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In vitro culture genotypic efficacy of different strawberry cultivars as affected by growth promoting substances

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ABSTRACT

Nodal segments of five strawberry cultivars, *viz.*, Festival, Chandler, Sweet Charlie, Selva and Seascape were excised and cultured to study the response of different strawberry cultivars under influence of growth promoting substances. Nodal segments were cultured for 21 days on the initiation medium supplemented with various thidiazuron (TDZ) levels (0.5, 1.0, 1.5 and 2.0 mg/l), BA (0.5, 1.0, 1.5 and 2.0 mg/l) and combination of various levels of BAP with GA (0.5 mg/l). Following shoot initiation, rooting was instigated on the medium supplemented with IBA concentrations for 4 weeks. Cultivars, growth regulators and their interactions showed significant effect on shoot induction and initiation. Chandler and Festival showed 100% proliferation in MS medium supplemented with 1.0 or 1.5 mg/l TDZ. Chandler with 1.0 mg/l TDZ also recorded maximum response for number of shoots and shoot length with minimum number of days taken to shoot initiation. However, maximum shoot length was recorded in 1.5 mg/l BA + 0.5 mg/l GA. Rooting response among different strawberry cultivars and IBA concentrations showed that Chandler and Festival recorded 100% rooting in IBA (0.5 and 1.0 mg/l) supplemented medium. Chandler in 1.0 mg/l IBA gave the maximum shoot number and root length with minimum number of days taken to root formation. Therefore, Chandler in 1.0 mg/l TDZ supplemented medium response better for shoot proliferation and other shooting characters. Chandler on medium supplied with 1 mg/l IBA responded well for rooting characters.

Key words: *In vitro* culture, nodal segments, proliferation, rooting, strawberry.

INTRODUCTION

The cultivated strawberry (*Fragaria* × *ananassa* Duch.) belongs to the family Rosaceae is one of the most important fruit of the world (Gantait *et al*., 4). Traditionally, strawberry is propagated by runners, which are very labour intensive; time consuming and results in the transmission of viral diseases (Gautam *et al*., 5). This led to introduction of micropropagation in strawberry plants about thirty years ago (Boxus, 1). Strawberry is among the first fruit crops where large scale commercial multiplication of plants through *in vitro* techniques is a success story. *In vitro* multiplication produces quality planting materials with several advantages. Therefore, at present the large scale commercial multiplication through tissue culture is widely adopted in strawberry industry. Growth regulators added to the basal medium for culture plays an important role in determining the nature of growth and development of plantlets *in vitro*. Ying *et al.* (17) found that strawberry genotypes considerably increased the number of shoots with an increased BA concentration in the M2 medium. Further, Morozova (11) reported that high concentration of BA is best for strawberry micropropagation. Contradictory, Boxus (2) suggested lower concentrations of BA for strawberry micropropagation. Thidiazuron (TDZ), a substituted phenyl urea with cytokinin and auxin-like effects, is considered as a highly efficacious bioregulator for morphogenesis in the tissue culture of many plant species. TDZ alone or in combination with 2,4-D or IBA (Debnath, 3; Passey *et al*., 12; Hanhineva *et al*., 6) was found to be effective for plantlet regeneration from strawberry leaves.

The genotype is one of the most crucial factors in the *in vitro* proliferation response. The regeneration response of a tissue in culture is primarily a genetically controlled process. The effect of genotype differences on the capacity of shoot multiplication was also evident as reported by Passey *et al*. (12). Nevertheless, genotypes, which do not respond to one stimulus are not necessarily non-regenerative as they may respond to other stimuli or modification to cultural practices. The growing list of genotypes of a particular species showing regeneration potential in response to different stimuli also supports this conclusion. Therefore, the present study was undertaken to assess the genotypic effects of selected strawberry cultivars in tissue culture and selecting the superior genotype for mass propagation under *in vitro.* Efficacies of the various growth regulators were also assessed.

MATERIALS AND METHODS

The present study was carried out at the ICAR-Indian Institute of Horticultural Research, Bengaluru,

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India. Single nodal explants of field grown strawberry of tender runners (7-10 cm) were used as explant. After the runners were severed, leaves and roots were trimmed off and nodal segments (1-2 cm) were pre-treated with 1% bavistin, 0.1% antibiotic formulation (streptomycin + tetracycline) and 0.5% CTAB for 90 min. The explants were washed in sterile double-distilled water thrice followed by 75% ethanol disinfection. The pre-treated explants were again treated with 0.1% $MgCl_2$ for 3 min. After six times of washing, the leaf sheaths were confiscated, exposed ends trimmed off, and the excised nodal explants (1-1.5 cm) were transferred to a bottle containing sterile double-distilled water. Retreatment of the excised explants were performed with 0.1% $HgCl_2$ for 10 sec, and subsequently followed by 5 times washing with sterile distilled water.

For shoot induction and proliferation, surface sterilized nodal segments were cultured on MS medium containing BA (0.5, 1.0, 1.5 and 2.0 mg/l), TDZ (0.5, 1.0, 1.5 and 2.0 mg/l), 0.5 mg/l BA + 0.5 mg/l GA, 0.5 mg/l BA + 1 mg/l GA, 1 mg/l BA + 0.5 mg/l GA, 1 mg/l BA + 1 mg/l GA, 1.5 mg/l BA + 0.5 mg/l GA, 1.5 mg/l BA + 1 mg/l GA, 2 mg/l BA + 0.5 mg/l GA, 2 mg/l BA + 1 mg/l GA. The cultures were examined daily and data for shoot initiation and proliferation was recorded after 21 days of culture. The micro-cuttings obtained were sub-cultured on fresh medium for further shoot proliferation and root initiation. Each treatment combination consists of ten replications. The shooting responses of various strawberry cultivars to *in vitro* culture using nodal explants were evaluated for growth characteristics such as percentage of explants showing shoot proliferation, days to shoot initiation, number of shoots per explant and length of shoot.

The micro-cuttings produced from the shoot induction treatments measuring 2.5 cm in length were transferred to MS medium containing 0.5, 1.0, 1.5 and 2.0 mg/l of IBA for root initiation. Ten replications were maintained for each treatment. The percentage of rooting, number of days to root initiation, number of roots per micro-cutting and root length were recorded in each treatment after 4 week sub-culture.

After rooting, acclimatization and hardening of plantlets was carried out in plastic cup containing media mixture of sterilized sand, soil and cocopeat (1:1: 2). The plastic cup having holes at the bottom were filled up to 2/3rd with hardening media. The soil mixture was saturated with water to field capacity. Every five days interval, plantlets from different concentrations was transferred at room temperature for hardening. Following, the plantlets were washed in water carefully to remove the media and transferred to plastic cups containing sterile potting media and finally covered with an inverted punched holes plastic cup and placed under fluorescent light in the culture room (24°C). The inverted plastic cups covers were removed after 1 week to permit further hardening, and one month after, hardened plantlets were relocated to glasshouse conditions.

Analysis of variance was carried out using Factorial completely randomized design with the help of Statistical Package for Agriculture Workers (CCS HAU, Hisar). Test of significance was conducted among cultivars, plant growth regulators and their interactions at $p \leq 0.05$.

RESULTS AND DISCUSSION

The result obtained on shoot proliferation percentage showed significant differences due to the effect of cultivars, growth regulators and their interactions (Table 1). Among the cultivars, Chandler showed the best response to *in vitro* culture for shoot proliferation (84.12%), followed by Festival (78.24%), while minimum shoot proliferation was obtained in Sweet Charlie (60.0%). which was *at par* with Seascape (55.29%). Among growth regulators, 1.0 mg/l TDZ when supplied to the medium gave the highest shoot proliferation (88.0%) followed by 1.5 mg/l BA, which was *at par* with 1.5 mg/l BA + 0.5 mg/l GA. Interaction between growth regulator and genotype revealed that 100% shoot proliferation was recorded in Chandler cultured in MS medium supplemented with 1.0 or 1.5 mg/l TDZ and Festival cultured on MS medium supplemented with 1.0 mg/l TDZ. The higher shoot proliferation in Chandler might be due to genetical effect (Passey *et al*., 12). MS medium supplemented with 1 mg/l TDZ resulted in maximum shoot proliferation. This is because TDZ devises a dual role, since it is a substituted phenylurea with cytokinin and auxin-like effects. Similarly, the response in this finding might be due to the accumulation of cytokinin, which was in consistent with the findings of Hare and Staden (7) in which they reported that TDZ has a capacity to inhibit the action of cytokinin oxidase. Thomas and Puthur (15) regarded TDZ as a highly efficacious bioregulator for morphogenesis in the tissue culture of several plant species and suggested that TDZ induces shoot regeneration better than other cytokinins. Furthermore, Huettman and Preece (8) described TDZ as the most potent currently available cytokinin-like substance in the tissue culture of woody plants. Similarly, the result in the present investigation also indicated that low concentration of TDZ proved more effective for shoot proliferation.

Significant effect of growth regulators, cultivars and their interaction for number of days taken to shoot initiation ($p \leq 0.05$) was observed (Table 2). Chandler took significantly less time to shoot initiation (8.72 days), which was *at par* with Festival (8.97 days). With respect to growth regulators, it was observed

Table 1. Effect of plant growth regulators on shoot proliferation (%) in different strawberry cultivars.

Treatment (mg/l)	Festival	Chandler	Selva	Seascape	Sweet Charlie	Mean
Control	40.00 (39.18)*	50.00 (45.00)	30.00 (33.09)	30.00 (33.09)	30.00 (33.09)	36.00 (36.69)
BA 0.5	70.00 (56.91)	80.00 (63.73)	60.00 (50.86)	40.00 (39.18)	40.00 (39.18)	58.00 (49.97)
BA 1.0	80.00 (63.74)	80.00 (63.74)	70.00 (56.91)	60.00 (50.86)	60.00 (50.86)	70.00 (57.23)
BA 1.5	90.00 (73.45)	100.00 (89.09)	90.00 (73.45)	70.00 (56.91)	60.00 (50.86)	82.00 (68.75)
BA 2.0	80.00 (63.74)	90.00 (73.45)	70.00 (56.91)	60.00 (50.86)	50.00 (45.00)	70.00 (57.99)
BA 0.5 + GA 0.5	70.00 (56.91)	70.00 (56.91)	50.00 (45.00)	50.00 (45.00)	40.00 (39.18)	56.00 (48.61)
BA 0.5 + GA 1.0	70.00 (56.91)	70.00 (56.91)	50.00 (45.00)	50.00 (45.00)	50.00 (45.00)	58.00 (49.77)
BA 1.0 + GA 0.5	70.00 (56.91)	80.00 (63.74)	60.00 (50.86)	60.00 (50.86)	50.00 (45.00)	64.00 (53.48)
BA 1.0 + GA 1.0	80.00 (64.03)	90.00 (73.45)	70.00 (56.91)	60.00 (50.86)	60.00 (50.86)	72.00 (59.22)
BA 1.5 + GA 0.5	90.00 (73.45)	100.00 (89.09)	80.00 (63.74)	70.00 (56.91)	70.00 (56.91)	82.00 (68.02)
BA 1.5 + GA 1.0	90.00 (73.45)	90.00 (73.45)	80.00 (63.74)	70.00 (56.91)	60.00 (50.86)	78.00 (63.69)
BA 2.0 + GA 0.5	80.00 (63.73)	80.00 (63.74)	70.00 (56.91)	60.00 (50.86)	60.00 (50.86)	70.00 (57.22)
BA 2.0 + GA 1.0	70.00 (56.91)	80.00 (63.74)	70.00 (56.91)	50.00 (45.00)	50.00 (45.00)	64.00 (53.51)
TDZ 0.5	80.00 (63.74)	80.00 (63.74)	70.00 (56.91)	70.00 (56.91)	50.00 (45.00)	70.00 (57.25)
TDZ 1.0	100.00 (89.09)	100.00 (89.09)	80.00 (63.74)	80.00 (63.74)	80.00 (63.74)	88.00 (73.88)
TDZ 1.5	90.00 (73.45)	100.00 (89.09)	80.00 (63.74)	70.00 (56.91)	60.00 (50.86)	80.00 (66.82)
TDZ 2.0	80.00 (63.74)	90.00 (73.45)	70.00 (56.91)	70.00 (56.91)	70.00 (12.08)	76.00 (52.61)
Mean	78.24 (64.08)	84.12 (70.09)	67.65 (55.97)	60.00 (50.99)	55.29 (45.55)	
$CD_{0.05}$	Plant growth regulator (PGRs) = 3.36, Cultivar (C) = 1.82, PGR × C = 7.54					

*Parenthesis data indicates Arc Sine transformed value.

that medium supplemented with 1.0 mg/l TDZ showed significantly less number of days (7.50 days) to shoot initiation, which was *at par* with 1.5 mg/l TDZ (7.60 days). Whereas, maximum number of days taken for shoot initiation was observed in control. The interaction effects of cultivar and growth regulator for days taken to shoot initiation exhibited non-significant difference. The variation among cultivars for number of days taken to shoot initiation might be due to genetic constitution of the cultivar. The regenerants induced from lower TDZ levels developed shoot and grew faster than those obtained from higher concentrations has also been reported (Lata *et al*., 9).

Number of shoots per explant was significantly influenced by cultivars, growth regulators and their interactions (Table 3). Among cultivars, number of shoots per explant was significantly more in Chandler (4.74) followed by Festival (4.34). Regarding growth regulators, 1.0 mg/l TDZ showed significantly higher number of shoots (6.36) per explant followed by 1.5 mg/l TDZ (5.68), which was at par with 0.5 mg/l TDZ (5.54). Genotypic interactions with growth regulators revealed that nodal cultures of Chandler produced the highest number of shoots (7.00) on medium supplemented with 1.0 mg/l TDZ, which was at par with Festival (6.40) in the same media composition. Mir *et al.* (10) also reported that Chandler recorded maximum regeneration, number of shoots, frequency of rooting, number of roots and roots length compared to other cultivars.

A significant difference among cultivars, growth regulators and their interactions was observed for length of shoots (Table 4). Among cultivars, Chandler gave the maximum shoot length (3.36 cm) followed by Festival (2.99 cm). With respect to growth regulators, medium containing 1.5 mg/l BA + 0.5 mg/l GA showed the maximum shoot length (4.52 cm) followed by 1.5 mg/l BA + 1 mg/l GA (4.21 cm). The interaction effect of cultivar and growth regulator showed that Chandler on medium supplemented with 1.5 mg/l BA + 0.5 mg/l GA produced maximum shoot length (5.20 cm) followed by Chandler (4.76 cm) on 1.5 mg/l BA + 1 mg/l GA and Festival (4.76 cm) on 1.5 mg/l BA + 0.5 mg/l GA. Mir *et al.* (12) found that Chandler produced maximum root length among cultivars. Combination of BA and GA supplied to the medium resulted in longer shoot length compared to BAP alone or TDZ. This might be because GA helps in stem elongation as reported by Sakila *et al*. (14). Furthermore, Tomsone *et al*. (16) has also reported that TDZ treatment resulted in the development of a number of short shoots and suggested that TDZ efficiently stimulated direct

Table 2. Effect of plant growth regulators on number of days taken to shoot initiation in different strawberry cultivars.

Treatment (mg/l)	Festival	Chandler	Selva	Seascape	Sweet Charlie	Mean
Control	11.00	10.50	11.40	11.90	12.00	11.36
BA 0.5	9.50	9.20	10.30	10.60	10.70	10.06
BA 1.0	9.20	8.90	10.20	10.40	10.50	9.84
BA 1.5	8.40	8.00	8.50	8.60	8.80	8.46
BA 2.0	9.00	8.90	9.50	9.60	9.70	9.34
BA 0.5 + GA 0.5	9.60	9.50	10.60	10.60	10.60	10.18
BA 0.5 + GA 1.0	9.50	9.40	10.40	10.50	10.60	10.08
BA 1.0 + GA 0.5	9.30	9.10	9.90	10.00	10.00	9.66
BA 1.0 + GA 1.0	8.70	8.50	8.90	9.20	9.30	8.92
BA 1.5 + GA 0.5	8.30	8.00	8.40	8.50	8.60	8.36
BA 1.5 + GA 1.0	8.70	8.40	9.00	9.20	9.30	8.92
BA 2.0 + GA 0.5	9.50	9.20	10.20	10.40	10.60	9.98
BA 2.0 + GA 1.0	10.10	9.90	10.80	10.90	11.00	10.54
TDZ 0.5	8.40	8.20	8.60	8.70	8.70	8.52
TDZ 1.0	7.40	7.10	7.50	7.70	7.80	7.50
TDZ 1.5	7.60	7.30	7.70	7.70	7.70	7.60
TDZ 2.0	8.30	8.10	8.50	8.60	8.70	8.44
Mean	8.97	8.72	9.44	9.59	9.68	9.28
$CD_{0.05}$	Plant growth regulator (PGR) = 0.51, Cultivar (C) = 0.27, PGR × C = NS					

NS = Non-significant

Table 3. Effect of plant growth regulators on number of shoots after 21 days of culture in different strawberry cultivars.

Treatment (mg/l)	Festival	Chandler	Selva	Seascape	Sweet Charlie	Mean
Control	2.10	2.30	1.60	1.80	1.70	1.90
BA 0.5	3.20	3.60	3.10	3.00	3.00	3.18
BA 1.0	4.50	5.00	4.40	4.40	4.40	4.54
BA 1.5	5.90	6.30	5.80	5.80	5.80	5.92
BA 2.0	4.60	5.00	4.50	4.40	4.30	4.56
BA 0.5 + GA 0.5	3.10	3.50	3.10	3.00	3.00	3.14
BA 0.5 + GA 1.0	3.20	3.70	3.10	3.10	3.10	3.24
BA 1.0 + GA 0.5	3.80	4.10	3.70	3.50	3.50	3.72
BA 1.0 + GA 1.0	4.20	4.50	4.00	3.90	3.80	4.08
BA 1.5 + GA 0.5	5.20	5.50	5.00	4.90	4.80	5.08
BA 1.5 + GA 1.0	4.50	4.80	4.30	4.10	3.90	4.32
BA 2.0 + GA 0.5	3.90	4.20	3.70	3.50	3.40	3.74
BA 2.0 + GA 1.0	3.30	3.60	3.10	3.00	3.00	3.20
TDZ 0.5	5.60	5.90	5.50	5.40	5.30	5.54
TDZ 1.0	6.40	7.00	6.20	6.10	6.10	6.36
TDZ 1.5	5.60	6.20	5.60	5.50	5.50	5.68
TDZ 2.0	4.70	5.30	4.70	4.40	4.30	4.68
Mean	4.34	4.74	4.20	4.11	4.05	
$CD_{0.05}$	Plant growth regulator (PGR) = 0.31, Cultivar (C) = 0.17, PGR × C = 0.68					

Table 4. Effect of plant growth regulators on shoot length (cm) of explants after 21 days of culture in different strawberry cultivars.

Treatment (mg/l)	Festival	Chandler	Selva	Seascape	Sweet Charlie	Mean
Control	0.91	1.06	0.8	0.73	0.72	0.84
BA 0.5	1.24	1.63	1.02	1.02	1.01	1.18
BA 1.0	2.21	2.42	2.18	2.15	2.09	1.21
BA 1.5	3.11	3.47	3.04	2.99	2.97	3.12
BA 2.0	2.21	2.72	2.05	1.95	1.92	2.17
BA 0.5 + GA 0.5	2.77	3.10	2.55	2.28	2.09	2.56
BA 0.5 + GA 1.0	3.17	3.64	3.00	2.89	2.88	3.12
BA 1.0 + GA 0.5	3.54	4.00	3.20	3.12	3.07	3.39
BA 1.0 + GA 1.0	4.10	4.43	4.00	3.91	3.90	4.07
BA 1.5 + GA 0.5	4.76	5.2	4.30	4.17	4.15	4.52
BA 1.5 + GA 1.0	4.21	4.77	4.07	4.02	4.00	4.21
BA 2.0 + GA 0.5	3.60	4.10	3.26	3.14	3.09	3.44
BA 2.0 + GA 1.0	3.18	3.66	3.03	2.90	2.88	3.13
TDZ 0.5	3.08	3.25	3.00	2.98	2.97	3.06
TDZ 1.0	3.50	4.01	3.20	3.11	3.09	3.38
TDZ 1.5	3.06	3.27	3.00	2.90	2.87	3.02
TDZ 2.0	2.20	2.41	2.05	2.01	2.00	2.13
Mean	2.99	3.36	2.81	2.72	2.69	
$CD_{0.05}$	Plant growth regulator (PGR) = 0.10, Cultivar (C) = 0.06, PGR × C = 0.23					

adventitive shoot regeneration from explants, but inhibited shoot elongation.

The *in vitro* culture efficacy among different strawberry genotypes with respect to rooting responses was significantly influenced by IBA concentrations and their interactions (Table 5). Chandler gave maximum rooting (92.0%) response, which was *at par* with Festival (90.0%). It was also observed that 1.0 mg/l IBA supplied to the medium gave highest rooting (98.0%) followed by 0.5 mg/l IBA (90.0%). Genotypic interaction with IBA concentration revealed that Chandler gave cent per cent rooting in IBA (0.5, 1 and 1.5 mg/l), which were at par with Festival in IBA (0.5 and 1 mg/l) treatments. While, minimum rooting percentage was observed in Sweet Charlie and Seascape under basal medium. Media supplemented with 1.0 mg/l IBA resulted in maximum rooting percentage over other levels of IBA. This result is in accordance with the findings of Ritu *et al*. (13) on strawberry cv. Chandler.

Data on number of days to root formation showed that cultivars response was significantly influenced by IBA concentrations (Table 6). Among cultivars, Chandler recorded minimum number of days (11.36) taken to root formation followed by Festival (11.90). With respect to IBA concentrations, it was observed that medium supplemented with 1.0 mg/l IBA showed the minimum (9.82 days) time to root formation, which was *at par* with 1.5 mg/l IBA (9.92 days). Minimum days taken for root formation by Chandler might be attributes to its genetic feature and addition of 1.5 mgl^{-1}IBA resulted in faster root initiation.

Cultivar, IBA concentration and their interactions had significant effect on number of roots per micro-cutting (Table 7). The maximum number of roots per micro-cutting was recorded in Chandler (3.78) followed by Festival (3.30). Among IBA concentrations, medium supplemented with 1.0 mg/l IBA resulted in highest number of roots (4.88) followed by 1.5 mg/l IBA (3.85). The interaction between cultivar and IBA concentration showed that Chandler in medium supplemented with 1.0 mg/l IBA recorded maximum number of roots per micro-cutting (5.50), which was at par with Festival in 1.0 mg/l IBA. These results are in corroboration of findings of Ritu *et al*. (13) who observed that IBA was best to produce maximum biomass, which was due to more number of roots.

Chandler accounted for the maximum root length (2.38 cm) of micro-cuttings followed by Festival (2.16 cm). The root length of micro-cuttings among IBA concentrations recorded the maximum (3.12 cm) with 1.0 mg/l IBA, which was significantly better over

other IBA concentrations. In the interaction effects, maximum root length was obtained in Chandler at 1.0 mg/l IBA (3.47 cm), which was at par with Festival (3.25 cm) on the same medium composition (Table 8). The variation in root characters could be due to variation in genetic makeup amongst cultivars and stimulation for root initiation and root growth may be due to IBA resulting in maximum root length.

Table 5. Effect of IBA on rooting in different strawberry cultivars.

Conc. (mg/l)	Festival	Chandler	Selva	Seascape	Sweet Charlie	Mean
IBA 0.0	70.00 (57.51)*	70.00 (57.51)	60.00 (50.86)	50.00 (45.00)	50.00 (45.00)	60.00 (51.17)
IBA 0.5	100.00 (89.09)	100.00 (89.09)	90.00 (73.45)	80.00 (63.74)	80.00 (63.74)	90.00 (75.81)
IBA 1.0	100.00 (89.09)	100.00 (89.09)	100.00 (89.09)	100.00 (89.09)	90.00 (73.45)	98.00 (85.96)
IBA 1.5	90.00 (73.45)	100.00 (89.09)	80.00 (63.74)	70.00 (57.51)	70.00 (57.51)	82.00 (68.26)
IBA 2.0	90.00 (73.45)	90.00 (73.45)	80.00 (63.74)	70.00 (57.51)	60.00 (50.86)	78.00 (63.80)
Mean	90.00 (76.52)	92.00 (79.65)	82.00 (68.17)	74.00 (62.57)	70.00 (58.11)	
$CD_{0.05}$	IBA concentration (I) = 3.69, Cultivar (C) = 3.71, I × C = 8.27					

*Transformed data

Table 6. Effect of IBA on number of days to root formation in different strawberry cultivars.

Conc. (mg/l)	Festival	Chandler	Selva	Seascape	Sweet Charlie	Mean
IBA 0.0	16.10	15.38	16.47	16.60	16.78	16.28
IBA 0.5	12.69	12.00	12.90	12.90	12.90	12.68
IBA 1.0	9.81	9.31	10.03	10.01	10.00	9.82
IBA 1.5	9.92	9.40	10.10	10.10	10.10	9.92
IBA 2.0	11.02	10.68	11.19	11.30	11.60	11.16
Mean	11.90	11.36	12.14	12.18	12.28	11.97
$CD_{0.05}$	IBA Concentration (I) = 0.46, Cultivar (C) = 0.46, I × C = NS					

NS = Non-significant

Table 7. Effect of IBA on number of roots per after 4 weeks of subculture in different strawberry cultivars.

Conc. (mg/l)	Festival	Chandler	Selva	Seascape	Sweet Charlie	Mean
IBA 0.0	1.50	1.80	1.40	1.40	1.40	1.50
IBA 0.5	3.00	3.60	3.00	2.80	2.80	3.04
IBA 1.0	5.00	5.50	4.80	4.60	4.50	4.88
IBA 1.5	4.00	4.40	3.70	3.60	3.50	3.84
IBA 2.0	3.00	3.60	2.90	2.70	2.70	2.98
Mean	3.30	3.78	3.16	3.02	2.98	3.25
$CD_{0.05}$	IBA Concentration (I) = 0.29, Cultivar (C) = 0.29, I × C = 0.65					

Table 8. Effect of IBA on root length (cm) after 4 weeks of subculture in different strawberry cultivars.

Conc. (mg/l)	Festival	Chandler	Selva	Seascape	Sweet Charlie	Mean
Control	0.92	1.07	0.82	0.75	0.74	0.86
IBA 0.5	2.00	2.20	1.91	1.86	1.81	1.96
IBA 1.0	3.25	3.47	3.02	2.97	2.91	3.12
IBA 1.5	2.62	2.97	2.48	2.45	2.43	2.59
IBA 2.0	2.00	2.18	1.90	1.85	1.81	1.95
Mean	2.16	2.38	2.03	1.98	1.94	2.10
$CD_{0.05}$	IBA concentration (I) = 0.09, Cultivar (C) = 0.10, I × C = 0.23					

Based on the overall performance of the cultivars on the medium supplemented with various growth regulators, it can be concluded that Chandler showed higher efficiency for shoot induction and proliferation compared to other cultivars when medium was supplemented with 1.0 mg/l TDZ and 1.0 mg/l IBA for better response to rooting.

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