of two decimal. Root and leaf samples were oven-dried at 60°C for 72 h then weighed and dry matter percentages were calculated.

Carrot seeds were sown on September 10th. Weeds were manually controlled and Diamino phosphate (DAP) was broadcasted three times at rate of 10 $gm^{-2}$ for each, before sowing, after thinning on November 3rd and on February 4th. Plants were

**Table 2.** Meteorological data, irrigation frequencies and applied water (mm) radish and carrot.

| Recorded parameters | Growing season months | | | | | |
|---|---|---|---|---|---|---|
| | September | October | November | December | January | February |
| Maximum temperature (°C) | 38.10 | 30.20 | 21.70 | 18.50 | 11.91 | 15.38 |
| Minimum temperature ( °C) | 19.8 | 13.60 | 7.30 | 6.40 | 3.64 | 6.22 |
| Mean temperature( °C) | 28.95 | 21.90 | 14.50 | 11.95 | 7.60 | 10.80 |
| Relative humidity (%) | 34.00 | 65.00 | 57.00 | 67.00 | 78.36 | 71.10 |
| Rainfall (mm) | 0.0 | 0.0 | 20.60 | 40.20 | 142.70 | 50.80 |
| Irrigation frequencies radish | 1.00 | 6.00 | 3.00 | 3.00 | 0.00 | 2.00 |
| Irrigation frequencies carrot | 2.0 | 6.0 | 3.0 | 3.0 | 0.0 | 2.0 |
| Free vapor at. (mm.d$^{-1}$) | 11.5 | 6.19 | 3.39 | 2.1 | 1.14 | 1.79 |
| Actual sunshine (H.d$^{-1}$) | 10.8 | 8.41 | 6.50 | 4.90 | 4.98 | 6.32 |

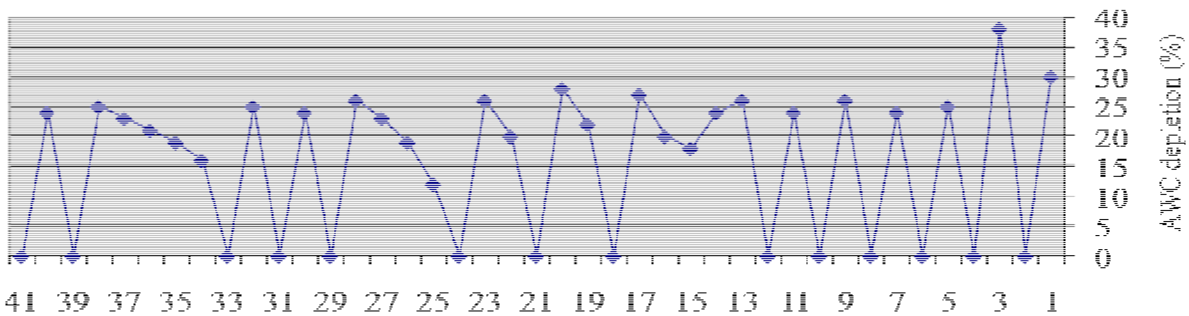


**Figure 1.** Irrigation frequencies for radish irrigated whenever 25% of soil AWC is depleted to a soil depth of 25 cm.

sprayed with Benomyl fungicide at rate 1 gL$^{-1}$as protective spray on October, 20th. Finally plants were harvested on March, 11th. Plants were washed up with tap water then they were brought to the laboratory. Leaves number per plant and unmarketable roots were counted.

Leaves length, root diameter, xylem diameter, root length were measured by ruler and total soluble solids of root was measured by handrefrectometer. Fresh weight of leaves per plant, individual plant fresh weight, unmarketable root fresh weight, marketable root fresh weight and root yield per m$^2$ were weighed by two decimal electrical balances. Area of root cross section, area of xylem cross section, percentage of xylem area, area of phloem, percentage of phloem area, dry matter percentage of leaves, dry matter percentage of root, root: leaves ratio and cylindricality were calculated (Bleasdale and Thompson, 1963). Leaves and root samples were weighed, then oven dried at 60°C for 72 h and dry weight of samples was recorded.

## RESULTS AND DISCUSSION

Response of local black radish to irrigation results exhibited that radishes were irrigated 15 times during the growing season (Figure 1), with each irrigation soil was brought up to a field capacity to a depth of 25 cm. Therefore, the evapotranspiration of radishes raised from supplemental watering was (146.25 mm) besides that raised from rainfall source (254.3 mm). This result suggested that irregular watering of radish plants decreased the yield and yield quality; therefore soil moisture should be sustained at slight drought at earlier growth stage followed by regular irrigation owing to the high significance in sustaining acceptable soil moisture to obtain uniform plant stand in field (Abdel, 2007).

Response of nates carrot to irrigation revealed that carrots required 175.5 mm supplementary irrigation combined with 254.3 mm rainfall incidences during growing season. Watering was highly required during October owing to the delay of considerable rainfall incidence on this month which was synchronized with high temperature and increasingly soil coverage by plant. Inadequate rainfalls were occurred during November, December and February. Therefore complementary watering was demonstrated 3, 3 and 2 times, respectively. However, supplementary irrigation was not required during January (Table 2). Intensive care of soil moisture fluctuation should be taken throughout carrot growing period since water scarcity being very harmful, particularly during storage root development (Abdel and Al-Saberi, 2009). Irregularity of soil moisture is usually accompanied by physiological disorder, especially root cracking. McGarry (1995) studied several carrot cultivars, he found that the force or energy required to fracture

**Table 3.** The influence of foliar spraying of Fe-EDDHA rates on growth and yields of plot cultivated black radish cultivar.

| Iron rates $mgL^{-1}$ | leaves fresh wt/pl g | Root fresh wt g | Plant fresh wt g | Leaves per plant | Root: Leaves ratio | Root diameter cm | Plant height cm | Radish yield $kgm^{-2}$ |
|---|---|---|---|---|---|---|---|---|
| 0 | 137.81b | 195.94b | 337.06b | 9.57b | 1.824b | 6.95b | 52.8c | 34.67c |
| 20 | 136.73b | 197.24b | 340.60b | 9.37b | 1.82b | 6.87b | 62.3ab | 30.79d |
| 30 | 131.72b | 223.08a | 315.24c | 9.39b | 2.09ab | 7.24ab | 64a | 37.76b |
| 40 | 191.70a | 335.08a | 483.50a | 11.57a | 2.69a | 7.94a | 59.13bc | 45.47a |
| Means | 151.67 | 241.72 | 380.51 | 10.12 | 2.1 | 7.29 | 59.56 | 38.06 |

carrot tissue is inversely related to turgor pressure, where at high turgor, the protoplast presses on the surrounding cell wall, reducing the force or energy needed to rupture it. He also found that, the carrot cell wall volume fraction might decrease during the latter stages of crop growth. However, carrot tissue strengths during the same period, suggesting that cell wall composition is modified during crop maturity. period of water stress will slow root growth, producing thickened cells and woody texture, flavour become bitter, or at least not as sweet as in carrots grown under ideal conditions. At least 38 mm of water is needed weekly, more in arid areas and light soil (Peirce, 1987). Carrots and turnips grown at optimal temperature and water supply, plant weight increases with increasing daily light integrated (by extending day length or light intensity) or increasing $CO_2$ concentration (Hole and Sutherland, 1990). Yucel (1992) presumed that rainfall around seedling emergence and before harvesting were the best predictors of sugar beet yield. However, in hotter, drier climates, the relationship between light interception and yield may not be closed. Mills, (2001) found that an abundant reserve of moisture is required to germinate a high quality product and adequate measure of moisture is approximately 38.1 mm of water every 7 to 10 days.

Radish experiment results revealed that application of (40 $mgL^{-1}$) iron in the form of Fe-EDDHA appeared to be the most effective treatment. It substantially exceeded the untreated check in terms of leaf fresh weight (39.1%), root fresh weight (20%), plant fresh weight (43.5%), leaf number per plant (20.1%), root: leaves ratio (62.3%), root diameter (14.24%) and yield (31.2%). Furthermore, (40 $mgL^{-1}$) was superior over 20 $mgL^{-1}$ treatment in leaf fresh weight (40.2%), root fresh weigh (69.9%), plant fresh weight (42%), leaf number per plant (23.5%), root: leaves ratio (62.4%), root diameter (16.76%), and yield (47.7%). This treatment was preponderated that of 30 $mgL^{-1}$ in leaf fresh weight (45.5%), plant fresh weight (53%), leaf number per plant (23.2%) and yield (20.4%). Iron treatment (30 $mgL^{-1}$) was less effective than (40 $mgL^{-1}$), as it significantly passed the control check in root fresh weight (13.9%), plant height (21.2%), and yield (8.9%). It also exceeded (20 $mgL^{-1}$) in root fresh weight (13.1%), and yield (22.64%) . Moreover, it was paramount over (40 $mgL^{-1}$) in term of plant dry weight (8.2%). The worst treatments were the untreated and (20 $mgL^{-1}$) iron treatments, particular the latter treatment which highly reduced the yield by (12.6%) when compared to check. Subsequently, iron treatments can be put in the following order (40 $mgL^{-1}$> 30 $mgL^{-1}$> control > 20 $mgL^{-1}$).

Regression analysis manifested that radish root fresh weight, plant fresh weight, root: leaves ratio, root diameter and yield were linearly responded to iron rates and could be estimated by the following equations: Root fresh weight (g) = [169.973 + 3.058 (iron rate)]; plant fresh weight (g) = [330.824 + 2.66758 (iron rate)]; root: leaves ratio = [1.6309 + 0.0210129 (iron rate)]; root diameter (cm) = [6.72989 + 0.0243057(iron rate)] and yield ($kg.m^{-2}$) = [30.0176 + 0.30044 (iron rate)]. Whereas, quadratic regression type were preponderated the responses of leaf fresh weights per plant, leaves number per plant and plant height which could be predicted from the following equations: leaf fresh weight per plant (g) = [139.589 – 2.52287 (iron rate) + 0.0923 (iron rate)$^{**2}$]; leaves per plant = [9.62053 – 0.102153 (iron rate) + 0.0036651 (iron rate)$^{**2}$] and plant height (cm) = 52.6826 + 0.8609 (iron rate) – 0.0172401(iron rate)$^{**2}$ ].

Radish results (Table 3) displayed the positive role of iron on fresh weight of leaves roots as they improved by high level of chlorophylls which resulted in photosynthesis improvements, and subsequently assimilate surplus source for leaves roots to facilitate their development particularly during juvenility. 10 $mgL^{-1}$ iron Fe-EDDHA profoundly increased leaves fresh weight ($Kgm^{-2}$). However, a combination of 10 $mgL^{-1}$ iron, (20 $gm^{-2}$) urea and 50 $mgL^{-1}$ $GA_3$ was found to be the most potent treatment in improving the radish marketable yields, lowest rootless plants and well performed roots (Al-Hamadany and Abdel, 2008). Iron application on plants grown on alkaline Iraqi soil is very beneficial not for radish only but also for other plants, for instance growth and yield of onion were highly improved by iron foliar sprays (Abdel, 1991). The obtained results may also be attributed to the role of iron on chlorophyll synthesis, since iron is the co-enzyme of chlorophyllide synthesase (Goodwin and Mercer, 1985). Therefore, iron had been

**Table 4.** The influence of cultivation methods and IBA rates on growth and yield of nates carrot cultivar.

| | | ll | Lno/p | lfwt | ldmp | pfwt | rdia | xdia | arts | axts | apts | cyl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cult.** | **Furrow** | 28.6b | 5.1b | 6.1a | 15.9a | 28.5b | 2.0b | 0.53a | 3.2b | 0.24a | 3.0b | 0.73a |
| | Plot | 32.7a | 6.3a | 6.4a | 14.9a | 33.9a | 2.3a | 0.57a | 4.2a | 0.28a | 3.9a | 0.69a |
| IBA | 0 | 25.5b | 6.3a | 6.2a | 15.7a | 30.2a | 2.2b | 0.55ab | 3.8ab | 0.26ab | 3.6b | 0.62a |
| rates | 20 | 30.4a | 6.2a | 6.1a | 15.8a | 30.8a | 2.0c | 0.64a | 3.2b | 0.34a | 2.9c | 0.79a |
| $mgL^{-1}$ | 30 | 33.0a | 5.4a | 7.1a | 15.3a | 31.9a | 2.1bc | 0.45b | 3.2b | 0.17b | 3.0bc | 0.77a |
| | 40 | 33.8a | 5.6a | 7.3a | 14.9a | 33.9a | 2.4a | 0.56ab | 4.5a | 0.26ab | 4.3a | 0.66a |

| | | ppa | pxa | pur | fwur | rl | rfwt | rdmp | rlr | rtss | Yfr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cult.** | **Furrow** | 92.6a | 7.5a | 27.1a | 2.0b | 10.0a | 22.4b | 11.3a | 3.9a | 8.7a | 8.7b |
| | Plot | 93.3a | 6.7a | 16.2b | 5.4a | 10.3a | 27.6a | 10.9a | 5.5a | 8.1a | 11.8a |
| IBA | 0 | 93.4a | 6.6b | 18.9a | 8.0a | 10.4a | 23.9a | 11.1a | 4.7ab | 8.7a | 10.1a |
| rates | 20 | 89.6b | 10.4a | 22.7a | 2.3b | 10.3a | 24.7a | 11.3a | 6.4a | 7.9a | 9.7a |
| $mgL^{-1}$ | 30 | 94.6a | 5.5b | 24.4a | 1.8b | 10.3a | 24.8a | 11.2a | 3.5b | 8.7a | 10.1a |
| | 40 | 94.2a | 5.8b | 20.7a | 2.6b | 9.8a | 26.6a | 10.7a | 4.3ab | 8.1a | 10.9a |

used as a remedy for leaf chorosis. Iron chlorosis in many crops can be minimized by selecting iron efficient varieties and Iron chlorosis can be corrected by soil application of iron cheater but the larger amount required makes the practice uneconomical for most crops (Minnesota, 2004). Symptoms of iron deficiency resulted in a marked decrease in dry matter accumulation, iron and chlorophyll contents. This effect was clearly due to the use by Fe-deficient plant of the endogenous iron bound to the humic fraction. They also found that, dry matter accumulation appeared to be greater than that expected on the basis of soluble iron supplied (Pinton et al., 1999).

Response of Nates carrot to cultivation methods results (Table 4) displayed that plot cultivation method was superior over furrow cultivation, as it profoundly exceeded furrow cultivation in reference to leaves length (14%), leaf numbers per plant (24%), plant fresh weight (19%), and diameter of the root cross section at root top (15%), area of root transfer section at root top (31%), area of phloem (31%), fresh weight of unmarketable root (170%), fresh weigh of individual marketable root (22%). In addition to that it substantially reduced percentage of unmarketable root (67%). These results are in agreement with those obtained by El-Saberi (2005). Superiority of plot cultivation on furrow might be referred to the higher competition among plants over light and nutrition under furrow cultivation. Since furrow cultivation contained two upper rows and two lower rows in which the lower rows were shaded by the upper two rows in the same furrow and thus poor plant statures were observed. Close results were also stated on letuce (Abdel, 2005). These results are also in accordance with those obtained by (Abdel and Al-Saberi, 2009) which were attributed to the higher final number of rooting plants under plot cultivation. The contrasting yield density relationships between carrots and other crops is a consequence of their adaptation to a reduction in the photosynthetic photon flux density. They found that at low photosynthetic photon flux density values, carrots maintain their leaf area, but not their shoot dry weight, so that their storage root growth is not severely reduced by low photosynthetic photon flux density value (Hole and Dreaman, 1993).

Response of Nates carrot cultivar to IBA foliar sprays (Table 4) manifested that 40 $mgL^{-1}$ was the overwhelming IBA rate as compared to other rates. It profoundly surpassed the untreated check in terms of leaf length (32.6%), root diameter (9.1%) and area of phloem transfer section of root (19.4%) . Moreover it exceeded that of 30 $mgL^{-1}$ in phloem area percentage (5%), root diameter (14.3%) and area of phloem transfer section of root (43.3%). This treatment was superior over 20 $mgL^{-1}$ in root diameter (20%) and phloem transfer section of root (48.3%). 30 $mgL^{-1}$IBA rate came next in the importance order. This rate was

**Table 4a.** The influence of cultivation and IBA rate interaction on growth and yield of nates carrot cultivar.

| | | | ph | Lno/p | lfwt | ldmp | pfwt | rdia | xdia | arts | axts | apts | cyl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Furrow | IBA rates $mgL^{-1}$ | 0 | 29.4b | 5.6bc | 6.4b | 16.0a | 28.3bc | 21.1bc | 0.5ab | 3.7b | 0.23ab | 3.4bc | 0.64ab |
| | | 20 | 27.4bc | 6.1ab | 5.4b | 16.3a | 24.4c | 1.9c | 0.59ab | 2.9b | 0.29ab | 2.63c | 0.74ab |
| | | 30 | 29.6b | 5.3bc | 7.0b | 15.3a | 30.5b | 2.1bc | 0.53ab | 3.0b | 0.23ab | 2.73bc | 0.76ab |
| | | 40 | 28. 1b | 4.7c | 5.5b | 16. 1a | 30. 7b | 2.1bc | 0.51ab | 3.3b | 0.21ab | 3.1bc | 0.8a |
| Plot | IBA rates $mgL^{-1}$ | 0 | 21.5c | 7.0a | 6.1b | 15.3a | 32.1ab | 2.3b | 0.6ab | 4.0b | 0.29ab | 3.7b | 0.61ab |
| | | 20 | 33.4ab | 6.3ab | 2.9c | 15.4a | 33.2ab | 2.1bc | 0.7a | 3.5b | 0.4a | 3.1bc | 0.84a |
| | | 30 | 36.5a | 5.6bc | 7.3ab | 15.3a | 33.4ab | 2.1bc | 0.37b | 3.4b | 0.11b | 3.3bc | 0.79a |
| | | 40 | 39.4a | 6.4ab | 9.2a | 13.8a | 37.0a | 2.7a | 0.6ab | 5.8a | 0.32ab | 5.5a | 0.52b |

| | | | ppa | pxa | pur | fwur | rl | rfwt | rdmp | rlr | rtss | yfr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Furrow | IBA rates $mgL^{-1}$ | **0** | 94.2abc | 5.8abc | 24.5ab | 1.6b | 10.1a | 21.8cd | 11.4a | 3.5b | 9.9a | 8.5cd |
| | | 20 | 90.2bc | 9.8ab | 24.1ab | 2.4b | 9.7a | 19.0d | 11.3a | 3.5b | 8.5ab | 7.2d |
| | | 30 | 92.4abc | 7.6abc | 29.8a | 1.9b | 10.6a | 23.5bd | 11.5a | 3.4b | 8.1ab | 9.4bcd |
| | | 40 | 93.5abc | 6.6abc | 30. 0a | 2.2b | 9.9a | 25.3bc | 11. 0a | 5.4b | 8.1ab | 9.2bcd |
| Plot | IBA rates $mgL^{-1}$ | 0 | 92.6abc | 7.5abc | 13.3b | 4.5a | 10.9a | 26.1abc | 10.8a | 9.3a | 7.5b | 11.6ab |
| | | 20 | 89.0c | 11.0a | 21.2ab | 2.2b | 10.8a | 30.3a | 11.2a | 3.6b | 7.3b | 12.2a |
| | | 30 | 96.7a | 3.4c | 18.9ab | 1.8b | 10.0a | 26.1abc | 11.0a | 3.6b | 9.4ab | 10.8abc |
| | | 40 | 95.0ab | 5.0bc | 11.5b | 3.1b | 9.7a | 27.8ab | 10.5a | 3.2b | 8.1ab | 12.6a |

*Leaves length (cm) = ll; number of leaves per plant = lno/p; leaf fresh weight per plant (g) = lfwt; leaf dry matter (%) =ldmp; plant fresh weight(g) = pfwt; root diameter (cm) = rdia; xylem diameter (cm) = xdia; area of root transfer section($cm^2$) = arts; area of xylem transfer section ($cm^2$) = axts; area of phloem transfer section ($cm^2$) = apts; percentage of ploem area (%) = ppa; percentage of xylem area (%) =pxa; percentage of unmarketable root(%) = pur; fresh weight of unmarketable root (g) = fwur; root length (cm) = rl; root fresh weight (g) = rfwt; root dry matter (%) = rdmp; root : leaf ratio = rlr; total soluble solids of root (%) = rtss; yield of fresh roots ($kg.m^{-2}$) = yfr.; cylindricality of root = cyl. ** Figures of unshared character area significant, 0.05 level Duncan's test.

paramount over untreated and 20 $mgL^{-1}$ rate in leaf length (32.6%) and phloem area percentage (5.1), respectively. However, 20 $mgL^{-1}$ IBA rate was the worst as it exhibited the highest xylem area of root transfer section and xylem area percentage. Finally it is worthy to mention that the highest unmarketable yield was confined to untreated treatment. Regression analysis revealed that leaves length, leaves number per plant, leaves fresh weight per plant, dry matter percentage of leaves, plant fresh weight, fresh weight of unmarketable root, root length, root fresh weight and root total soluble solids were linearly responded to IBA rates. The above traits could be estimated by the following equations: leaves length (cm) = [22.7766 + 0.216697(IBA rate)]; leaves number per plant = [6.39229 – 0.0267821(IBA rate)]; leaves fresh weight per plant (g) = [5.96179 + 0.0310179(IBA rate)]; dry matter percentage of leaves = [15.9371 – 0.0194286(IBA rate)]; plant fresh weight (g) = [29.0773 + 0.0930929(IBA rate)]; fresh weigh of unmarketable root (g) = [6.96225 – 0.145225(IBA rate)]; root length (cm) = [10.4939 – 0.0136714(IBA rate)]; root fresh weigh (g) = [23.6792 + 0.0577571(IBA rate)]; TSS (%) = [8.7632 –0.0111429(IBA rate)]. Whereas, root diameter, root cross section area, phloem cross section of root, percentage of unmarketable root, root dry matter percentage, root cylindricality, and marketable yield were quadratically responded to IBA rates and their values could be predicted from the following equations: root diameter (cm) = [2.1963 – 0.0289648(IBA rate) + 0.0008256 (IBA rate)$^{**2}$]; cross section area of root (cm$^{2}$) = [3.84368 – 0.0985216 (IBA rate) + 0.0028335(IBA rate)$^{**2}$]; phloem area (cm$^{2}$) = [3.57963 – 0.0917438(IBA rate) + 0.0026719 (IBA rate)$^{**2}$]; percentage of unmarketable root = [18.7608 + 0.41661 (IBA rate) – 0.0089196 (IBA rate)$^{**2}$]; dry matter percentage of root = [11.1024 + 0.0451307 (IBA rate) – 0.0013608 (IBA rate)$^{**2}$]; root cylindricality (%) = [0.62025 + 0.0161(IBA rate) – 0.000375 (IBA rate)$^{**2}$] and yield (kg.m$^{-2}$) = [10.0482 – 0.0558358 (IBA rate) + 0.0019168 (IBA rate)$^{**2}$]. Other parameters like xylem diameter, area of xylem cross section, root phloem area, root xylem area, and root:leaves ratio displayed cubic regression type of relation to IBA rates, and they could be forecasted with the below equations: xylem diameter (cm) = [0.55 + 0.565938(IBA rate) – 0.0037797 (IBA rate)$^{**2}$ + 0.0000592 (IBA rate)$^{**3}$]; cross section area of xylem (cm$^{-2}$) = [0.26 + 0.0489979 (IBA rate) – 0.0032647(IBA rate)$^{**2}$ + 0.0000511(IBA rate)$^{**3}$]; phloem area percentage = [93.3588 - 1.38088 (IBA rate) + 0.0842203 (IBA rate)$^{**2}$ – 0.0012284 (IBA rate)$^{**3}$]; xylem area percentage = [6.6375 + 1.37759 (IBA rate) – 0.0839547 (IBA rate)$^{**2}$ + 0.0012242 (IBA rate)$^{**3}$]; root: leaves ratio = [3.8625 + 1.15167 (IBA rate) – 0.0690938 (IBA rate)$^{**2}$ + 0.0010115 (IBA rate)$^{**3}$]. Very close results were obtained by Abdel (2007b) and Abdel and Al-Saberi (2009), they referred their results to the role of auxin on storage root performance, assimilate portioning, and cell expansions. Growth regulators have large effect on the distribution of dry matter between the shoots and storage organs, suggesting that endogenous hormones control dry matter partitioning (McKee and Morris, 1986). Yang et al. (1993) assumed that auxin is essential for cell enlargement and growth of the leaves, flowers and other organs as well as stem.

Plot grown **c**arrot sprayed with IBA rate of 40 mgL$^{-1}$ appeared to be the paramount interaction treatment, as compared to other (Table 4a). Since it gave the highest leaves length (39.4 cm), plant fresh weigh (37 g), root diameter (2.7 cm), area of root cross section at root crown (5.8 cm$^{2}$), area of root phloem (5.5 cm$^{2}$) and yield of fresh roots (12.6 kgm$^{-2}$). These results might be interpreted on the basis of the role of IBA and IAA in conducting tissue performance, metabolic enzymes. Abdel (2007) found that IBA treated radish resulted in substantial marketable yield improvement which was attributed to the role of IBA in assimilate transductions and to its role in the cell wall expansion, since IBA acting as an auxin or auxin precursor (Estelle, 1998). IAA production and transport could explain the venation pattern and the vascular hypertrophy caused by IAA transport inhibition outside IAA source for the shoot apical meristem supports the notion that IAA transport and procambium differentiation dictate phyllotaxy and organogenesis (Avsain-Kretchmer et al., 2002).

Finally, the results highly recommended the use of Black Radish cultivar for fall-winter growing season where cool environment preponderance owing to its substantial resistances to both chilling and pith tissue deterioration (Root Pithiness), as compared to previous studies on Red Radish which showed vulnerability to root pithiness as soon as been exposed to winter cool weather (Table 2). Moreover, results also advice Iraqi growers to adopt Nates carrot cultivar due to its root test and shape which attract Iraqi consumers. Results also exhibited the possibility of growing these cultivars under rainfed in years of 400 mm or higher rain incidences in Dohuk, Iraq.

## REFERENCES


Abdel CG (1991). Effect of iron and boron application on bulb productions of two cultivars of onion (*Allium cepa* L.). Mesopotamia J. Agric., 23(4): 19-22.

Abdel CG (2005). Water relation in lettuce (*Lactuca ativa* L. var longifolia). Mesopotamia. J. of Agric., 33(4): 2-16.

Abdel CG (2007). Production of irrigated radish (*Raphanus sativus* L.): The influence of Indole-3-butyric acid (IBA) on growth and yield of furrow cultivated Local Black radish cultivar. J. Dohuk Univ., 10(2): 1-9.

Abdel CG (2007a). Production of irrigated radish (*Raphanus sativus* L.): The influence of gibberellic acid ($GA_3$) on growth and yield of Local Black radish cultivar grown under plot and furrow cultivation methods. J. Dohuk Univ., 10(2): 40-49.

Abdel CG (20087b). Improving the production of well irrigated carrots (*Daucus carrota* L. var sativus cv Nates) grown under plot and furrow cultivations by: Naphthalene acetic acid (NAA) application. J. Dohuk Univ., 10(2): 49-65.

Abdel CG (2008). Production of well irrigated radish (*Raphanus sativus* L.): The influence of Indole-3-butyric acid (IBA) on growth and yield quality of red radish. J. Tikrit Univ. Agric. Sci., 8(1): 322-330.

Abdel CG, Al-Saberi MR (2009). Improving the production of well irrigated carrots (*Daucus carrota* L. var sativus cv Nates) grown under plot and furrow cultivations by: Gibberellic acid ($GA_3$) application. Euphrates J. of Agric. Sci., 1(2): 1-13.

Al-Hamadany SYH, Abdel CG (2008). Improving radish yield by the application nitrogen fertilizer. J. of Tikrit Univ. for Agric. Sci., 8(2): 360-370.

Al-Saberi MR (2005). Effect of some cultural practices on lettuce (*Lactuca sativa* L.) growth and yield. MSc Thesis, Horticulture Dept. Agriculture and Forestry College, Mosul University, Mosul, Iraq.

Avsain-Kretchmer O, Cheng JC, Chen L, Moctezuma E, Ro-Sung Z (2002). Indole acetic acid distribution pattern during Arabidopsis leaf antogeny. Plant Physiol., 130: 199-209.

Bleasdale JKA, RThompson (1963). An objective method of recording and comparing the shapes of carrots roots. J. Hortic. Sci., 38: 232-241.

de Klerk JM, Wvd K, Tong Jcd (1999). Formation of adventitious root: New concept, new possibilities. Chem., 270: 19093-19099.

Estelle M (1998). Polar auxin transport: A new support for an old model. Plant Cell, 10: 11777.

Goodwin TW, Mercer EI (1985). Introduction To Plant Biochemistry. Second Ed. PERGAMON PRESS.

Hole CC, Dreaman J (1993).The effect of photon flux density on distribution of assimilate between shoot and storage root of carrot, red beet and radish. Sci. Horticult., 55: 213-225.

Hole CC, RA Sutherland (1990). The effect of photo flux density and duration of photosynthetic period on growth and dry matter

distribution in carrot. Ann. Bot., 65: 63-69.
Hopkins WG (1999). Introduction To Plant Physiology. Second Ed. John Wiley & Sons, IMC. New York, p. 310-365.
McGarry A (1995). Cellular basis of tissue toughness in carrot (*Daucus carota* L.) storage roots. Ann. Bot., 75: 157-163.
McKee JMT, Morris GEL (1986). Effect of gibberellic acid and chloromequat chloride on the proportion of phloem and xylem parenchyma in the storage root of carrot (*Daucus carota* L.). Plant Growth Regulation, 4, 203-211.
Mills HA (2001). Vegetable Crops. January 2000 Revised 2001. File://G:\ Vegetables.htm.
Minnesota, (2004). Nutritional management for commertial fruit and vegetable crops in Minnesota. Websilt:http:// Soil test coafes.
Peirce LC (1987). Vegetables: Characteristics, Producing and Marketing. John Wiely and Sons Pub. New York, p. 263.
Pinton R, Cesco S, Santi S, Agnolon F, Varanini Z (1999). Water extractable humic substance enhance iron deficiency responses by Fe-deficient cucumber plants. Plant and Soil, 210: 145-157.
Poincelot R P (2004). Sustainable Horticulture: Today and Tomorrow. 1-Pub Printice Hall, p. 728.
Yucel S (1992). Relationships between sugar beet yield and quality and climatic factors in Turkey. International Institute for Sugar Beet Research, 55th Winter Congress. International Institute for Sugar Beet Research Brussels, Belgium, pp. 223-238.
Yang T, Law DM, Davies PJ (1993). Magnitude and kinetics of stem elongation induced by exogenous indole-3-acetic acid in intact light-grown pea seedlings. Plant Physiol., 102: 717-724.