Effect of Calcium Concentration and Cultural Media on Growth and Flowering of *Paphiopedilum*

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Key words: *Paphiopedilum*, Cultural medium, Calcium, Growth, Flowering.

Summary

Plants were grown in four different cultural media, including: (1) the mixture of pine bark, charcoal, and pumice rock (BCP), (2) pine bark (B), (3) granulate sponge (GS) and (4) the mixture of pine bark and sphagnum moss (BS). And plants were fertilized with four different calcium concentrations as 0, 100, 300 and 500 ppm. The results showed that regardless cultural medium, calcium concentration has no affect on growth of plants but plants treated with 100 and 300 ppm Ca, seem to be a good performance than other Ca concentration on vegetative stage. However, plants treated with 300 ppm Ca produced higher number of flower at 33.33% followed by 100 ppm, 500 ppm and 0 ppm Ca as 25, 22.22 and 19.44%, respectively. Regardless calcium concentration, plants were grown in pine bark, showed the lowest quality on vegetative stage, finally they did not produce any flower in the flowering stage. Whereas, plants were grown in BS and GS produced equal flowers, which is the most number of flowers at 41.67%, followed by BCP as 16.67%.

Introduction

In nature, the Paphiopedilum is commonly found growing in the light friable humus and in well-drained crevices and cracks. A good flow of air through the root system, an adequate water supply, a suitable growth media types and the drainage system are a main factor which help to minimize yield loss against infection from pathogens (Cribb, 1998). Many researchers

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suggested that the use of mixed media is better than a single one (Richter, 1972). Wang and Konow (2002) reported that using the combination of bark and peat gave more number of leaves, fresh weights and leaf area than in bark only.

Beside the growth media, calcium is also important for the quality of floriculture and vegetable crops (Gislerød, 1999). Garduno *et al*. (2008) concluded that the dose of calcium used in hydroponic gerbera at 12 meq L^{-1} Ca^{2+} (*G. jamesonii* 'Amaretto') and at 9 meq L^{-1} Ca^{2+}(*G. jamesonii* 'Darling') gave the greatest dry mass weight, flower production, and quality of the inflorescence. However, there was no report about the appropriate growth medium and fertilization on cultivation of *Paphiopedilum* available. Therefore, in this study I would like to investigate the effect of the different cultural medium, calcium fertilizer used in *Paphiopedilum* growth.

Material and Methods

Material:

Potted plants of *Paphio.* In-charm Lily (White Knight x *lawrenceanum*) derived from tissue culture in 6 cm pot with the medium (mixtured by charcoal, pine bark and pumice rock) were purchased from In-charm Orchid Nursery. Similar size of potted plants with leaf span between 8-10 cm were selected and shifted to 9 cm pot and also changed the culture medium from original medium to experimental cultural medium on January 27th, 2009.

Methods:

The four types of different cultural media used in this experiment were as (1) the mixture of pine bark No.9, charcoal, and pumice rock (BCP, ratio = 1:1:1, V/V), (2) pine bark No.9 (B), (3) granulate sponge (GS), and (4) the mixture of pine bark and sphagnum moss (BS = 1:1, V/V).

Modified Hoagland and Arnon nutrient solution (1950) was used, calcium nitrate ($Ca(NO3)_2.4H2O$) was replaced by calcium chloride ($CaCl_2.2H_2O$) and adjusted concentration to 0 ppm, 100 ppm, 300 ppm and 500 ppm. The pH of fertilizer solution was adjusted to 6.0. The plants were fertigated with four levels of calcium formulas from July, 2009 until January, 2011. Each pot was fertigated 100 ml. Growth of plants was recorded every month until the end of experiment. Root activity, total soluble sugar and starch were analyzed at both vegetative and reproductive periods.

Analysis and measurement

(1) Plant growth parameters: leaf fresh weight, leaf dry weight, root fresh weight, root dry

weight, number of roots, leaf length, leaf width, leaf thickness and leaf span were measured every month.

(2) Root activity: Measured according to Steponkus and Lanphear (1967), after washed out the cultural medium from roots, root tips were cut to weigh 0.1 g, and then placed into TTC solution (0.9% triphenyl tetrazolium chloride, 0.05 mM Na_2HPO_4 0.05 mM and KH_2PO_4 buffer, pH 7.4), the sample was placed in the dark for 17 hrs. Then, the root from TTC solution was taken out and washed 2-3 times by RO water. Put the samples in the test tubes, added 20 ml 95% methyl alcohol, and then placed in water bath 78℃ for 20 minutes, after that wait until temperature decreased and then add 95% methyl alcohol to 20 ml. The extract solution was measured at 480 nm wavelengths using a spectrophotometer (Hitachi U-2001, Hitachi Co., Japan).

(3) Carbohydrate analysis: Dry ground sample was weighed accurately (0.1 g) into test tubes (15×125 mm), added 10 ml reverse osmosis water, heated at 30℃ in water bath for 3 hrs., left at room temperature for 10 min, after that centrifuged at 2500 rpm for 30 min, the supernatant was decanted for analyzing total soluble sugar (TSS) and insoluble substance at the bottom of each test tube after centrifugation was taken to analyze starch

(4) Physical measurement\ of cultural media: Bulk density (BD): Bulk density was calculated by dividing dry weight (105℃ 24 h) by volume.Total porosity (TP): Total porosity was equal to the volume of the water at saturation. Container capacity (CC): Cultural media were measure follow a standardized system by Deboodt & Verdonck (1972).

Results

I. Effect of calcium on vegetative growth of *Paphiopedilum* in different cultural media.

(A) Effect of calcium on vegetative growth of *Paphiopedilum* grown in the mixture of pine bark, charcoal and pumice rock (BCP).

All calcium treatment had no effect on leaf span, leaf length and leaf width. The more roots were 13.00 or 10.67 after fertilizing 0 ppm Ca or 300 ppm Ca, respectively (Table 1). After giving 100 ppm Ca for 8 months, the highest leaf fresh weight or leaf dry weight was 9.25 g or 1.34 g, respectively. The leaf fresh weight and leaf dry weight was the lowest as 5.35 g and 0.78 g when 500 ppm Ca was used. As well as the highest root fresh and dry weight was 1.55 g and 0.37 g at 500 ppm Ca (Table 2). Total soluble sugar (TSS) and starch were unaffected by Ca concentration. Plants were treated with Ca 100 ppm showed higher root activity (Table 3).

Table 1. Effect of calcium concentrations on leaf span, leaf length, leaf width, leaf thickness and number of roots of *Paphiopedilum* grown in the mixture of pine bark, charcoal and pumice rock (BCP) at vegetative period.

Ca conc. (ppm)	Leaf span (cm)	Leaf length (cm)	Leaf width (cm)	Leaf thickness (mm)	No. of roots
0	19.07 a[z]	10.53 a	2.75 a	0.92 a	13.00 a
100	18.83 a	9.67 aa	2.52 a	0.92 a	9.33 b
300	18.83 a	10.40 a	2.46 a	0.76 b	10.67 ab
500	17.27 a	9.67 a	2.34 a	0.88 ab	8.67 b

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

Table 2. Effect of calcium concentrations on leaf fresh weight, leaf dry weight, root fresh weight and root dry weight of *Paphiopedilum* grown in the mixture of pine bark, charcoal and pumice rock (BCP) at vegetative period.

Ca conc.	Leaf		Root	
(ppm)	Fresh weight (g)	Dry weight (g)	Fresh weight (g)	Dry weight (g)
0	6.53 c[z]	0.89 b	1.26 b	0.29 b
100	9.25 a	1.34 a	1.21 b	0.29 b
300	8.42 b	1.31 a	1.50 a	0.29 b
500	5.35 d	0.78 c	1.55 a	0.37 a

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

Table 3. Effect of calcium concentrations on total soluble sugar and starch of leaves and root activity of *Paphiopedilum* grown in the mixture of pine bark, charcoal and pumice rock (BCP) at vegetative period.

Ca conc. (ppm)	TSS (%)	Starch (%)	Root activity (OD.A480/g)
0	33.65 a[z]	18.71 a	1.61 c
100	35.04 a	22.53 a	2.18 a
300	35.69 a	18.33 a	1.94 b
500	35.01 a	16.94 a	1.45 d

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

(B) Effect of calcium on vegetative growth of *Paphiopedilum* grown in granulate sponge (GS).

The result showed that t Plants treated with 100 ppm Ca had the highest leaf length and leaf thickness as 12.67 cm and 0.90 mm, respectively (Table 4). As well as plants showed the highest leaf fresh weight, leaf dry weight, root fresh weight and root dry weight as 10.64 g, 1.74 g, 1.27 g and 0.31 g, respectively, after treating with 100 ppm Ca (Table 5). There were no significant difference in TSS and starch after treating with different Ca levels. Plants treated with 300 ppm Ca showed the highest root activity was 1.79 OD.A480/g.

Table 4. Effect of calcium concentrations on leaf span, leaf length, leaf width, leaf thickness and number of roots of *Paphiopedilum* grown in granulate sponge (GS) at vegetative period.

Ca conc. (ppm)	Leaf span (cm)	Leaf length (cm)	Leaf width (cm)	Leaf thickness (mm)	No. of roots
0	19.27 a[z]	11.47 ab	3.21 a	0.83 b	7.67 a
100	20.67 a	12.67 a	3.30 a	0.90 a	9.33 a
300	19.67 a	12.00 ab	3.10 a	0.79 b	8.67 a
500	17.90 a	10.50 b	2.97 a	0.73 c	10.00 a

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

Table 5. Effect of calcium concentrations on leaf fresh weight, leaf dry weight, root fresh weight and root dry weight of *Paphiopedilum* grown in granulate sponge (GS) at vegetative period.

Ca conc.	Leaf		Root	
(ppm)	Fresh weight (g)	Dry weight (g)	Fresh weight (g)	Dry weight (g)
0	9.75 ab[z]	1.35 b	0.74 b	0.18 b
100	10.62 a	1.74 a	1.27 a	0.31 a
300	7.97 c	1.30 b	0.96 b	0.26 ab
500	8.86 bc	1.37 ab	1.27 a	0.28 ab

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

Table 6. Effect of calcium concentrations on total soluble sugar and starch of leaves and root activity of *Paphiopedilum* grown in granulate sponge (GS) at vegetative period.

Ca conc. (ppm)	TSS (%)	Starch (%)	Root activity (OD.A480/g)
0	35.31 a[z]	20.02 a	1.34 c
100	34.73 a	19.05 a	2.21 a
300	35.90 a	24.03 a	2.52 a
500	36.59 a	20.02 a	1.79 a

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

(C) Effect of calcium on vegetative growth of *Paphiopedilum* grown in the mixture of pine bark and sphagnum moss (BS).

Leaf span, leaf width, leaf thickness and number of root were unaffected by different Ca concentration. However, leaf length was high at 300 ppm and 500 ppm Ca as 12.40 g and 12.03 g, respectively (Table 7). There was no different significance in leaf fresh weight, leaf dry weight, root fresh weight and root dry weight at any Ca concentrations (Table 8). TSS was unaffected by different Ca concentration, whereas plants treated with 300 ppm Ca showed the highest starch (22.17%) and the highest root activity (1.61 OD.A480/g) (Table 9).

Table 7. Effect of calcium concentrations on leaf span, leaf length, leaf width, leaf thickness and number of roots of *Paphiopedilum* grown in the mixture of pine bark and sphagnum moss (BS) at vegetative period.

Ca conc. (ppm)	Leaf span (cm)	Leaf length (cm)	Leaf width (cm)	Leaf thickness (mm)	No. of roots
0	19.77 a[z]	9.83 bc	3.03 a	0.92 a	8.00 a
100	20.27 a	8.00 c	3.03 a	0.91 a	8.00 a
300	18.00 a	12.03 ab	2.89 a	0.82 a	7.33 a
500	20.00 a	12.40 a	3.19 a	0.73 a	8.00 a

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

Table 8. Effect of calcium concentrations on leaf fresh weight, leaf dry weight, root fresh weight and root dry weight of *Paphiopedilum* grown in the mixture of pine bark and sphagnum moss (BS) at vegetative period.

Ca conc.	Leaf		Root	
(ppm)	Fresh weight (g)	Dry weight (g)	Fresh weight (g)	Dry weight (g)
0	9.91 a[z]	2.29 a	1.38 a	0.32 a
100	10.09 a	1.97 a	1.37 a	0.30 a
300	8.93 a	2.01 a	1.28 a	0.34 a
500	8.30 a	3.07 a	1.28 a	0.31 a

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

Table 9. Effect of calcium concentrations on total soluble sugar and starch of leaves and root activity of *Paphiopedilum* grown in the mixture of pine bark and sphagnum moss (BS) at vegetative period.

Ca conc. (ppm)	TSS (%)	Starch (%)	Root activity (OD.A480/g)
0	33.16 a[z]	15.71 b	1.30 b
100	32.50 a	14.13 b	0.87 d
300	31.96 a	22.17 a	1.61 a
500	29.67 a	17.48 ab	1.10 c

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

(D) Effect of calcium on vegetative growth of *Paphiopedilum* grown in pine bark (B).

Leaf span, leaf length, leaf width, leaf thickness and number of roots were unaffected by different Ca concentration (Table 10). Plants treated with 300 ppm Ca showed that leaf fresh weight, leaf dry weight, root fresh weight and root dry weight were the highest as 6.72 g, 1.15 g, 1.65 g and 0.36 g, respectively (Table 11). TSS increased as increasing Ca concentration, however there was no different significant, whereas plants treated with 100 ppm Ca showed the highest starch as 23.46%. Root activity was higher than other treatments after treating with 300 ppm Ca, (Table 12).

Table 10. Effect of calcium concentrations on leaf span, leaf length, leaf width, leaf thickness and number of roots of *Paphiopedilum* grown in pine bark (B) at vegetative period.

Ca conc. (ppm)	Leaf span (cm)	Leaf length (cm)	Leaf width (cm)	Leaf thickness (mm)	No. of roots
0	15.83 a[z]	9.07 a	2.51 a	0.92 a	10.33 a
100	16.00 a	8.93 a	2.51 a	0.87 a	9.67 a
300	15.67 a	8.07 a	2.09 a	0.88 a	9.00 a
500	17.00 a	9.50 a	2.61 a	0.74 a	7.67 a

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

Table 11. Effect of calcium concentrations on leaf fresh weight, leaf dry weight, root fresh weight and root dry weight of *Paphiopedilum* grown in pine bark (B) at vegetative period.

Ca conc.	Leaf		Root	
(ppm)	Fresh weight (g)	Dry weight (g)	Fresh weight (g)	Dry weight (g)
0	4.44 b[z]	0.80 b	0.64 ab	0.17 b
100	6.55 a	0.97 ab	1.45 a	0.32 a
300	6.72 a	1.15 a	1.65 a	0.36 a
500	5.84 ab	0.96 ab	1.58 a	0.32 a

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

Table 12. Effect of calcium concentrations on total soluble sugar and starch of leaves and root activity of *Paphiopedilum* grown in pine bark (B) at vegetative period.

Ca conc. (ppm)	TSS (%)	Starch (%)	Root activity (OD.A480/g)
0	32.10 a[z]	18.47 b	1.48 b
100	32.35 a	23.46 a	1.62 ab
300	33.15 a	17.55 b	1.74 a
500	35.49 a	22.28 a	1.72 a

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

II. Effect of cultural media on vegetative growth of *Paphiopedilum* at 300 ppm Ca.

Plants were grown in GS and BS produced higher leaf span, leaf length and leaf width more than plant grown in B (Table 13). Plants had the highest leaf fresh weight (8.93 g) when grown in BS, although their leaf dry weight had no significantly different. Root fresh weight and dry weight of plant which grown in GS less than that grown in BS (Table 14), but plant were grown in GS had higher root activity comparing with BS. All cultural media were unaffected to TSS, starch, and total chlorophyll (Table 15).

Table 13. Effect of cultural media on leaf span, leaf length, leaf width, leaf thickness and number of roots of *Paphiopedilum* after treating with 300 ppm calcium at vegetative period.

Cultural media	Leaf span (cm)	Leaf length (cm)	Leaf width (cm)	Leaf thickness (mm)	No. of roots
BCP	18.83 a[z]	10.40 ab	2.46 ab	0.76 a	10.67 a
GS	19.67 a	12.00 a	3.10 a	0.79 a	8.67 ab
BS	18.00 a	12.03 a	2.89 a	0.82 a	7.33 b
B	15.67 a	8.07 b	2.09 b	0.88 a	9.00 ab

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

[x]Cultural media refer to description at material methods

Table 14. Effect of cultural media on leaf fresh weight, leaf dry weight, root fresh weight and root dry weight of *Paphiopedilum* after treating with 300 ppm calcium at vegetative period.

Cultural	Leaf		Root	
media[x]	Fresh weight (g)	Dry weight (g)	Fresh weight (g)	Dry weight (g)
BCP	8.42 a[z]	1.31 a	1.50 a	0.29 ab
GS	7.97 ab	1.30 a	0.96 b	0.26 b
BS	8.93 a	1.28 a	2.01 a	0.34 ab
B	6.72 b	1.15 a	1.65 a	0.36 a

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

[x]Cultural media refer to description at material methods.

Table 15. Effect of cultural media on total soluble sugar and starch of leaves and root activity of *Paphiopedilum* after treating with 300 ppm calcium at vegetative period.

Cultural media[x]	TSS (%)	Starch (%)	Root activity (OD.A480/g)
BCP	35.69 a[z]	18.33 a	1.94 b
GS	35.90 a	24.03 a	2.52 a
BS	31.96 a	22.21 a	1.61 c
B	33.15 a	17.55 a	1.74 c

[z]Mean separation within columns by Duncan's multiple range test at $P \leq 0.05$.

[x]Cultural media refer to description at table 13.

III. Effect of calcium concentration on flowering initiation of *Paphiopedilum* in different cultural media.

Regardless cultural medium, plants treated with 0 ppm Ca produced the lowest amount flowers (19.44%). Whereas plants treated with 300 ppm Ca, produced the highest number of flowering (33.33%) (Fig. 1).

For BCP medium, there was no flower bud after treated with 0 and 500 ppm Ca. concentration. Plants were treated with 100 and 300 ppm Ca concentration, each treatment produced 33.33% flower bud. Ca concentration had no affect on starch and root activity. Plants showed the highest TSS treating with 300 ppm Ca (Table 16). For GS medium, all Ca concentration treatment produced flower. Plant produced high number of flower at 300 and 0 ppn Ca as 55.56% and 44.44 %, respectively. Plants were treated with 100 and 500 ppm Ca, each treatment produced 33.33% flower bud. Starch was unaffected by Ca concentration but 500 ppm Ca showed the highest TSS (16.69%). Plants treated with 0 and 300 ppm Ca, showed higher root activity (Table 17). For BS medium, all Ca concentration treatment produced flower. Plants produced the highest number of flower at 500 ppm Ca (55.56%). Plants produced 44.44% number of flower at 300 ppm Ca. There was no significantly different on TSS, starch and root activity at any Ca concentration (Table 18). For pine bark medium, plants did not produce flower in any Ca concentration (Fig. 1). TSS, starch and root activity were unaffected by Ca concentration (Table 19).

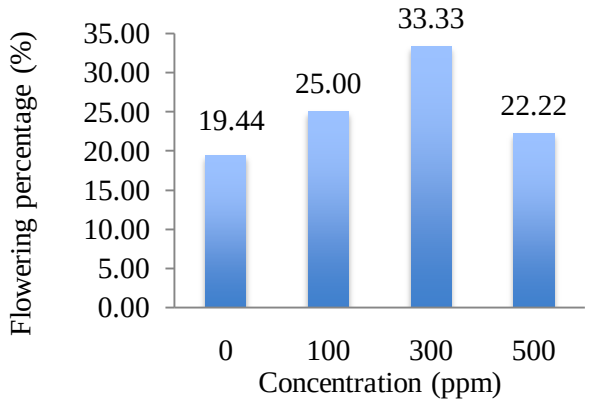

Fig. 1. Percentage of plants flowering in different calcium concentrations.

Table 16. Effect of calcium concentrations on total soluble sugar and starch of leaves and root activity of *Paphiopedilum* grown in the mixture of pine bark, charcoal and pumice rock (BCP) at flower bud period.

Ca conc. (ppm)	TSS (%)	Starch (%)	Root activity (OD.A480/g)
0	15.35 ab[z]	9.66 a	3.64 a
100	16.05 ab	7.41 a	3.44 a
300	17.15 a	9.51 a	3.74 a
500	14.22 b	9.19 a	3.66 a

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

Table 17. Effect of calcium concentrations on total soluble sugar and starch of leaves and root activity of *Paphiopedilum* grown in granulate sponge (GS) at flower bud period.

Ca conc. (ppm)	TSS (%)	Starch (%)	Root activity (OD.A480/g)
0	14.62 ab[z]	9.21 a	3.26 a
100	14.20 b	11.15 a	2.41 b
300	15.84 ab	11.08 a	3.14 a
500	16.79 a	11.15 a	2.36 b

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

Table 18. Effect of calcium concentrations on total soluble sugar and starch of leaves and root activity of *Paphiopedilum* grown in the mixture of pine bark and sphagnum moss (BS) at flower bud period.

Ca conc. (ppm)	TSS (%)	Starch (%)	Root activity (OD.A480/g)
0	15.56 a[z]	10.77 a	3.20 a
100	15.85 a	10.71 a	2.72 a
300	16.26 a	11.31 a	3.11 a
500	14.32 a	14.07 a	2.87 a

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

Table 19. Effect of calcium concentrations on total soluble sugar and starch of leaves and root activity of *Paphiopedilum* grown in bark (B) at flower bud period.

Ca conc. (ppm)	TSS (%)	Starch (%)	Root activity (OD.A480/g)
0	14.98 a[z]	8.57 a	3.30 a
100	14.41 a	7.83 a	2.92 a
300	15.24 a	8.56 a	3.05 a
500	15.25 a	8.93 a	2.98 a

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

IV. Effect of cultural media on flowering initiation of *Paphiopedilum* at different calcium concentrations.

Regardless Ca concentration, plants were grown in B, did not produced any flowers. Plants grown in BS and GS, produced more flowers than plants grown in BCP 25% (Fig. 2).

At 0 ppm Ca, plants were grown in B and BCP did not produced any flowers, whereas plants grown in GS produced flowers more than plant grown in BS was 44.44 and 33.33%. At 100 ppm Ca, plants produced flowers in BCP, GS and BS as the same amount was 33.33%. At 300 ppm Ca, plants grown in GS, BS and BCP produced flowers as 55.56, 44.44 and 33.33%, respectively. At 500 ppm Ca, plants grown in BS, produced flowers more than plant grown in GS was 55.56 and 33.33% (Table 20).

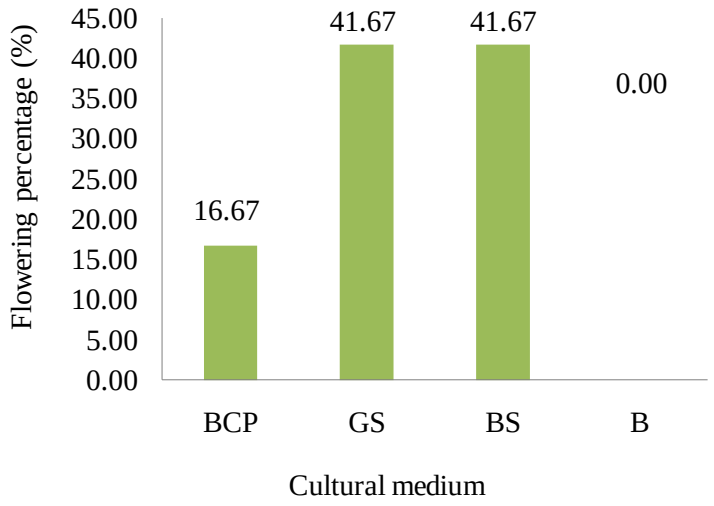

Fig. 2. Percentage of plants flowering in different cultural media

Table 20. Effect of cultural media on total soluble sugar and starch of leaves and root activity of *Paphiopedilum* after treating with 300 ppm calcium at flower bud period.

Cultural media[x]	TSS (%)	Starch (%)	Root activity (OD.A480/g)
BCP	17.15 a[z]	9.51 a	3.74 a
GS	15.84 a	11.08 a	3.14 a
BS	16.26 a	11.31 a	3.11 a
B	15.24 a	8.56 a	3.05 a

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

[x]Cultural media refer to description at table 13.

V. Change of cultural medium properties after planting.

There were a few changes of physical properties after planting 17 months. CC was decreased and AFP was increased from start experiment, however GS had still the highest CC (44.54%) as the same in beginning of experiment. Pine bark had the most AFP but did not different compared to BS. GS had higher TP than BS, BCP and B, it also had the lowest BD (0.10 g/cm^3). The highest BD (0.30 g/cm^3) was showed in BCP, which was the same in before planting (Table 21).

Table 21. The physical properties of cultural medium before planting.

Cultural media	TP (%)		CC (%)		AFP (%)		BD (g/cm^3)	
	Before	After	Before	After	Before	After	Before	After
BCP	83.70d[z]	83.69c[z]	33.43c	31.28b	52.42b	50.27ab	0.31a	0.30a
GS	95.24a	93.40a	44.54a	38.09a	57.16b	48.87b	0.10d	0.07d
BS	91.22b	91.65b	39.79b	34.55ab	56.67b	51.86a	0.16c	0.15c
B	85.49c	84.56c	32.36c	20.87c	64.62a	52.21a	0.25b	0.23b

[z]Mean separation within columns by Duncan's multiple range test at P≤ 0.05.

Discussion

Plants were grown in BCP, GS and BS had better upper shoot growth than plant were grown in B at vegetative period (Table 13), according to they had highly CC (Table 21), which refer to good ability of adequate moisture and nutrition retention. However plants in GS and BS produced low root quality due to the death of some original root as comparing to BCP and B, may have retained too much water during the cool period induced to water log and bad ventilation, from the result of properties measure experiment, found that B had more AFP than other medium (Table 21). BS and GS had highly water holding capacity and air filled porosity both start and end of experiment (Table 21), these properties affected to quality of root which influence to ability of nutrition uptake.

Regardless cultural medium, plants treated with 300 ppm Ca, produced the most number of flower follow by 100, 500 and 0 ppm Ca (Fig. 1). TSS and starch content had no different significant between plants were grown in B, which did not produce flower and other media, which produced flower. However compared to vegetative period at the same concentration, found that TSS and starch at flower bud period reduced about half of amount from vegetative period (Table 15, 20). TSS and starch was reduced, may cause plants used it for flower bud initiation, Vaz *et al* (2004) reported that floral bud development of *P. pusilla* was negatively affected by long days, higher soluble sugar and starch levels were detected in plants cultivated under long days.

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鈣濃度與栽培介質對仙履蘭生長及開花之影響

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關鍵字：仙履蘭、栽培介質、鈣肥、生長、開花

摘要：不同的介質處理，分別為(1)樹皮、木炭及碎石混合 (BCP)，(2)樹皮 (B)，(3)科技土 (GS) 以及(4)樹皮混合水苔 (BS)，與不同鈣肥濃度處理：分別為 0、100、300、及 500 ppm，實驗結果顯示不論介質種類，鈣肥濃度對植株之生長沒有影響。在植株營養生長階段施用鈣肥濃度為 100 及 300 ppm 時，植株外觀較其它鈣肥濃度處理組佳。然而，植株處理不同濃度之鈣肥，以 300 ppm 有較多的花朵數產生，為 33.33%，其次為 100 ppm、500 ppm 及對照組，依序為 25%、22.22%及 19.44%。植株栽種於樹皮介質中，不論鈣肥濃度多寡，顯示有最差的生長，且最後皆生殖生長及無開花現象。然而植株栽種於介質為樹皮混合水苔以及科技土處理，產生較多的花朵數為 41.67%，其次為樹皮、木炭及碎石混合處理 (16.67%)。

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