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Effect of Various Magnesium Concentrations on the Quantity of Chlorophyll of 4 Varieties of Strawberry Plants (*Fragaria ananassas* D.) Cultivated in Inert Media

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Abstract: This study tested the concentration of magnesium 0.4, 0.7, 1.4 and 2.8 meq L^{-1} on the varieties of strawberry plants Seonhong, Maehyang, Keumhyang and Seolhyang cultivated in inert media. The application of the concentration 0.4 meq L^{-1} on the whole of studied plants gave the smallest quantity of chlorophyll. However, it was not noted a significant difference between the concentrations 0.7, 1.4 and 2.8 meq L^{-1}. Between the varieties and for the concentrations 0.4 and 0.7 meq L^{-1}, we obtained on the leaves of Seonhong' the highest quantity of chlorophyll. The smallest quantity was registered on Seolhyang. For the concentration 2.8 meq L^{-1}, the greatest quantity was recognized on Maehyang and Keumhyang. We also obtained the smallest quantity on Seolhyang. Concerning the physiological stages, during the first stalk flowering, we noted that the greatest quantity of total chlorophyll was on the leaves of Fruit setting stage. It is followed by the leaves of beginning fruit setting stage and finally by leaves of flowering stage.

Key words: Magnesium concentrations, chlorophyll, strawberry, inert media, physiological stages

INTRODUCTION

Chlorophyll content is an essential biochemical parameter to track the main developmental stages and yield of plant.

Magnesium is an essential nutritious element for the growth of plants. Because, it plays a major part in the constitution of chlorophyll; base of photosynthesis (Papenbrock *et al*., 2000).

Without source of magnesia available, the plant cannot develop because of the multiple roles of magnesium. However, in a hydro mineral solution intended for the plants, the concentrations must be adapted to ionic balance. Because, an excess or a deficiency can disturb the uptake of others elements (Huang and Redmann, 1995).

The knowledge of the relatively optimal Mg concentration enables us to adjust the ratio $K^+/(Ca^{++}+Mg^{++})$. This relationship, which must border 0.67 according to the species and to physiological stages of the plants contributes, with an adequate pH, in a significant way to the uptake of totality other minerals (Fanasca *et al*., 2006).

In this experiment, we studied the effect of 4 nutritive solutions differentiated by the Mg^{++} concentrations on the contents of chlorophyll from three foliar levels of 4 varieties: Seonhong, Maehyang, Keumhyang and Seolhyang.

These Mg^{++} concentrations corresponded to 0.4, 0.7, 1.4 and 2.8 meq L^{-1}.

The three foliar levels were represented, respectively by the primary flowers, the secondary flowers and the tertiary flowers of the first floral stalk. They corresponded at the physiological stages flowering; beginning set fruiting and set fruiting.

MATERIALS AND METHODS

Greenhouse: The test was held in a greenhouse with a controlled environment in Pai Chai University. It was led in inert media.

Plant: The strawberry varieties used Maehyang, Keumhyang and Seolhyang were created and developed in the Experimental Station of Research on the Strawberry plant of Nonsan (Korea). The variety Seonhong was created at the Experimental Station of Horticulture of Busan (Korea).

Substrate: The substrate used is the perlite. We used a mixture with equal volume the perlite of a gauge from 2 to 5 mm and another lower than 1 mm. This is given an optimal retention of the solution in the substrate (Choi *et al*., 2000).

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Steering the fertirrigation: The plantation of runners in the pots containing the perlite, took place on December 10. These runners came from the quoted stations.

The irrigation was done with the water distilled from December 10 until March 10. Because, as we know it, the strawberry is a perennial plant. Consequently, the accumulation of the reserves is done in the roots and the rhizomes during the breeding of the seedlings in seedbed. The irrigation with distilled water was necessary in present experimentation. It evacuates these reserves. That will enable us to see the effect of the various solutions used in this test.

Controls were carried out every three days on the solution of leaching. They related, particularly, measurements of the electro conductivity. It varied between 1.72 to 2.00 mS and the pH around 6.30.

The standards of these both parameters for a culture of strawberry plant vary between 6.30 of 7 for the pH and between 1.5 to 2.5 mS for the electro conductivity (Skiredj, 2005).

The irrigation with the various nutritive solutions was done according to the EC and pH. A contribution of 500 mL was brought, for drainage 150 mL. That is corresponding at 30% of volume brought. Rate drainage from 30 to 40% is necessary to ovoid the accumulation of the elements in the substrate. Other ways, that causes abrupt variations of the solution (Latigui, 1992).

Chlorophyllmeter SPAD-502: In present study, we have used the SPAD-502 chlorophyllemètre. It works by transmittance. It assesses the transmission of light emitted by a Light Emitting Diode (LED) (diode, or LED for electro-luminescent) through the sheet (Minolta Co. Ltd., 1989).

The correlations were calculated between the values SPAD and Chlorophyll extracted by acetone. All these correlations were highly significant, between the values SPAD and chlorophyll per unit area (Dwyer *et al*., 1994; Smeal and Zhang, 1994; Bavarescol, 1995; Westcott and Wraith, 1995).

This apparatus informs us, also on the relation values SPAD-Chlorophyll-nitrogen (Leize *et al*., 2001). It also enables us to make nitrogen adjustments; necessary to the growth of plants (Guler *et al*., 2006). The unit is an independent value.

Jeff *et al*. (1994) showed that the values obtained by this chlorophyll meter were positively correlated with the nitrogen concentrations of the leaves of several varieties strawberry plants.

Experimental device: We have used a device with 3 hierarchical factors. The principal factor, called factor A, has represented the 4 nutritive solutions. The first factor subordinate to the main factor called factor B. It represented the varieties of strawberry plants. The second factor subordinate to the precedent, called factor C represented the 3 foliar levels. On these latter the uptake for the evaluation of the chlorophyll quantity were carried out.

We had 7 repetitions by treatment and by factor, That is to say: factor A×factor B×factor C×7 repetitions, from where a total of 336 measures.

Taken measurements: The evaluation of chlorophyll was carried out by chlorophyll meter SPAD 502. This apparatus gives us the evaluation of total chlorophyll, without damaging the leaves present on the plants (Fahrurrozi *et al*., 2001).

We measured the quantity of total chlorophyll on the median leaflet of each leave concerned.

This operation proceeded the 12/5 after apparition of the first Fruit setting. This stage is estimated after the fall of the petals. In parallel, we had the stage beginning Fruit setting and the stage flowering with not completely opened petals.

The studied factors

Factor A: solution: This factor represents the various solutions (Table 1). It is consisting of 4 treatments. These four nutritive solutions are differentiated by the variation from the concentration of magnesium.

For the other essential minerals K^+, NO_3^-, $H_2PO_4^-$ for the development of chlorophyll, we have an identical concentration in the all solutions.

Also, we have used a same concentration (0.7 ml L^{-1}) of micro nutrient (Table 2).

Treatment [0.4]: In this treatment (Table 1) the Mg^{++} concentration is 0.4 meq L^{-1}. This solution is characterized by an electro conductivity = 1.71 mS, a pH (5.80) and a ratio $K^+/(Ca^{++}+Mg^{++})$ = 0.89.

Table 1: The macro-element composition of nutrient solution tested

	Ionic concentrations (meq L^{-1})									
Treatments	K^+	Ca^{2+}	Mg^{2+}	Na^+	H^+	NO_3^-	$H_2PO_4^-$	SO_4^{2-}	Cl^-	Ratio(K/(Ca+Mg)
[0.4]	3.5	3.5	0.4	1.75	0.18	7 18	0.7	1.45	0.0	0.89
[0.7]	3.5	3.5	0.7	1.40	0.18	7.18	0.7	1.4	0.0	0.83
[1.4]	3.5	3.5	1.4	0.70	0.18	7.18	0.7	1.4	0.0	0.71
[2.8]	3.5	3.5	2.8	0.70	0.18	7.18	0.7	1.4	1.4	0.56

Table 2: Composition of micronutrients mother solution

Micro elements	Values (g L^{-1})
$FeSO_4.7H_2O$	9.37
$MnCl_2, 4H_2O$	1.81
H_3BO_3	2.86
$ZnSO_4.7H_2O$	0.22
$CuSO_4.5H_2O$	0.08
$Na_2MoO_4.2H_2O$	0.02

Treatment [0.7]: In this treatment (Table 1) the Mg^{++} concentration is 0.7 meq L^{-1}. This solution is characterized by an electro conductivity =1.71 mS, a pH (5.88) and $K^+/(Ca^{++}+Mg^{++}) = 0.83$.

Treatment [1.4]: In this treatment (Table 1) the Mg^{++} concentration is 1.4 meq L^{-1}. This solution is characterized by an electro conductivity = 1.69 mS and a pH (5.70) and $K/(Ca^{++}+Mg^{2+}) = 0.89$.

Treatment [2.8]: In this treatment (Table 1) the Mg^{++} concentration is 2.8 meq L^{-1}. This solution is characterized by an electro conductivity = 1.98 mS, a pH (5.75) and $K^+/(Ca^{++}+Mg^{++}) = 0.55$.

About the micronutrients we have used 0.7 ml L^{-1} from a mother solution (Table 2).

Factor B: varieties: This factor which is subordinated to the precedent was composed from 4 treatments. Those represented the 4 studied varieties of strawberry plants. We have: Seonhong, Maehyang, Keumhyang and Seolhyang.

Treatment 1: This treatment represented by the variety Seonhong which is issued by the crossing Maehyang (M) X Jonhong (F). It is fasted among 4 cultivars used in this experiment.

Treatment 2: It is represented by a variety Maehyang which is issued by the crossing Tochinomine (M) X Akihime (F). Height plant is taller than other cultivars tested.

Treatment 3: It was represented by the variety Keumhyang which is issued by the crossing Akihime (M) X Tochiotome (F). Its growth is faster than Maehyang and slower than Seolhyang.

Treatment 4: It was represented by the variety Seolhyang which is issued by the crossing Akihime (M) X Read pearl (F). Its growth is very fast. But, it is slower than Maehyang.

Factor C: Foliar levels: In this test, we have used the first floral stalk. It is constituted with primary flowers, secondary flowers and thirty flowers. The development of these flowers is synchronized with a growth of leaves feeders (Latigui, 1992).

This factor was composed with 3 treatments. They related to the physiologically differentiated leaves with the age. They corresponded at the physiological stages flowering, beginning fruit setting and fruit setting for this first floral stalk.

These leaves are characterized by their feeder role which they play with respect to the physiological stages related to floral initiation, to flowering to fruit setting and the maturity of the fruit (Hamilton-Kemp *et al*., 1993).

Treatment flowering: It represented the youngest leaves. This one corresponded at the stage flowering of first floral stalk. During this stage, the total chlorophyll is not yet completely. The leaves produces proteins necessary to floral induction and a growth hormones intended for these same flowers (Tarenghi and Martin, 1995). In this case, magnesium plays, also a very important role in the development of proteins.

Treatment beginning fruit setting: It represented the older leaves than the preceding one. This one corresponds at the stage beginning fruit setting of first floral stalk. At this stage, the leaves almost constituted the totality of chlorophyll. The source role of the leaves, by comparison of the fruit, is completely functional (Latigui, 1992).

Treatment fruit setting: It represented the adult leaves. It corresponds at the stage fruit setting of first floral stalk. In this stage, total chlorophyll is entirely made up. The photosynthetic activity is in its optimum for the nutrition of the young fruit. In the case, a deficiency of its principal components such as Mg^{++} or N, the synthesis of chlorophyll will be compromised.

RESULTS AND DISCUSSION

The analysis of the variance revealed us a very significant effect on a level of probability of 1% ($p<0.001$) for all the studied factors. In this fact, we were brought to study the multiple comparisons of the averages.

We analyzed the results of the 4 Mg^{++} concentrations on the production of chlorophyll.

The effect of the various Mg concentrations on the whole of the studied plants: These results related to the average of chlorophyll for the three foliar levels of the whole of the varieties (Fig. 1).

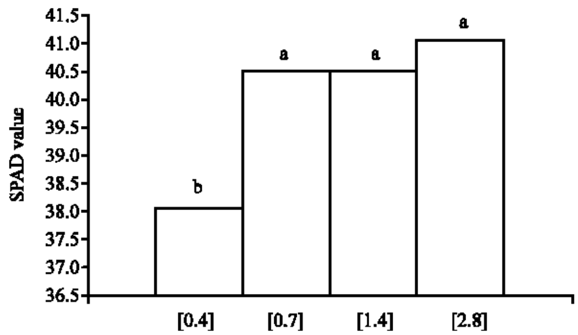

Fig. 1: Effect of the various Mg^{++} concentrations on the quantity of chlorophyll (represented by SPAD value) of the whole plants studied ($p<0.001$)

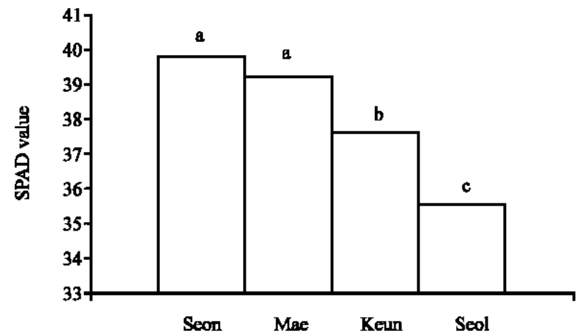

Fig. 2: The effect of the concentration 0.4 Mg^{++} meq L^{-1} of the quantities of chlorophyll (represented by SPAD value) on the 4 varieties ($p<0.001$)

The variance analysis showed us a very significant effect ($p<0.001$). The plants irrigated with the solution [0.4] gave the smallest quantity of chlorophyll 38.07 U SPAD compared to the plants of three others treatments [0.7], [1.4] and [2.8] with respectively 40.47, 40.51 and 41.04 U SPAD. However, between the last three treatments the multiple comparisons of the averages did not reveal of significant difference.

Koling (1997) showed that an Mg^{++} deficiency reduces significantly the photosynthesis at the spruce. Woo *et al.* (1987) showed that the synthesis of the amino acids is related to an elevated concentration of Mg^{++}.

It is to be retained, in this case, that a variable Mg^{++} concentration between 0.7 and 2.8 meq L^{-1} allows a good development of the plants from the plantation until the stage first fruit setting.

According to present results and by varying the Mg^{++} concentrations, we have several possibilities of adjustment of the $K^{+}/(Ca^{++}+Mg^{++})$, whose antagonism of its element can disturb the absorption of other elements (Kreimer *et al.*, 1988). That will enable us to have the possibility of obtaining the adequate ratio necessary to the physiological stages concerned.

Comparison relating to the various magnesium concentrations on the 4 varieties

Effect of the concentration [0.4]: In this treatment (Fig. 2), we recorded on the variety Seol hyang 35.54 U SPAD. It is the smallest quantity of chlorophyll compared to the other varieties.

The highest rate was recorded on the varieties Seon hong with 39.83 U SPAD and 39.27 U SPAD for Mae hyang. Followed by of Keum hyang 35.54 U SPAD.

Effect of the concentration [0.7]: In this treatment (Fig. 3), the multiple comparison of average showed that on the varieties Seon hong and Keum hyang, we obtained the

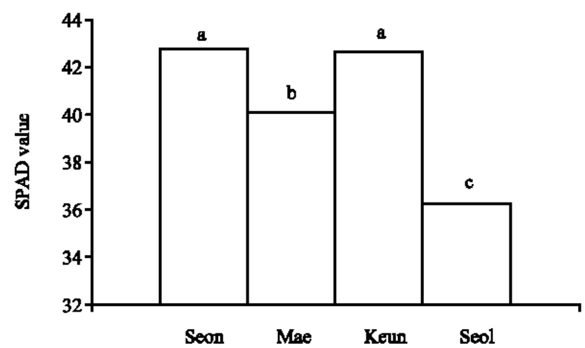

Fig. 3: The effect of the concentration 0.7 Mg^{++} meq L^{-1} on the quantities of chlorophyll (represented by SPAD value) of the 4 varieties ($p<0.001$)

highest quantity of chlorophyll with respectively 42.78 and 40.14 U SPAD. They followed by the variety Mae hyang with 42.67 U SPAD.

The smallest quantity 36.30 U SPAD was also recorded on the leaves of Seol hyang.

Effect of the concentration [1.4]: In this treatment (Fig. 4) we obtained the same classification as the preceding treatment. We obtained the highest quantity 43.28 U SPAD on the variety Seon hong followed by 41.85 U SPAD on Keum hyang and 39.35 U SPAD on Mae hyang.

The smallest quantity 37.57 U SPAD was obtained on the variety 'Seolhyang.

Effect of the concentration [2.8]: For the Mg^{++} concentration 2.8 meq L^{-1}, the highest quantities 42.78 U SPAD (Fig. 5) were obtained on the varieties Keumhyang and 42.73 U SPAD on Maehyang '.They are followed by 41.15 U SPAD on Seonhong. About the variety Seolhyang as for all the other concentrations, it

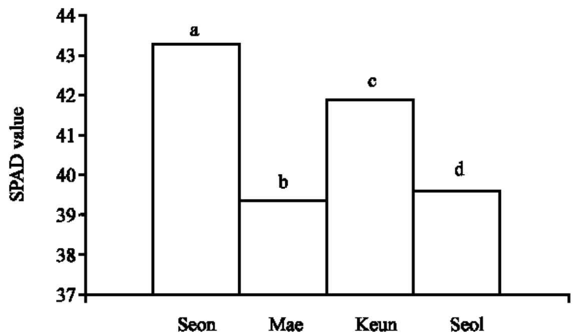

Fig. 4: The effect of the concentration 1.4 Mg^{++} meq L^{-1} on the quantities of chlorophyll (represented by SPAD value) of the 4 varieties ($p < 0.001$)

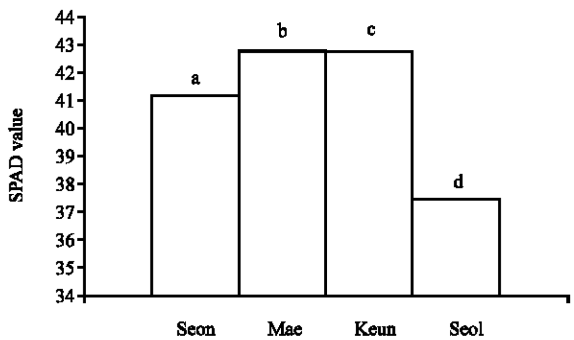

Fig. 5: The effect of the concentration 2.8 Mg^{++} meq L^{-1} on the quantities of chlorophyll (represented by SPAD value) of the 4 studied varieties ($p<0.001$)

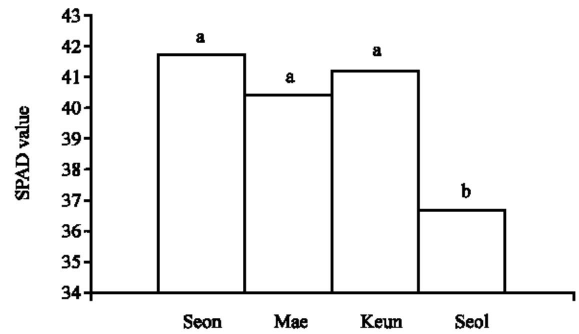

Fig. 6: Quantity of chlorophyll (represented by SPAD value) of the leaves of each studied variety ($p<0.001$)

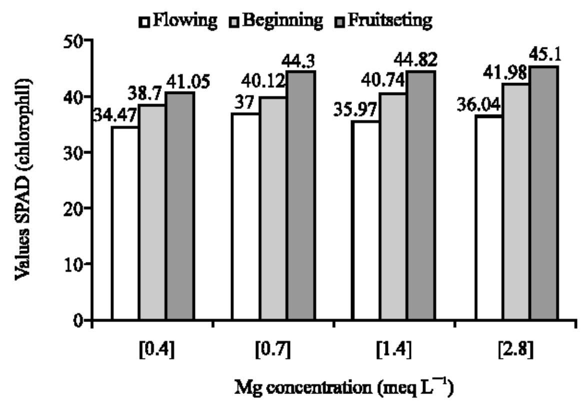

Fig. 7: Quantities of chlorophyll (represented by SPAD value) contained in the leaves of the three studied foliar levels ($p<0.001$)

was classified in last position 37.5 U SPAD. Woo *et al.* (1987) showed that the synthesis of the amino acids is related to a concentration raised out of Mg.

Comparison of the quantities of the total chlorophyll contained in each of the 4 varieties: By comparing the 4 varieties between them (Fig. 6), we noted that the average of the chlorophyll of the three foliar levels 36.73 U SPAD of Seolhyang is weakest than the other varieties. However, the multiple comparisons of the averages did not reveal a difference between Seonhong, Maehyang and Keumhyang with respectively 41.76, 40.37 and 41.24 U SPAD.

Effect of the 3 physiological stages: The variance analysis showed a very significant difference between the leaves corresponding at the three physiological stages compared to the 4 solutions used in our test.

On the leaves corresponding at the stage fruit setting (Fig. 7) which is oldest compared to the others, we obtained the highest rate of chlorophyll for the 4 Mg concentrations used. Peng *et al.* (1993) showed that on the leaves corresponding at the stage fructification the quantity of chlorophyll is higher.

The smallest quantity was, also obtained on the youngest leaves for each Mg concentration. They correspond at the stage flowering. Tarenghi and Martin (1995) showed that the young leaves produce more amino acids. Consequently, the totality of chlorophyll is not entirely made up.

On the leaves of beginning fruit setting the stage, we obtained an intermediate value.

CONCLUSION

We know that the magnesium plays a significant role in the ionic balance $K^+/(Ca^{+}+Mg)^{++}$ of the nutritive solutions. This report should be around 0.67. Otherwise, by the phenomenon of antagonism certain elements would not be absorbed by the plant.

On the whole of this test results, we noted that the magnesium concentrations ranging between 0.7 and

2.8 meq L^{-1}. give the same quantity of chlorophyll for the varieties Seonhong, Maehyang and Keumhyang on the first floral stalk. That means, we have many possibilities to vary the concentrations of Mg^{++}, K^{+} and Ca without disturb the ration $K^{+}/(Ca^{++}+Mg^{++})$. The production of fruit may be controlled by increasing the concentration of K^{+}.

On the other hand, on the leaves of the Seolhyang variety we obtained the smallest quantity of total chlorophyll. It is probable that this variety requires a higher Mg^{++} concentration.

Compared to the other three varieties Seonhong has given the greatest amount of chlorophyll with the lowest concentration Mg^{++}; data that can be taken into consideration when formulating nutritive solution for this variety.

For the three studied physiological stages, we confirmed the source role of the feeder leaves with respect to flowering stages, beginning fruit setting and enlargement of the fruits. Costa *et al.* (2001) and Schepers *et al.* (1992) confirmed that the young leaves have the lowest amount of chlorophyll, unlike the old leaves.

In our case, we used only 7.18 meq L^{-1} NO_3 whereas with a concentration varying between 7 and 12 meq L^{-1} (NO_3 80% and NH_4 20%) on the tomatoes and eggplants, the majority of the varieties express the totality of their genetic potentialities (Latigui, 1992).

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