Effect of Rock Phosphate and Mycorrhiza on Vegetative Growth and Productivity of *Ricinus communis* var Red Arish under North Sinai Conditions

Wafaa H. Abd-Allah and Khater, Rania M.

Medicinal & Aromatic Plants Dept., Desert Research Center, Cairo, Egypt.

**ABSTRACT**

An experiment was carried out during the 2014-2015 seasons at East of El-Qantara-North Sinai Research Station, at Desert Research Center, North Sinai Governorate, to study the effect of rock phosphate and mycorrhiza on growth, yield and chemical composition of *Ricinus communis* var red arish under North Sinai conditions. The results revealed that applying 200 kg phosphate rock per fed. plus mycorrhiza increased higher seeds yield, highest oil percentage and oil yield in the first and second season significantly as compared with control. Determined fatty acid composition of the oil by using gas chromatography-mass spectrometry (GC-MS) showed that the ricinoleic acid was the major constituent of fatty acid after applying 150 kg phosphate rock plus mycorrhiza compared with other fatty acids, i.e., linoleic, oleic, stearic and palmitic.

**Key words:** Castor, Phosphate rock and mycorrhiza, Yield, and fatty acid

**Introduction**

There has been an increasing interest in medicinal plant researches owe to the organic richness and far less side (Kennedy et al, 2013). Castor bean (*Ricinus communis* L.) commonly called castor, is a strong perennial shrub belongs to family (Euphorbiaceae); it has been used in many parts of the world as a medicinal plant and oil consuming purposes (Scarpa and Geuric, 1982).

Castor plant found in South Africa, India, Brazil, and Russia. and even warm temperate regions of the world. The plant is native of India and cultivated throughout the country in gardens and fields and also grows wild in waste places (Eudmar et al., 2011). *Ricinus communis* is a small wooden tree which grows to about 2-4 meters in height and its leaves are about 15-45 cm long; long-stalked; palmate of 5-12 lobes with coarsely toothed segments with milky latex and very small typically greenish flowers. The plant is drought and pest resistant, and can be grown practically anywhere land is available. Many kinds are cultivated as ornamentals and some are of commercial importance. plants generally referred to as plants in which one or more of its parts contains essential phytochemicals that may be exploited for therapeutic purposes, or such that may be used as precursors in chemo pharmaceutical synthesis. The presence of these phytochemicals in plants have been found to be very beneficial to human systems as most food consumed by human often contain less quantity of these biomolecules. Moreover their consumption results in far less side effects when compared to pharmaceutical synthetic drugs. Plant phytochemicals are known to possess essential biological activities among which are antioxidant, antimicrobial, anti-inflammatory, antiviral, antifungal, antihelmintic, anticoagulant, anticarcinogenic, anti-asthmatic, anti-hypertensive, antiallergic, diuretic, and even shown to improved fertility (Salunke and Desai, 1992; Marjorie, 1996; Williamson et al., 2002; Jena and Gupta, 2012; Farombi, 2003; Ogunniyi, 2006; Islam et al., 2010; Rao et al., 2010 and Kensa and Syhed, 2011; Taur and Patil, 2011 and Salihu et al., 2014). The plant of commercial relevance since its oil is used for manufacturing surfactants, lubrication, and illumination. Coatings, greases, fungistats, pharmaceuticals, cosmetics (Reed, 1976). Oil used externally for dermatitis and eye ailments, (Alfred Thomas, 2005). Also in the medical field, blood filters, can be made from Castor bean oil, and internal and external body pumps and bone prostheses can be made of Castor bean resin, a lighter material than platinum with no observed rejection problem. Ricinoleic acid has served in contraceptive jellies. Ricin toxic protein in the seeds, act as a blood coagulant. Castor oil pomace, the residue after crushing, is used as a high-nitrogen fertilizer. The oil is also used in the car and construction industries. The average yield of castor is very low because of inferior fertility
status of soil and fertilizer management. There is no systematic information available on nutritional requirements of castor grown under Sinai condition. Moreover, soils from these areas are generally characterized by poor soil structure, lack of organic matter, low water-holding capacity, and nutrient deficiency. Phosphorus deficiency is one of the most widespread mineral nutrient stresses limiting crop production in the world (Sanchez and Salinas, 1981; Holford, 1997). Phosphorus is the essential nutrient required for the plant growth and is found in many soils in organic and complex inorganic forms. Due to its slow solubility and mobility, plants can not readily utilize P in an organic or complex inorganic form (Schachtman et al., 1998).

Inorganic phosphate present in soluble forms in the soil can be readily utilized by plants but in limited amounts. The enzyme phosphatase produced by mycorrhizal extra radial hyphae hydrolyses and releases P from organic complexes and facilitates the absorption of P and other nutrients thereby creating a depletion zone around the roots (Toro et al., 1997; Jackobson et al., 1992). These depletion zones give mycorrhizal plants a great advantage because of the ability of mycorrhizal to extend past this nutrient depletion zone to enhance absorption (Sylvia et al., 1992). Thus mycorrhizal fungi intervene to enhance nutrient uptake through the spread of extra radial hyphae into the surrounding soil and hydrolyzing an unavailable sources of P with the aid of secreted enzymes such as phosphatase (Koide, 2000). Enhancement of phosphorus uptake by mycorrhizal and transfer to the host plant has been reported by several workers (Cardoso et al., 2006).

Therefore, a study was inserted to find out optimum dose of phosphorus for castor grown in sandy soil to improve the ability of plants species to resist this harsh environment. As well as, mycorrhizal symbiosis is a key component in helping plants to survive under adverse environmental conditions and considered as one of the mechanisms of tolerance and water stress avoidance and it can increase phosphorus availability in soils fertilized with rock phosphates (Vassilev et al., 2012 and Estrada et al., 2013).

The objective of this work was to study the effect of rock phosphate and mycorrhiza on growth, yield and chemical composition of Ricinus communis var red arish under North Sinai conditions.

Materials and Methods

The present study was carried out at El-Qantarasharq-North Sinai, Research Station at Desert Research Center, North Sinai Governorate, during the two successive seasons of 2014/2015.

Plant material and procedure:

The seed of castor bean (Ricinus communis L.) cv. red Arish, were obtained from Egyptian Desert Gene Bank, Desert Research Center, Cairo, Egypt.

Planting dates:

The seeds were sown directly in the soil at 15th March 2014 and 2015 in both seasons, respectively. The distance between rows was 150 cm and 100 cm between hills. The plants were thinned after 30 days of sowing for one plant per hill. Drip irrigation system was used with drippers (2 liter / hour /hill) in the whole period of both seasons for only one hour every three days (Tamer, 2011).

Soil characters were analyzed in the Desert Research Center laboratory according to Black, (1982). Soil samples representing the experimental area was taken at 0-30 cm depth. The Physical and chemical analysis of the soil is shown in (Tables 1).

| Table 1: Physical and chemical analysis of the used soil in El-Qantarasharq station (Desert Research Center), North Sinai, Egypt |
|---------------------------------|---------------|---------------|----------------|---------------|----------------|---------------|
| **Mechanical analysis**         | **Value**     | **Chemical analysis** |
| Fine sand %                     | 43.28         | **Soluble anions (meq/L)** | Value |
|                                 |               | CO₃⁻            | Ca             | 8.92          | N              | 0.16          |
| Coarse sand %                   | 42.26         | **Soluble Kations (meq/L)** | Value |
|                                 |               | CL              | Mg             | 7.95          | P              | 13.21         |
| Silt %                          | 13.28         | SO₄²⁻           | Na             | 20.42         | K              | 69.67         |
| Clay %                          | 1.18          | **pH**          | K              | 1.21          | CaCO₃          | 6.20          |
| Soil texture                    | Sandy         | **E.C Mmhos/ cm** | 3.85 |

*The chemical properties of soil in ppm (water extract 1:2.5 v/v)*
The treatments were conducted as follows:

1- Control
2- Mycorrhiza
3- 100 kg Rock Phosphate /*Feddan (Feddan = 4200 m²)
4- 100 kg Rock Phosphate/ Feddan plus mycorrhiza
5- 150 kg Rock Phosphate/ Feddan
6- 150 kg Rock Phosphate /Feddan plus mycorrhiza
7- 200 kg Rock Phosphate/ Feddan
8- 200 kg Rock Phosphate/ Feddan plus mycorrhiza

Organic fertilizer (20 m³ per Feddan as Compost) was added before planting in each season in only one dose. Ammonium sulphate (20.5% N) at the rate of (200 kg per fed.) and potassium sulfate (48% K₂O), at the rate of (100 kg per fed.) as for nitrogen and potassium fertilizers they were divided and applied in three equal doses in both seasons. The first was added one month after planting, while the second was added after 2 months and the third was added after three months.

Bio-fertilizer:

Mycorrhiza (Genera mix of Gigaspora and Glomus were obtained from Microbiology Laboratory, Faculty of Agriculture, Ain Shams University, Egypt, as (1L/ 1KG seeds). Spore suspension of mycorrhiza spores count 1 × 10⁴ spores/ml. mycorrhiza was mixed with the seeds as soak for one hour.

Organic fertilizer:

Compost was applied during soil preparation at a rate of 20 ton/fed. Whereas, the rock phosphate was applied during soil preparation. The source of compost was obtained from Sikam Company and the chemical properties of compost (CM) are shown in Tables (2).

| Table 2: The chemical properties of Compost (CM) used for growing (castor) (Ricinus communis L.) plants during the 2014 and 2015 seasons. |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| pH              | E.C mmhos       | Soluble cations meq/L | Soluble anions meq/L |
|                 |                 | Ca²⁺ | Mg²⁺ | Na⁺  | K⁺   | CO₃⁻ | HCO₃⁻ | Cl⁻  | SO₄²⁻ |
| 8.10            | 3.10            | 15.00 | 45.00 | 90.00 | 30.00 | -    | 45.00 | 10.00 | 140.50 |
| Humidity        | Ash             | O.M  | N%   | P%   | K%   |       |       |       |        |
| 25%             |                 | 9%   | 65%  | 2%   | 1.5% | 1%   |       |       |        |

Harvesting:

Harvesting was carried out in the last week of September until second week of October in both seasons 2014 and 2015, respectively.

Data recorded:

During the two seasons the following data were recorded at the end of the experiment:
1- Plant height (cm)
2- Number of branches/plant
3- Fresh and dry weight (g)/plant
4- Number of inflorescences/plant
5- Seed yield per plant (g) and feddan (kg)
6- Seed index (weight of 1000 seeds) (g)

Determination of fixed oil percentage:

Soxhlet method was used for estimation of fixed oil as stated by the A.O.A.C. (1970).

Determination of fixed oil yield per plant (g):

This was calculated as follows:
Chemical analysis:

Fatty acids determination:

The methyl esters of fatty acids were determined according to Stahl (1967). The residues represented the methylated fatty acids which analyzed by G.L.C. method. Identification of fatty acids was carried out using Gas Liquid Chromatography, 6890 Gas Chromatography Method. The analysis was carried out under the following conditions:

Oven:
Initial temperature: 70°C. Initial time: 1 min.

Ramps:

<table>
<thead>
<tr>
<th>Rate</th>
<th>Final temperature</th>
<th>Final time</th>
</tr>
</thead>
<tbody>
<tr>
<td>40°C/min.</td>
<td>120°C</td>
<td>1 min.</td>
</tr>
<tr>
<td>4°C/min.</td>
<td>220°C</td>
<td>20 min.</td>
</tr>
</tbody>
</table>

Injection temperature: 250°C.
Detector temperature: 280°C.
Flame ionization detector: «F.I.D.»

Flow rates:

- N₂ (carrier gas) 30 ml/min.
- H₂ 30 ml/min.
- Air 300 ml/min.

Elements Determination:

N, P and K elements were determined in the acid digested solution, which was prepared according to Hach et al., (1987). Nitrogen content was determined by modified micro Kjeldahle method as described by A. O. A. C. (1970). Phosphorus was calorimetrically determined using method described by Murphy and Riley (1962) for potassium it was estimated using flame photometry according to Cottenie et al., (1982).

Total carbohydrates:

Total carbohydrates percentages in the dried leaves was determined according to Chaplin and Kennedy (1994).

Statistical analysis:

The complete randomized block design was used in the experiments (4 treatments) with 4 replicates. Every replicate contained 10 hills. The statistical analysis was carried out according to Costat Statistical Software (1986). L.S.D. test was used to compare the means of treatments.

Results and Discussion

Vegetative growth:

Data in Table (3) show that the least plant height was recorded for the two seasons with control, also mycorrhiza alone or 100Kg /F rock phosphate resulted in less values for plant height than full dose of rock phosphate as 200 kg/f + M followed descending by using 150Kg /F phosphate + M. Also 150 kg /F phosphate + M still express its superiority in increasing the plant height. However 150Kg /F phosphate + M appeared to be satisfy in enhancing plant height comparing to other treatments. As for branches number plant (Table 3), it was followed the same trend as shown plant height. Concerning fresh and dry weight of plant, data in Tables (3) indicate that application of either control alone or mycorrhiza significantly decreased fresh and dry weight/plant comparing to the other treatments, while 200Kg /F phosphate + M or 150Kg /F phosphate + M resulted in the best results for fresh and dry weight.
harmony with Paida (1976) and Patel, (1985). Phosphates + M was the best treatment in enhancing oil yield per plant or per feddan. These results are in agreement with those obtained by Osorio (2001). Osorio, et al. (2012); Osorio, et al., 2013; Nuccio et al. (2013).

Seed production:

Data in Table (4) show that the least number of capsules per plant, seeds yield per plant (g), seeds yield per fed(kg), and 100 seed weight(g) were recorded for the two seasons with control, also mycorrhiza alone or 100 kg /F phosphate rock resulted in less values for the above mentioned parameters. Additionally, irrespective of the above mentioned treatments, using the treatments of 200Kg /F phosphate + M and 200Kg /F phosphate succeeded in increasing Number of capsules per plant, seeds yield per plant (g), seeds yield per fed (kg) and100- seed weight (g) when compared with the other treatments. Also 150Kg /F phosphate + M still express its superiority in increasing the number of capsules, seeds yield per plant (g), seeds yield per fed(kg), and 100 seed weight (g). However 200Kg /F phosphate + M appeared to be best in enhancing the number of capsules, seeds yield per plant (g), seeds yield per fed (kg), and 100 seed weight (g) comparing to other treatments. Anyhow, the other treatments occupied intermediate position between the above mentioned extremes. These findings were in agreement with those obtained by Osorio (2001) Osorio, et al. (2012); Osorio, et al., 2013; Nuccio et al. (2013).

Table 4: Effect of rock phosphate and mycorrhiza on number capsules, seeds yield (g) per plant, seeds yield per fed(kg), and 100 seed weight(g) of Ricinus communis L. under North Sinai conditions.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Number of capsules per plant</th>
<th>Seeds yield per plant (g)</th>
<th>Seeds yield per fed(kg)</th>
<th>100-seed weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
<td>2nd</td>
<td>1st</td>
<td>2nd</td>
</tr>
<tr>
<td>Control</td>
<td>72.67</td>
<td>73.00</td>
<td>61.66</td>
<td>58.53</td>
</tr>
<tr>
<td>Mycorrhiza (M)</td>
<td>93.00</td>
<td>92.67</td>
<td>64.66</td>
<td>65.33</td>
</tr>
<tr>
<td>100 Kg (RP)</td>
<td>163.00</td>
<td>163.33</td>
<td>117.67</td>
<td>115.67</td>
</tr>
<tr>
<td>100 Kg (RP) + M</td>
<td>285.00</td>
<td>285.33</td>
<td>152.67</td>
<td>149.00</td>
</tr>
<tr>
<td>150 Kg (RP)</td>
<td>304.33</td>
<td>305.00</td>
<td>205.00</td>
<td>199.00</td>
</tr>
<tr>
<td>150 Kg (RP) + M</td>
<td>435.33</td>
<td>435.67</td>
<td>244.33</td>
<td>240.00</td>
</tr>
<tr>
<td>200 Kg (RP)</td>
<td>487.33</td>
<td>486.67</td>
<td>273.00</td>
<td>274.00</td>
</tr>
<tr>
<td>200 Kg (RP) + M</td>
<td>505.33</td>
<td>506.67</td>
<td>314.00</td>
<td>310.33</td>
</tr>
<tr>
<td>L.S.D. at 5%</td>
<td>1.13</td>
<td>0.98</td>
<td>1.13</td>
<td>0.98</td>
</tr>
</tbody>
</table>

Oil percentage, oil yield /plant (ml) and oil yield /fed (L):

Data in Table (5) indicate that all applied treatments show significant increase in oil percentage, at yield per plant or yield per feddan, however application of any dose up to rocke phosphate as 200 kg + M was affective in enhancing oil percentage that rock phosphate or mycorrhiza each alone, but 200 kg rock phosphates + M was the best treatment in enhancing oil yield per plant or per feddan. These results are in harmony with Paida (1976) and Patel, (1985).
Unsaturated fatty acids (UFA)
Saturated fatty acid (SFA)
Ricinoleic
Linoleic
Oleic
Stearic
Palmitic
*communis* applying the com
approved to be the most effective treatment led to the greatest carbohydrates percentage
leaves. Fertilized
percentages in leaves as fertilizer alone or combined with
as
lowest palmitic
phosphrock+
control plants. The highest increments in Linoleic acid and Stearic acids were obtained by 200Kg/F
phosph +
150Kg/F rock phosphate +
fatty acid in costar oil was increased by using the treatment of 200 Kg/F roc
applications. The saturated fatty acids palmetic, which constituent a substantial component of the saturated
fatty acid (ricinoleic) (76.54) was obtained from the treatment of 150Kg /F phosphate rock +
ricinoleic unsaturated fatty acids is the major one (Alfred Thomas, 2005). The highest increment in
saturated fatty acid. Oleic and Palmitic ac
combination of phosphate rock and
Mycorrhiza
While 200Kg /F phosphate rock  showed its superiority for increasing NPK
Data in Table (7) indicate that NPK percentages recorded the least values with Control or mycorriza
conditions.

**Main component of the fatty acid:**

Data in Table (6) indicate that, the effect of applied treatments on oil constituents, it is clear that, the combination of phosphate rock and mycorriza had a significant effect on producing the highest value of saturated fatty acid. Oleic and Palmitic acid is substantial component of the saturated fatty acids, while ricinoleic unsaturated fatty acids is the major one (Alfred Thomas, 2005). The highest increment in ricinoleic was recorded by using the treatment 150Kg /F phosphate rock + mycorriza followed by 150Kg /F rock phosphate and 200Kg /F phosphate rock as single applications. The highest value of unsaturated fatty acid (ricinoleic) (76.54) was obtained from the treatment of 150Kg /F phosphate rock + mycorriza. On the other hand the least value of saturated fatty acid was belonging to Control and mycorriza as single applications. The saturated fatty acids palmetic, which constituent a substantial component of the saturated fatty acid in costar oil was increased by using the treatment of 200 Kg/F rock phosphate followed by 150Kg/F rock phosphate + mycorriza (f) +M which were (6.40 & 6.38) decendingly100 Kg/F rock phosph + mycorriza treatment increase was observed in linoleic and oleic acid compared with the control plants. The highest increments in Linoleic acid and Stearic acids were obtained by 200Kg/F phosphrock+ mycorriza this treatment had marked effect on this respect. Generally, control plant has the lowest palmitic acid and the lowest Oleic acid, Linoleic acid and Stearic acids.

**Table 5:** Effect of rock phosphate and mycorriza on oil percentage, oil yield /plant (ml) and oil yield /fed (L) of *Ricinus communis* L, under North Sinai conditions.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Oil percentage</th>
<th>Oil yield /plant (ml)</th>
<th>Oil yield /fed (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>33.5</td>
<td>33.30</td>
<td>20.66</td>
</tr>
<tr>
<td>Mycorriza (M)</td>
<td>35.71</td>
<td>35.75</td>
<td>23.09</td>
</tr>
<tr>
<td>100 Kg (RP) + M</td>
<td>36.33</td>
<td>36.36</td>
<td>42.75</td>
</tr>
<tr>
<td>150 Kg (RP) + M</td>
<td>38.41</td>
<td>38.43</td>
<td>58.64</td>
</tr>
<tr>
<td>200 Kg (RP) + M</td>
<td>38.81</td>
<td>38.77</td>
<td>107.50</td>
</tr>
<tr>
<td>L.S.D. at 5%</td>
<td>1.46</td>
<td>1.33</td>
<td>6.75</td>
</tr>
</tbody>
</table>

(P): Rock phosphate  M: Mycorriza

**Table 6:** Effect of rock phosphate and mycorriza on fatty acid composition(%) of *Ricinus communis* L under North Sinai conditions.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Control</th>
<th>Mycorrhyza (M)</th>
<th>100 Kg (RP)</th>
<th>100 Kg (RP) + M</th>
<th>150Kg (RP)</th>
<th>150 Kg (RP) + M</th>
<th>200 Kg (RP)</th>
<th>200 Kg (RP) + M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palmitic</td>
<td>4.3</td>
<td>4.9</td>
<td>5.3</td>
<td>5.93</td>
<td>6.30</td>
<td>6.35</td>
<td>6.40</td>
<td>6.38</td>
</tr>
<tr>
<td>Stearic</td>
<td>3.31</td>
<td>3.81</td>
<td>4.21</td>
<td>4.31</td>
<td>4.39</td>
<td>4.39</td>
<td>4.11</td>
<td>4.29</td>
</tr>
<tr>
<td>Oleic</td>
<td>5.21</td>
<td>5.88</td>
<td>6.21</td>
<td>6.34</td>
<td>6.42</td>
<td>6.39</td>
<td>6.21</td>
<td>6.41</td>
</tr>
<tr>
<td>Linoleic</td>
<td>3.5</td>
<td>4.31</td>
<td>4.5</td>
<td>4.85</td>
<td>4.61</td>
<td>4.3</td>
<td>4.5</td>
<td>4.44</td>
</tr>
<tr>
<td>Ricinoleic</td>
<td>74.54</td>
<td>74.94</td>
<td>75.77</td>
<td>75.84</td>
<td>76.14</td>
<td>76.54</td>
<td>76.14</td>
<td>75.66</td>
</tr>
<tr>
<td>Saturated fatty acid (sfa)</td>
<td>82.15</td>
<td>83.65</td>
<td>85.28</td>
<td>86.08</td>
<td>87.28</td>
<td>86.65</td>
<td>86.35</td>
<td></td>
</tr>
<tr>
<td>Unsaturated fatty acids (UFA)</td>
<td>8.71</td>
<td>10.19</td>
<td>10.71</td>
<td>11.19</td>
<td>11.03</td>
<td>10.69</td>
<td>10.71</td>
<td>10.85</td>
</tr>
<tr>
<td>Total</td>
<td>90.86</td>
<td>93.84</td>
<td>95.99</td>
<td>97.27</td>
<td>97.86</td>
<td>97.97</td>
<td>97.36</td>
<td>97.18</td>
</tr>
</tbody>
</table>

**Nitrogen, phosphorus, potassium, and total carbohydrates in the leaves:**

Data in Table (7) indicate that NPK percentages recorded the least values with Control or mycorriza as separate application. While 200Kg /F phosphate rock showed its superiority for increasing NPK percentages in leaves as fertilizer alone or combined with mycorriza. On the other side application of 150Kg /F phosphate rock or 150Kg /F phosphate rock + mycorriza enhanced the NPK percentages in the leaves. Fertilized *Ricinus communis* plants with 200Kg /F phosphate rock + mycorriza treatment approved to be the most effective treatment led to the greatest carbohydrates percentage followed by applying the combination of 200Kg /F phosphate rock in both seasons. Moreover, treating *Ricinus communis* plants with 150Kg /F phosphate rock + mycorriza resulted in highly content of carbohydrates
in the first season and in the second season. On the other side, the treatment of Control or Mycorrhiza resulted in the least total carbohydrates percentage.

Table 7: Effect of rock phosphate and mycorrhiza on nitrogen, phosphorus, potassium and total carbohydrates percentage on leaves of *Ricinus communis* L. under North Sinai conditions.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>N %</th>
<th>P %</th>
<th>K %</th>
<th>TI Total carbohydrates %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
<td>2nd</td>
<td>1st</td>
<td>2nd</td>
</tr>
<tr>
<td>Control</td>
<td>3.17</td>
<td>3.15</td>
<td>0.35</td>
<td>0.34</td>
</tr>
<tr>
<td>Mycorrhiza (M)</td>
<td>3.25</td>
<td>3.23</td>
<td>0.37</td>
<td>0.38</td>
</tr>
<tr>
<td>100 Kg (RP)</td>
<td>3.25</td>
<td>3.24</td>
<td>0.43</td>
<td>0.42</td>
</tr>
<tr>
<td>100 Kg (RP) + M</td>
<td>3.22</td>
<td>3.24</td>
<td>0.45</td>
<td>0.47</td>
</tr>
<tr>
<td>150 Kg (RP)</td>
<td>3.24</td>
<td>3.26</td>
<td>0.46</td>
<td>0.45</td>
</tr>
<tr>
<td>150 Kg (RP) + M</td>
<td>3.26</td>
<td>3.27</td>
<td>0.50</td>
<td>0.49</td>
</tr>
<tr>
<td>200 Kg (RP)</td>
<td>3.27</td>
<td>3.26</td>
<td>0.47</td>
<td>0.48</td>
</tr>
<tr>
<td>200 Kg (RP) + M</td>
<td>3.27</td>
<td>3.24</td>
<td>0.57</td>
<td>0.55</td>
</tr>
</tbody>
</table>

(RP): Rock phosphate   M: Mycorrhiza

Discussion

In general, from the aforementioned results data presented in tables (3&4) clearly show that the highest plants, number of branches, fresh weight, dry weights, number of capsules per plant, seeds yield per plant, seeds yield per fed and 100-seed weight of castor the treatments of 200 Kg/F phosphate rock(f) +M and 150 Kg/F phosphate rock(f) +M were significantly higher than those of 200 Kg/F phosphate rock(f) and 150 Kg/F phosphate rock(f) as single application in this study. Particularly, the dual inoculation with phosphate rock and Mycorrhiza (M) synergistic effects on all previous parameters. The positive effect of phosphate rock on all previous parameters can be attributed to its considerable influences on meristematic activity i.e., the increase in cells number and increase in their activities. Similar effects were found in *Leucaena leucocephala* (Osorio and Habte, 2001), clover (Souchie et al., 2006), Kostelelzy virginica (Zhang et al., 2011and Zhang et al., (2013). These results may be due to an effective phosphorus solubilization ability (Souchie et al.,2006) and/or by phytohormone production (Barea et al.,2002). In this paper, mycorrhiza contribution on growth promotion may be related to the improvement of phosphorus solubilization ability (Table 3, Table 4). Mycorrhizal fungi enhanced oil percentage, oil yield/plant and oil yield/fed (Table 5). In seed castor a result in congruence with other studies (Sannazzaro et al., 2006; Sheng et al., 2008). Mycorrhizal inoculation enhances phosphorus and potassium % in leaves uptake in the plant, and this leads to increasing chlorophyll content, and improves the overall rendering of mycorrhizal plants Table (7) (Giri and Mukerji,2004). Also, potassium is required for the translocation of carbohydrates. These results are in agreement with those obtained by the absorbency of these elements was increased. So, the percentages of these elements can be increased. This study showed that combined inoculation of phosphate rock + mycorrhiza could reinforce the chlorophyll content and total carbohydrates % in the leaves of castor beans synergistically. This may be due to soil inoculated with mycorrhiza increased the content of available phosphorus in soil and stimulating the production of plant hormones (Jacobsen et al., 1992). Also, the increasing in growth parameters by phosphate rock + M application may be turned to the effect of microbial activity on increasing the availability of elements and their supply to plants and its effect on the physiological processes such as photosynthesis activity as well as the utilization of carbohydrates. Also, the increase in plant growth by phosphate rock +M may be attributed to the role of nitrogen in formation of protoplasm and most organic components such as amino acids, nucleic acids, many enzymes and energy transfer compounds (ADP and ATP) Spernath (1990) and El-Merich et al.,(1997); Osorio, and Habte. (2012); Osorio, and Habte. (2013); Yadav and Aggarwal (2011) and Nuccio et al (2013) reported that, an arbuscular mycorrhizal fungus significantly modifies the soil bacterial community and nitrogen cycling during litter decomposition.

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