Effect of various concentrations of agar and sucrose on growth and tuberization of four Potato (*Solanum tuberosum* L.) varieties under *in vitro, invivo* conditions

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Abstract:

The study tends to evaluate the effect of different concentrations of agar treatment (5, 7, and 9 $g.l^{-1}$) with sucrose (20, 30, and 40 $g.l^{-1}$) on *in vitro* shoot regeneration and rooting in one step using tuber-eyes and node explants of four potatoes (*Solanum tuberosum* L) varieties "Sagitta, Challenger, SM 13–132– 05 and Taurus", and minitubers production under greenhouses conditions which are going to be grown in Kurdistan -Iraq. The results showed that SM 13–132– 05 cultivar was superior upon the other cultivars under *in vitro* conditions through multiplication tests (Agar concentration 7 $g.l^{-1}$ and sucrose concentration 30 $g.l^{-1}$) and greenhouse conditions by producing the highest shoot multiplication (3.17 shoots/ explant, 12.84 leaves/ explant and 14.51cm mean length of roots) and the best number of minitubers (5.72 minitubers/ plantlet) in greenhouse. Whereas, Challenger had the lowest number of minitubers (3.75/ plantlet). On the other hand, there was no significant differences in the effect of the different concentrations of Agar and sucrose on the four cultivars in terms of the rooting percentage.

Keywords: Potato, PGRs, disinfection, acclimatization, potato minitubers.

Introduction

Potato (*Solanum tuberosum* L.) is going under the Solanaceae family and can be classified as an annual solanaceous plant that comes from the Andes (14). Its global production is estimated at 359,071,403 metric tons in 2020 (17). Potato plants can be propagated normally either sexually by botanical seeds or asexually by planting tubers (underground stem) (15). Potato is considered one of the most important and such commercial products in many countries (9). This is due to its measured as one of the most significant plants that can answer the growing hunger problem all over the world. Moreover, potatoes are a vital food-security crop and cereal crop alternative owing to their high production and nutritional content (3). So, it is a multiuse product and is the 4th following wheat, rice, and maize (1). Nowadays, Potato is cultivated in more than 150 countries, and studies and research are continuously done to enhance their production (4).

In Kurdistan region of Iraq generally and Duhok governorate especially, potato is widely cultivated, and it can be planted in both spring and fall seasons (10). Its production has increased dramatically since the first decade of the twenty-first century; this is coming back to many reasons such as the favorable climate and soil fertility which offer ideal conditions for the best potato production (20).

As has been mentioned perversely, potato propagation, either in a sexual or asexual way may cause several systemic bacteria, fungi, and virus infections that led to degeneration in the plants). This will lead to yield decreasing with large amounts of losses (10). Therefore, using virus-free propagative materials, with high phytosanitary, functional, and genetic quality is measuring of great value in order to ensure that the potato plant is expressing its maximum yield production (16). Due to this, the technique of plant tissue culture (*in vitro* culture) techniques and their practical applications have been applied to potato plant production in order to create a large number of clones from a single seed or explants in a short period of time, select desirable traits, eradicate plant diseases using sterile methods and careful selection (2). Additionally, this aids in the expert propagation of valuable genetic material, germplasm preservation, creation of virus-free plants, and breeding (8).

The first paper on potato micropropagation to be published was written by Steward and Caplin (12). After that, hundreds of further research publications were created and published (13). *In vitro* propagation is viewed as an alternative to traditional methods of potato propagation (5), which are carried out specifically by seed tubers, segments of tubers, and occasionally seeds in a vegetative manner. However, techniques of *in vitro* propagation beginning from meristem tips, nodal segments, or microtubers are more dependable for preserving the genotypes' multiplied germplasm (15). According to Hoque (7), Everson and Renan created a procedure for propagating potatoes in liquid culture media using various combinations of growth regulators and demonstrated high efficacy of the potato micropropagation under continual agitation conditions (12). Regarding agar and sucrose, Agar is also confirmed as one of the best gelling agents for use in the creation of tissue culture medium. In plant tissue culture, it serves as a supportive agent. Due to its contribution to the availability of water and dissolved chemicals that affect the growth of different explants (18). In 1978, (19) disclosed a technique for quickly multiplying potatoes when single node explants were grown on agar-solidified or liquid MS media with 2% sucrose and 2.0 mg/l Ca pantothenate, and the same results were confirmed by Hossain and sucrose is frequently utilized as the primary ingredient to enrich culture media (6).

This study was carried out to evaluate the effect of agar and sucrose at different concentrations on *in vitro* shoot regeneration and rooting formation of four potato varieties, and the *ex vitro* production of minitubers during acclimatization in potting media under greenhouse conditions.

Materials and Methods

Plant materials

Throughout the study, four potatoes cultivars "Sagitta, Challenger, SM13–132–05, and Taurus" were selected to examine their micro-propagation performance under selected concentrations and combinations of agar and sucrose in the plant tissue culture laboratories - Department of Horticulture, College of Agricultural Engineering Sciences, Duhok University, Kurdistan region of Iraq. After the tubers got sprouted, the explants fresh and disease-free were taken from different parts of the plant including tuber eyes and nodes about 2.0 to 2.5 cm long (figure 1).

After removal, the sprouts were surface cleaned by putting in a glass jar and washing them with tap water and washing detergent agents after covering them with a piece of cloth for nearly 20 minutes in order to eliminate all possibly attached dust and germs with 2-3 drops of tween-80 as a surfactant agent catalyst which helps the substance stick to the surfaces of the explants. The sprouts were then put into a beaker with a wide mouth capacity of 250 ml. After primary sterilization, the sterilized explants were moved inside the laminar airflow cabinet. Next, (inside the Air-flow cabinet) the explants were treated with different concentrations and durations of sodium hypochlorite (NaOCl) diluted to 50% with distilled and sterilized water. Then, also treated with 70% Ethanol. Finally, they were washed 3 to 4 times with sterilized distilled water to get rid of the remnants of suspended materials. The disinfected sprouts were placed in a 9 cm Petri dish and covered. Young, healthy micro shoots were cultured on the culture initiation medium on a shoot multiplication, full-strength MS basal medium containing various concentrations of BA (0, 1, 2, 3, 4 $mg.l^{-1}$) and kinetin (0, 1, 2, 3, 4 $mg.l^{-1}$), and Agar treatment (5, 7 and 9 $g.l^{-1}$) with Sucrose (20, 30 and 40 $g.l^{-1}$). Three shoots for each cultivars (Sagitta, Challenger, SM 13–132– 05, and Taurus) were inoculated per jar with five replications for each treatment. After two weeks, the shoots have been aseptically removed and inoculated onto the medium for multiplication. In the chambers of the growth rooms, culture vessels were dispersed at random after being properly labeled and sealed. At certain intervals, the development of shoots at various stages of multiplication has been monitored. After four weeks in culture, the number of shoots, mean length of shoots, and the number of leaves were recorded as shoot multiplication parameters (figure 2). Also, the number of roots, mean length of roots, and root percentage were recorded as rooting formation parameters.

The well-rooted plantlets of about 6-8 cm in height were ready for transplanting. Then, after being removed from culture flasks, the healthy potato plantlets or rooted plantlets were taken to be transferred into the open air in the lab, and their roots were rinsed with distilled water and placed in Benlate fungicide (0.05%) for 5 minutes to prevent fungus infections. The plantlets were placed in containers that measured 8x8x10 cm and contained peat moss. Pots were kept in controlled environments for five days while being incubated in clear plastic containers. A fertilizer solution containing ¼ strength of MS salts was sprayed on the plantlets. After 5 days, the plastic container was opened to be developed under ordinary greenhouse conditions. After 75 days, the plants were harvested and the number of minitubers per

plant, the weight of each minituber, and the total amount of minitubers were recorded as harvesting parameters (figure 3). The experiment was arranged as CRD (complete randomized design) and the comparison between means was done by Duncan's multiple range test (SAS, 2013).

Results and Discussion

Explants' disinfestation efforts were exceedingly successful, as evidenced by the cultures' 100% survival rate in the absence of any contamination. Thus, the healthy cultures were quickly transferred to the stage of shoot multiplication.

Table (1) clearly shows that MS 13-132-05 variety grown on MS medium solidified with 7 $g.l^{-1}$ agar and enriched with 30 $g.l^{-1}$ sucrose was significantly superior to the other varieties by expressing the greatest number of shoots/ explant (3.175), and the least number of shoots was given by Sagitta cultivar when Agar 5 $g.l^{-1}$ and sucrose 20 $g.l^{-1}$ which recorded 0.415 shoots/ explant. Regarding the variety effect loneliness, MS 13-132-05 was significantly superior to other varieties by giving the highest number of shoots/ explant (1.529). Agar concentration of 7 $g.l^{-1}$ and sucrose concentration of 30 $g.l^{-1}$ was superior to the others which recorded (1.605 and 1.574 respectively). Table (2) visibly indicates that both MS 13-132-05 and Taurus cultivars grown on MS medium solidified with 7 $g.l^{-1}$ agar and enriched with 30 g.l-^{1} sucrose were significantly superior upon the other varieties by giving the highest number of leaves/ explant (12.841 and 12.778 respectively), and the least number of leaves was given by Sagitta cultivar when Agar 7 g.l-1 and sucrose 20 $g.l^{-1}$ which recorded 3.858 leaves/ explant. Regarding the variety effect lonely, Challenger was significantly superior to other varieties by giving the highest number of leaves/ explant (7.647). Agar concentration of 7 $g.l^{-1}$ and sucrose concentration of 30 $g.l^{-1}$ was superior to the others recorded (8.293 and 8.559 respectively). Table (3) clearly demonstrates that MS 13-132-05 variety grown on MS medium solidified with 7 $g.l^{-1}$ agar and enriched with 30 g.l-1 sucrose was significantly superior to the other varieties by giving the highest mean length of shoots/ explant (6.512cm), and the least mean length of shoots was given by Sagitta cultivar when sucrose 20 $g.l^{-1}$ and Agar 5 $g.l^{-1}$ and 7 $g.l^{-1}$ which recorded 1.675cm and 1.716cm respectively. Regarding the variety effect loneliness, MS 13-132-05 was significantly superior to other varieties by giving the highest mean length of shoots/ explant (4.781cm). Agar concentration 7 $g.l^{-1}$ and sucrose concentration 30 $g.l^{-1}$ was superior to the others recorded (3.740 cm and 4.034 cm respectively).

The following results belong to the multiplication test and have compatibility with others got by Milinkovic *et. al.,* (2012) who reported that sucrose 30 g l^{-1} and agar 6–8 g l^{-1} is the most communal nutrient medium for *in vitro* potato micropropagation.

In Table (4), it can be clearly seen that both the Sagitta variety grown on MS medium solidified with 7 $g.l^{-1}$ agar and enriched with 30 $g.l^{-1}$ sucrose and MS 13-132-05 variety grown on MS medium solidified with 5 g.l-1 agar and enriched with 20 g.l-1 sucrose were significantly superior upon the other varieties by giving the highest number of roots/ explant (14.525 and 13.425 respectively), and the least number of roots was given by Challenge cultivar when Agar 7 $g.l^{-1}$ and sucrose 20 $g.l^{-1}$ which recorded 4.500 roots/ explant. Regarding the variety effect loneliness, MS 13-132-05 was significantly superior to other varieties by giving the highest number of roots/explants (8.627). Agar concentration of 7 $g.l^{-1}$ and sucrose concentration of 30 $g.l^{-1}$ was superior to the others which recorded (8.811 and 8.625 respectively). Table (5), shows that both Sagitta and MS 13-132-05

varieties grown on MS medium solidified with 7 $g.l^{-1}$ agar and enriched with 30 $g.l^{-1}$ sucrose were significantly superior to the other varieties by giving the highest mean length of roots/ explant (15.007 cm and 14.515cm respectively), and the least mean length of roots was given by Taurus cultivar when Agar 7 $g.l^{-1}$ and sucrose 20 $g.l^{-1}$ which recorded 4.257cm. Regarding the variety effect loneliness, MS 13-132-05 was significantly superior to other varieties by giving the highest mean length of roots/ explant (8.694cm). Agar concentration 7 $g.l^{-1}$ and sucrose concentration 30 $g.l^{-1}$ were superior to the others which recorded (at 8.995cm and 9.393cm respectively).

Table (6), shows that there were no significant differences in the effect of the different concentrations of each Agar and sucrose on the four cultivars in terms of the rooting percentage. These results were in agreement with once got by Toam (2022) who presented that potato is well known to be easy in rooting when nodal segments are cultured on MS media free of growth hormones. Additionally, according to Venkatasalam *et al* (18), agar is regarded as one of the best gelling agents for use in the creation of tissue culture medium. It serves as a supportive agent and contributes to the availability of water and dissolved chemicals that affect the growth of different explants. While, sucrose is frequently utilized as the primary ingredient to enrich culture media (11). After the well grown potato plantlets (6 - 8 cm in height) were taken to be transferred into the out-air conditions in the lab after removing them from culture flasks and treated with Benlate fungicide (0.05%), the plantlets were planted in pots containing peat moss. Pots had been incubated in transparent plastic containers for five days and placed under controlled conditions. The polyethylene cover was removed after five days so that it could be developed in a typical greenhouse environment. Table (7) showed that SM13-132-05 cultivar was superior upon other cultivars by giving the largest number of minitubers/ plant (5.71). whereas, Challenger had the lowest number of minitubers (3.75). On the other hand, Sagitta, Challenger and SM13-132-05 cultivars were significantly superior upon Taurus cultivar in mean weight.

Figure (1): Initiation stage of potato plant
A- Initially sprouted tubers ready to excise the explants, B- Initiation stage

Figure (2): plantlets after 30 days of cultivation in culture medium

Figure (3): Minitubers production under greenhouses conditions (after 75 days of cultivation in peatmoss)

Table 1. The response of different potato varieties to agar and sucrose concentrations on the number of shoots/ explant after four weeks in culture on MS medium (v=variety)

variety	Agar	sucrose			V* Agar	Mean variety
		20	30	40		
Sagitta	5	0.415 g	0.915 d-g	0.917 d-g	0.75 f	1.036 c
	7	0.751 fg	2.499 b	0.917 d-g	1.39 bc	
	9	1.083 c-f	0.830 efg	1.000 c-f	0.97 ef	
Challenger	5	1.083 c-f	1.000 c-f	1.000 c-f	1.03 e	1.185 b
	7	1.000 c-f	2.333 b	1.083 c-f	1.47 bc	
	9	1.000 c-f	1.000 c-f	1.167 c-f	1.06 ed	
SM 13–132– 05	5	1.250 c-f	1.358 cde	1.166 c-f	1.26 bcd	1.529 a
	7	1.500 c	3.175 a	1.308 cde	1.99 a	
	9	1.333 cde	1.417 cd	1.250 c-f	1.33 bcd	
Taurus	5	0.917 d-g	0.917	1.333 cde	1.06 ed	1.234 b
	7	1.167 c-f	2.358 b	1.167 c-f	1.56 b	
	9	1.000 c-f	1.083 c-f	1.167 c-f	1.08 ed	
mean sucrose		1.042 b	1.574 a	1.123 b	mean Agar	
V * sucrose		0.750 e	1.415 b	0.944 de		
		1.028 cd	1.444 b	1.083 cd		
		1.361 b	1.983 a	1.241 bc		
		1.028 cd	1.453 b	1.222 bcd		
Agar* sucrose	5	0.916 b	1.048 b	1.104 b	5	1.023 b
	7	1.104 b	2.591 a	1.119 b	7	1.605 a
	9	1.104 b	1.083 b	1.146 b	9	1.111 b

Table 2. The response of different potato varieties to agar and sucrose concentrations on the number of leaves/ explant after four weeks in culture on MS medium(v=variety)

variety	Agar	sucrose			V* Agar	Mean variet
		20	30	40		
Sagitta	5	2.7833 p	7.1675 e-j	7.2000 e-j	5.7169 g	6.25231 b
	7	3.8583 o	10.3333 c	5.7508 lmn	6.6475 ef	
	9	6.4833 h-l	4.8600 n	7.8342 def	6.3925 f	
Challenger	5	7.9158 de	7.6658 efg	7.7000 efg	7.7606 c	7.64722 a
	7	7.5417	11.2917 b	6.7833 f-l	8.5389 b	
	9	6.3667 i-l	6.1167 j-m	7.4433 e-i	6.6422 ef	
SM 13–132– 05	5	7.2417 e-i	7.6833 efg	6.9158 e-k	7.2803 cd	7.71583 a
	7	6.7375 f-l	12.8417 a	6.8042 e-l	8.7944 ab	
	9	6.6583 g-l	6.7800 f-l	7.7800 d-g	7.0728 de	
Taurus	5	5.1942 mn	7.3600 e-i	8.7767 d	7.1103 de	7.78074 a
	7	7.6667 efg	12.7783 a	7.1375 e-j	9.1942 a	
	9	7.4167 e-i	7.8333 def	5.8633 klm	7.0378 de	
mean sucrose		6.3220 c	8.5593 a	7.1658 b	mean Agar	
V * sucrose		4.3750 e	7.4536 c	6.9283 cd		
		7.2747 cd	8.3581 b	7.3089 cd		
		6.8792 cd	9.1017 a	7.1667 cd		
		6.7592 d	9.3239 a	7.2592 cd		
Agar* sucrose	5	5.7838 d	7.4692 b	7.6481 b	5	6.9670 b
	7	6.4510 c	11.8113 a	6.6190 c	7	8.2938 a
	9	6.7313 c	6.3975 c	7.2302 b	9	6.7863 b

Table 3. The response of different potato varieties to agar and sucrose concentration on the mean length of shoots/ explant after four weeks in culture on MS medium(v=variety)

variety]	Agar	sucrose			V* Agar	Mean variety
		20	30	40		
Sagitta	5	8.2500 c-f	7.6500 e-h	4.7500 lm	6.8833 cd	7.63472 b
	7	4.4875 m	14.5250 a	8.5250 cde	9.1792 a	
	9	5.9500 i-l	5.9000 i-l	8.6750 cde	6.8417cd	
Challenger	5	11.3500 b	5.7750 i-m	5.8250 i-m	7.6500 b	6.68611 c
	7	4.5000 m	8.1500 d-g	7.1250 f-i	6.5917d	
	9	5.4250 klm	5.6000 j-m	6.4250 h-k	5.8167 e	
SM 13–132– 05	5	13.4250 a	8.5100 cde	5.4500 klm	9.1283 a	8.62750 a
	7	5.3000 klm	12.0500 b	11.5500 b	9.6333 a	
	9	5.4500klm	8.9125 cde	7.0000 f-i	7.1208 bcd	
Taurus	5	9.2000 cd	6.9075 g-j	6.1175i-l	7.4083 bc	7.68833 b
	7	6.3350 ijk	13.6550 a	9.5350 c	9.8417 a	
	9	5.9525 i-l	5.8750 i-l	5.6175 j-m	5.8150 e	
mean sucrose		7.1354 b	8.6258 a	7.2163 b	mean Agar	
V * sucrose		6.2292 f	9.3583 ab	7.3167 d		
		7.0917 ed	6.5083 ef	6.4583ef		
		8.0583 c	9.8242 a	8.000 cd		
		7.1625 ed	8.8125 b	7.0900 ed		
Agar* sucrose	5	10.5563 b	7.2106 d	5.5356 f	5	7.7675 b
	7	5.1556 f	12.0950 a	9.1838 c	7	8.8115 a
	9	5.6944 f	6.5719 e	6.9294 de	9	6.3985 c

variety	Agar	sucrose			V* Agar	Mean variety
		20	30	40		
Sagitta	5	1.6750 o	2.8167 k-n	2.7917 k-n	2.4278 f	2.59620 c
	7	1.7167 o	4.0417 f-i	2.8842 klm	2.8808 de	
	9	1.9950 no	2.2500 mno	3.1950 i-l	2.4800 ef	
Challenger	5	4.9417 cde	4.0742fgh	3.2500 h-k	4.0886 b	3.59083 b
	7	2.3917 m-o	3.2750 h-k	4.0067 f-i	3.2244 cd	
	9	2.8750 klm	3.1867 i-l	4.3167 def	3.4594 c	
SM 13–132– 05	5	4.8967 cde	5.0875 cd	4.9167cde	4.9669 a	4.78157 a
	7	4.1917 efg	6.5125 a	3.7900 f-j	4.8314 a	
	9	4.0833 fgh	3.9142 f-i	5.6417 bc	4.5464 a	
Taurus	5	2.8083 k-n	3.8367 f-j	3.4333 g-k	3.3594 c	3.55407 b
	7	2.7250 k-n	5.8942 ab	3.4583 h-k	4.0258 b	
	9	3.0500 j-m	3.5250 f-k	3.2558 h-k	3.2769 cd	
mean sucrose		3.1125 c	4.0345 a	3.7450 b	mean Agar	
V * sucrose		1.7956 g	3.0361 ef	2.9569 ef		
		3.4028 de	3.5119 cd	3.8578 c		
		4.3906 b	5.1714 a	4.7828 ab		
		2.8611 f	4.4186 b	3.3825 de		
Agar* sucrose	5	3.5804 cd	3.9538 bc	3.5979 cd	5	3.7107 a
	7	2.7563 f	4.9308 a	3.5348 d	7	3.7406 a
	9	3.0008 ef	3.2190 de	4.1023 b	9	3.4407 b

Table 4. The response of different potato varieties to agar and sucrose concentrations on the number of roots/ explant after four weeks in culture on MS medium(v=variety)

variety	Agar	sucrose			V* Agar	Mean variety
		20	30	40		
Sagita	5	9.1000 cd	11.1000 b	8.3500 c-g	9.5167 b	9.03194 a
	7	6.0100 j-n	15.0075a	7.3850 f-j	9.4675 b	
	9	8.7750 c-f	8.2350 c-h	7.3250 f-k	8.1117 de	
Challenger	5	8.9000 cde	8.7750 c-f	9.7250 c	9.1333 bc	8.05583 b
	7	6.8000 h-l	11.7025 b	7.3750 f-j	8.6258 cd	
	9	5.9500 j-n	7.3750 f-j	5.9000 j-n	6.4083 gh	
SM 13–132– 05	5	5.8600 k-n	7.5350 e-i	9.6000 c	7.6650 e	8.69472 a
	7	7.8525 d-i	14.5150 a	9.2350 cd	10.5342 a	
	9	8.2750 c-h	7.0150 g-l	8.3650 c-g	7.8850 gh	
Taurus	5	8.9100 cde	4.900 no	6.8825 g-l	6.8975 fg	6.67333 c
	7	4.2575 o	11.3125 b	6.4975 i-m	7.3558 ef	
	9	6.3750 i-m	5.2500mno	5.6750 lmn	5.7667 h	
mean sucrose		7.2554 c	9.3935 a	7.6929 b	mean Agar	
V * sucrose		7.9617 c	11.4475 a	7.6867 c		
		7.2167 cd	9.2842 bc	7.6667 c		
		7.3292 c	9.6883 b	9.0667 b		
		6.5142 de	7.1542 cd	6.3517 e		
Agar* sucrose	5	8.1925 bc	8.0775 bc	8.6394 b	5	8.3031 b
	7	6.2300 f	13.1344 a	7.6231 cd	7	8.9958 a
	9	7.3438 de	6.9688 de	6.8163 ef	9	7.0429 c

Table 5. The response of different potato varieties to agar and sucrose concentrations on the roots percentage/ explant after four weeks in culture on SM medium(v=variety)

variety	Agar	sucrose			V* Agar	Mean variety
		20	30	40		
Sagitta	5	100 a	100 a	100 a	100 a	100 a
	7	100 a	100 a	100 a	100 a	
	9	100 a	100 a	100 a	100 a	
Challenger	5	100 a	100 a	100 a	100 a	100 a
	7	100 a	100 a	100 a	100 a	
	9	100 a	100 a	100 a	100 a	
SM 13–132– 05	5	100 a	100 a	100 a	100 a	100 a
	7	100 a	100 a	100 a	100 a	
	9	100 a	100 a	100 a	100 a	
Taurus	5	100 a	100 a	100 a	100 a	100 a
	7	100 a	100 a	100 a	100 a	
	9	100 a	100 a	100 a	100 a	
mean sucrose		100 a	100 a	100 a	mean Agar	
V * sucrose		100 a	100 a	100 a		
		100 a	100 a	100 a		
		100 a	100 a	100 a		
		100 a	100 a	100 a		
Agar* sucrose	5	100 a	100 a	100 a	5	100 a
	7	100 a	100 a	100 a	7	100 a
	9	100 a	100 a	100 a	9	100 a

Table 6. Mean weights and Number of minitubers per plant of the tested varieties grown in peat moss under greenhouse conditions after 75 days from cultivation

Varieties	Number of Minitubers/ Plantlet	Mean Weight (g)
Sagitta	4.61 b	26.2 a
Challenger	3.75 c	25.1 a
MS 13-132-05	5.71 a	25.0 a
Taurus	4.85 b	19.4 b

Conclusion

The findings of this study suggest that the tissue culture approach could be used to locally generate potato minitubers in the Iraqi Kurdistan Region. It was discovered that the main blend of plant tissue culture can be employed for mass propagation successfully.

The formed minitubers can function successfully in the field to produce seed tubers that meet the required standards. This dependable and effective micropropagation method can be used more widely to increase local production of widely used potato cultivars, which will assist in lowering the annual import of foreign potato seed tubers. This will have a significant impact on lowering production costs and increasing the annual income of local farmers. The interesting finding was that SM 13 – 132 – 05 cultivar was superior to the other cultivars under *in vitro* (Agar concentration 7 $g.l^{-1}$ and sucrose concentration 30 $g.l^{-1}$), and greenhouse conditions by getting the

highest multiplication results in terms of shoots/ explant, number of leaves/ explant and mean length of shoots, and also the highest number of minitubers under greenhouse conditions.

Conflict of Interest

The authors have no conflict of interest.

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