Abstract
Fertilizers application plays a pivotal role in the production of vegetables and fruits. Too low or high fertilizers levels can reduce the growth and development process of plants which may affect the crop yield. To investigate the fact, a field experiment was carried out to check the growth and yield of radish on a sandy soil, under desert climatic conditions by using drip irrigation system. The field work was carried out on a randomized complete block design (RCBD) having nine different rates of water soluble NPK\textsubscript{(20-20-20)} fertilizer, i.e. (\(T_1\) = control, \(T_2\) = 0.25, \(T_3\) = 0.50, \(T_4\) = 0.75, \(T_5\) = 1.00, \(T_6\) = 1.25, \(T_7\) = 1.50, \(T_8\) = 1.75, and \(T_9\) = 2.00) grams plant\(^{-1}\) fertilization \(^{-1}\) respectively. The results revealed that NPK\textsubscript{(20-20-20)} fertilizers with different rates brought a positive effect in radish cultivation. Amongst all the treatments, \(T_6\) was observed to be more suitable and economical dose as it took the tallest radish plants (38.83 cm), highest number of leaves (20.74), highest leaves weight (260.12 g), highest root length (32.62 cm), maximum root diameter (11.06 cm), highest root weight (198.80 g), maximum total biomass (458.91 g) and maximum root yield (76.23 t/ha) respectively. However, control plots showed inadequate results regarding all the parameters. The application of NPK\textsubscript{(20-20-20)} \((T_6 = 1.25\text{ grams plant}^{-1}\text{ fertilization}^{-1})\) was found suitable for the best possible growth and yield of radish under desert conditions. Application of fertilizers beyond this level seems to be an un-economical and wasteful practice.

Keywords: Radish, Fertigation, NPK Fertilizers, Drip Irrigation, Desert, Agriculture, UAE.

INTRODUCTION

Radish (\textit{Raphanus sativus} L.) is an enormous vegetable to add your salad for a bit of colour and spice. Radish contains alkaline elements which help to digest food and cures constipation, beneficial for stomach pain due to gas, and to get rid of intestinal worms (El-Desuki \textit{et al}., 2005). Radishes are very much demanding throughout the year due to their health benefits, therefore its proper cultivation is essential in order to maintain the quality and fulfill the demand respectively. Cultivation involves several activities undertaken by farmers over a period of time. These activities or tasks are referred to as agricultural practices (Arshad, 2015b). Cultivation of radish involves; preparation of soil, sowing, adding manure and fertilizers, irrigation, protecting from weeds, harvesting and storage etc. The preparation of soil is the first step before growing radish. One of the most important tasks in agriculture is to turn the soil and loosen it. This allows the roots to penetrate deep into the soil. The process of losing and turning the soil is called tilling or ploughing (Arshad, 2015c).

Sowing is the most important part of radish production. Before sowing good quality seeds with high germination percentage should be selected (Kashem, \textit{et al}., 2009). An appropriate distance between the seeds is important to avoid overcrowding of plants. This allows plants to get sufficient sunlight, nutrients and water from the soil. Addition of on time application of fertilizers to the soil is very much essential for the growth of plants (Arshad, 2015a). Too less or excessive dosage of fertilizers may negatively affect the quality parameters of radish. Generally, farmer’s community uses inorganic fertilizers to gain more radish yield. Nitrogen improves the absorption & respiration process in plant and activates vegetation (Usman \textit{et al}., 2000). Radish plants with more leaves can give more root yield as compared to the plants having less leaves. Nitrogen is the main component of protein & chlorophyll. Deficiency of nitrogen turns the leaves yellowish, and results in low crop production. For the case of Radish production the phosphorus and potassium is required during the sowing time for sprouting of seeds, early maturation, transportation of photosynthesis products, and to increase the root size and diameter respectively (Djurovka \textit{et al}., 1997).
Water is important for the proper growth and development of root and leaves. Water is essential because germination of seeds doesn’t take place under dry conditions (Jawad et al., 2015). Nutrients dissolved in water get transported to each part of the plant. To maintain the moisture of the soil for healthy growth of radish, field have to be irrigated regularly as less water under hot climate makes the radish tough and bitter in taste. The frequency of irrigation varies from soil to soil, and season to season. In desert agriculture where water availability is poor, farmers are using drip irrigation system to irrigate their crops (Arshad et al., 2014b). In this system, the water falls drop by drop just at the position of the roots. In field many other undesirable plants may grow naturally along with the radish. Tilling before sowing of the radish helps in uprooting and killing of weeds (Pandey, et al., 1996). The picking of a radish after it is mature is called harvesting. In harvesting, radish is pulled out from the soil surface which usually takes 30-40 days depending upon the variety (Balouch et al., 2014). The present research work was conducted to evaluate the effect of different levels of NPK\(_{(20-20-20)}\) fertilizer on the growth and production parameters of radish.

**MATERIALS AND METHODS**

**Location**

The research work was carried out at a private farmhouse, in Liwa, Western Region of Abu Dhabi, UAE, in January 2016. The soil of the farmhouse was sandy in nature, with hydraulic conductivity (1.051 x 10\(^{-4}\) m/sec), bulk density (1.4 g/cm\(^3\)), and porosity (0.43) respectively. In order to increase the moisture holding capacity within the soil, poultry manure was mixed with sand and irrigation was done through drip irrigation system respectively.

**Field Experiment**

The present research was carried out on a randomized complete block design (RCBD) having nine different rates of water soluble NPK\(_{(20-20-20)}\) fertilizer, i.e. (T\(_1\) = control, T\(_2\) = 0.25, T\(_3\) = 0.50, T\(_4\) = 0.75, T\(_5\) = 1.00, T\(_6\) = 1.25, T\(_7\) = 1.50, T\(_8\) = 1.75, and T\(_9\) = 2.00) grams plant\(^{-1}\) fertigation\(^{3}\) respectively. Initially the seed bed was prepared by using traditional hoes and drip irrigation lines were installed for the irrigation purpose accordingly (Arshad et al., 2014a). Small holes were dig adjacent to the emitters and 10 gram poultry mixture with sand along with equal amount NPK\(_{(12-12-17)}\) was mixed and filled in to the holes and pre-irrigated accordingly. The plant to plant distance was kept 6cm and distance among lateral was kept 30cm respectively (Balouch et al., 2014). Radish variety (Mino Early White) was used in this research and which was sown at rate of 3 kg per acre in January 05, 2016.

The NPK\(_{(20-20-20)}\) fertilizer was applied to all the subplots throughout the research period on every alternate day and to maintain the moisture within the soil, water applied to the soil twice a day i.e. during morning and evening hours (Pamwar et al., 2000). Furthermore, to maintain the root quality and early ripening calcium and manganese fertilizers are also applied in equal amount to all sub-plots on weekly basis. The first harvesting was done after 37 days from sowing date. Irrigation prior to picking was done to reducing root damage (Arshad et al., 2015). In order to identify the best treatment ten plants from each of the treatments were tagged and data were recorded after harvesting. The agronomic parameters for the growth and yield characters studied were plant height (cm), number of leaves per plant, weight of leaves per plant, root length (cm), root diameter (cm), root weight plant 1 (g), total biomass (g), and root yield (tons / ha). Finally all the data analysis and statistical analysis were done through ANOVA procedure accordingly.

**RESULTS AND DISCUSSION**

A study was initiated to check the effects of different rates of water soluble NPK\(_{(20-20-20)}\) fertilizer on the growth and yield of radish under sandy soil and desert climatic conditions. The subject study revealed that radish plant height, number of leaves, weight of leaves, root length, root diameter, root weight, total biomass, and root yield differed very significantly (P<0.05) between applications of different rates of water soluble NPK\(_{(20-20-20)}\) fertilizer as mentioned in Table 1. The critical gathered observations and data for the above discussed parameters during the present study are appended below:

- **Plant Height**

  Statistically remarkable results were observed for plant height for all treatments as shown in Table 1. The maximum plant height (38.83 cm) was recorded for the treatment T\(_6\) followed by T\(_5\) (37.19 cm) respectively. While the minimum plant height (26.91 cm) was recorded for the treatment T\(_1\) i.e. in control plot respectively. As plant height is an initial sign of vegetative growth therefore, on time and required application of NPK\(_{(20-20-20)}\) fertilizer increases the soil fertility which results in healthy crop. Due to proper application of fertigation during root developing period the plants attain maximum height. While, minimum plant height was observed due to the unavailability of required amount of NPK\(_{(20-20-20)}\) fertilizer, required by the plants during growth and development stages. These results are in agreement with (Jawad et al., 2015; Arshad et al., 2014c), who concluded that by increasing the rates of NPK fertilizer, the height of plant can also be increased for radish and capsicum green bell.

- **Number of Leaves**

  Statistically significant results were observed for number of leaves per plant for all treatments (Table 01). The maximum number of leaves per plant was observed for the treatment T\(_6\) (20.74) followed by T\(_5\) (20.13) and T\(_7\) (19.93) respectively. Once again the minimum number of leaves was observed for the treatment T\(_1\) (control) with (14.49) leaves per plant. The radish is a quick growing vegetable and requires appropriate amount of NPK fertilizers for its growth
especially when grown under desert condition where essential nutrients within the soil are very low for its growth and development. The plants attain maximum number of leaves may be due to the appropriate application of adequate amount of NPK\textsubscript{(20-20-20)} fertilizer, which produce healthy leaves for plant and results in enhancing the vegetative growth of plant respectively. While minimum numbers of leaves were observed in plants due to unavailability of essential nutrients, for the production of healthy leaves. The results were supported by the findings of (Jilani et al., 2010; Arshad et al., 2016), who concluded that number of leaves per plant can be increased with the application of appropriate amount of fertilizers needed by plants during its growth and development period.

Leaves weight

The maximum leaves weight per plant (260.12 gm) was observed for T\textsubscript{6}, followed by T\textsubscript{5} (258.70 gm) and T\textsubscript{7} (256.11 gm) whereas, minimum leaves weight per plant (143.68 gm) was observed in case of T\textsubscript{1}, while, remaining treatments showed intermediate leaves weight (Table 1). The presence of sufficient amount of NPK\textsubscript{(20-20-20)} fertilizer, enhanced the soil fertility level and improves the plant growth, due to which the plants ultimately produce healthy leaves which increased the weight of the leaves per plant. The results are in agreement with the findings of (Parvez et al., 2003) who concluded that leaves weights increased by increasing the rates of NPK fertilizers in radish respectively.

Root Length

During the research study it had been observed that different rates of water soluble NPK\textsubscript{(20-20-20)} fertilizers, significantly affected the root length of radish. The maximum root length (32.62 cm) was obtained by treatment T\textsubscript{6}, while the minimum root length (20.26 cm) was observed in T\textsubscript{1} i.e. control plots. The increase in root length is mainly depends on the environmental and agronomic factors, therefore the plants having more number of leaves have generally more root length. Likewise soil condition and texture also plays a critical role in enhancing the root length. Similar results were observed by (Bilekudari, et al., 2005; Arshad et al., 2015) who reported that root length of radish and carrot was found more in those plants which produced more number of leaves.

Root Diameter

Statistically significant results were observed for root diameter with maximum (11.06 cm) and minimum (8.30 cm) for treatment T\textsubscript{6} and in control (no fertilizer) respectively. These results showed that the root growth was increased with the increase in fertilizer dosage during growth period of the plant. However, over fertigation i.e. excessive fertilizers application starts decreasing the root length which is ultimately a non-economical and wasteful practice. These results are in agreement with (Arshad et al., 2015; Asghar et al., 2006) for carrot and radish, who observed that the root diameter increased with the increased in NPK fertilizers, however, it starts decreasing when the fertilizers treatment applied beyond its desired level.

Table 1. Effect of Different Rates of Water Soluble NPK\textsubscript{(20-20-20)} Fertilizer on Different Statistical Agronomic Parameters of Radish

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant Height (cm)</th>
<th>No. of Leaves per Plant</th>
<th>Leaves Weight per Plant (g)</th>
<th>Root Length per Plant (cm)</th>
<th>Root Diameter per Plant (cm)</th>
<th>Root Weight per Plant (g)</th>
<th>Total Biomass per Plant (g)</th>
<th>Root Yield t / ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>T\textsubscript{1} (Control)</td>
<td>26.91c</td>
<td>14.49c</td>
<td>143.68e</td>
<td>20.26e</td>
<td>8.30c</td>
<td>117.12f</td>
<td>260.79f</td>
<td>37.88c</td>
</tr>
<tr>
<td>T\textsubscript{2}</td>
<td>31.66bc</td>
<td>17.05bc</td>
<td>169.03de</td>
<td>23.84d</td>
<td>9.77b</td>
<td>137.78e</td>
<td>306.82e</td>
<td>44.57b</td>
</tr>
<tr>
<td>T\textsubscript{3}</td>
<td>34.04b</td>
<td>18.33b</td>
<td>181.76d</td>
<td>25.63c</td>
<td>10.50a</td>
<td>148.16d</td>
<td>329.91de</td>
<td>47.92ab</td>
</tr>
<tr>
<td>T\textsubscript{4}</td>
<td>36.54a</td>
<td>19.07a</td>
<td>208.43bc</td>
<td>27.00c</td>
<td>10.59a</td>
<td>166.02bc</td>
<td>374.44cd</td>
<td>56.81a</td>
</tr>
<tr>
<td>T\textsubscript{5}</td>
<td>37.19a</td>
<td>20.13a</td>
<td>258.70a</td>
<td>27.48b</td>
<td>10.85a</td>
<td>175.30b</td>
<td>434.00bc</td>
<td>67.20a</td>
</tr>
<tr>
<td>T\textsubscript{6}</td>
<td>38.83a</td>
<td>20.74a</td>
<td>260.12a</td>
<td>32.62a</td>
<td>11.06a</td>
<td>198.80a</td>
<td>458.91a</td>
<td>76.23a</td>
</tr>
<tr>
<td>T\textsubscript{7}</td>
<td>36.91a</td>
<td>19.93a</td>
<td>256.11a</td>
<td>27.20b</td>
<td>10.74a</td>
<td>173.54b</td>
<td>429.66bc</td>
<td>66.53a</td>
</tr>
<tr>
<td>T\textsubscript{8}</td>
<td>36.08a</td>
<td>18.72ab</td>
<td>240.59b</td>
<td>25.56cd</td>
<td>10.09a</td>
<td>163.03c</td>
<td>403.62c</td>
<td>62.50a</td>
</tr>
<tr>
<td>T\textsubscript{9}</td>
<td>34.32ab</td>
<td>18.69a</td>
<td>204.26c</td>
<td>26.46bc</td>
<td>10.38a</td>
<td>162.70c</td>
<td>366.95d</td>
<td>55.67a</td>
</tr>
<tr>
<td>LSD (P&lt;0.05)</td>
<td>3.86</td>
<td>2.03</td>
<td>7.87</td>
<td>2.91</td>
<td>1.14</td>
<td>6.52</td>
<td>6.88</td>
<td>23.50</td>
</tr>
</tbody>
</table>

* Means followed by different letter shows significant result at 5% level of significance.
Root Weight
During the research study it had been observed that different rates of water soluble NPK\textsubscript{(20-20-20)} fertilizers, significantly affected the root weight of radish. The maximum root weight per plant (198.80 g) was achieved in treatment T\textsubscript{6} which was statistically similar with treatment T\textsubscript{5} and T\textsubscript{7} respectively. The minimum root weight per plant (117.12 g) was recorded in treatment T\textsubscript{1} (control). The high root weight per plant in radish may be due to on time, balanced fertilizers application along with proper plant spacing which produced healthy leaves and help plants to increase its roots size. Similar results were obtained by (Balouch et al., 2014) who reported that root weight of radish increased remarkably with the increase in NPK fertilizers rates up to 150-75-100 kg / ha.

Total Biomass
Statistically considerable results were observed for total biomass per plant which is the sum of weight of root and leaves of radish respectively. Once again the maximum (458.91 g) and minimum (260.79 g) biomass was recorded in treatment T\textsubscript{6} and T\textsubscript{1} (control plot) respectively. The total biomass of a plant is a factor that is directly influenced by number of leaves, leaves length, weight of leaves, root length, root diameter and root weight per plant respectively. The plants having more number of leaves and root weight will produce more biomass accordingly. The present results supported by the findings of (Akoumianakis et al., 2011), who reported that in sandy soil, balanced level of fertilizers can improves the soil structure and allows the plant to grow more leaves with good root size to produce higher biomass per plant.

Root Yield
The observed data showed that root yield was significantly affected by different rates of water soluble NPK\textsubscript{(20-20-20)} fertilizers for radish. The maximum (76.23 tons / ha) root yield was achieved for treatment T\textsubscript{6} followed by the treatment T\textsubscript{5} and T\textsubscript{7} respectively. On the other hand, the minimum yield (37.88 tons / ha) was observed in treatment T\textsubscript{1} respectively. The root yield found high may be due balanced fertilizers level within the soil due to which soil fertility increased and supports the growth and root development of plants. Addition of sufficient amount of water soluble NPK\textsubscript{(20-20-20)} fertilizers improves the quantitative parameters of radish i.e. leaf and root weight which ultimately increased the yield. Similar results were obtained by (Arshad et al., 2015; Wachstum et al., 2002), who reported that balanced level of fertilizers can gave maximum carrot and radish root yield per hectare.

CONCLUSION
From the results obtained it could be concluded that the water soluble NPK\textsubscript{(20-20-20)} fertilizers with different rates brought a positive effect in radish cultivation under sandy soil conditions. Amongst all the treatments, T\textsubscript{6} was observed to be more suitable and economical dose as it took the tallest radish plants (38.83 cm), highest number of leaves (20.74), highest leaves weight (260.12 g), highest root length (32.62 cm), maximum root diameter (11.06 cm), highest root weight (198.80 g), maximum total biomass (458.91 g) and maximum root yield (76.23 t/ha) respectively. However, control plots showed inadequate results regarding all the parameters. Too low or high fertilizers levels may reduce the yield and yield parameters of radish. The application of NPK\textsubscript{(20-20-20)} (T\textsubscript{6} = 1.25 grams plant\textsuperscript{-1} fertigation\textsuperscript{-1}) were suitable for best possible growth and yield of radish under desert conditions. Application of fertilizers beyond this level seems to be an un-economical and wasteful practice. As an area under study was sandy; therefore these suggestions are applicable for only sandy soils while the results may vary for other types of soil.

ACKNOWLEDGEMENT
We are thankful to anonymous reviewers for their valuable suggestions to execute the experiment.

CONFLICT OF INTEREST
The authors declare that they don’t have any conflicts of interest and are also not interested in competing with anyone.

REFERENCES


