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# Type of Bio-Stimulant and Application Method Effects on Stem Quality and Root System Growth in L.A. Lily

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**Summary**

The aim of this research was to evaluate the effects of three new different agricultural bio-stimulants, based on hydrolyzed protein coming from algae (M.A.E.), animal epithelium (A.P.H.), and lucerne origin (H.S.), compared to a control treatment (distilled water) on crop cycle, stem quality and root system growth in L. A. 'Brindisi' soilless cultivation. The bio-stimulants were applied eight times both at foliar and drenching level. The three bio-stimulants gave performances similar among them and higher than the water only according to some of the parameters: the crop cycle came early, the leaves resulted more expanded in the lamina and greener, the flower buds had a higher diameter; the root system showed a higher length development. Finally stem and bulb dry weights values were higher than the control. The bio-stimulant based on animal epithelium differed, from the vegetal and the algae-based ones, in the flower buds number (same values of the control), in the fresh and dry weights of leaves, buds and stem roots (values higher than the control ones). Regarding the cut stem quality if, on the one hand, drenching application method enhanced the stem height, on the other the foliar application increased in the flower buds number. With regard to bulb roots the foliar application method promoted the highest fresh weight value. The A.P.H. with foliar application, compared to the water, advanced both the harvest of nine days.

**Key words.** flower bulbs – sustainable agriculture – humic substances – marine algae extract – hydrolyzed animal protein – amino acid

## Introduction

In a modern floriculture new insights are required in order to achieve sufficient and sustainable yields and quality. A possible approach is represented by the application, to the grown species, of bio-stimulants, or „metabolic enhancers", non-fertilizer and non-polluting products, natural and organic substances, free from chemicals or synthetic plant growth regulators, able to increase plant metabolism, growth, health, yield and quality (Berlyn and Sivaramakrishnan 1996; Zhang and Schmidt 1999). Their role is also that of improving the absorption efficiency of the nutrients supplied by manuring (Frankenberger and Arshad 1995), thus modifying the root architecture, increasing the root development and predisposing the plants to a higher nutrients absorption (Ertani et al. 2009). Lately in the international literature, numerous commercially available bio-stimulants have been described, they fall into three major categories including humic substances (H.S.), coming predominantly from lignified cell walls (for example the Lucerne protein hydrolysate) and acting as cytokinin or auxin (O'Donnell 1973; Sanderson and Jameson 1986); marine algae extracts (M.A.E.) from seaweeds (*Aschophyllum nodosum* L. is the most widely used seaweed in agriculture) with chemical components that affect plant growth as cytokinins and auxins (Crouch and Van Staden 1993) and animal protein hydrolysates (A.P.H.) present in materials of animal origin like epithelium, hair or blood, that result in the formation of a range of compounds of organic nitrogenous nature known as amino-acids (mono peptides) with various molecular weights (Polo et al. 2006).

The research about bio-stimulants is therefore strongly oriented towards searching and testing the effectiveness and efficiency of new products on the bio-agronomic characteristic of cultivated species.

In spite of being widely used in vegetable and fruit growing, very little work has been done on the use of bio-stimulants on floricultural crops: Van Staden et al. (1994) and Russo et al. (1994) on marigold, Vernieri et al. (2005) and Vujošević (2007) on bedding plants. Moreover, there is a total lack of research on the effects of bio-stimulants on *Lilium*. It belong to one of the six more important genera of worldwide produced flower bulbs (De Hertogh and Le Nard 1993) and it is interesting for the application of bio-stimulants because it has two types of roots: annual

stem roots which are produced above the main bulb on the flowering stem and basal roots from the base of the bulb (bulb roots), which are usually contractile (Waisel 1998). Greenhouse soilless cultivation for lily production has many advantages with respect to soil production, including providing the ideal physical structure for moisture retention and aeration, avoidance of soil-borne pests and diseases, and higher control over plant nutrition (De Lucia et al. 2003). The aim of this research was to evaluate, in a L.A. lily soilless cultivation, the effects and the interaction of three new different agricultural bio-stimulants and their application method on crop cycle, stem quality and root system development.

## Materials and Methods

### *Plant material and treatments applications*

This study was conducted in the Department of agro-environmental and territorial Sciences, University of Bari, in Southern Italy (41°07' N, 16°52' E), during the autumn-winter period (from November 2009 to March 2010). Bulbs of *Lilium* 'Brindisi' (L.A.: *L. longiflorum* × *L.* x. *elegans)*, hybridized by Vletter & Den Ham Beheer in 2000, 18–20 cm in circumference, coming from Holland, were planted on November 20th in an soilless cultivation, in brown PVC containers (21 cm in diameter) filled with perlite (by Perlite Italiana), grown in a climate-controlled greenhouse (20 °C/15 °C day/night, 60 % RH, natural photoperiod), and fertirrigated by a micro-irrigation system with a modified Hoagland's nutrient solution. The plants were fertigated, depending on the growing and microclimate conditions; the E.C. and the pH of the nutrient solution were 1.2 and 6.3 mS $cm^{-1}$, respectively.

Three different new commercial bio-stimulants:
B1 (M.A.E. – Hydro Alga), B2 (A.P.H. – Hydro Gold Super) and B3 (H.S. – Vigor L Rapido), separately compared with B0, a control treatment (distilled water), were applied as foliar spray (F) and as perlite drenching (D); eight experimental treatments were made.

M.A.E. is made of the 30 % of *Aschophyllum nodosum* (L.) Le Jolis algae extract with hormones such as cytokinins (56 ppm) and auxins (456 ppm).

A.P.H. is made of enzymatic hydrolysates obtained from animal epithelium. It is obtained by the enzymatic hydrolysis of cows red blood cells under alkaline conditions; it has a high total content of L-α amino-acids and free amino-acids and a high organic-nitrogen content (Table 1). H.S. is obtained by the enzymatic hydrolysis of a Lucerne (*Medicago sativa* L.) protein extract based on amino-acids and peptides. It contains 15 % organic C, 4.5 % organic N, 28 % total amino-acids, 3.5 % free amino-acids.

The above quoted bio-stimulants were applied eight times (every week from the first ten leaves appearance to flower buds differentiation both at the concentration of 1.5 g $L^{-1}$ in solution with distilled water, as suggested by the company which provided the commercial products. F was made through a hand sprayer on the leaves of lily plants until dripping and D with a volume of 150 mL per pot.

### *Plant growth analysis*

At the opening of the first flower bud, plants were harvested. The crop cycle length (as number of days from planting to flowering) was calculated, and the cut stem was separated from the root system. The plant growth analysis was performed using both bio-morphometric and fresh and dry weight measurements on epigeal organs (stems, leaves and flower buds) and root system (bulbs, stem roots and bulb roots). The dry weight was determined after drying them in an oven at 70 °C for 72 h; the leaf surface area was measured with the area meter (Delta-T, Decagon Devices, Pullman, Washington, USA); the SPAD index determination was performed with the SPAD Chlorophyll Meter (Minolta Camera Co., Lts, Osaka, Japan).

Table 1. Composition of the animal protein hydrolisates used as treatment A.P.H. in the experiment (one sample analyzed).

| Type of Amino acid | mg $L^{-1}$ | Type of Amino acid | mg $L^{-1}$ |
|---|---|---|---|
| Total Amino acid | 56.30 | Isoleucine | 0.82 |
| Aspartic Acid | 3.37 | Histidine | 3.62 |
| Glutammic Acid | 5.42 | Leucine | 1.90 |
| Alanine | 5.94 | Lysine | 1.66 |
| Arginine | 2.90 | Methionine | 0.45 |
| Cisteine+cistine | 0.08 | Proline | 7.37 |
| Fenilalanine | 1.13 | Serine | 0.71 |
| Glysine | 13.00 | Tyrosine | 0.46 |
| Idrossiproline | 5.79 | Threonine | 0.43 |
| Valine | 1.27 | Triptofane | 0.02 |

*Statistics*

The experimental test was conducted using four randomized blocks, each block including eight treatments (four bio-stimulants and two application methods). Each treatment consisted of four replicates with 20 plants in each replication.

The data were subjected to the two-ways analysis of variance (ANOVA) in order to assess the influence of: bio-stimulants (water, M.A.E., A.P.H., H.S.), application method (F and D) and their interaction on crop cycle, stem quality and root system growth.

The statistical differences among the means were determined by the tests of Student-Neuman-Keuls (S.N.K.) at the level of significance $P < 0.05$.

## Results

The experimental results of the collected data showed that the bio-stimulants, used during lily forcing, had beneficial effect on crop cycle, stem quality and root system growth.

Lilies grown with bio-stimulants had a shorter crop cycle, on average 4.5 d less than the plants grown in water (Table 2). A significant interaction was found between bio-stimulant and application method on crop cycle. The plants under foliar application method harvested earlier than those under drenching application (on average 78 compared to 81 d). The shortest crop cycle by far was found when A.P.H. was applied as foliar spray with an average value of only 77 d. The APH as foliar spray, compared to water as foliar spray, advanced the harvest of nine days (Fig. 1). The early flowering of lilies under foliar bio-stimulants could be the result of a faster plant development due to good root system.

The stem height was significantly affected only by the bio-stimulant application: the longest lily stems were obtained with the drenching treatment: 100.6 and 96.8 cm, respectively, with an increase of 4 % on average (Table 2). Higher leaves area values occurred in plants treated with bio-stimulants, with an increase of 26 % on average compared to the water. A.P.H. showed the highest values (by far) similar to those obtained in M.A.E. and H.S.. No differences were found in the leaves number per stem. All the bio-stimulants had positive effect on the SPAD index: they showed a significantly enhanced effect compared to the water, with an increase of 7 % on average.The number of flower buds per stem was affected by both the experimental factors: A.P.H. showed the highest values similar to those obtained in the water, while no significant difference insists between M.A.E. and H.S.. The foliar spray application significantly enhanced the number of flower buds compared to drenching application: 6.4 and 5.0 flower buds, respectively, with an increase of 28 % on average; the B × A interaction proved to be significant.

Table 2. Effect of the bio-stimulants and their application method on crop cycle. morpho-physiological features and epigeal and hypogeal organs fresh weight.

| Treatments | Crop cycle (d) | Stem height (cm) | Leaves (n) | Leaf area ($cm^2$) | SPAD index | Flower buds (n) | Bud diam. (mm) | R.s.[a] length (cm) | Stem f.w.[b] (g) | Leaves f.w. (g) | Buds f.w. (g) | Bulb f.w. (g) | Bulb roots f.w (g) | Stem roots f.w (g) | R/S f.w. ratio[c] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bio-stimulants (B) | | | | | | | | | | | | | | | |
| Water | 84.6 b | 97.7 | 71.8 | 10.2 b | 57.6 b | 7.0 a | 20.0 b | 10.2 b | 72.0 a | 44.0 b | 43.4 b | 17.4 | 32.5 c | 21.9 c | 33.4 c |
| M.A.E. | 80.9 a | 101.2 | 69.7 | 12.3 a | 61.7 a | 5.5 b | 22.5 a | 12.3 a | 69.0 ab | 53.7 a | 40.5 b | 19.6 | 45.4 b | 32.8 b | 47.9 b |
| A.P.H. | 78.5 a | 98.4 | 69.1 | 12.9 a | 62.3 a | 6.2 a | 21.7 a | 12.9 a | 68.0 ab | 53.9 a | 46.2 a | 19.7 | 52.1 a | 36.1 a | 52.5 a |
| H.S. | 80.8 a | 98.3 | 67.1 | 12.0 a | 61.2 a | 5.2 b | 22.1 a | 12.0 a | 66.0 b | 46.1 b | 39.0 b | 19.7 | 46.3 b | 34.5 b | 53.6 a |
| Application method (A) | | | | | | | | | | | | | | | |
| Foliar spray | 80.8 | 96.8 b | 69.2 | 12.1 | 62.1 | 6.4 a | 21.4 | 12.1 | 66.9 | 51.2 | 43.8 | 19.5 | 45.8 a | 31.5 | 48.4 |
| Drech | 81.6 | 100.6 a | 69.7 | 11.7 | 59.7 | 5.0 b | 21.7 | 11.7 | 66.1 | 50.2 | 37.0 | 18.4 | 41.7 b | 31.3 | 47.6 |
| Significance | | | | | | | | | | | | | | | |
| B | * | NS | NS | ** | * | * | ** | ** | * | * | * | NS | ** | ** | ** |
| A | NS | * | NS | NS | NS | * | NS | NS | NS | NS | NS | NS | * | NS | NS |
| B × A | * | NS | NS | NS | NS | * | NS | NS | NS | NS | NS | NS | * | * | NS |

[a] R.s. = Root system; [b] f.w. = fresh weight; [c] = values measured excluding the bulb fresh weight.
Significance levels: NS = not significant; * = $P < 0.05$; ** = $P < 0.01$; SNK at < 0.05. Means having the same letters within a column are not significantly different ($P < 0.05$) according to the S.N.K. test.

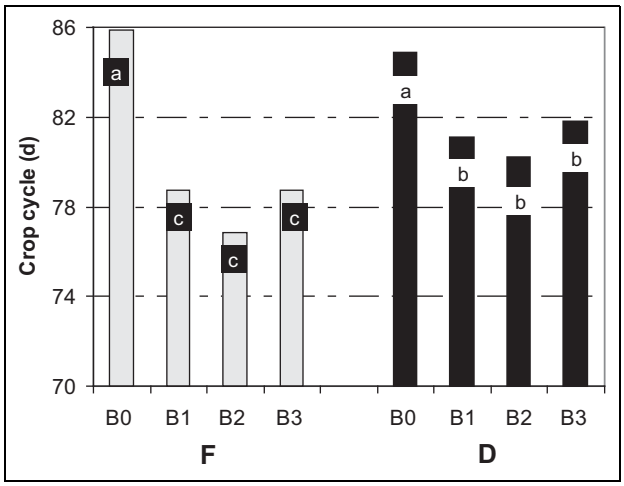



Fig. 1. Influence of interaction between bio-stimulants and their application on crop cycle.

Higher flower bud diameter values occurred in plants treated with bio-stimulants, with an increase of 10 % on average compared to the water. The bio-stimulant use greatly affected the root length compared to the water, showing an average increase of 20 % (Table 2). At the end of the experimental period, the plants treated with bio-stimulants let us register a fresh biomass accumulation in the plant epigeal and hypogeal organs (Table 2). Regarding the stem fresh weight the water showed the highest values similar to those obtained in M.A.E. and A.P.H., while a slightly significant difference insists between water and H.S.. The fresh weight of leaves was influenced by the bio-stimulants: M.A.E. and A.P.H. showed a significantly enhanced effect compared to H.S. and to the water; A.P.H. increased the bud fresh weight compared to the water, M.A.E. and H.S. (with an increase of 13 % on average).

A.P.H. strongly and significantly improved both the bulb roots and stem roots fresh weights compared to the other substances and to the water. A.P.H. had an average increase of 14 % in bulb roots fresh weight and of 7 % in stem roots fresh weight compared to the two other bio-stimulants and of the 60 % in bulb roots fresh weight and of 65 % in stem roots fresh weight compared to the water. The foliar spray application method significantly enhanced the bulb roots fresh weight compared to the drenching application: 45.8 and 41.7 g, respectively, with an increase of 10 % on average. The B × A proved to be significant.

The highest values of root – to shoot fresh mass ratio occurred in plants treated with A.P.H. and H.S.; no difference was found with the bio-stimulants application method (Table 2).

The bio-stimulants use greatly affected the stem dry weight compared to the water, showing an average increase of 20 %. M.A.E. and A.P.H. had a positive effect on the leaves dry weight compared to H.S. and to the water (Table 3).The flower bud dry weight was affected by both the experimental factors: A.P.H. was the most effective bio-stimulant in enhancing flower bud dry weight (plus 20 % compared to the other treatments). The foliar spray application method significantly enhanced the flower bud dry weight compared to the drenching application method: 5.0 g and 3.9 g, respectively, with an increase of 28 % on average. Regarding the bulb dry weight all the bio-stimulant were more efficient than the water; A.P.H.

Table 3. Effect of the bio-stimulants and their application method on epigeal and hypogeal organs dry weight.

| Treatments | Stem | Leaves | Buds | Bulb | Bulb roots | Stem roots | R/S ratio[c] |
|---|---|---|---|---|---|---|---|
| Bio-stimulants (B) | | | | | | | |
| Water | 8.21 b | 5.45 b | 4.37 b | 2.26 b | 2.28d | 1.31 c | 0.26 c |
| M.A.E. | 9.43 a | 6.96 a | 4.55 b | 2.84 a | 4.09 b | 2.62 b | 0.41 b |
| A.P.H. | 9.72 a | 6.92 a | 5.27 a | 2.96 a | 5.73 a | 3.61 a | 0.56 a |
| H.S. | 9.26 a | 5.94 b | 4.39 b | 2.92 a | 3.70 c | 2.44 b | 0.41 b |
| Application method (A) | | | | | | | |
| Foliar spray | 9.31 | 6.67 | 5.01 a | 2.79 | 4.01 a | 2.44 | |
| Drech | 9.22 | 6.59 | 3.92 b | 2.64 | 3.65 b | 2.43 | |
| Significance | | | | | | | |
| B | * | * | * | * | * | * | * |
| A | NS | NS | * | NS | NS | NS | NS |
| B × A | NS | NS | NS | NS | NS | NS | NS |

Significance levels: NS = not significant; * = P < 0.05; ** = P < 0.01; SNK at < 0.05. Means having the same letters within a column are not significantly different (P < 0.05) according to the S.N.K. test.

had a positive affect on bulb roots dry weight compared to the other bio-stimulant and to the water (Table 3).

## Discussion

Bio-stimulants are usually applied in addition to standard fertilization treatments to improve the nutrient use efficiency or the products quality (HECKMAN 1994).

The results reported in this work indicate that the examined bio-stimulants are able to exercise a consistent action of harvesting precocity in 'Brindisi' lily, probably encouraging flowering by initiating robust plant growth, due to a good root system (Table 2). ABETZ and YOUNG (1983) and STIRK et al. (2004) proved that seaweed concentrate induces early flowering and fruit set in a number of crop plants. Our results are similar to the findings of VERNIERI et al. (2005), in *Impatiens* and *Salvia* and of MARFÀ et al. (2009) in strawberry plants: the application of enzymatic hydrolysates obtained from animal haemoglobin (P.H.H.), specifically porcine blood, had positive effects on early harvesting. The growth analysis in this research showed that the bio-stimulants significantly increased the leaf area of 'Brindisi' lily. In M.A.E. it was partially due to the direct effect of the bio-stimulants containing betaine. According to BLUNDEN and WILDGOOSE (1977) and COSTA et al. (2006), the exogenous application of these compounds has been shown to have a cytokinin-like activity. FERRINI and NICESE (2002) in *Quercus robur* seedlings found higher values of leaf area and leaf dry weight in the treated plants than in the control. In our experimental conditions all the bio-stimulants resulted in higher SPAD values in the leaves of the treated plants in comparison to water plants (Table 2). Our results agree with BLUNDEN et al. (1997): the application of a low concentration of *Ascophyllum nodosum* extract is effective on foliage of tomato, wheat, barley and maize crops. This increase in chlorophyll content was a result of the reduction in chlorophyll degradation, which might be partly caused by the betaines in the seaweed extract (WHAPHAM et al. 1993). About bio-stimulant product based on amino acid and short chains of peptides, as A.P.H., in the same experiments it has also been observed an increase in the number of flowers (FILITI et al. 1986).

In 'Brindisi' Lily, the yield, associated with fresh weight of epigeal and hypogeal organs (Table 2), was increased by the use of A.P.H. compared to the water and to M.A.E, and H.S.. These results agree with MARFÀ et al. (2009) who obtained positive effects on the fresh weight values of strawberry plants.

In our experimental research, a clear growth increment in stem and bulb was detected in terms of dry weights (Table 3), confirming the bio-stimulants effectiveness compared to water. A number of researchers have found that bio-stimulants can increase root growth, our results (Table 2) agree with VAUGHAN (1974) who proposed that humic acids may primarily increase root growth by increasing root cell elongation.

Concluding, the three new biostimulants gave performances similar among them and higher than the water only according to some of the parameters: the crop cycle came early, the leaves resulted more expanded in the lamina and greener, the flower buds had a higher diameter; the root system showed a higher length development (Table 2). Finally stem and bulb dry weights values were higher than the control.

The biostimuant based on animal epithelium (A.P.H.) differed, from the vegetal (H.S.) and the algae-based (M.A.E.) ones, in the flower buds number (same values of the control), in the fresh and dry weights of leaves, buds, and stem roots (values higher than the control ones) (Table 2 and 3).

Regarding the cut stem quality, if, on the one hand, drenching application method enhanced the stem height, on the other the foliar application increased in the flower buds/stem number. With regard to bulb roots the foliar application promoted the highest fresh weight value.

The A.P.H. with foliar application, compared to the water, advanced both the harvest of nine days (Fig. 1).

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## References

ABETZ, P. and C.L. YOUNG 1983: The effect of seaweed extract sprays derived from *Ascophyllum nodosum* on lettuce and cauliflower crops. Botanica Marina **26**, 487–492.

BERLYN, G.P. and S. SIVARAMAKRISHNAN 1996: The use of organic biostimulants to reduce fertilizer use, increase stress resistance, and promote growth. Nat. Proc. Forest and Conservation Nursery Ass. Meet. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, USA, 106–112.

BLUNDEN, G. and P. B. WILDGOOSE 1977: The effects of aqueous seaweed extract and kinetin on potato yields. J. Sci. Food and Agr. **28**, 121–125.

BLUNDEN, G., T. JENKINS and Y.-W. LIU 1997: Enhanced leaf chlorophyll levels in plants treated with seaweed extract. J. Applied Phycol. **8**, 535–543.

COSTA, G., C. ANDREOTTI, F. SPINELLI and W. RADEMACHER 2006: Prohexadione-ca: more than a growth regulator for pome fruit trees. Acta Hort. (ISHS) **727**, 107–116.

CROUCH, I.J. and J. VAN STADEN 1993: Evidence for the presence of plant growth regulators in commercial seaweed products. Plant Growth Regulators **13**, 21–29.

De Hertogh, A.A. and M. Le Nard 1993: World production and horticultural utilization of flower bulbs. In: De Hertogh, A.A. and M. Le Nard (eds.): The physiology of flower bulbs. Amsterdam: Elsevier Science Publishers **2**, 21–28.

De Lucia, B., L. Mancini and A. Ventrelli 2003: Effects of nutrient solution salinity (NaCl) on the yield level and quality characteristics in *Lilium* soilless culture. Acta Hort. (ISHS) **609**, 401–406.

Ertani, A., L. Cavani, D. Pizzeghello, E. Brandellero, A. Altissimo, C. Ciavatta and S. Nardi 2009: Biostimulant activities of two protein hydrolysates on the growth and nitrogen metabolism in maize seedlings. J. Plant Nutr. Soil Sci. **172**, 237–244

Ferrini, F. and F.P. Nicese 2002: Response of English oak (*Quercus robur* L.) trees to biostimulants application in the urban environment. J. Arbor. **28**, 70–75.

Filiti, N., G. Cristoferi and P. Maini 1986: Effects of biostimulant in fruit trees. Acta Hort. (ISHS) **179**, 277–278.

Frankenberger, W.T. and M. Arshad 1995: Phytohormones in soils: microbial production and function, Ed. Dekker, M., Inc: New York.

Heckman, J.R. 1994: Effect of an organic bio-stimulant on cabbage yield. J. Home and Consumer Hort. **1**, 111–113.

Marfà, O., R. Cáceres, J. Polo and J. Ródenas 2009: Animal protein hydrolysate as a biostimulant for transplanted strawberry plants subjected to cold stress. Acta Hort. (ISHS) **842**, 315–318.

O'Donnell, R.W. 1973: The auxin-like effects of humic preparations from leonardite. Soil Science **116**, 106–112.

Polo, J., R. Barroso, J. Ródenas, J. Azcón-Bieto, R. Cáceres and O. Marfà 2006: Porcine haemoglobin hydrolysate as a biostimulant for lettuce plants subject to conditions of thermal stress. HortTechnology **16**, 483–487.

Russo, R.O., R.P. Poincelot and G.P. Berlyn 1994: The use of a commercial organic biostimulant for improved production of marigold cultivars. J. Home & Consumer. Hort. **1**, 83–93.

Sanderson, K.J. and P.E. Jameson 1986: The cytokinins in a liquid seaweed extract: could they be the active ingredients? Acta Hort. (ISHS) **179**, 113–116.

Stirk, W.A., G.D. Arthur, A.F. Lourens, O. Novák, M. Strnad and J. van Staden 2004: Changes in cytokinin and auxin concentrations in seaweed concentrates when stored at an elevated temperature. J. Appl. Phycol. **16**, 31–39.

Van Staden, J., S. J. Upfold and F. E. Drewes 1994: Effect of seaweed concentrate on growth and development of the marigold *Tagetes patula*. J. Appl. Phycol. **6**, 427–428.

Vaughan, D. 1974: A possible mechanism for humic acid action on cell elongations in root segments of *Pisum sativum* L. under aseptic condition. Soil Biol. Biochem. **6**, 241–247.

Vernieri, P., A. Ferrante, E. Borghesi and G. Magnani 2005: Piante fiorite di qualità con l'impiego di biostimolanti. L'Informatore Agrario **16**, 57–60 (In Italian).

Vujošević, A.N., S. Lakić, D. Lazarević, D. Beatović and S. Jelačić 2007: Effect of natural bio-stimulant and slow-release fertilizers in commercial production of begonia sapling (*Begonia semperflorens*) J. Agric. Sci. **52**, 33–42.

Waisel, Y. 1998: Biology of root formation and development. In: Hingham. M.A. (ed.): Kluwer Academic Press.

Whapham, C. A., G. Blunden, T. Jenkins and S. D. Hankins 1993: Significance of betaines in the increased chlorophyll content of plants treated with seaweed extract. J. Appl. Phycol. **5**, 231–234.

Zhang, X. and R.E. Schmidt 1999: Antioxidant response to hormone-containing product in Kentucky bluegrass subjected to drought. Crop Sci. **39**, 545–551.

Zhang, X., E.H. Ervin and R.E. Schmidt 2003: Effects of liquid application of a seaweed extract and a humic acid on creeping bentgrass (*Agrostis palustris* Huds. A.). J. Amer. Soc. Hort. Sci. **128**, 492–496.

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