Enhancing germination of kiwifruit seeds with temperature, medium and gibberellic acid

H. Çelik, H. Zenginbal, M. Özcan

Department of Horticulture, Faculty of Agriculture, University of Ondokuz Mayis, Samsun, Turkey

ABSTRACT: Germination responses to temperature, medium and gibberellic acid (GA3) treatments were studied in kiwifruit (*Actinidia deliciosa* Chev. cv. Hayward) seeds. The seeds treated with four GA3 concentrations (0, 2,000, 4,000 and 6,000 ppm) were sown in trays with peat moss, perlite + heater humus and soil mixture and subjected to the temperatures of 20°C, 25°C, 30°C and 35°C with bottom heating, under controlled conditions. All the treatments significantly affected the kiwifruit seeds germination. Seeds sown in peat moss and subjected to the temperature of 35°C with bottom heating reached the maximum germination percentage (99.17%). Peat moss and 6,000 ppm GA3 treatment also had a high germination rate (79%). Moreover, peat moss caused an earlier start of germination than the other mediums and shortened the germination period.

Keywords: kiwifruit seed; PGR; temperature; medium; germination

Kiwifruit (*Actinidia deliciosa* Chev.) is a delicious fruit and has gained a worldwide popularity in the recent past because of its wide climatic adaptability, unique blend of taste, precocity and high nutritive and medicinal values. Kiwifruit is primarily produced for the fresh fruit market and its processing is typically only a way of using rejected fruits. Due to its very high returns per unit area, the fruit growers show a keen interest in this fruit (Chandel et al. 1998; Strik, Cahn 1996). Kiwifruit can be propagated in several ways. Grafting the desired variety onto a seedling rootstock is the general commercial practice. Plants can also be grown from cuttings or by budding (Sale 1985; Lawes 1992). Moreover, *Actinidia* roots fairly readily from hardwood or softwood cuttings (Diaz Hernandez, Garcia Berrios 1997). Even if seeds are an important material for both a propagation of seedlings and breeding new kiwifruit cultivars, their germination capacity is very low (Strik, Cahn 1996). In addition, some other disadvantages in generative propagation occurred such as the impossibility of determining the sex expression of seedlings and a genetic differentiation. Seedlings have more vigorous and longer root system than plants propagated from cuttings (Ozcan 2000). Therefore the adaptation ability of kiwifruit vine obtained by grafting is better than the adaptation of plants grown from their own root system (Sale 1985; Ozcan, Erisgin 2000). Getting good bare root or container plants is essential for a good start, and so most plants are grafted on Hayward or Bruno seedling rootstock (Beutel 1990). Because of the low germination of kiwifruit seeds, they must be treated with chemicals and kept in the damp, aerated conditions under low, alternate day and night temperature to increase the germination rate (Sale 1985; Kim et al. 1988). According to the researchers, stratification under cool and moist conditions and/or gibberellic acid treatments (2.5–5.0 ppm for 24 or 10–40 ppm or 50–150 ppm for 24 h) improved the germination rate (Lawes, Anderson 1980; Ahn et al. 1984; Lawes 1992; Hasey et al. 1994; Verma et al. 1998; Ynoue et al. 1999). High concentrations of gibberellic acid treatments (2,000–6,000 ppm for 24 h) could shorten the germination period as compared to low concentrations (Lawes, Sim 1980; Sale 1985). Ozcan (2000) indicated that kiwifruit seeds stored in fruits under 0°C for a month and treated with 2,000 or 6,000 ppm gibberellic acid gave the highest germination results (35.47%). Ozcan and Erisgin (2000) also found that 2,500 ppm GA3 treatment gave a high germination rate (31.67%). Temperature (Lawes, Anderson 1980; Mattiuz et al. 1996) and germination medium (Gao et al. 1984;

Sale 1985; Hasey et al. 1994; Verma et al. 1998; Strik, Cahn 1996) also affect the germination and emergence of the kiwifruit seeds. As the kiwifruit cultivation has become an important trade in Turkey, growers needed to obtain more vines with seedling rootstocks suitable for water limited areas. The germination percentage of kiwifruit seeds was lower and there were unsatisfactory researches based on a single factor. Thus it was necessary to study a combined effect of several factors that would increase the germination of kiwifruit seeds.

In the present study we tried to search out a combined effect of temperature provided by bottom heating, germination medium and gibberellic acid treatments on the germination of kiwifruit seeds under controlled conditions.

MATERIAL AND METHODS

Collecting the seeds

Kiwifruit seeds were obtained from soft, well-ripened fruits of Hayward cultivar grown in the Black Sea Region. They were extracted by a low speed food blender, the liquefied pulp was washed away through a fine sieve with running tap water and then they were air-dried until they reached a 15% moisture content and were kept in 0.17 mm-thick polyethylene bags in an open container at room temperature for the days prior to the beginning of the study.

GA3 treatments

Seeds were immersed in 2,000, 4,000 and 6,000 ppm GA3 (Berelex, Zeneca Ltd.) solutions for 24 h. The solutions have 7.3 pH at room temperature. The seeds for control application (0 ppm GA3) were immersed into distilled water with the same pH, temperature and time conditions. For each GA3 treatment, 1,800 seeds were soaked in twice their volume of solution. After GA3 application, seeds were washed with sterile distilled water, left to dry for 24 hours, and then dipped in a weak solution of bleaching powder for surface sterilization as indicated by Sale (1985).

Germination medium

The seeds were sown in the peat moss, perlite + heater humus and soil mixture in the 10 m long and 1 m wide trays with the set temperatures of 20°C, 25°C, 30°C and 35°C maintained by bottom heating. The peat moss (Klasmann-Deilmann *Standard Form*) had 75–80% water capacity, 15–20% water, 90–95% air capacity and 70–100 ppm dry density, and 6.0 pH. The perlite + heater humus medium combined of 60% perlite and 40% heater humus, and had 7–7.5 pH. The soil mixture included 60% peat moss (Klasmann-Deilmann *Standard Form*), 25% farmyard manure and 15% sand, with 7.5 pH. Sand had no organic material while farmyard manure contained 83.8% water, 0.29% nitrogen, 0.17% phosphorus, 0.10% potassium and 0.34% calcium. Volume gravity (g/cm^3), total porosity (%), air capacity (%), available water (%) and buffering ability (%) of the perlite and heater humus were 0.130 and 0.164; 94.2 and 88.5; 62.4 and 38.0; 9.3 and 18.5; and 4.8 and 3.3, respectively. All seeds were sown on 27th March 2000 and the recordings of germination began on 15th April 2000. The Previcur 607 SL (Aventis Co. Ltd.) containing 722 g pure Promacarb-HCL per litre was used as a fungicide. It was applied to the medium every day by addition to the irrigation water until the end of the experiment. All mediums were irrigated four times a day by means of sprinkle irrigation with tap water (6.5 pH, no nutrition).

Temperature application with bottom heating

Each tray had a medium subjected to different temperatures with bottom heating. The set point temperatures were 20, 25, 30 and 35°C. The trays were not covered with any material and were subjected to the same diurnal range of ambient temperature in the greenhouse. All temperatures were controlled by thermostatic active base units and temperature changes of both ambient air and mediums were

Table 1. Mean diurnal temperature of the growth medium during the experiment

Set temperatures (°C)	Mean temperature (°C)		
	peat moss	perlite + heater humus	soil mixture
20–20–20	23.23	22.02	17.33
25–25–25	28.27	26.32	23.23
30–30–30	33.25	32.28	28.11
35–35–35	39.35	37.16	32.17

Table 2. Germination percentage of kiwifruit seeds according to the temperature and mediums

Mediums	Temperature (°C)				Mean
	20	25	30	35	
Perlite + heater humus	52.17 b*	7.50 g	6.33 g	15.00 efg	20.25 b***
Peat moss	97.00 a	92.17 a	23.33 d	99.17 a	77.92 a
Soil mixture	37.50 c	21.50 def	10.00 fg	32.33 cd	25.33 b
Mean	62.22 a**	40.39 c	13.22 d	48.83 b	

There are no significant differences between the data marked with the same letters
*LSD 1% = 11.23, **LSD 1%= 6.486, ***LSD 1% = 5.617

recorded using a thermo-couple thermometer (*Digi-Sense*® Dualogr). Mean diurnal temperatures of the growth medium during the experiment are given in Table 1.

Installation of the trays and experimental design

Firstly, four trays having 1 m in width, 40 cm in depth and 10 m in length were installed in the greenhouse. The trays were placed on an iron frame, 1 m above the ground. Secondly, electrical heating copper cables (TARTES Co. Ltd.) with thermostatically active base units were laid down over small brook gravels and then a lattice of iron wires with 0.3 × 0.3 mm holes was spread over the cables. Each tray was divided into three parts and filled with medium (30 cm deep).

A 3-factorial completely randomized block design with three replicates was used for this experiment. Each replicate had 50 seeds. Totally 7,200 seeds were sown. Germination percentage was recorded at daily intervals after the first emergence was observed (seedlings had 2 cm epicotyl's length considered). Data collected from the application as percentage were transformed using the arc-sin√x transformation, and statistical analyses were applied to the transformed data by using MSTAT-C pocket program (Russell D. Freed, Crop and Soil Sciences Department, Michigan State University). The original data are presented in the tables. Duncan's Multiple Range Test was used to indicate the differences between the average data.

RESULTS

There were significant differences between the influence of mediums and temperatures on the germination of kiwifruit seeds. Seeds sown in peat moss with 35°C bottom heating gave the highest germination rate (99.17%). Soil mixture with 30°C bottom heating gave the lowest germination percentage (10.00%). The mediums alone influenced the results differently. Peat moss had the highest germination rate (77.92%) (Table 2). The combination of perlite and heater humus gave the lowest germination rate (20.25%) (Table 2). Soil mixture and perlite + heater humus showed nearly an equal germination rate but peat moss had a rapid and strict linear increment. GA3 doses and medium combinations also significantly affected kiwifruit seed germination. Seeds treated with 6,000 ppm GA3 and sown in peat moss gave the highest germination rate (79%). Seeds that had no GA3 application (control) and were sown in perlite + heater humus medium showed the lowest germination percentage (15.5%). According to Table 3, GA3 treatments alone had no significant effect on kiwi seed germination. However seeds treated with 6,000 ppm GA3 had the lowest (35.56%) and those treated with 2,000 ppm GA3 had the highest (43.94%) germination rate (Table 3). According to the GA3 doses, there was a linear increment of germination rate in days after seed sowing (Fig. 1b) as well as in the case of mediums (Fig. 1c).

Table 3. Germination percentage of kiwifruit seeds according to the medium and GA3 doses

Mediums	GA3 (ppm)			
	0	2,000	4,000	6,000
Perlite + heater humus	15.50 c*	25.33 bc	22.33 bc	17.83 bc
Peat moss	78.17 a	78.17 a	76.33 a	79.00 a
Soil mixture	28.00 bc	28.33 b	23.17 bc	21.83 bc
Mean	40.56**	43.94	40.61	33.56

There are no significant differences between the data marked with the same letters
*LSD 1% = 11.23, **non significant

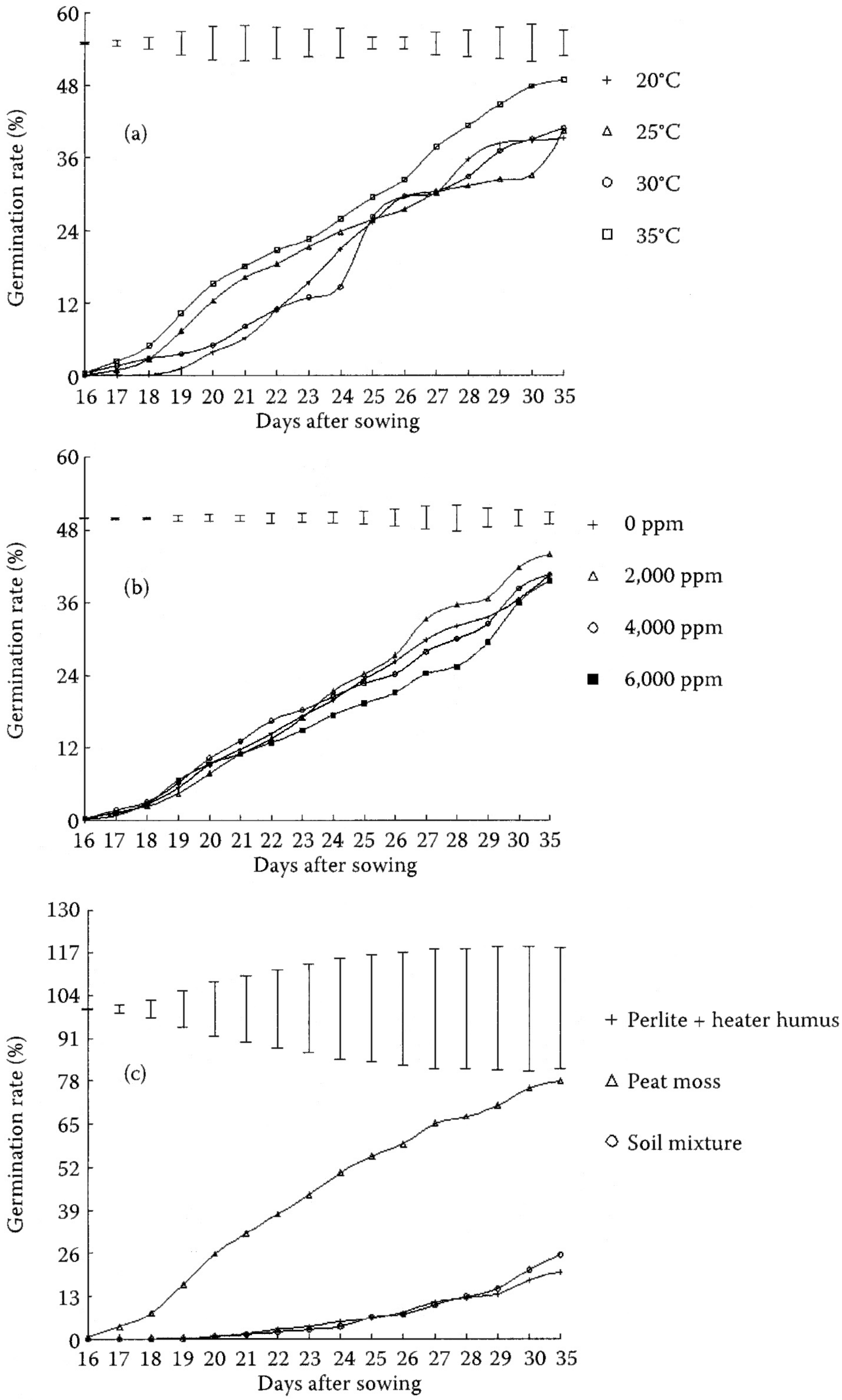

Fig. 1. Changes in the germination rates of kiwifruit seeds as a function of temperature (a), gibberellic acid concentration (b) and mediums (c) during the days after seed sowing. The vertical bars indicate least significant differences at 1% level

Interactive effects were obvious between medium and temperature, medium and GA3 treatments and temperature and GA3 applications (Tables 2, 3 and 4). The combination of 20°C and 2,000 ppm GA3 treatment showed the highest germination rate 70.67%. The rate of germination showed regular and linear increments with the highest temperatures. Lower temperatures resulted in an alternation of kiwifruit seed germination rate; according to the temperature, the least significant differences be-

Table 4. Germination percentage of kiwifruit seeds according to the temperature and GA3 doses

Temperature (°C)	GA3 (ppm)			
	0	2,000	4,000	6,000
20	63.33 ab*	70.67 a	63.78 ab	51.11 bc
25	44.22 cd	40.44 cd	32.44 d	44.44 cd
30	9.33 e	14.67 e	14.44 e	14.44 e
35	45.33 cd	50.00 bc	51.78 bc	48.22 c

There are no significant differences between the data marked with the same letters
* LSD 1% = 12.97

tween germination rates appeared in the beginning of the germination and then deepened during the days after seed sowing (Fig. 1a).

Germination rate of seeds sown in peat moss increased linearly with the increase of GA3 doses at all temperature regimes, these increments were however more rapid at higher GA3 doses. As for lower GA3 doses, seed germination increased with the decreasing temperature but for higher GA3 doses the temperature had to be high to increase the germination rate. Temperature and GA3 doses showed a polynomial relation for germination rate of seeds sown in perlite + heater humus. In this medium, germination rate slightly increased with GA3 doses increasing to 4,000 ppm and after this dose increment in germination rate was more rapid.

In soil mixture, germination rate of kiwifruit seeds increased linearly with increasing GA3 doses in all temperature regimes, except for control (0 ppm GA3). Germination rate showed a linear increment with increasing medium temperature and it was more rapid in high GA3 doses.

DISCUSSION

Kiwifruit seeds show difficulties to germinate. As the root systems of seedlings obtained from seeds are better than the roots of cuttings, grafting the desired variety onto the seedling rootstocks is the most common way to propagate kiwifruit. Grafted kiwifruit vines adapt well to different soil conditions. There are several reports in the literature which demonstrate that the use of pre-chill under cool conditions, various chemicals and diurnal or constant temperatures are suitable procedures for enhancing the kiwifruit seed germination (Lawes, Anderson 1980; Ahn et al. 1984; Mattiuz et al. 1996; Verma et al. 1998; Ynoue et al. 1999; Ozcan 2000; Ozcan, Erisgin 2000). However, none of them mentions an interactive effect of temperature, medium and GA3 applications. The present experiments proved that all applications could stimulate kiwifruit (*Actinidia deliciosa* Chev.) seed germination at different extents. It was determined in previous studies that germination of kiwifruit seeds ranged from 35.47% (6,000 ppm GA3, soil mixture) (Ozcan 2000) to 36.85% (2,500 ppm GA3) (Mattiuz et al. 1996). Ozcan (2000) also stated that a lower germination percentage could be caused by soil mixture, inconstant moisture content and microorganisms.

We observed that the total germination rate of kiwifruit seeds sown in peat moss increased to 77.92%, which must have been a combined effect of peat moss, temperature and GA3 concentration. Seeds sown in peat moss and subjected to 35°C bottom heating reached nearly full germination (99.17%). Kim et al. (1988) stated that the constant temperature between 20–25°C is good for kiwifruit germination. On the other hand, Sale (1985) noted that alternate or diurnal temperature applications could give more reliable results than constant temperatures. Hence, temperature applications are indispensable both for an early emergence and for shortening the germination period. We concluded that the temperature application with bottom heating is indispensable during several weeks after sowing kiwifruit seeds. Although Gao et al. (1984) found that kiwifruit seeds could start to germinate within 52 days under controlled environment with 15°C, our findings proved that this time could be shortened up to 16 days only under any high temperature regime (25, 30 or 35°C). This duration is also shorter than in Sale's (1985) and Samanci's (1990) reports. In addition, our study confirmed a considerable contrast in results of germination of kiwifruit seeds sown in different mediums. Peat moss was the most suitable medium for an early emergence as well as for total germination rate of kiwifruit seeds. Soil mixture reduced the rate of germination of kiwifruit seeds even when treated with temperature (Samanci 1990) or gibberellin application (Ozcan, Erisgin 2000). As for the GA3 application, we found that it accelerated germination, when compared to the control. Although there were no significant differences between GA3 doses, the best results were obtained from 2,000 ppm GA3 application (43.94%).

These results are higher than the results of Gao et al. (1984), Sale (1985), Kim et al. (1988), Samanci (1990), Mattiuz et al. (1996), Ozcan and Erisgin (2000) and Ozcan (2000).

In conclusion, peat moss is more suitable medium for kiwifruit planting than perlite + heater humus or soil mixture, namely because of the early emergence and the highest germination rate. Due to its constant moisture and pH characteristics, kiwifruit seeds reached the best results with it. Other mediums' compactness and inconstant moisture affected the seed germination negatively and most of the seeds did not germinate and deteriorated. Kiwifruit seed germination rate was also highly influenced by GA3 and temperature interactive effect. For peat moss and soil mixture these interactive effects are linearly increasing; for perlite + heater humus they are polynomial. Seed germination increased with the increase of GA3 doses under all high temperature regimes. According to the total germination rate, the temperature treatment was significantly more effective in improving seed germination than the treatment with higher GA3 doses.

References

AHN H.K., KIM S.K., OH J.H., 1984. Seed germination of *Actinidia arguta* as affected by chilling, gibberellin, kinetin and light. Journal of Korean Society of Horticultural Sciences, *25*: 290–296.

BEUTEL J.A., 1990. Kiwifruit. In: JANICK J., SIMON J.E. (eds.), Advances in New Crops. Portland, Timber Press: 309–316.

CHANDEL J.S., NEGI K.S., JINDAL K.K., 1998. Studies on vegetative propagation in kiwi (*Actinidia deliciosa* Chev.). Indian Journal of Horticulture, *55*: 52–54.

DIAZ HERNANDEZ M.B., GARCIA BERRIOS J., 1997. Performance of kiwifruit plant material propagated by different methods. Acta Horticulturae, *444*: 155–169.

GAO X.Z., XIE M., CHEN X.X., ZHAO A.X., 1984. Increasing seed germination of *Actinidia chinensis* Planch. Horticultural Abstracts, *54*: 6072.

HASEY K.J., JOHNSON R.S., GRANT J.A., REIL W.O., 1994. Kiwifruit Growing and Handling. University of California, Division of Agriculture and Natural Resources: 21–22.

KIM I.S., HWANG J.L., HAN K.P., LEE K.E., 1988. Studies on the germination of seeds in native *Actinidia* species. Horticultural Abstracts, *58*: 7336.

LAWES G.S., ANDERSON D.R., 1980. Influence of temperature and gibberellic acid on kiwifruit (*Actinidia chinensis*) seed germination. New Zealand Journal of Experimental Agriculture, *8*: 277–280.

LAWES G.S., SIM B.L., 1980. An analysis of factors affecting the propagation of kiwifruit. The Orchardist of New Zealand, *53*: 88–90.

LAWES G.S., 1992. Propagation of kiwifruit. MAF Echology, Soil and Plant Research Group. Ruakura Agriculture Centre, Hamilton, New Zealand: 12.

MATTIUZ B., FERRI V.C., FACHINELLO J.C., NEDEL J.L., 1996. Effects of gibberellic acid and low temperature on seed germination in kiwifruit (*Actinidia deliciosa* A. Chev.) cultivar Bruno. Scientia Agricola, *53*: 80–83.

OZCAN M., 2000. The effects of different applications on germination of kiwifruit seeds. OMU, Journal of Faculty of Agriculture, *15*: 48–52.

OZCAN M., ERISGIN E., 2000. The effects of some application on seed germination and seedling growth in kiwifruit. Bulletin of Pure and Applied Sciences, *19*: 25–31.

SALE R.P., 1985. Kiwifruit Culture. Wellington, V. R. Ward Government Printer: 96.

SAMANCI H., 1990. Kiwifruit Growing. Yalova, TAV, *22*: 112.

STRIK B., CAHN H., 1996. Growing Kiwifruit. *EC 1464*. Corvallis, Oregon State University.

VERMA S.K., PLANT K.C., MUNEEM K.C., ARYA R.R., 1998. Seed germination studies in kiwifruit (*Actinidia chinensis*). South Indian Horticulture, *46*: 279–281.

YNOUE C.K., ONO E.O., MARCHI L. DE O.S., 1999. The effect of gibberellic acid on kiwi (*Actinidia chinensis* Pl.) seed germination. Scientia Agricola, *56*: 9–12.

Received for publication May 3, 2005
Accepted after corrections June 7, 2005

Zvýšení schopnosti vzcházení semen kiwi za využití teploty, média a kyseliny giberelové

ABSTRAKT: V experimentu byl sledován vliv účinků teploty, pěstebního substrátu a kyseliny giberelové na vzcházení semen kiwi (*Actinidia deliciosa* Chev. cv. Hayward). Semena byla ošetřena čtyřmi koncentracemi GA3 (0, 2 000, 4 000, 6 000 ppm) a vyseta do rašeliny, perlitu + rašeliny a půdní směsi o teplotě 20 °C, 25 °C, 30 °C a 35 °C se spodním vytápěním s kontrolovanými podmínkami. Všechna měření přinesla statisticky významné výsledky vzcházení semen kiwi. Maximální vzcházení (99,17 %) přinášela semena, která byla vyseta do rašeliny o teplotě 35 °C se spodním vytápěním. Vysoká, 79% vzcházivost byla zjištěna rovněž při výsevu do rašeliny za ošetření osiva 6 000 ppm GA3. Rašelina také způsobila dřívější vzcházivost a kratší periodu vzcházení než ostatní pěstební média.

Klíčová slova: semena kiwi; PGR; teplota; médium; vzcházení

Corresponding author:

Ass. Prof. Dr. Hüseyin Çelik, University of Ondokuz Mayis, Faculty of Agriculture, Department of Horticulture, 55139 Kurupelit-Samsun, Turkey
tel.: + 90 362 457 6020, fax: + 90 362 457 6034, e-mail: huscelik@omu.edu.tr