Influence of substrates on in vitro rooting and acclimatization of micropropagated strawberry (Fragaria x ananassa Duch.)

Wafaa, A. Fekry and H. M. Wahdan

ABSTRACT

This work was conducted at the Tissue Culture Lab., Center of Genetic Engineering and Biotechnology, Fac. Agric., Ain Shams University, Egypt, to optimize a successful technique for in vitro shoot rooting and acclimatization by using different substrates with strawberry (Fragaria x ananassa Duch.) cvs, "Festival" and "Marquez". As for in vitro rooting, various substrates were tested, Agar with 0.1 mg\textsuperscript{-1} IBA (control), peat moss, vermiculite or mixture of both (1:1 v/v). After four weeks of culture, rooting percentages ranged from 96 to 83.33\% by both peat moss and vermiculite each alone, respectively. Marquez produces maximum number of roots (5.20 and 5.03) and shoot length (4.73 and 4.60 cm) when plantlets were cultured on agar with 0.1 mg\textsuperscript{-1} IBA (control) and peat moss alone, respectively. Meanwhile, "Festival" had increased number of roots and shoot length on agar amended with 0.1 mg IBA or the mixture of peat moss and vermiculite (1:1 v/v). The longest root length was recorded by peat moss alone with the two cultivars. On the other hand, the lowest values of root features (number and length) as well as shoot length were recorded by using vermiculite as substrate with the two cultivars. Rooted plantlets of about 4.5 cm long were subsequently transferred to various substrates for acclimatization. The survival percentage reached 96 and 93\%, respectively for the two cultivars "Marquez" and "Festival" when the transplants were acclimatized on a mixture of peat moss + vermiculite + sand (1:1:1 v/v/v). The two studied cultivars had the same significant effect for increasing root parameters (number and length) when the transplant acclimatized on substrate consisted of peat moss + vermiculite + sand (1:1:1 v/v/v) and number of leaves when grown in peat moss alone. Also, Festival cv. gave the same maximum value of root length when acclimatized on vermiculite substrate alone or when mixed with peat moss and sand (1:1:1 v/v/v). 

Key words: Strawberry, in vitro rooting, peat moss, vermiculite, Acclimation

Introduction

Micropropagation is a powerful biotechnology for plant multiplication. Plant regeneration through tissue culture has been widely utilized for rapid and mass multiplication of many species including strawberry (Amer, 2013).

In vitro rooting induction can be mediated by adding plant growth regulators to the culture medium (Rama, 2012 and Ghasemi et al., 2015). However, the survival percentage of these plants during acclimatization is reduced (Zhou et al., 2005) and this often becomes a practical problem. In this respect, Gonclaves et al. (1988) suggested that the lower survival rate during plant acclimatization may be due to non-functionality of the in vitro developed rooting system. Many commercial laboratories do not root microcutting in vitro, because it is labour-intensive and expensive. The process of rooting in vitro has been estimated to account for approximately 35 to 75\% of the total cost of micropropagation (Debergh and Maene, 1981 and Hazarika, 2003). A variety of studies have shown that physiological functions of tissue cultured roots are different compared to the roots that develop on classical grown plants (Labrousse et al., 2012). Tissue cultured plants develop adventitious roots on micropropagated shoots, these roots must be strong and functional enough to support the plant in later growth and development (Richie, 1994). Usually, agar is used to solidify the medium of in vitro cultures. Different studies mentioned problems relating to the root quality when developed in agar medium (Keatmetha and Suksa-Ard, 2004; Labrousse et al., 2012). Anaerobic conditions in agar substrate due to the lack of development of root hairs in roots and this consequently made a difficulty to get a good functional

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root system in vitro and can dramatically reduce water and mineral nutrient uptake, thus representing a limiting key step to acclimatization in different substrates (Keatmetha and Suksa-Ard, 2004; Labrousse et al., 2012 and Barpete et al., 2014). Other substrates than agar like peat moss, vermiculite or mixture of them have physical properties which help to overcome the low O2 pressure in agar medium. On the same time, decreased oxygen level in a medium had a relationship with poor rooting, decrease in root hair length as well as root respiration (Keatmetha and Suksa-Ard, 2004 and Labrousse et al., 2012).

It is very important to determine the factors affecting the ex vitro acclimatization of tissue cultured plants (Kumar and Rao, 2012). One of the important factors affecting on survival percentage of transplants during acclimatization is the type of potting substrate (Kaur et al., 2011; El-Zeiny et al., 2013 and Barpete, 2014).

Hardening is a time-consuming and labour-intensive process contributing to major portion of the production cost. In this respect, the goal of this research was to work out for selecting the favourable substrates increasing in vitro rooting efficiency and high survival rate as well as growth during acclimatization of Festival and Marquez strawberry cultivars.

Materials and Methods

The present study was carried out at the Tissue Culture Lab., Center of Genetic Engineering and Biotechnology, Fac. Agric., Ain Shams University, Egypt, during the period from 2013 to 2015 to study the effect of different substrates on in vitro rooting and during acclimatization on the rooting and survival percentage as well as growth of the two strawberry cultivars Festival and Marquez. Runner tips of two strawberry (Faragaria x ananassa Duch.) cultivars were used as plant materials.

Preparation and sterilization of plant material:

Runners (about 10-15 cm in length) were collected from greenhouse on June as a source of explants. Excised runner tips (5.0 cm in length) were washed under running tap water, then washed with sterilized distilled water. Explants were subjected to chemical sterilization under laminar air flow cabinet using 70% ethyl alcohol for 5 min. and rinsed by sterile double distilled water. Subsequently, the runner tips were sterilized again by 5 % sodium hypochlorite (NaOCl) solution with gently shaking for 20 min. followed by 3-5 times washing by sterile doubled distilled water.

Establishment stage and shoot proliferation:

The meristems were trimmed to 0.4 -0.5 mm and inoculated in jars containing 30.0 ml of MS medium (Murashig and Skoog 1962) supplemented with GA3 at 0.1 mg l-1 and 0.1 mg l-1 BA as plant growth regulators and 30 g l-1 sucrose. The pH of the medium was adjusted to 5.7 and 7 g l-1 agar as well as 3 g l-1 activated charcoal (AC) were added before autoclaving at 1.06 kg/cm2, 121°C for 20 min. The cultures were incubated at 25 ± 2 °C with 16h photoperiod under fluorescent lamps providing 25.2 µmol m-2s-1 of photosynthetic photon flux. Subcultures were done three times every 21 days interval. Regenerated multiple shoots about 10 mm in length were placed on a medium contained the same MS medium previously described and incubated under the same conditions. After about 3-4 weeks, elongated shoots were prepared for rooting.

In vitro rooting substrates:

Shoots with 2.0 cm length of the two tested cultivars Festival and Marquez were inoculated in different rooting substrates, i.e. agar (control), peat moss, vermiculite and mixture of peat moss and vermiculite (1:1 v/v), the total treatments were eight. As for agar substrate, shoots were cultured in jars containing 30.0 ml of MS medium supplemented with IBA at 0.1 mg l-1, 30 g sucrose, 3 g l-1 activated charcoal and solidified with 7 g l-1 agar. The pH was adjusted to 5.7. As for the other substrates, jars were filled with thirty milliliters of peat moss, vermiculite or mixture of both (1:1 v/v) and moistened with 20 ml distilled water. All jars of the experiment were capped with aluminum foil before sterilization at 121°C with pressure of 1.2 kg/cm2 for 15 min. The shoots were cultured (five shoots/jar) under laminar air flow cabinet and kept in the incubation room at 25± 2 °C with 16h photoperiod.
After 4 weeks of culture the following parameters were evaluated: the percentage of rooting, number of roots, root and shoot length per plantlet.

**Acclimatization substrates:**

Rooted shoots of the two cultivars Festival and Marquez were removed from culture vessel and washed in distilled water in order to completely remove rooting substrate before being transferred to plastic pots (15 cm diameter) filled with peat moss, vermiculite, peat moss + vermiculite (1:1 v/v) and peat moss + vermiculite + sand (1:1:1 v/v/v). Pots were transferred to the greenhouse and covered with clear polyethylene sheets to create a high relative humidity. Moreover, spraying with water under the plastic sheets were carried out daily while the irrigation took place 2-3 times a week. After 10 days of acclimatization, the plastic sheets were gradually opened. The acclimatization plants were fertilized (N/P/K 19/19/19) weekly with equal amount of complete fertilizer at 2 g/l as foliar spray.

The following data were recorded in this stage: survival percentage (Number of succeeded transplants/total number of transplants x 100), number of roots, root length and number of leaves per transplant.

**Experimental design and statistical analysis:**

The two experiments were arranged in a split plot design where cultivars were arranged in the main plots and substrates were distributed randomly in the sub plots. All treatments were conducted in three replicates, five jars in each treatment for each replicate and five shoots were planted in each jar for the two cultivars during the in vitro rooting experiment, whereas contained one plant per pot for each replicate in the acclimatization trial. All statistical analysis were performed by using the SPSS software according to Pallant (2001). Means were compared according to L.S.D. at 5% level test to determine the significance differences among the treatments.

**Results and Discussion**

**In vitro rooting substrates:**

*In vitro* rooting of regenerated strawberry shoots started to induction about 15 days after the initiation of culture when the basal ends were swelling.

**Effects of cultivars:**

Data in Table 1 show clearly that all studied growth characters expressed as number of roots, root and shoot length were significantly affected by the two cultivars, Festival and Marquez. The highest number of roots (4.74) and root length (4.17 cm) were produced by Marquez cv. On the other hand, higher value of shoot length (4.56 cm) was obtained by Festival cultivar. Such differences in growth between the studied cultivars may be attributed to the potential of genetic differences among such genotypes. In this regard, Singh and Shymal (2001) and Barpate et al. (2014) recorded similar results.

**Table 1:** Effect of strawberry cultivars on root characteristics and shoot length during rooting stage

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>No. of roots/plantlet</th>
<th>Root length (cm)</th>
<th>Shoot length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Festival</td>
<td>4.59</td>
<td>3.30</td>
<td>4.56</td>
</tr>
<tr>
<td>Marquez</td>
<td>4.74</td>
<td>4.17</td>
<td>4.51</td>
</tr>
<tr>
<td>LSD at 5%</td>
<td>0.02</td>
<td>0.12</td>
<td>0.03</td>
</tr>
</tbody>
</table>

**Effect of substrates:**

The presented data in Fig.1 show that rooting percentage increased when the plantlets were cultured in peat moss alone (96%) and followed by equal rooting percentage (90%) with the mixture
between peat moss and vermiculite or agar, but decreased to 83.33% when the plantlets were rooted in vermiculite alone.

![Fig. 1: Effect of rooting substrates on rooting percentage of strawberry plantlets during rooting stage.](image)

As for the growth, obtained data in Table 2 show that the different used substrates had significant effect on root characters (number and length) and shoot length of plantlet. In this concern, agar amended with 0.1 mg\(^{-1}\) IBA (Control) was the best substrate for increasing number of roots (5.06 roots) and shoot length (4.73cm) of plantlet. In this respect, Li et al. (2009) revealed that auxins are the major plant hormones affect the rooting and the main role of auxin in tissue culture is stimulating cell division and development. On the same time, peat moss recorded the highest value of root length (4.47cm), but there is no differences between peat moss alone or when mixed with vermiculite on number of roots and shoot length. On the other hand, plantlets cultured in vermiculite alone recorded the lowest values of the studied characters, i.e. number of roots (3.91 roots), root length (3.38cm) and shoot length (4.18 cm).

**Table 2: Effect of rooting substrates on root characteristics and shoot length during rooting stage**

<table>
<thead>
<tr>
<th>Substrate</th>
<th>No. of roots/plantlet</th>
<th>Root length (cm)</th>
<th>Shoot length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agar</td>
<td>5.06</td>
<td>3.58</td>
<td>4.73</td>
</tr>
<tr>
<td>Peat moss</td>
<td>4.86</td>
<td>4.47</td>
<td>4.60</td>
</tr>
<tr>
<td>Vermiculite</td>
<td>3.91</td>
<td>3.38</td>
<td>4.18</td>
</tr>
<tr>
<td>Peat moss + vermiculite (1:1)</td>
<td>4.84</td>
<td>3.53</td>
<td>4.63</td>
</tr>
<tr>
<td>LSD at 5%</td>
<td>0.04</td>
<td>0.04</td>
<td>0.03</td>
</tr>
</tbody>
</table>

In this regard, Wahdan (1983) reported that greater numbers of rooted plantlets were recorded in Jiffy7 (in honey jars) kept on controlled environment room. Obtained results of peat moss are in agreement with those reported by Keatmetha and Suksa-Ard (2004) and Labrousse et al. (2012) who found that used peat moss as substrates in vitro cultured enhanced rooting and increase the number and length of roots. On the other side, obtained results of vermiculite alone on in vitro culture are not confirmed with those reported by Gabriel et al. (2002) and Keatmethas and Suksa-Ard (2004) who indicated that in order to optimize root induction in vitro, the replacement of the agar medium by another substrate such as vermiculite or a mixture of vermiculite and perlite is recommended. In this respect, previous studies demonstrated that different responses to rooting in vitro were the result of rooting substrates. Although there is a positive effect of agar for increasing number of roots, many authors have mentioned problems relating to the root quality when developing in agar medium before transplanting which can markedly affect the survival rate (Borkowska, 2001 and Keatmetha and Suksa-Ard, 2004). The lack of development of root hair in roots formed in agar medium generally made it difficult to get a good functional system in vitro. In addition, the roots were more fragile and did not present
ramification. Anaerobic root development without root hairs in agar medium considered the main problem and affect the vigor of plantlet after transplanting. In this concern, Galway et al. (1997), Bidel et al. (2000), Gabriel et al. (2002), Labrousse et al. (2012) and Aasim et al. (2013) indicated that absence of root hair and poor growth are attributed to hypoxia in agar medium and they hypothesized the presence of several limiting factors for root growth in agar medium, in addition to O₂ depletion, progressive dehydration and acidification may also have reduced the meristem growth. Moreover, actively tip-growing root hair cells are characterized by apolarized apex rich in golgi vesicles and mitochondria, suggesting important ATP needs for root hair growth where the high amounts of ATP in root hair imply a good O₂ in agar medium is lower than those found in conventional substrates. Consequently, to enhance root induction of shoot in vitro, more aeration of rooting substrate is recommended since it has higher dissolved oxygen rate and contains more water.

Effect of the interaction:

With regard to the effect of the interaction between the tested cultivars (Festiva and Marquez) and in vitro rooting substrates (Agar with 0.1 mg⁻¹ IBA, peat moss, vermiculite and mixture between peat moss and vermiculite) data in Table 3 revealed that Marquez strawberry cultivar recorded the highest values of root number when rooted in agar with 0.1 mg⁻¹ IBA (5.20) followed by the substrate peat moss alone (5.03) or in mixture with vermiculite (4.93). Festival cultivar had the same trend in this respect. The longest roots were obtained by Marquez cv (4.83 cm) followed by Festival cv (4.10 cm) when in vitro rooted in peat moss alone or when mixed with vermiculite. As for shoot length, both the two cultivars Marquez and Festival had the same trend mostly with all used substrates in this respect. The best results obtained by agar with 0.1 mg⁻¹ IBA or the mixture between peat moss and vermiculite or peat moss alone. On the other hand, rooted the two strawberry cultivars in the substrate vermiculite lonely gave the lowest values with all studied features.

Table 3: Effect of the interaction between strawberry cultivars (Festival and Marquez) and rooting substrates on root characteristics and shoot length during rooting stage

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Substrate</th>
<th>No. of Roots/plantlet</th>
<th>Root length (cm)</th>
<th>Shoot length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Festival</td>
<td>Agar</td>
<td>4.93</td>
<td>3.06</td>
<td>4.73</td>
</tr>
<tr>
<td></td>
<td>Peat moss</td>
<td>4.70</td>
<td>4.10</td>
<td>4.60</td>
</tr>
<tr>
<td></td>
<td>Vermiculite</td>
<td>4.00</td>
<td>3.00</td>
<td>4.20</td>
</tr>
<tr>
<td></td>
<td>Peatmoss + vermiculite (1:1)</td>
<td>4.75</td>
<td>3.06</td>
<td>4.73</td>
</tr>
<tr>
<td>Marquez</td>
<td>Agar</td>
<td>5.20</td>
<td>4.10</td>
<td>4.73</td>
</tr>
<tr>
<td></td>
<td>Peat moss</td>
<td>5.03</td>
<td>4.83</td>
<td>4.60</td>
</tr>
<tr>
<td></td>
<td>Vermiculite</td>
<td>3.83</td>
<td>3.76</td>
<td>4.17</td>
</tr>
<tr>
<td></td>
<td>Peatmoss + vermiculite (1:1)</td>
<td>4.93</td>
<td>4.00</td>
<td>4.53</td>
</tr>
<tr>
<td>LSD at 5%</td>
<td></td>
<td>0.06</td>
<td>0.06</td>
<td>0.05</td>
</tr>
</tbody>
</table>

It could be concluded from these treatments that the peat moss substrate used alone or mixed with vermiculite (1:1 v/v) were effective for increasing rooting percentage, number of roots, root and shoot length per plantlet in vitro rooting of the two strawberry cultivars Marquez and Festival as well as to overcome the problems relating to the root quality when developed in agar medium beside to save money and time.

Acclimatization substrates:

Effect of cultivars:

The two strawberry cultivars Festival and Marquez had significant effect on the studied growth parameters expressed as number and length of root as well as number of leaves per transplant during acclimatization stage as illustrated in Fig. 2. In this respect, Festival cv reflected the highest values in all studied growth characteristics. Such differences among the two cultivars may be attributed to the genetic differences between them as recorded by Mohamed, Nagwa (2003).
Effect of substrates:

With regard to the effect of various used substrates and their mixtures on growth of strawberry transplants, data in Fig. 3 show that the plantlets acclimatized in the mixture of peat moss + vermiculite + sand (1:1:1 v/v/v) gave the maximum values of root growth (number and length) per transplant. However, the highest number of leaves was obtained using peat moss alone. In this respect, vermiculite alone showed a significant effect on number of roots (6.34) and root length (7.44 cm) compared with peat moss (5.79 and 6.69 cm, respectively).

As for transplant survival percentage, data presented in Fig. 4 show that the survival rate recorded about 94% by the mixture of peat moss + vermiculite + sand (1:1:1 v/v/v) and 73% by the vermiculite substrate alone. In this respect, Rajan (2007) reported that micropropagation was successful only when plants were transferred from culture condition to soil with high survival rate and better growth. The quality of transplant depends mainly on the substrate utilized. In this regard, Hartmann et al. (1997), Deoe Silva et al. (1998), Kampf et al. (1998) and Moreira et al. (2006) suggested that good growth, more adventitious roots and reduced mortality of plants during acclimatization depend on composition and quality of the substrate. The substrate must combine a light texture with adequate nutritive quality, good moisture-retaining capacity and good aeration. Regarding to vermiculite, it has less bulk density indicated less substrate compactness and more pore spaces which allowed better root aeration, nutrients and water uptake for subsequent growth enhancement and more water holding capacity and thus can hold nutrients in reserve to release them later (Hartmann et al., 1990 and Biter and Mohamed, 2009).

As for the establishment success in peat, it may be due to better aeration, less water retention capacity, moderate pH and lack of any organic components (Hutchinson, 1984).

Although vermiculite had increased number and length of roots the survival percentage was decreased (73%) compared with peat moss (86%) and this result may be ascribe to the increase of leaves number by used the substrate peat moss which due to stimulate the photosynthesis process and consequently the transplant growth and survival.

Obtained results for the effect of different substrates on growth during transplants acclimatization stage are in agreement with Badawi et al. (1990) and Amer (2013) on strawberry and Palee et al. (2012) and Barpete et al. (2014) on different plants with peat moss and Mohamed (1999) on strawberry, Mohamed et al. (2001), Bitar and Mohamed (2009) and El – Zeiny et al. (2013) by vermiculite. Obtained results of the mixture between peat moss and vermiculite are in a good line with those reported by Husaini et al. (2008), Moradi et al. (2011), Amer (2013) who found that the mixture of peat moss

<table>
<thead>
<tr>
<th>Characters</th>
<th>No. of leaves</th>
<th>Root length (cm)</th>
<th>No. of roots</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSD at 5%</td>
<td>0.18</td>
<td>0.17</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Fig. 2: Effect of strawberry cultivars on transplants growth characteristics during acclimatization stage.
+ vermiculite increased the survival percentage as well as number and length of roots. However, Amine and El-Atrach (2012) and El –Zeiny et al. (2013) came to the similar highest values of survival percentage (over 90%) , number of roots and root length for transplants cultured in mixture of the substrates peat moss+ vermiculite+ sand during acclimatization stage.

![Graph showing growth characteristics of strawberry transplants](image1)

<table>
<thead>
<tr>
<th>Characters</th>
<th>No. of leaves</th>
<th>Root length (cm)</th>
<th>No. of roots</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSD at 5%</td>
<td>0.25</td>
<td>0.24</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Fig. 3: Effect of various substrates and their mixtures on growth characteristics of strawberry transplants during acclimatization stage.

![Graph showing survival percentage of strawberry transplants](image2)

Fig. 4: Effect of various substrates and their mixtures on survival percentage of strawberry transplants during acclimatization stage.

Effect of the interaction:

With regard to the interaction between Festival and Marquez strawberry cultivars and different substrates as well as their mixtures on growth characters at acclimatization stage, data recorded in Table 4 show that both cultivars Festival and Marquez achieved the highest values of roots number and length.
by using the mixture of the substrates peat moss + vermiculite+ sand (1:1:1 v/v/v), while the highest number of leaves by peat moss alone.

Table 4: Effect of the interaction between strawberry cultivars (Festival and Marquez) and various substrates and their mixtures on growth characteristics of transplants during acclimatization stage

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Substrate</th>
<th>No. of roots/transplant</th>
<th>Root length (cm)</th>
<th>No. of leaves/transplant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Festival</td>
<td>Peat moss</td>
<td>6.15</td>
<td>7.16</td>
<td>5.60</td>
</tr>
<tr>
<td></td>
<td>Vermiculite</td>
<td>6.13</td>
<td>8.25</td>
<td>5.08</td>
</tr>
<tr>
<td></td>
<td>Peatmoss + vermiculite (1:1)</td>
<td>5.58</td>
<td>7.58</td>
<td>4.70</td>
</tr>
<tr>
<td></td>
<td>Peatmoss + vermiculite + sand (1:1:1)</td>
<td>6.55</td>
<td>8.25</td>
<td>5.31</td>
</tr>
<tr>
<td>Marquez</td>
<td>Peat moss</td>
<td>5.43</td>
<td>6.21</td>
<td>5.68</td>
</tr>
<tr>
<td></td>
<td>Vermiculite</td>
<td>5.95</td>
<td>6.63</td>
<td>5.01</td>
</tr>
<tr>
<td></td>
<td>Peatmoss + vermiculite (1:1)</td>
<td>5.15</td>
<td>7.01</td>
<td>4.31</td>
</tr>
<tr>
<td></td>
<td>Peatmoss + vermiculite + sand(1:1:1)</td>
<td>6.75</td>
<td>8.16</td>
<td>5.25</td>
</tr>
<tr>
<td>LSD at 5%</td>
<td></td>
<td>0.24</td>
<td>0.47</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Also, it is clear from such data that Festival cv. recorded the maximum values of root length per transplant when acclimatized in vermiculite alone or mixed with peat moss and sand (1:1:1v/v/v). Obtained results are confirmed by those reported by Mohamed (1999) and Mohamed et al., (2001) on the effective of vermiculite contained media than used alone. With respect to the survival percentage, data present in Fig.5 recorded the highest value (96%) with Marquez cultivar and 93% by Festival cv. when the transplant acclimatized in the mixture of peat moss + vermiculite+ sand (1:1:1v/v/v). On the other hand, the lowest value (70% and 76%), respectively for the two cvs, Festival and Marquez were showed by used vermiculite alone. In this respect, using vermiculite in combination with peat moss gave best result than used it alone. Obtained results are in agreement with those reported by Husaini et al., (2008) in this concern.

![Fig. 5: Effect of the interaction between strawberry cultivars (Festival and Marquez) and various substrates and their mixtures on survival percentage of transplants during acclimatization stage.](image)

Generally, it could be concluded that the two strawberry cultivars Festival and Marquez transplants had the best growth characteristics (number of leaves, root number and length) as well as the survival percentage over than 90% when grown during acclimatization in a mixture of substrates peat moss + vermiculite+ sand (1:1:1v/v/v)
Conclusion

Although agar could be used for micropropagation of the two strawberry cultivars, Festival and Marquez, the results showed that the enhancement of normal root development can be gained if rooting stage was performed on micro-porous substrates, i.e. peat moss or mixture of it with vermiculite which had better air permeability as well as appropriate retention and thus had deleterious effects on plant acclimatization in greenhouse. On the other hand, shoots rooted in these two substrates were easy to handle because roots are not disturbed and induce more quickly with simultaneous shoot growth. The improved rooting and acclimatization achieved by this work could optimize the commercial propagation of the two strawberry cultivars Festival and Marquez which may save time and labour cost.

References


