

EFFECT OF BIOFERTILIZERS INOCULATION METHODS AND SOME FOLIAR APPLICATION TREATMENTS ON YIELD AND QUALITY OF PEA PLANTS

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ABSTRACT

Two field experiments were conducted at a Private Farm near Aga, Dakahlia Governorate during two successive winter seasons of 2012/2013 and 2013/2014 to investigate the effect of bio-fertilizers inoculation method, some foliar application treatments and their interactions on vegetative growth characters, chemical constituents, yield and quality traits of pea (*Pisum sativum* L.). Four inoculation methods of bio-fertilizers (mixture of *Rhizobium leguminosarum*, *Bacillus megatherium* and *Bacillus circulans*), i.e. without inoculation, seeds inoculation pre-sowing, soil inoculation after germination and dual inoculation (seeds plus soil) and four foliar application treatments (control, seaweed extract at 2.5 ml/l, ascorbic acid at 200 ppm and yeast extract at 5 g/l). The data were recorded for yield and its components (pod length, pods weight/plant, No. of pods/plant, No. of green seeds/pod, weight of 100 green seeds and total yield/ fed.). Chemical constituents (N, P and K%) in leaves and pods. Pods quality (carbohydrates, crude protein, reducing, non reducing sugar and total sugar).

Obtained results showed that dual inoculation (seeds pre-sowing and soil after germination) combined with yeast extract as a foliar application surpassed other treatments in yield and its components, pods quality parameters and chemical constituents of leaves and pods.

Keywords: Pea (*Pisum sativum* L.), bio-fertilizers, seaweed extract, ascorbic acid and yeast extract

INTRODUCTION

Pea (*Pisum sativum* L.) is one of the most important leguminous vegetable crops grown during winter season in Egypt. It occupies a great figure in the local consumption and export. The total area grown with garden peas in Egypt was 47951 feddan, which produced 180631 ton with an average yield 3.77 ton/fed., While dry peas was 162 fed. and average productivity 0.77 ton/fed. (according to agricultural statistics, Ministry of Agriculture, 2012).

There is a great need for further studies under Egyptian condition to establish recommendation for reducing the amount of chemical NPK fertilizers to raise the quantity, improve the quality and limit the environmental pollution. Bio-fertilization has become in the last few decades a positive partial alternative to chemical fertilizers especially nitrogen and phosphorus fertilizers. Bio-fertilizers are very safe for human, animal and environment and using them reduce, at a lower extent, the great pollution occurred in our environment.

Recently, great attention has been focused on the possibility of using natural and safe substituents, i.e., seaweed extract, yeast extract and

ascorbic acid in order to improve plant growth, flowering, fruit setting and total yield of horticultural plants. Seaweed extract is used as major bio-stimulant formulations in vegetable crops. Cytokinins and auxins have been identified and quantified in seaweed extract (Sanderson *et al.*, 1987). These natural products has been shown to enhance plant growth in many vegetable crops under normal or stressed condition (Nour *et al.*,2010 on tomato; Hamed, 2012 on snap bean and Rathore *et al.*, 2009 on soybean). Yeast extract is a natural bio-substance suggested to be of useful promotional and nutritional functions, due to their hormones, sugars, amino acids, nucleic acids, vitamins and minerals content. The positive effect of applying yeast extract in increasing yield and quality parameters of many vegetables was reported by many researchers (El-Desoki and El-Gereadly, 2006; Dawa *et al.*, 2008 on pea and Dawa *et al.*, 2013 on pepper) In addition, ascorbic acid (AsA) is one of the most important and abundantly occurring water soluble antioxidants in plants (Smirnoff, 2000b). ascorbic acid can be increased by exogenous application of AsA through the rooting medium (Chen and Gallie, 2004), as a foliar spray or as seeds priming. The positive effect of AsA application in many increasing yield and quality parameters of pea was reported by many researchers (Kamal and Abd Al-Gaid, 2008 and Gheeth *et al.*,2013 on pea)

This work aims to evaluate yield and its components, N,P,K percentage in leaves and pods, quality parameters of pea pods in response to different inoculation methods of bio-fertilizers, some foliar treatments and their interactions

MATERIALS AND METHODS

Two field experiments were conducted at a Private Farm near Aga, Dakahlia Governorate during two successive winter seasons of 2012/2013 and 2013/2014 to investigate the effect of bio-fertilizers inoculation method, some foliar application treatments and their interactions on some chemical constituents of leaves and pods, yield and quality traits of pea (*Pisum sativum* L.) cv. master B. The experiments of the study were executed in split plot in a randomized block design with four replicates. Bio-fertilizers treatments were presented in the main plots, while foliar application treatments were assigned in the sub plots. The sub plot area was 15 m² which contained three ridges, each 5m long and 1m width, one row was left between each to experimental unit without spraying as a guard row to avoid the overlapping of spraying solution. Each experiment included 16 treatments comprising four inoculation methods of bio-fertilizers (mixture of *Rhizobium leguminosarum*, *Bacillus megatherium* and *Bacillus circulans*) and four foliar application treatments as follow:

Bio-fertilizer inoculation methods:

- 1- Without inoculation.
- 2- Seeds inoculation pre-sowing.
- 3- Soil inoculation (by injection after germination).
- 4- Seeds and soil inoculation.

Bio-fertilizers treatment involved a mixture of beneficial microorganisms including *Rhizobium leguminosarum*, *Bacillus megatherium* bacteria which make phosphate more available and *Bacillus circulans* bacteria which make potassium more available. All inoculants were provided by bio-fertilizer unit, Fac. Agric., Ain Shams University.

The seeds were divided into two equal parts. The first part was inoculated with mixture bio-fertilizers, while the second part was un inoculated. The inoculation injection was added to the wet soil at the root absorption zone of each plant after 10 days from sowing.

Foliar application treatments:

- 1- Control (sprayed with tap water).
- 2- Seaweed extract at a rate of 2.5 ml/l.
- 3- Ascorbic acid at a concentration of 200 ppm.
- 4- Yeast extract at a rate of 5 g/l. Active dry yeast mixed with sugar at ratio of 1:1 and dissolved in water, then left for 3 hours at room temperature. Then it was frozen for disruption of yeast tissue and releasing their content. Preparation of yeast solution was done according to El-Ghamriny *et al.* (1999).

Plants were sprayed three times with the different treatments as foliar spray starting after three weeks from sowing and repeated after 10 days from the last one. Each plot received 2L solutions of each concentration using spreading agent in all treatments to improve adherence of the spray to the plant foliage for increasing seaweed extract, ascorbic acid and yeast extract absorption by plant. The untreated plants were sprayed with tap water and spreading agent.

Cultural practices:

The seeds were sown immediately in the moderately moist soil on 1st November 2012/2013 and 2013/2014 seasons. Seeds were sown in hills by hand at 10 cm apart on 6 rows of each ridge.

The mineral fertilization were added at a half recommended dose as; 30 kg N/fed. in the form of ammonium nitrate (33%N) and 25 kg K₂O/fed. in the form of potassium sulfate (50 %K₂O). The fertilizers N and K were divided in two equal doses, the first one was added before the first irrigation and the second one was before the following irrigation. Phosphorous fertilizer was 20 kg P₂O₅/fed. as form of calcium superphosphate (15.5% P₂O₅), it was added during the experimental field preparation. During the growing seasons, all other agricultural practices were done as the recommendation of the Ministry of Agriculture, Egypt. The physical and chemical properties of the experimental soil have presented in Table (1) according to Chapman and Pratt (1971)

Data recorded:

Plant Chemical composition:

After 50 days from the sowing, a sample of 10 plants were randomly taken from each experimental unit and oven dried at 70 C. Dried plant sample (leaves and seeds) were digested with sulphuric and perchloric acid (3:1) to determine N, P and K of leaves and seeds:

- **Total nitrogen and total phosphorus content:** were determined according the methods described by **Jackson (1967)** and **potassium content:** was determined according the methods described by **Black (1965)**.

Yield and its components:

Green pods of each plot were harvested at the proper maturity stage, then the following parameters were recorded:

- Average pod length (cm).
- Average pods weight/plant (g).
- Number pods/plant.
- No. of green seeds/pod.
- Weight of 100 green seeds (g).
- **Total yield:** It was calculated as the total weight of pods (ton/fed.).

Table (1): Physical and chemical analysis of the experimental soil during 2012/2013 and 2013/2014 seasons.

Physical properties	First season	Second season
O.M %	1.32	1.21
CaCO3 %	3.05	2.87
Coarse sand %	2.78	2.45
Fine Sand%	29.32	30.16
Silt %	33.56	35.05
Clay %	34.34	32.34
S.p %	62.5	61.4
Texture class	Loamy	Loamy
Chemical properties		
pH*	7.82	7.85
EC** dS/m	1.13	1.09
Available (ppm)	N	46.2
	P	3.95
	K	230
	Fe	14.62
	Zn	0.95
	Mn	9.42
		8.57

*Soil suspension (1:2.5), ** Soil extraction (1:5), OM: Organic matter, SP: saturation percentage, EC: Electric conductivity

Seed quality:

A representative samples of 100 g. of green seeds from each experimental plot were taken randomly and oven dried at 70 °C to determine the following characters:

- Total carbohydrates:** It were determined according to Somogy (1952).
- Reducing, non reducing sugar and total sugar:** It was determined according to the method of Forsee (1938).
- **Crude protein:** It was calculated by multiplying the total nitrogen by the factor 6.25.

Statistical analysis:

The obtained data were subjected to statistical analysis as split plot design with four replicates in the both seasons according to Gomez and

Gomez (1984). The differences between the treatments were compared using least significant differences (LSD at 5% level of significance) as described by Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

Yield and its components:

Concerning the effect of bio-fertilizer on pod length, pod weight/plant, No. of pods/plant, No. of green seeds/pod, weight of 100 green seeds and total yield/ fed., data in Table (2) showed that all these parameters under investigation gave significant differences among the values of these parameters. The maximum value of all these parameters were executed for the treatment of dual inoculation (seeds and soil) followed by inoculation seeds only pre-sowing. The highest yield was obtained from treatment of inoculation seeds and soil (5.90 and 4.15 ton/fed. in the first and second season, respectively) While

the lowest yield was obtained with control treatment (without bio-fertilizer).

Data in the same Table also indicated that foliar spraying of pea plants with some foliar applications (seaweed extract, yeast extract and ascorbic acid) significantly increased the mean values of all these parameters as compared with the control treatment. For foliar application under study; spraying pea plants with yeast extract gave the highest values of all these parameters during both seasons.

The interaction effects between bio-fertilizer and foliar amendments on pea yield and its components (i.e, pod length, pod weight/plant, No. of pods/plant, No. of green seeds/pod, weight of 100 green seeds and total yield/ feddan) plants during the two seasons were presented in Table (3). It was obvious that foliar spraying of seaweed extract, yeast extract and ascorbic acid significantly increased the mean values of all parameters combined with all bio-fertilizer inoculation methods seeds or soil or seeds plus soil as compared with untreated plants. In this respect, foliar spraying of yeast extract combined with dual inoculation (seeds and soil) was superior for increasing the values of these parameters.

The obtained increment of yield and its components may be due to increase of vegetative growth characters. Hence vigorous growth increase in turn the amount of metabolites synthesized and dry matter accumulation by the plants as mentioned by Dawa *et al.* (2008) on pea and Dawa *et al.* (2013) on pepper. Moreover, the increase in total green pod yield owe directly to increase in both number and weight of pods as well as green pod yield/plant. These results were in agreement with those reported by Ghodia (2012) on cowpea.

Data of the same table also indicated that foliar spraying of pea plants with some foliar applications i.e, (seaweed extract, yeast extract and ascorbic acid) significantly increased the mean values of all these parameters as compared with the control treatment.

For foliar application under study spraying with yeast extract gave the highest values of all these parameters during both seasons. The positive effects of applying yeast extract was attributed to its own contents of different nutrients, high percentage of protein, large amount of vitamin B and natural plant growth regulators such as cytokinins (Nagodawithana, 1991). Physiological roles of vitamins and amino acids in the yeast extract which increased the metabolic processes role and levels of endogenous hormones that may promote the vegetative growth parameters and reflected on enhancing yield. Also increasing pods yield response to yeast extract could be attributed to the increasing of total leaf area and dry matter accumulation, photosynthetic pigments and assimilates supply and hence enhancement of pods growth rates. Similar trend of results were reported by Tartoura (2001), El-Desoki and El-Geready (2006), Dawa *et al.* (2003) and (2008) on pea.

Respecting the yield and its components enhancing potential of the seaweed extract might be due to that seaweed extract is a bio-stimulant, which provide pea plants with micro, macro nutrients and significant amounts of cytokinins, auxins and betaines which increase chlorophyll production by boosting the photosynthetic process, thereby stimulating vegetative growth. So that, plant performance would be improved accordingly and reflect on its productivity. These results are in harmony with the findings of Nour *et al.* (2010) on tomato, Hamed (2012) on snap bean, Rathore *et al.* (2009) on soybean.

The increases in yield of pea and its components due to application of ascorbic acid may be due to that ascorbic acid is involved in the regulation of photosynthesis, enhancing cell division and expansion, root elongation, and trans-membrane electron transport (Smirnoff, 2000a).

Recent investigations revealed that ascorbate content regulates plant defense gene expression and modulate plant growth and development via phytohormone signaling (Pastori *et al.*, 2003) thereby increased total yield. These results are in the same line with those reported by Kamal and Abd Al-Gaid (2008) and Gheeth *et al.* (2013) on pea

N, P and K percentages in leaves and seeds:

Concerning the effect of bio-fertilizer on nitrogen, phosphorus and potassium percentages in leaves and pods, data presented in Table (4) showed that N, P and K percentages in leaves and pods were significantly increased with inoculation of seeds pre-sowing, soil after sowing and seeds plus soil compared to the control treatment (without inoculation) in both seasons. The highest values were obtained from plants inoculation of seeds plus soil followed by seeds inoculation only.

Regarding the effect of foliar applications on N, P and K contents in leaves and pods, data in the same Table showed that different foliar applications caused a significant increase in N, P and K percentages. The highest values were obtained from plants sprayed with yeast extract followed by ascorbic acid.

Concerning the effect of interaction between bio-fertilizer inoculation method and foliar applications on nitrogen, phosphorus and potassium contents in leaves and seeds, obtained results in Table (5) showed that N, P and K percentages were significantly increased under spraying plants with seaweed extract, yeast extract and ascorbic acid combined with all bio-fertilizer inoculation methods as compared to the untreated plants (without bio-fertilizers). The highest values were obtained from plants had dual inoculation (seed plus soil) combined with yeast extract, followed with spraying with ascorbic acid.

Regarding the significant enhancing effect of biofertilizer inoculation methods, it may be due to the positive effect on chemical composition in leaves by providing supplement doses of nutrient to the plants and in some cases providing plants with some promoting growth regulators. In addition, biofertilizer increase microorganisms living in the soil and these microorganisms working on the organic matter in the soil to convert organic N to mineral N. Also biofertilizers play a fundamental role in converting P and K fixed form to be ready soluble for plant nutrition and making the uptake of nutrients by plants more easy. These results are in the same line with those reported by Dawa *et al.* (2008) on pea and Ghodia (2012) on cowpea.

Concerning the enhancement of seaweed extract on N, P and K percentages in leaves and pods, seaweed extract have been found to improve root system which could be influenced by endogenous auxins as well as other compounds in the extracts. Also, seaweed extracts improve nutrient uptake by roots (Crouch *et al.*, 1990), resulting in root systems with improved water and nutrient efficiency, thereby causing enhanced general plant growth. Although they may contain different levels of minerals, bio-stimulants they are unable to provide all the nutrients needed by a plant in required quantities (Schmidt *et al.*, 2003). However, their main benefit is to improve plant mineral uptake by roots (Vernieri *et al.*, 2005) and in the leaves (Mancuso *et al.*, 2006).

The enhancement effect of yeast extract on N, P and K may be attributed to increases of leaf area and photosynthetic pigments thus increase photosynthesis process and hence more photosynthates being created as well as enhancement of mineral translocation from roots to leaves. This observation agrees with the reports of El-Desuki and El-Geready (2006) on pea, El-Tohamy and El-Geready (2007) on snap bean and Shokr and Fathy (2009) on snab bean.

Regarding the effect of ascorbic acid, Hager and Holocher (1994) reported that it is involved in the regulation of photosynthesis, cell expansion, root elongation, and trans-membrane electron transport and in several important enzyme reactions, such as violaxanthin deepoxidase these led to increase macro and micro element uptake.

Seed quality:

Concerning the effect of bio-fertilizer on total carbohydrates, crude protein reducing, non reducing sugar and total sugar contents, data in Table (6) indicated that there were significant differences among bio-fertilizer inoculation methods for all quality parameters. The dual inoculation (seed and soil) was superior in increasing all mentioned parameters significantly except reducing sugars, since soil inoculation recorded the highest values.

With regard to the effect of foliar application under investigation on total carbohydrates, crude protein, reducing, non reducing sugar and total sugar contents in pea plants, data in Table (6) revealed a significant effect for foliar application treatments on pods quality in both seasons of the study. In this respect, it can be noticed that foliar spraying of yeast extract as foliar amendment generally was associated with the highest values of these parameters followed with ascorbic acid treatment.

Table (6): Effect of bio-fertilizer inoculation method and some foliar applications on seed quality traits of pea during 1st (2012/2013) and 2nd (2013/2014) seasons.

Characters	Carbohydrates %		Crude proteins %		R. sugar %		N. R. sugar %		Total sugar %	
	1 st season	2 nd season								
Bio-fertilizer inoculation method*										
Without	48.05	49.46	17.69	16.55	3.38	3.74	12.09	10.40	15.47	14.14
Seeds	49.93	51.43	21.44	19.68	3.27	3.61	13.02	11.03	16.29	14.63
Soil	49.00	50.49	19.61	18.23	3.64	4.03	12.21	10.40	15.86	14.44
Seeds+ Soil	50.74	52.29	23.06	21.23	3.13	3.43	13.59	11.53	16.59	14.96
LSD at 5%	0.01	0.05	0.37	0.10	0.04	0.02	0.03	0.06	0.17	0.07
Foliar applications										
Control	48.88	50.29	19.23	17.82	3.16	3.48	12.67	10.74	15.71	14.23
Seaweed	49.32	50.79	19.91	18.70	3.35	3.70	12.65	10.75	16.01	14.45
Yeast	49.92	51.44	21.79	19.94	3.46	3.82	12.86	11.05	16.32	14.88
Ascorbic	49.61	51.13	20.86	19.23	3.45	3.80	12.72	10.82	16.17	14.61
LSD at 5%	0.03	0.04	0.30	0.12	0.03	0.03	0.03	0.05	0.18	0.05

*Mixture of *Rhizobium leguminosarum*, *Bacillus megatherium* and *Bacillus circulans*

R. sugar: reducing sugar, N. R. sugar: non-reducing sugar

As shown from the data presented in Table (7), the interaction between bio-fertilizer inoculation method and foliar applications had a significant effect on total carbohydrates, crude protein on reducing, non reducing sugar and total sugar in both seasons. The highest values were obtained from plants treated with dual inoculation (seed plus soil) combined with spraying yeast extract in all parameters except reducing sugars.

The increases in N, P and K percentages in seed may be due to the increases of these elements in the leaves which consequently translocated to seeds as shown in the Table (6).

The positive effects of seaweed treatment on the content of sugars and carbohydrates may be due to its enhancable effect on leaf area (photosynthetic surfaces), content of chlorophylls and content of some important minerals as shown by Dawa *et al.* (2013) on pepper, similar findings was reported by Rathore *et al.* (2009) on soybean and Hamed (2012) on snap bean. While the positive effect of yeast extract on quality parameters of pea is due to that yeast preparation contained carbohydrates, sugars, proteins, fatty acids, amino acids, hormones, macro and micro elements in suitable balance. The obtained results are in harmony with those of Tartoura (2001) on pea and Abd El-Hady (2014) on cucumber. Concerning the effect of ascorbic acid on the quality parameters of pea pods, The increments sugars total carbohydrates than the corresponding values of the control plants., these results could be explained by the findings obtained by Price (1966) who reported that ascorbic acid increased nucleic acid content, especially RNA and protein content of wheat grains. It also influenced by synthesis of enzymes, and proteins, in addition it acts as co-enzyme in metabolic changes (Reda *et al.*, 1977; Fadl *et al.*, 1978 and Abdel-Halim, 1995).

These results are in harmony with the findings of Kamal and Abd Al-Gaid (2008), Gheeth *et al.* (2013) on pea plants.

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تأثير طرق التلقيح بالاسمدة الحيوية وبعض معاملات الرش الورقى على المحصول وجودته لنباتات البسلة

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أجريت تجربتان حقليتان فى مزرعة خاصة بالقرب من مدينة أجا بمحافظة الدقهلية خلال موسمى الزراعة الشتويين ٢٠١٢/٢٠١٣ و ٢٠١٣/٢٠١٤ لدراسة تأثير طرق التلقيح بالتسميد الحيوى المختلفة وبعض معاملات الرش الورقى والتفاعل بينهم على المحتوى الكيماوى و محصول البسلة وجودته. تم إستخدام أربع طرق مختلفة من التلقيح بالتسميد الحيوى (مخلوط من الرايزوبيم والباسيلس ميجاتيرم وباسيلس سيركيولانس) هى (بدون تلقيح ، تلقيح البذرة قبل الزراعة ، تلقيح التربة بعد نمو البادرات و تلقيح البذرة قبل الزراعة مع تلقيح التربة بعد الإنبات) مع أربع معاملات للرش الورقى هى (الكنترول، مستخلص الطحالب البحرية ٢.٥ مل/لتر ، حمض الإسكوريك ٢٠٠ جزء فى المليون، ومستخلص الخميرة ٥ جم/لتر).

وقد سجلت النتائج بالنسبة للمحصول (طول القرن - وزن القرن/نبات - عدد القرون/نبات - عدد البذور الخضراء/قرن - وزن ١٠٠ بذرة خضراء - المحصول الكلى/فدان) وبالنسبة للمحتوى الكيماوى تم تقدير العناصر النيتروجين و الفوسفور و البوتاسيوم فى الأوراق والبذور وكذلك تم تقدير جودة البذور عن طريق الكربوهيدرات و البروتين و السكريات المختزلة و غير المختزلة و السكريات الكلية.

و أظهرت النتائج أن تلقيح البذرة قبل الزراعة مع تلقيح التربة بعد الإنبات تفوقت على طرق التلقيح الأخرى متداخلة مع الرش بمستخلص الخميرة على محصول البسلة وجودته و المحتوى الكيماوى للأوراق و البذور.

Table (2): Effect of bio-fertilizer inoculation method and some foliar applications on yield and its components of pea plants during 1st (2012/2013) and 2nd (2013/2014) seasons.

Characters	Pod length (cm)		Pods weight/plant (g)		No. of pods/plant		No. of green seeds/pod		Weight of 100 green seeds (g)		Total yield (ton/fed.)	
	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season						
Bio-fertilizer inoculation method*												
Without	9.78	9.41	14.13	10.37	3.25	2.53	6.04	5.31	40.69	38.31	4.10	2.76
Seeds	10.51	10.63	19.49	13.34	4.19	3.28	6.85	7.70	49.69	50.69	5.41	3.74
Soil	10.28	10.06	17.92	11.66	3.82	2.93	6.48	6.50	46.25	45.50	4.95	3.18
Soil+ Seeds	11.04	11.34	22.53	15.24	4.64	3.65	7.40	9.11	53.88	54.81	5.90	4.15
LSD at 5%	0.19	0.15	1.66	1.21	0.23	0.17	0.09	0.15	1.93	1.20	0.31	0.24
Foliar applications												
Control	10.14	10.09	17.30	11.92	3.70	2.95	6.47	6.49	45.19	45.19	4.81	3.29
Seaweed	10.31	10.33	18.12	12.46	3.94	3.08	6.64	7.20	46.94	47.25	5.00	3.43
Yeast	10.64	10.59	19.60	13.42	4.17	3.23	6.90	7.53	50.12	48.81	5.36	3.59
Ascorbic	10.51	10.44	19.04	12.81	4.09	3.14	6.78	7.38	48.25	48.06	5.18	3.51
LSD at 5%	0.10	0.07	0.37	0.28	0.07	0.02	0.06	0.09	0.79	0.38	0.09	0.09

* Mixture of *Rhizobium leguminosarum*, *Bacillus megatherium* and *Bacillus circulans*

Table (3): Effect of interaction between bio-fertilizer inoculation methods and some foliar applications on yield and its components of pea plants during 1st (2012/2013) and 2nd (2013/2014) seasons.

Characters		Pod length (cm)		Pods weight /plant (g)		No. of pods/plant		No. of green seeds/pod		Weight of 100 green seeds (g)		Total yield (ton/fed.)	
Inoculation methods	Foliar application	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season						
Without	Control	9.50	9.20	11.98	9.84	2.83	2.39	5.73	4.24	38.00	36.00	3.64	2.64
	Seaweed	9.70	9.40	14.11	10.36	3.21	2.50	6.03	5.55	40.75	38.25	3.97	2.78
	Yeast	10.00	9.60	15.35	10.73	3.51	2.65	6.29	5.75	42.50	40.25	4.57	2.74
	Ascorbic	9.90	9.45	15.06	10.55	3.44	2.58	6.14	5.69	41.50	38.75	4.21	2.88
Seeds	Control	10.30	10.40	18.76	12.59	4.03	3.13	6.66	7.24	48.00	48.75	5.20	3.58
	Seaweed	10.50	10.60	18.91	13.09	4.18	3.26	6.76	7.64	49.25	50.75	5.32	3.74
	Yeast	10.70	10.80	20.44	14.05	4.30	3.43	7.09	8.08	51.25	51.75	5.58	3.85
	Ascorbic	10.55	10.70	19.84	13.64	4.26	3.33	6.90	7.84	50.25	51.50	5.52	3.78
Soil	Control	10.10	9.80	17.18	10.98	3.51	2.78	6.33	5.99	44.25	43.00	4.74	3.02
	Seaweed	10.20	10.00	17.40	11.41	3.84	2.91	6.46	6.54	45.75	45.25	4.82	3.11
	Yeast	10.45	10.30	18.79	12.36	4.03	3.05	6.61	6.81	48.00	47.25	5.19	3.40
	Ascorbic	10.35	10.15	18.31	11.88	3.91	2.98	6.54	6.65	47.00	46.50	5.04	3.18
Soil+ Seeds	Control	10.65	10.95	21.29	14.29	4.45	3.50	7.16	8.50	50.50	53.00	5.67	3.94
	Seaweed	10.85	11.30	22.03	14.98	4.54	3.64	7.31	9.09	52.00	54.75	5.88	4.08
	Yeast	11.40	11.65	23.84	16.53	4.83	3.78	7.61	9.50	58.75	56.00	6.09	4.37
	Ascorbic	11.25	11.45	22.96	15.18	4.74	3.70	7.53	9.35	54.25	55.50	5.94	4.20
LSD at 5 %		0.24	0.19	1.73	1.55	0.26	0.17	0.12	0.20	2.25	1.32	0.32	0.27

* Mixture of Rhizobium leguminosarum, Bacillus megatherium and Bacillus circulans

Table (4): Effect of bio-fertilizer and some foliar applications on N, P and K percentages in pea leaves and seeds during 1st (2012/2013) and 2nd (2013/2014) seasons.

Characters	Leaves						Green seeds					
	N %		P %		K %		N %		P %		K %	
Treatments	1 st season	2 nd season										
Bio-fertilizer inoculation method*												
Without	3.36	3.22	0.268	0.263	1.74	2.01	2.83	2.65	0.390	0.345	1.42	1.55
Seeds	3.96	3.76	0.327	0.314	2.15	2.48	3.43	3.16	0.457	0.403	1.82	1.96
Soil	3.67	3.51	0.299	0.288	1.95	2.25	3.17	2.93	0.425	0.374	1.61	1.76
Seeds+ Soil	4.22	4.02	0.358	0.344	2.34	2.74	3.69	3.40	0.481	0.424	1.98	2.17
LSD at 5%	0.02	0.02	0.003	0.003	0.04	0.02	0.03	0.02	0.004	0.002	0.03	0.02
Foliar applications												
Control	3.68	3.52	0.299	0.288	1.94	2.27	3.08	2.86	0.416	0.368	1.57	1.72
Seaweed	3.78	3.60	0.310	0.298	2.03	2.34	3.22	2.99	0.433	0.381	1.67	1.83
Yeast	3.92	3.72	0.324	0.316	2.14	2.47	3.49	3.21	0.459	0.402	1.84	2.01
Ascorbic	3.84	3.66	0.318	0.306	2.08	2.41	3.34	3.08	0.445	0.394	1.76	1.89
LSD at 5%	0.02	0.03	0.002	0.002	0.02	0.02	0.03	0.02	0.002	0.003	0.02	0.02

*Mixture of *Rhizobium leguminosarum*, *Bacillus megatherium* and *Bacillus circulans*

Table (5): Effect of interaction between bio-fertilizer and some foliar applications on N, P and K percentages in pea leaves and seeds during 1st (2012/2013) and 2nd (2013/2014) seasons.

Characters		Leaves						Green seeds					
		N %		P %		K %		N %		P %		K %	
Inoculation methods	Foliar application	1 st season	2 nd season										
Without	Control	3.25	3.14	0.255	0.248	1.65	1.92	2.60	2.48	0.370	0.327	1.25	1.39
	Seaweed	3.33	3.17	0.265	0.254	1.68	1.96	2.77	2.58	0.389	0.342	1.40	1.51
	Yeast	3.47	3.31	0.279	0.287	1.84	2.11	3.06	2.84	0.408	0.361	1.56	1.69
	Ascorbic	3.40	3.25	0.273	0.263	1.79	2.07	2.90	2.68	0.396	0.350	1.50	1.61
Seeds	Control	3.84	3.61	0.312	0.299	2.04	2.34	3.27	3.00	0.436	0.383	1.66	1.83
	Seaweed	3.95	3.78	0.325	0.314	2.17	2.49	3.33	3.08	0.446	0.396	1.78	1.93
	Yeast	4.06	3.85	0.338	0.324	2.23	2.59	3.67	3.36	0.481	0.421	1.97	2.12
	Ascorbic	4.00	3.81	0.333	0.319	2.19	2.52	3.45	3.20	0.464	0.413	1.86	1.98
Soil	Control	3.51	3.41	0.287	0.275	1.87	2.20	2.92	2.70	0.399	0.353	1.49	1.61
	Seaweed	3.62	3.44	0.295	0.285	1.93	2.23	3.13	2.91	0.420	0.369	1.56	1.71
	Yeast	3.81	3.63	0.312	0.300	2.02	2.30	3.36	3.11	0.448	0.392	1.76	1.94
	Ascorbic	3.74	3.55	0.303	0.294	1.97	2.27	3.26	3.00	0.432	0.382	1.63	1.78
Soil+ Seeds	Control	4.12	3.91	0.344	0.331	2.22	2.61	3.52	3.26	0.461	0.409	1.88	2.05
	Seaweed	4.23	4.03	0.357	0.341	2.32	2.69	3.64	3.38	0.477	0.420	1.94	2.15
	Yeast	4.32	4.10	0.368	0.355	2.45	2.89	3.86	3.52	0.499	0.437	2.07	2.29
	Ascorbic	4.22	4.03	0.362	0.348	2.39	2.79	3.74	3.44	0.487	0.433	2.05	2.20
LSD at 5 %		0.04	0.05	0.004	0.005	0.04	0.04	0.05	0.04	0.005	0.005	0.05	0.04

*Mixture of Rhizobium leguminosarum, Bacillus megatherium and Bacillus circulans

Table (7): Effect of interaction between bio-fertilizer inoculation method and some foliar applications on seed quality of pea pods during 1st (2012/2013) and 2nd (2013/2014) seasons.

Characters		Carbohydrates %		Crude proteins %		R. sugar %		N. R. sugar %		Total sugar %	
Inoculation methods	Foliar application	1 st season	2 nd season								
Without	Control	47.52	48.88	16.25	15.65	3.34	3.70	11.85	10.15	15.20	13.86
	Seaweed	47.91	49.35	17.29	16.21	3.38	3.73	12.00	10.19	15.39	13.92
	Yeast	48.55	50.01	19.13	17.69	3.42	3.81	12.32	10.90	15.75	14.71
	Ascorbic	48.23	49.62	18.11	16.64	3.38	3.71	12.19	10.37	15.56	14.08
Seeds	Control	49.31	50.80	20.41	18.64	3.24	3.53	12.81	10.73	16.05	14.27
	Seaweed	49.80	51.20	20.81	19.17	3.24	3.59	12.97	11.00	16.22	14.60
	Yeast	50.47	51.99	22.95	20.84	3.32	3.67	13.17	11.25	16.50	14.92
	Ascorbic	50.16	51.72	21.58	20.08	3.29	3.63	13.13	11.12	16.40	14.75
Soil	Control	48.40	49.78	18.28	16.75	3.09	3.43	12.55	10.73	15.65	14.16
	Seaweed	48.93	50.44	18.81	18.20	3.74	4.13	12.05	10.26	15.80	14.40
	Yeast	49.49	51.02	20.99	19.20	3.90	4.30	12.23	10.40	16.13	14.71
	Ascorbic	49.19	50.70	20.36	18.76	3.85	4.26	12.01	10.22	15.87	14.49
Soil+ Seeds	Control	50.28	51.71	21.99	20.26	2.99	3.27	13.49	11.35	15.95	14.62
	Seaweed	50.64	52.20	22.73	21.21	3.04	3.35	13.59	11.54	16.61	14.90
	Yeast	51.19	52.76	24.11	22.01	3.21	3.52	13.70	11.65	16.92	15.18
	Ascorbic	50.86	52.50	23.39	21.46	3.29	3.59	13.57	11.56	16.86	15.15
LSD at 5%		0.06	0.08	0.60	0.22	0.06	0.05	0.06	0.09	0.34	0.11

*Mixture of *Rhizobium leguminosarum*, *Bacillus megatherium* and *Bacillus circulans*
R. sugar: reducing sugar, N. R. sugar: non-reducing sugar

