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Effect of starter solutions in soil and foliar spray with some stimulants on growth and productivity of chinese cabbage

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ABSTRACT

Two field experiments were carried out at a Farm in El-Shahyna Village Kafrelsheikh Governorate (North Delta), Egypt, during the two successive winter seasons of 2012 and 2013 to study the effect of starter solutions of NPK fertilizers in soil and foliar application of some stimulants (amino acids and seaweed extract) as well as their interactions on growth and yield of Chinese cabbage plants (*Brassica rapa* L. subsp. pekinensis) cv. (Manoko). Four starter fertilizers treatments included three sources of N, i.e., ammonium sulfate (20.5 % N), ammonium nitrate (33.5 %) and urea (46%) as well as without starter solution and two sources of stimulants. The experiments were carried out in a split-plot with three replications.The results indicated that, starter solutions treatments resulted in highly significant increases in stem length, stem diameter, whole stem weight, number of total leaves/ plant and fresh weights of outer leaves (inedible), inner leaves (edible) , total leaves / plant and weights of total yield (whole head) and marketable yield (edible head) compared with the control treatment (without starter solution) in both seasons. The increase (%) in weights of total and marketable yield resulted from using starter solution No. 1 (containing Ammonium Sulfate), No. 2 (containing ammonium nitrate) and No. 3 (containing urea) over the control(without starter solution) were (51.8 and 67.6(%) , 59.1 and 75.6(%) , 55.7 and 75.6(%) (as av. two seasons), respectively.Amino acid and seaweed extract treatments caused highly significant increases in stem diameter, whole stem weight, number of total leaves/ plant, weights of outer leaves (inedible), inner leaves (edible) and total leaves/ plant , fresh weights of total yield (whole head) and marketable yield (edible head) compared to the control (unsprayed) treatment in both seasons. Such increases were highly significant in the first season for leaf area / plant and leaf area index (LAI). Moreover, they had a significant increase in stem length in both seasons such increase were significant in the second one for leaf area /plant and leaf area index (LAI). The increase (%) in weights of total and marketable yield resulted from foliar spray with amino acid and seaweed extract over no spray were 43.3 and 43.0(%), 14.8 and 14.3(%) (As av. two seasons), respectively. The highest values of previous characteristics were recorded when Chinese cabbage plants sprayed with amino acid followed by seaweed extract compared with unsprayed plants which had the lowest values in both seasons. The combined interaction between starter solutions and foliar spray with some stimulants had no significant effect on stem characteristics, leaves characteristics and weights of total and marketable yield in both seasons.

Keywords: Chinese cabbage, starter solutions, NPK fertilizers, biostimulants, amino acid, seaweed extract, foliar spray.

INTRODUCTION

Chinese cabbage (*Brassica rapa* L. subsp. pekinensis) is a leafy vegetable crop which has a major economic importance in many countries including Egypt. Chinese cabbage is a member of the *Brassicaceae* family, which may be called brassicas, crucifers or Cole crops. This includes various crops such as broccoli, Brusseles sprouts, cauliflower, cabbage, radish and others (Burt *et al.,* 2006). It has a short vegetation period, and it belongs to that group of plants which are the fastest growing of all leafy vegetables, in good conditions heads can be cut ten weeks after sowing; loose-headed types two to three weeks sooner, while seedlings four to five weeks after sowing (Larcom, 2003).

In Egypt, Chinese cabbage is recently introduced as a winter crop grown throughout the country along the Nile valley as well as in new reclaimed lands (El-Mohamedy *et al.,*2009). By its nature, Chinese cabbage it is a biannual plant. Its short vegetation period allows the obtaining of harvestable part and seeds in the same year, being thus characterized, in this case, as an annual plant (Munro and Small, 1997).

Starter fertilizer is a method for precise fertilization. By using this method every plant gets the exact amount needed and fertilization of soil without roots is minimized exact amount needed and fertilization of soil without roots is minimized (Ekengard, 2008).

In early studies the starter solutions were mainly P and K but later work includes also the effect of N in starters (Costigan and Heaviside 1988; Stone 1998; Stone *et al*. 1999). The purpose of a starter fertilizer is to supply a small amount of nutrients in the early stages of growth before the root system is sufficiently developed to reach banded fertilizer. This is accomplished by placement of small amounts of fertilizer near the seed or by dissolving fertilizer in the transplant water. Little information is available about use N sources in starter solutions, i.e., ammonium sulfate, ammonium nitrate and urea, but no trials for evaluating them under Kafrelsheikh conditions.

In recent years, the world focused his attention to minimize environmental pollution and human health impacts, by reducing the use of synthetic fertilizers and chemicals in crops production, especially vegetables which eat fresh using natural alternatives, (IFAOM/SOEL, 2000 and FAO/TTC, 2001).

Engaging in the vegetable production the chemicals of regulatory effect on plant growth and development (biostimulators) is one of means for obtaining the increase in yield per unit area and a higher yield quality. However, plant biostimulation has recently become an increasingly more common treatment in modern agricultural production, among such substances are seaweed extract and amino acids.

Recently, much works has been conducted on several natural compounds including amino acids to be applied as a foliar feeding to increase growth and yield of economical crops, as a biostimulant (Strove, 1986 and Abd El-Ghaffar, 2012).

Hence, the present research was carried out to study the effect of starter solution of NPK fertilizer (containing N sources) treatments and some stimulants (amino acid and seaweed extract) on vegetative growth and yield

of Chinese cabbage plants during winter season under Kafrelsheikh conditions.

MATERIALS AND METHODS

Field experiments were carried out at a Farm in El-Shahina Village, KafrelSheikh Governorate (North Delta), Egypt. during the two successive winter seasons of 2012 and 2013.

The soil of the experimental farm has a clay texture. Soil analysis were done according to Jackson (1967) and Piper (1947) and presented in Table (1).

Table (1): Some physical and chemical properties of the experimental soil during both seasons of 2012 and 2013.

Soil properties									Available nutrients (ppm)					
season	Coarse sand(%)	Fine sand (%)	Silt (%)	Clay (%)	Texture class	EC dS / m (1:5)	pH	O.M. %	N	P	K	Fe	Zn	Mn
2012	2.18	12.37	16.71	68.74	Clayey	1.52	8.3	1.5	47.5	34	348	12.11	3.24	1.12
2013	2.55	11.95	17.68	67.82		1.43	8.1	1.48	45.0	36	340	12.06	2.9	1.1

In early winter season seeds of Chinese cabbage (*Brassica rapa* L. subsp. pekinensis) cv. 'Manoko' were sown on November 21st in both seasons, in seedling trays filled with a mixture of peat moss and vermiculite (1:1 v/v). Chemical fertilizers and fungicides were added to the mixture according to the recommendation of the Ministry of Agriculture, Egypt. The trays were cared by irrigation, fertilization and pest management in the nursery. The transplants were transplanted on January 1st of 2012 and 2013.

The normal cultural practices of Chinese cabbage production were followed as recommendation. Transplants took place on both sides of each ridge (80 cm width) at a space of 35 cm (McKay and Phillips 1990), planting density was 7.14 plants/m^2). The experimental sub-plot area was 12 m^2 (5m length x 0.8 m width x 3 row).

Treatments used:

A- Starter solutions of NPK fertilizers:

The concentrations of N, P_2O_5 and K_2O were 1575, 2400 and 2400 ppm, respectively. Three sources of N were used as ammonium sulfate $(NH_4)SO_4$, ammonium nitrate NH_4NO_3 and urea $CO(NH_2)_2$.

1-Starter solution No. 1: (1 kg ammonium sulfate (20.5% N) + 1 kg monoammonium phosphate (11-48-0)+ 1 kg potassium sulfate (48% K_2O) / 200 liter water.

2- Starter solution No. 2: (612 g ammonium nitrate (33.5 % N) + 1 kg monoammonium phosphate (11-48-0) +1 kg potassium sulfate (48% K_2O) / 200 liter water.

3-Starter solution No.3 : (446 g urea (46% N) + 1 kg monoammonium phosphate (11-48-0) +1 kg potassium sulfate (48% K_2O) / 200 liter water.

4-Control (without starter solution).

The starter solutions were added in soil at one day after transplanting.

B - Foliar applications:

Three foliar applications of some stimulants as follows:

1 - **Amino acids** : It was used at 1 cm/l and prepared as an aqueous solution. Analysis of amino acid is shown in Table (2).

2 – **Seaweed extract** : It was used at 1.5 cm/l and prepared as an aqueous solution. Analysis of seaweed extract is shown in Table (3).

3 – **Control** (unsprayed) .

Chinese cabbage plants were sprayed with amino acid and seaweed extract three times at 15 days interval, beginning two weeks after transplanting .

The experiment included 12 treatments which were the combinations of the four starter solutions treatments and three foliar spray with some stimulants treatments. The previous treatments were arranged in a split-plot using a randomized complet e blocks design with three replications. Starter solutions treatments were randomly assigned in the main plots where each main plot was splitted to three treatments of foliar spray with some stimulants as sub-plots.

Table (2): Analysis of amino acid (amino active).

Components					**Vitamins**						
Amino acids	**Organic acids**	**N**	**Progibbrellic acids**	**carbohydrates**	**A (Retinol)**	**D (Calciferol)**	**E (Tocopherol)**	**B_1 (Thiamin)**	**B_2 (Riboflavine)**	**B_6 (Pyridoxine)**	**B_{12} (Cyanocobalamin)**
40.000 ppm	40.000 ppm	8%	400 ppm	unknown	500 IU	1000 IU	10 mg	10 mg	10 mg	5 mg	60 meg

Table (3): Analysis of seaweed extracts (Alga 600).

Components							
Alginic acid	**N**	**K**	**Fe**	**S**	**Ca**	**Mg**	**Growth regulators**
10 – 12%	1 %	18.5 %	0.06 %	2.2%	0.17%	0.42%	600 ppm

Data recorded

Vegetative growth:

Vegetative growth parameters such as stem characteristics (length, diameter and weight) and leaves characteristics (number of outer leaves, inner leaves, total leaves and fresh weights of outer leaves , inner leaves, total leaves and leaf area/plant and leaf area index LAI) were recorded.

Leaf area/plant (cm^2): Leaf area/plant: It was measured in (m^2),10 fresh of outer leaves samples were collected from each plant and by known diameter cork borer, disks were made, then determined plant leaf area as:

$$\text{Leaf area/ plant}(m^2) = \frac{\text{Area of the disks } (cm^2) \times \text{weight of leaves/plant}}{\text{weight of disks X } 10000}$$

$$\text{Leaf area index (LAI)} = \frac{\text{Leaf area per plant}(cm^2)}{\text{Soil surface area per plant } (cm^2)}$$

Chinese cabbage yield:

Data included total yield (whole head weight) and marketable yield (edible head). The increases in weights of total and marketable yield as a percentage were calculated by using the following equation:

$$\text{Yield weight increase (\%)} = \frac{\text{Treatment yield – control yield}}{\text{Control yield}} \times 100$$

The previous characters were estimated from five plants which were randomly chosen from each experimental unit (sub- plot) at 55 days after transplanting. Data were tested by analysis of variance according to Little and Hills (1975). Duncan's multiple range test was used for comparison among treatments means Duncan, (1955)

RESULTS AND DISCUSSION

I . Vegetative growth

A . Effect of starter solutions of NPK fertilizers

Data in Table (4) show that starter solutions of NPK fertilizers treatments resulted in highly significant increases in stem length, stem diameter, stem weight, number of total leaves and weights of outer leaves (inedible), inner leaves (edible) and total leaves /plant compared with the control treatment (without starter solution) in both seasons. However, the differences among

three treatments of starter NPK fertilizer (contained N sources) were nonsignificant in both seasons. Moreover, the starter fertilizer had a significant effect on number of inner leaves (edible) in the first season only and number of outer leaves (inedible) in the second season only. On the other hand, starter solutions of NPK fertilizers had no significant effect and had no constant trend on leaf area / plant and leaf area index in both seasons. Similar results were obtained by Ekengard, (2008) and Susila, *et al.,*(2011), they show that inorganic starter solution application resulted in a better plant growth.

The beneficial effect of the starter solution of NPK fertilizer was to accelerate root development (AVRDC, 2004) which subsequently increased plant establishment growth and yield (Susila, *et al.,* 2011). Also, application of starter solutions of soluble nutrients in addition to inorganic fertilizer application is an effective technique to increase plant dry weight and N, P and K uptakes, and to promote rapid early growth of crops, especially crops with fast early growth rates (AVRDC, 2004).

B . Effect of foliar spray with some stimulants:

Data presented in Table (5) indicate that amino acids and seaweed extract treatments resulted in highly significant increases in stem diameter, whole stem weight and weights of outer leaves (inedible), inner leaves (edible) and total leaves / plan and number of total leaves per plant compared with non-sprayed treatment in both seasons. In addition stimulants (amino acid and seaweed extract) also had significant increases in stem length number of outer leaves (inedible)and number of inner leaves (edible) compared to the control (unsprayed) in both seasons.

Data also show that stimulants caused highly significant increases in leaf area / plant and leaf area index (LAI) in the first season, such increase were significant in the second one.

The highest values of stem characteristics (length, diameter and weight), number and weight of leaves / plant and leaf area in both seasons were recorded when the Chinese cabbage plant sprayed with amino acids, followed by seaweed extract as compared to control (unsprayed) which had the lowest values.

Many investigators had similar results on some vegetable plants by using amino acids (Abd El-Aal, 2012 and Rania, 2012) and seaweed extract (El-Aidy *et al.,* 2002, and Abd El-Ghaffar, 2012).

The importance of amino acids came from their widely use for the biosynthesis of a large variety of nonproteinic nitrogenous materials, i.e., pigments, vitamins, coenzymes, purine, and pyrimidine bases. Studies have proved that amino acids can directly or indirectly influence the physiological activities in plant growth and development (Al-Said and Kamal, 2008). Also, amino acids is a well-known biostimulant which has positive effects on plant growth, yield and significantly mitigates the injuries caused by abiotic stresses (Kowalczyk and Zielony, 2008).

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C. Effect of interaction between starter solutions of NPK and foliar spray with some stimulants :

Data in Tables (6,7 ,8 and 9) show that the combined interaction between starter solutions of NPK fertilizers and foliar spray with some stimulants had a nonsegnificant effect on stem characteristics , number of leaves / plant , weight of leaves /plant and leaf area in both seasons.

II. Chinese cabbage yield :

A. Effect of starter solutions of NPK fertilizers:

These results in Table (10) clearly demonstrate that the application of starter solutions reveal that all starter solutions treatments resulted in highly significant increases in weights of total yield (whole head) and marketable yield (edible head) compared with the control(no starter solution) treatment in both seasons. However the differences in weights of total and marketable yield due to starter solution No. 1 (containing ammonium sulfate), No. 2 (ammonium nitrate) and No. 3 (urea) were nonsignificant. Similar results were obtained by Stone, *et al.*, (1997), Stone *et al.,* (1999), Stone, (2000) and Susila *et al.,* (2011).

The increase (%) in weight of total yield resulted from using starter solution No.1 (containing ammonium sulfate), No. 2 (ammonium nitrate) and No. 3 (Urea) over the control (without starter solution) were 51.86 , 59.1 and 55.7 (%) (as average of two seasons), respectively. Moreover, the increase % in weights of marketable yield resulted from using starter solutions No. 1, No. 2 and No. 3 over without starter solution were 67.6 , 75.6 and 75.6(%) (as average of two seasons), respectively.

B . Effect of foliar spray with some stimulants:

Data in Table (11) reveal that stimulants had highly significant increase in weights of total yield (whole head) and marketable yield (edible head) compared with the control (unsprayed) treatment in both seasons. The highest weight of total yield (whole head) and marketable yield (edible head) were obtained when the Chinese cabbage plants sprayed with amino acids, followed by seaweed extract as compared with control which had the lowest record.

Similar resulted were obtained by many researches using foliar spray with amino acids Abd El-Ghaffar, (2012) and seaweed extract Blunden, (1977) and Abd El-Ghaffar, (2012).

The application of seaweed extract for different crops was a great importance due to contain high levels of organic matter, micro elements, vitamins and fatty acids and also rich in growth regulators such as auxins, cytokinin and gibberellins (Blunden, 1991 , Crouch and Van Staden, 1994 and Khan *et al.,* 2009).

Foliar sprays of seaweed extracts, as nature organic substrates, are used in vegetable crops production for stimulating and hastening plant growth consequently, increasing early and total yield (El-Aidy *et al*., 2002; Bourak and Fonseca, 2008 and Abd El-Ghaffar, 2012) .

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The stimulative effect of foliar spray with seaweed extract and amino acids on total yield and marketable yield of Chinese cabbage may be due to that seaweed extract and amino acids contain mineral nutrients, growth regulators and vitamins (Tables 2 and 3).

The increase (%) in weight of total yield resulted from foliar spray with amino acid and seaweed extract over control (unsprayed) were 43.3 and 14.8 (%) (as average of two seasons), respectively. Moreover, the increase (%) in weights of marketable yield resulted from foliar spray with amino acid and seaweed extract over the control (unsprayed) were 43.0 and 14.3 (%) (as average of two seasons), respectively.

C. Effect of the interaction between starter solutions of NPK fertilizers and foliar spray with stimulants:

Data in Tables (12 and 13) show that the interaction between starter solutions of NPK fertilizers and biostimulants had no a significant effect on the weight of total yield (whole head) and marketable yield (edible head) of Chinese cabbage plants in both seasons.

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.تـأثير المحاليـل البادئـة فـي التربـة والـرش الـورقي بـبعض المنشـطات علـي نمـو وانتاجية الكرنب الصيني

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أجريت تجربتان حقليتان في حقل بقرية الشهاينة ، محافظة كفرالشيخ (شمال الدلتا)، مصر في الموسمين الشتويين لعامي ٢٠١٢ ، ٢٠١٣ وكان الهدف دراسة تأثير المحاليل البادئة في التربة والرش الورقي بالمنشطات الحيوية (الاحماض الامينيه و مستخلص الطحالب) بالاضافة الي التفاعل بينهما وتأثيره علي النمو الخضري والمحصول لنبات الكرنب الصيني صنف (مانوكو) قد تم استخدام اربعة معاملات للمحاليل البادئة شملت ثلاثة مصادر مختلفه للنيتروجين كانت كالتالي سلفات الامونيوم (٢٠.٥ %) ونترات الامونيوم (٣٣.٥%) واليوريا (٤٦%) بالاضافه الي المعامله الكنترول (عدم الاضافه الارضيه للمحاليل البادئه) ومصدرين من المنشطات هي الاحماض الامينيه ومستخلص الطحالب ، وقد استخدم تصميم القطع المنشقة في ثلاث مكررات.

ولقد اوضحت النتائج ان تاثير الاضافه الارضيه للمحاليل البادئه كان عالي المعنويه علي صفات طول الساق، قطر الساق،وزن الساق ،عدد الاوراق الكلية للنبات والوزن الغض لكل من الاوراق الخارجيه(الغير صالحه للاكل)،والاوراق الداخليه (الصالحه للاكل) والاوراق الكليه للنبات ، كذلك الوزن الكلي للنبات ووزن المحصول الاقتصادي بالمقارنه بالمعامله الكنترول (عدم الاضافه الارضيه) في كلا الموسمين. ولقد كانت النسبه المئويه للزياده في المحصول الكلي والمحصول الاقتصادي (كمتوسط للموسمين) كنتيجة للاضافه الارضيه للمحاليل البادئه رقم ١ ، ٢ ،٣ هي : (٥١.٨ ، ٦٧.٦ %) و (٥٩.١ ، ٧٥.٦ %) و (٥٥.٧ ،٧٥.٦%) علي التوالي مقارنة بالكنترول (عدم الاضافه الارضيه).

ادت المعامله بالرش الورقي بالاحماض الامينيه ومستخلص الطحالب لزياده عاليه المعنويه لكلا من قطر الساق ،وزن الساق ، عدد الاوراق الكلي للنبات والوزن الغض لكل من الاوراق الخارجيه (غير صالحه للاكل)، الاوراق الداخليه (الصالحه للاكل) والاوراق الكليه للنبات والوزن الكلي للنبات ووزن المحصول الاقتصادي الصالح للتسويق بالقارنه بالمعامله الكنترول (عدم الرش) في كلا الموسمين. مثل هذه الزياده كانت عاليه المعنويه لكلا من المساحه الورقيه للنبات ودليل المساحه الورقيه في الموسم الاول فقط، علاوه علي ذلك كان لتلك المعامله تأثير معنوي علي طول الساق في كلا الموسمين والمساحه الورقيه للنبات ودليل المساحه الورقيه في الموسم الثاني . وكانت النسبه المئويه للزيادة في المحصول الكلي والمحصول الاقتصادي (كمتوسط للموسمين) كنتيجه للرش الورقي بالاحماض الامينيه ومستخلص الطحالب هي : (٤٣.٣ ، ٤٣.٠ %) و (١٤.٨ ، ١٤.٣ %) علي التوالي مقارنه بالكنترول (عدم الرش).

اعلي القيم للصفات المدروسه تم التحصل عليها عند رش نباتات الكرنب الصيني بالاحماض الامينيه يليها مستخلص الطحالب مقارنه بمعامله الكنترول (عدم الرش) والتي اعطت اقل القيم في كلا الموسمين.

لم يؤثر التفاعل المشترك بين المحاليل البادئه في التربه والرش الورقي ببعض المنشطات تاثيرا معنويا علي صفات الساق ، الاوراق و الوزن الكلي والاقتصادي في كلا الموسمين.

قام بتحكيم ابحث

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Starter solutions	Stem characteristics			Leaves characteristics							
				Number of leaves / plant			Weight of leaves (Kg) / plant			Leaf area	
	Stem length (cm)	Stem diameter (cm)	Whole stem weight (g)	Outer leaves (inedible)	Inner leaves (edible)	Number of total leaves / plant	Outer leaves (inedible)	Inner leaves (edible)	weight of total leaves (Kg)/ plant	Leaf area/ plant (m2)	Leaf area index
2012 Season											
Starter No.1	3.03 a	3.59 a	25.56 a	35.11	49.11 ab	84.22 a	0.542 a	1.046 a	1.589 a	1.387	9.90
Starter No.2	3.12 a	3.63 a	27.22 a	36.67	50.11 a	86.89 a	0.562 a	1.081 a	1.644 a	1.323	9.44
Starter No.3	3.02 a	3.61 a	25.56 a	35.44	49.89 a	85.33 a	0.559 a	1.052 a	1.611 a	1.532	10.92
Control (without starter solution)	2.24 b	2.91 b	15.73 b	34.44	44.44 b	78.89 b	0.421 b	0.649 b	1.072 b	1.216	8.70
F test	**	**	**	NS	*	**	**	**	**	NS	NS
2013 Season											
Starter No.1	3.06 a	3.49 a	23.33 a	37.67 a	47.78	85.56 a	0.608 a	0.979 a	1.587 a	1.424	10.16
Starter No.2	2.90 a	3.50 a	24.08 a	37.33 ab	48.78	86.11 a	0.604 a	1.038 a	1.644 a	1.372	9.79
Starter No.3	3.00 a	3.47 a	23.70 a	36.33 b	48.67	83.89 a	0.572 a	1.034 a	1.608 a	1.296	9.27
Control (without starter solution)	2.27 b	2.59 b	13.70 b	33.67 b	45.00	78.67 b	0.430 b	0.562 b	0.993 b	1.286	9.16
F test	**	**	**	*	NS	**	**	**	**	NS	NS

Stimulants	Stem characteristics		Leaves characteristics								
				Number of leaves / plant			Weight of leaves (Kg)/ plant			Leaf area	
	Stem length (cm)	Stem diameter (cm)	Whole stem weight (g)	Outer leaves (inedible)	Inner leaves (edible)	Number of total leaves / plant	Outer leaves (inedible) (kg)	Inner leaves (edible) (kg)	weight of total leaves (kg)	Leaf area/ plant (m2)	Leaf area index
2012 Season											
Amino acid	3.075 a	3.90 a	31.24 a	37.25a	49.92 a	87.167 a	0.633 a	1.161 a	1.795 a	1.597 a	11.42 a
Seaweed ext.	2.858 ab	3.31 ab	21.53 b	36.17a	47.17 b	83.417 ab	0.496 b	0.906 ab	1.403 ab	1.402 a	10.00 a
Control (without spraying)	2.633 b	3.11 b	17.78 b	32.83b	48.08 b	80.917 b	0.435 b	0.803 b	1.239 b	1.094 b	7.80 b
F test	*	**	**	*	*	**	**	**	**	**	**
2013 Season											
Amino acid	3.017 a	3.62 a	25.82 a	37.25 a	48.92 a	85.833 a	0.647 a	1.071 a	1.719 a	1.503 a	10.73a

Seaweed ext.	**2.750 ab**	**3.27 ab**	**20.84 ab**	**37.42 a**	**47.92 ab**	**85.417 ab**	**0.559 ab**	**0.878 b**	**1.439 b**	**1.371 ab**	**9.78a**
Control (without spraying)	**2.575 b**	**2.90 b**	**16.94 b**	**34.08 b**	**45.83 b**	**79.917 b**	**0.455 b**	**0.761 b**	**1.216 b**	**1.160 b**	**8.27b**
F test	*	**	**	*	*	**	**	**	**	*	*

te + p_2o_5 +K_2o), starter solution No. 2(N as Ammonium Nitrate + p_2o_5 +K_2o) and Starter solution No. 3 (N as Urea + p_2o_5 +K_2o)

*** and * indicate significant differences at P< 0.01 and P< 0.05 and respectively, according to F test values having the same alphabetical letter within each column are not significantly different at the 5% level, according to Duncan's test**

Stimulants	Stem characteristics								
	Stem length (cm)			Stem diameter (cm)			Stem weight (g)		
	Amino acid	Seaweed ext.	Control(without spraying)	Amino acid	Seaweed ext.	Control(without spraying)	Amino acid	Seaweed ext.	Control(without spraying)
Starter	**2012 Season**								

solutions									
Starter No.1	3.17	3.07	2.87	4.17	3.37	3.23	37.20	21.67	17.80
Starter No.2	3.57	2.93	2.87	4.23	3.37	3.30	36.10	23.90	21.67
Starter No.3	3.17	3.10	2.80	4.07	3.60	3.17	33.90	23.33	19.43
Control (without starter solution)	2.40	2.33	2.00	3.10	2.90	2.73	17.77	17.20	12.23
F test	NS			NS			NS		
2013 Season									
Starter No.1	3.30	2.80	2.77	3.93	3.50	3.03	28.33	23.33	18.33
Starter No.2	3.20	2.90	2.60	4.03	3.50	2.97	31.10	24.47	16.67
Starter No.3	3.10	3.10	2.80	3.80	3.43	3.17	26.67	22.77	21.67
Control (without starter solution)	2.47	2.20	2.13	2.70	2.63	2.43	17.20	12.80	11.10
F test	NS			NS			NS		

NS indicates not significant, according to F test

Stimulants	Number of leaves / plant								
	Outer leaves (inedible)			Inner leaves (edible)			number of total leaves / plant		
	Amino acid	Seaweed ext.	Control(without	Amino acid	Seaweed ext.	Control(without	Amino acid	Seaweed ext.	Control(without

Starter solution No. 1 (N as Ammonium Sulfate + p_2o_5 +K_2o), starter solution No. 2(N as Ammonium Nitrate + p_2o_5 +K_2o) and Starter solution No. 3 (N as Urea + p_2o_5 +K_2o)

			spraying)			spraying)			spraying)
Starter solutions	**2012 Season**								
Starter No.1	**35.33**	**35.67**	**34.33**	**51.00**	**47.67**	**48.67**	**86.33**	**83.33**	**83.00**
Starter No.2	**39.00**	**37.33**	**33.67**	**53.33**	**45.67**	**51.33**	**92.33**	**83.33**	**85.00**
Starter No.3	**38.00**	**37.00**	**31.33**	**51.00**	**50.33**	**48.33**	**89.00**	**87.33**	**79.67**
Control (without starter solution)	**36.67**	**34.67**	**32.00**	**44.33**	**45.00**	**44.00**	**81.00**	**79.67**	**76.00**
F test	**NS**			**NS**			**NS**		
2013 Season									
Starter No.1	**38.67**	**39.00**	**35.33**	**50.00**	**47.67**	**45.67**	**88.67**	**87.00**	**81.00**
Starter No.2	**38.67**	**38.33**	**35.00**	**49.33**	**50.00**	**47.00**	**88.00**	**88.33**	**82.00**
Starter No.3	**37.33**	**37.67**	**34.00**	**50.33**	**48.00**	**47.67**	**84.33**	**85.67**	**81.67**
Control (without starter solution)	**34.33**	**34.67**	**32.00**	**46.00**	**46.00**	**43.00**	**80.33**	**80.67**	**75.00**
F test	**NS**			**NS**			**NS**		

NS indicates not significant, according to F test

Starter solution No. 1 (N as Ammonium Sulfate + p_2o_5 +K_2o), starter solution No. 2(N as Ammonium Nitrate + p_2o_5 +K_2o) and Starter solution No. 3 (N as Urea + p_2o_5 +K_2o)

Stimulants	Fresh weight of leaves (Kg) / plant		
	Outer leaves (inedible)	Inner leaves (edible)	Weight of total leaves (Kg)/ plant

	Amino acid	Seaweed ext.	Control(without spraying)	Amino acid	Seaweed ext.	Control(without spraying)	Amino acid	Seaweed ext.	Control(without spraying)
Starter solutions	**2011/2012 Season**								
Starter No.1	**0.68**	**0.49**	**0.46**	**1.30**	**1.00**	**0.84**	**1.98**	**1.48**	**1.31**
Starter No.2	**0.66**	**0.56**	**0.47**	**1.33**	**0.97**	**0.94**	**2.00**	**1.53**	**1.40**
Starter No.3	**0.69**	**0.54**	**0.44**	**1.29**	**0.97**	**0.90**	**1.98**	**1.51**	**1.34**
Control (without starter solution)	**0.50**	**0.40**	**0.37**	**0.73**	**0.69**	**0.53**	**1.22**	**1.09**	**0.91**
F test	**NS**			**NS**			**NS**		
	2012/2013 Season								
Starter No.1	**0.69**	**0.63**	**0.51**	**1.21**	**0.92**	**0.81**	**1.90**	**1.55**	**1.31**
Starter No.2	**0.74**	**0.60**	**0.47**	**1.25**	**1.06**	**0.81**	**1.99**	**1.66**	**1.28**
Starter No.3	**0.63**	**0.57**	**0.51**	**1.17**	**0.96**	**0.97**	**1.81**	**1.54**	**1.48**
Control (without starter solution)	**0.52**	**0.44**	**0.33**	**0.66**	**0.56**	**0.47**	**1.18**	**1.01**	**0.80**

F test	**NS**	**NS**	**NS**

NS indicates not significant, according to F test

	Leaf area

Starter solution No. 1 (N as Ammonium Sulfate + p_2o_5 +K_2o), starter solution No. 2(N as Ammonium Nitrate + p_2o_5 +K_2o) and Starter solution No. 3 (N as Urea + p_2o_5 +K_2o)

Stimulants	Leaf area/ plant (m^2)			Leaf area index			
	Amino acid	Seaweed ext.	Control(without spraying)	Amino acid	Seaweed ext.	Control(without spraying)	
Starter solutions	**2012 Season**						
Starter No.1	**1.57**	**1.36**	**1.23**	**11.23**	**9.73**	**8.73**	
Starter No.2	**1.41**	**1.40**	**1.16**	**10.10**	**10.00**	**8.23**	
Starter No.3	**1.92**	**1.64**	**1.04**	**13.67**	**11.67**	**7.43**	
Control (without starter solution)	**1.49**	**1.21**	**0.95**	**10.67**	**8.63**	**6.80**	**NS**
F test	**NS**			**NS**			
2013 Season							
Starter No.1	**1.48**	**1.49**	**1.30**	**10.57**	**10.63**	**9.27**	
Starter No.2	**1.48**	**1.39**	**1.24**	**10.57**	**9.93**	**8.87**	
Starter No.3	**1.54**	**1.24**	**1.10**	**11.03**	**8.87**	**7.87**	
Control (without starter solution)	**1.51**	**1.36**	**0.99**	**10.70**	**9.67**	**7.07**	
F test	**NS**			**NS**			

indicates not significant, according to F test

Starter solution No. 1 (N as Ammonium Sulfate + p_2o_5 +K_2o), starter solution No. 2(N as Ammonium Nitrate + p_2o_5 +K_2o) and Starter solution No. 3 (N as Urea + p_2o_5 +K_2o).

Starter solutions	Total yield (whole head weight) (stem + total leaves)			Marketable yield (edible head weight) (stem + inner leaves)		
	Per plant(kg)	Per feddan (ton)	Increase in wt. %	Per plant(kg)	Per feddan (ton)	Increase in wt. %
2012 Season						
Starter No.1	1.572 a	47.17 a	43.95	1.071 a	32.13 a	61.29
Starter No.2	1.670 a	50.10 a	52.93	1.108 a	33.23 a	66.86
Starter No.3	1.637 a	49.10 a	49.90	1.078 a	32.33 a	62.50
Control (without starter solution)	1.092 b	32.77 b	-	0.664 b	19.93 b	-
F test	**	**	-	**	**	-

2013 Season

Stimulants	Total yield (Whole head weight) (stem + total leaves)			Marketable yield (edible head weight) (stem + inner leaves)		
	Per plant (kg)	Per feddan (ton)	Increase in wt. %	Per plant(kg)	Per feddan (ton)	Increase in wt. %
Starter No.1	1.610 a	48.30 a	59.56	1.002 a	30.10 a	73.95
Starter No.2	1.667 a	50.00 a	65.21	1.062 a	31.87 a	84.37
Starter No.3	1.630 a	48.90 a	61.56	1.058 a	31.73 a	88.68
Control (without starter solution)	1.009 b	30.27 b	-	0.576 b	17.27 b	-
F test	**	**	-	**	**	-

** indicates significant differences at P< 0.01 according to F test values having the same alphabetical letter within each column are not significantly different at the 5% level, according to Duncan's test solution Starter No. 1 (N as Ammonium Sulfate + p2o5 +K2o), solution starter No. 2(N as Ammonium Nitrate + p2o5 +K2o) and Starter solution No. 3 (N as Urea + p2o5 +K2o

2012 Season						
Amino acid	**1.825 a**	**54.75 a**	**45.53**	**1.192 a**	**35.78 a**	**45.18**
Seaweed	**1.399 ab**	**41.98 ab**	**11.56**	**0.928 ab**	**27.83 ab**	**13.03**
Control (without spraying)	**1.254 b**	**37.63 b**	**-**	**0.821 b**	**24.63 b**	**-**
F test	**	**	-	**	**	-
2013 Season						
Amino acid	**1.743 a**	**52.3 a**	**41.13**	**1.097 a**	**32.9 a**	**41.00**
Seaweed	**1.458 b**	**43.75 b**	**18.05**	**0.899 b**	**26.98 b**	**15.55**
Control (without spraying)	**1.235 b**	**37.1 b**	**-**	**0.778 b**	**23.33 b**	**-**
F test	**	**	-	**	**	-

****indicates significant differences at P< 0.01 according to F test values having the same alphabetical letter within each column are not significantly different at the 5% level, according to Duncan's test.**

Stimulants	Total yield (Whole head weight)								
	Per plant (kg)			Per feddan (ton)			Increase in wt. %		
	Amino acid	Seaweed ext.	Control(without spraying)	Amino acid	Seaweed ext.	Control(without spraying)	Amino acid	Seaweed ext.	Control(without spraying)
Starter solutions	2012 Season								
Starter No.1	2.013	1.380	1.323	60.40	41.40	39.70	121.20	51.64	45.38
Starter No.2	2.033	1.553	1.423	61.00	46.60	42.70	123.40	70.65	56.37
Starter No.3	2.013	1.537	1.360	60.40	46.10	40.80	121.20	68.90	49.45
Control (without starter solution)	1.240	1.127	0.910	37.20	33.80	27.30	36.26	23.84	-
F test	NS			NS			-		
	2013 Season								
Starter No.1	1.927	1.573	1.330	57.80	47.20	39.90	135.86	92.53	62.79
Starter No.2	2.020	1.687	1.293	60.60	50.60	38.80	147.24	106.48	58.26
Starter No.3	1.833	1.557	1.500	55.00	46.70	45.00	124.35	90.57	83.59
Control (without starter	1.193	1.017	0.817	35.80	30.50	24.50	46.02	24.47	-

solution)									
F test	**NS**			**NS**			**-**		

NS indicates not significant, according to F test.

Starter solution No. 1 (N as Ammonium Sulfate + p_2o_5 +K_2o), starter solution No. 2(N as Ammonium Nitrate + p_2o_5 +K_2o) and Starter solution No. 3 (N as Urea + p_2o_5 +K_2o).

Stimulants	Marketable yield (Edible head weight)								
	Per plant(kg)			Per feddan (ton)			Increase in wt. %		
	Amino acid	Seaweed ext.	Control(with no spray)	Amino acid	Seaweed ext.	Control(with no spray)	Amino acid	Seaweed ext.	Control(with no spray)
starter solutions 2012 Season					55				
Starter No.1	1.337	1.017	0.860	40.10	30.50	25.80	144.42	85.92	57.22
Starter No.2	1.370	0.997	0.957	41.10	29.90	28.70	150.45	82.26	74.95
Starter No.3	1.320	0.933	0.920	39.60	29.80	27.60	141.31	70.56	68.19
Control (without starter solution)	0.743	0.703	0.547	22.30	21.10	16.40	35.83	28.51	-
F test	NS			NS			-		
2013 Season									
Starter No.1	1.237	0.947	0.823	37.10	28.40	24.70	159.32	98.53	72.53
Starter No.2	1.277	1.087	0.823	38.30	32.60	24.70	167.70	127.88	72.53
Starter No.3	1.200	0.987	0.987	36.00	29.60	29.60	151.57	106.91	106.90
Control (without starter solution)	0.673	0.577	0.477	20.20	17.30	14.30	41.09	20.96	-
F test	NS			NS			-		