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Abeer Mousa
Soil and Water Research Department, Nuclear Research Center. Atomic Energy Authority, Cairo, Egypt., abeeraboseer@yahoo.com

Rabab Ibrahim
Soil and Water Research Department, Nuclear Research Center. Atomic Energy Authority, Cairo, Egypt., rm.ibrahim21@yahoo.com

Yehia Galal
Soil and Water Research Department, Nuclear Research Center. Atomic Energy Authority, Cairo, Egypt., galalyehia@yahoo.com

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CONTRIBUTION OF ORGANIC COMPOST AND BACTERIAL INOCULATION IN IMPROVING QUALITY OF QUINOA SEEDS

Abeer M. Mousa *, Rabab M. Ibrahim, Yehia G. Galal

Soil and Water Research Department, Nuclear Research Center. Atomic Energy Authority, Cairo, *P.O.* 13759, Egypt.
*Corresponding Author: abeeraboseer@yahoo.com
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ABSTRACT

Biofertilizers and organic compost are a important source of plant supplements during the plant development. Compost was used to pots under greenhouse condition with the application doses of 0, 50, 100, and 200 kg ha^{-1} on the basis of its nitrogen content. Bacterial strains of *Azotobacter chroococcum* (a symbiotic nitrogen fixer) and *Bacillus polymyxa* as plant growth-promoting rhizobacteria (PGPR) were applied as biofertilizers. Pot test was done to quality the role of organic compost in combination with bacterial inoculation. In general, organic compost and biofertilizers improved growth and seed quality of quinoa. Then again, the collaboration between bacterial inoculation and nitrogen doses had significant effect for all studied traits. Nitrogen dose of 200 kg N ha^{-1} was end up being the best dose for nitrogen addition of soil for N %, protein content %, P % and K % with dual inoculum. The higher physiological content of nitrogen (5.52 %), crude protein (34.5 %), phosphorus (0.81%) and potassium (1.65%) were recorded from application 200 kg N ha^{-1} with dual inoculum (*Azotobacter chroococcum* , *Bacillus polymyxa*). The combination of nitrogen dose of 200 kg N ha^{-1} with dual inoculation was promising combination that generated highest plant dry weight 36.4 g $plant^{-1}$ and gave the highest seed yield 8.33 g $plant^{-1}$ with yield increase of about 88.48 % over the uninoculated. Finally, the efficiencies of compost obtained from composting method on the growth, mineral nutrition and nutrient of quinoa, which will consider a natural agreeable creation of organic quinoa for markets.

Key words: Quinoa; *Azotobacter chroococcum*; *Bacillus polymyxa;* Compost

1. INTRODUCTION

Quinoa (*Chenopodium quinoa* Willd.), individual of *Chenopodiaceae* family is a seed crop that has been developed for thousands of years in the Andean area of South America for its nutritious seed and leaves [1]. The protein content of quinoa seed is rich in amino acids, especially methionine, threonine and lysine, which are the restricting amino acids in most cereal grains [2,3]. Generally, quinoa seeds have a higher dietary value than different cereals like barley, wheat, rice, and corn. Also, in light of the fact that the quinoa seeds are liberated from gluten proteins, they can be utilized to create pan bread without gluten items like past, bread, cookies, biscuits, and cakes for human utilization [4].

The Organization of FAO has pronounced the year two thousand thirteen as the extended time of quinoa [5]. In Egypt, little information is known about it and it's ideally suited as a potential new crop option for Egyptian producers.

Some studies observed large outcomes even with starting carbon /nitrogen ratio between 20 and 50. Higher carbon /nitrogen ratios (compared to those recommended) slowed the rate of composting and revealed nutrient deficiencies in microbiota because extreme substrate enrichment. While lower C/N causes an increment in the nitrogen content of carbon degradable and inorganic nitrogen, which can be lost as ammonia through volatilization or draining [6]. An overall pattern is seen with a decreased C/N ratio all through the cycle because of a higher proportion of waste decay carbon to mineralization nitrogen [7]. To upgrade C/N during composting, large amounts of mass materials like waste materials (for example rice husks, peanut husks and wood shavings) are recommended. It is realized that they developed an increase in porosity in the beginning material and uniform waste prior to composting [8].

Recycling of crop residues in farming through compost production carries organic substances that are highly needed in the soil and are a significant part for the strength of agricultural ecosystems [9]. Many efforts were done to recognize the nitrogen fertilization needed for quinoa. Related to that, quinoa reacted well to nitrogen and completed yield up to 350 kg ha^{-1} at 120 kg N ha^{-1}, seeds yield helped by 94 when contrasted with the unfertilized control [10]. Anyway, completed an upward in yield (averaging 12%) at 80 to 120 kg N ha^{-1} [11]**.** Quinoa reacts to nitrogen fertilizer by increment the harvest improvement and produce as just as the quality of seeds. Fertilizer use productivity according to huge degree of soil fertility. To use of fertilizers in a sustainable manner, management practices must aim at maximizing the quantity of nutrients which are adopted by the crop and minimizing the total amount of nutrients which can be lost from the soil. Further, developing agronomic productivity gives both direct and indirect economic advantages: bigger yield upward can be performed for a particular level of fertilizer applied; or less fertilizer is expected to complete a particular yield target [12]. Nitrogen really key since everything except a significant part of chlorophyll, the compound through which plants use daylight energy to make carbohydrate from water and CO_2 for example photosynthesis. It can be significant addition for plant development, improvement and generation and a significant part of amino acids, the building unit of proteins. Phosphorus in plants further develops blossom arrangement and seed creation, more uniform and prior crop development, expands nitrogen fixing limit, upgrades in crop quality builds protection from plant sicknesses, upholds improvement all through lifetime growth [13].

The development characters, seed yield and seeds quality of quinoa plant developed under Egyptian conditions for two progressive seasons were improved by the use of minimize the total amount of the mineral fertilizer and biofertilizers nitrobin and/or phosphorin [14]. Likewise, the yield parameters of quinoa were expanded with expanding nitrogen fertilizer rates, humic acid and ascorbic acid as well as the addition of organic manure under states of Ras Suder soil during two examined seasons [15].

The use of PGPRs in farming to be the key for lowering chemical fertilization, expanding plant development and furthermore, controlling microbial pathogens, protecting plants from infections. PGPRs present different mechanisms that directly advantage plants, like nitrogen fixing, phosphate availability, siderophores creation and plant hormones biosynthesis; and besides, indirect mechanisms, diminishing the potential deleterious impacts of microbial pathogens by antibiotic creation, or lytic enzymes synthesis [16].

In some studies, effects of some PGPR such *as Azospirillum, Azotobacter spp., Bacillus spp., Pseudomonas spp*. have been studied on barley, tomato and pepper plants. The PGPR used in organic farming, yield increase between 10% and 28% can be achieved and it can be used as organic fertilizer in organic farming [17]. The use of different PGPR are of great importance in organic agriculture applications in terms of sustainability of organic agriculture, ensuring the continuity of resources and reducing the cost of agricultural input [18].

The quantity of studies on coordinated organic compost and biofertilizers of quinoa plants is still very restricted , particularly in Egypt. This point is viewed one of the main significant recent in investigations identified with the soil, and plants. The target of this work is to discriminate the most proper nitrogen nutrient management in coordinated with bacterial inoculation for getting the greatest quality of quinoa seed yield (*Chenopodium quinoa*) under organic farming system.

2. MATERIALS AND METHODS

2.1. Composting process

2.1.1. Bacteria used for composting process:

Achromobacter spanius, Bacillus amyloliquefaciens, and *Stenotrophomonas maltophilia* as cellulase producing bacteria were actually provided by [19]. Three strains were the most potent cellulolytic endophytic bacteria able to degrade many cellulosic sources. *Achromobacter spanius* isolated from seedlings of *Acacia sp.* trees collected from Desert Research Center, Mataria Suburb–Cairo–Egypt, *Bacillus amyloliquefaciens* isolated from wheat (*Triticum aestivum*), plants from Ras Sedr–South Sinai Governrate– Egypt and *Stenotrophomonas maltophilia* isolated form olive (*Olea europaea*) plants from Ras Sedr–South Sinai Governrate–Egypt.The strains were identified by 16 S rRNA gene sequencing to provide genus and species by Sigma Scientific Services Co.

2.1.2. Preparation process:

Raw materials of rice, faba bean and wheat straw were utilized for preparing organic compost. Initially, 10 kg of each straw were chopped into little pieces, and afterward combined as one. Moisture content was kept up at 60% all through the active composting period and 10 ml from 10^8 CFU ml^{-1} of each strain *Achromobacter spanius*, *B. amyloliquefaciens*, and *Stenotrophomonas maltophilia* per 1 kg of raw material was inoculated. The mixtures were turned at 7 days intervals to look after porosity. The heap was covered with plastic sheet .When the heat was evolved in the heap, it was gone over to circulate air underneath the composting heap and afterward covered with plastic sheet. It is hence important to mix the composting material every 2 weeks through the whole period of composting. Additional water is vital if the composting material dry. The volume was lessening to almost 50% of the first heap and the color was changed to dark brown. The heap was reached to a mature stage after three months and utilized for direct incorporation into the soil at preparation stage prior to planting. In a mature compost, most of the material will become moist, soft in texture and develop a deep brown color and is readily crushed between the fingers. Hence, a technique for assessing the level of development of maturity is fundamental as cellulase and xylanase enzymes, organic carbon %, nitrogen % and C: N ratio during compositing process [20].

2.1.3. Extraction and determination of enzymes activities from compost:

Cellulase and xylanase activities were completed in water based extracts got by mixing the compost with 0.05 M citrate buffer (pH 4.8) in a ratio 1:15 (w/v) and stirring at 200 rpm for 30 min . The extract was then centrifuged at 10,000 rpm for 10 min and filtered [21]. Cellulase and xylanase activities were tested in three replicates and estimated based on standard procedure was tested by incubating 0.5 mL 2% (w/v) carboxymethylcellulose (CMC) in sodium acetate buffer (0.05 M, pH 5) with 0.5 mL sample for 30 min. Xylanase activity was tested under almost the same conditions as above with the exception of using 1% (w/v) birchwood xylan as reaction substrate [22]. All above reaction mixtures were boiled with 1 mL dinitrosalicylic acid (DNS) and 2 drops of 0.1 M sodium hydroxide to measure the reducing sugars released [23].

The cellulase activity was examined dependent on the measure of glucose formed after the incubation of compost samples with carboxymethylcellulose, where the cellulase activity was defined as the amount of enzyme demanded to produce 1mg of glucose per 24 h. One unit (U) of xylanase activity was defined as the release of 1 mg of xylose equals per min and per g of dry weight compost [22].

2.1.4. Chemical analysis:

The total organic carbon (TOC) in the compost was tested by [24]. Total nitrogen content of compost samples was determined with a Kjeldahl analysis system according to [25].

2.2. Pot Experiment

2.2.1. Microbial inoculation:

Azotobacter chroococcum as asymbiotic nitrogen fixer and indol acetic acid (IAA) producer and *Bacillus polymyxa* as PGPR were used as bacterial inoculants Fig. (1). It were provided from our Microbiology lab., Soil and Water Research Department, Egyptian Atomic Energy Authority (EAEA).

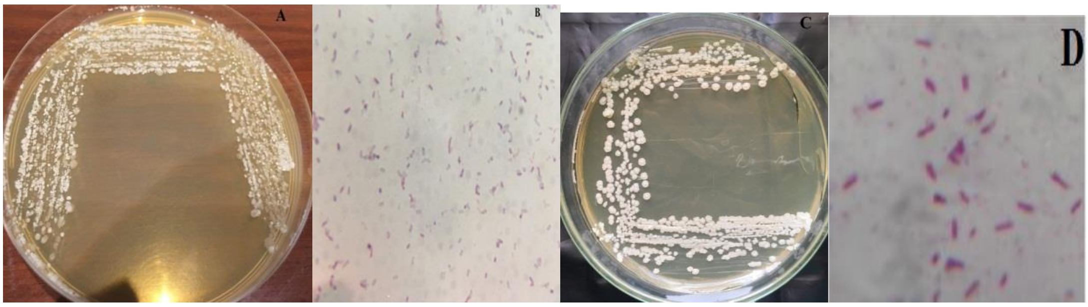

Fig. (1). Showing (A) *Bacillus polymyxa* culture cells (B) *Bacillus polymyxa* under light microscope with magnification power of X100 (C) *Azotobacter chroococcum* culture cells (D) *Azotobacter chroococcum* under light microscope with magnification power of X100.

2.2.2. Soil:

The soil in this study was reclaimed from sandy soil. Soil sample was gathered from surface layer (0 - 30 cm) of Soil and Water Research Department farm, Nuclear Research Center. Physico-chemical characteristics of the experimental soil were introduced in Table (1). Analyses of soil samples were tested by [26].

Table 1: Some physical and chemical properties of experimental soil

Property	Value
Particle size distribution (%)	
Coarse sand	64.1
Fine sand	26.4
Clay	6.8
Silt	2.7
Soil Texture	Sand
pH (1:2.5 paste)	7.97
E.C. (ds m^{-1})	0.27
Total N (%)	0.007
Cations (meq 100 g^{-1} soil)	
Ca^{++}	1.25
Mg^{++}	1.00
Na^{+}	0.32
K^{+}	0.09
Anions (meq 100 g^{-1} soil)	
SO_4^{-}	0.53
CO_3^{-}	0.00
HCO^{-}_3	0.88
Cl^{-}	1.25

2.2.3. Experimental layout

In November 2018 winter season, a pot was managed at department farm using quinoa as a test crop. A seed of quinoa (*Chenopodium quinoa* wild ECABA QS5 C.V) was given by Desert Research Center, Egypt. Quinoa seeds were spread around in pots with 30 cm height, 30 cm diameter, containing 10 kg soil, 5 seedlings per pot. The compost loaded with bacterial inocula (*B. polymxa* and /or *Azotobacter chroococum* 10 ml from 10^8 CFU ml^{-1}) was incorporated into the soil during preparation for sowing. The pots including various treatments were organized in totally randomized block design under greenhouse condition. All farming practices were kept into thought and pots were watered at given time. After 120 days, plants were harvested. Nitrogen fertilizer in the form of compost was applied at dose of 50, 100 and 200 kg N ha^{-1}, calculated based on N% of residues. Potassium sulphate (48% K_2So_4) at the dose 288 kg ha^{-1} and calcium superphosphate at the dose 93.75 kg h^{-1} P_2O_5 were applied before transplanting of quinoa plants.

2.2.4. Measurements:

Before the finish of the pot experiment, 120 days after planting, some plants were harvested. Dry weight from the aerial part of the plant was measurement after drying the harvested in oven at 75 °C until consistent weight. For assurance of total nitrogen content in seeds, samples were estimated by [25]. The total nitrogen amount of the seed tests were multiplied by a conversion factor of 6.25 to determine crude protein [27]. Phosphorus and potassium content in quinoa seeds were determined according to [26].

Experiments were designed in a randomized complete block design in three replicates. The results were statistically analyzed and, the least significant differences were according to [28].

3. RESULTS AND DISCUSSION

3.1 Composting process:

Cellulase and xylanase are main of the different enzymes which are associated in hydrolysis of organic matter. Cellulase activity expanded from 5.96 mg kg^{-1} at 0 days to 212 mg kg^{-1} at 60 days of compositing and then declined at later interval at 90 days. The best result of xylanase activity was seen at 60 days and thereafter, it declined. In the compost, the nitrogen content shifted from 0.75 % to 1.91 % following 90 days of decomposition and the greatest expansion in the phosphorus was observed at 90 days Table (2). The higher measure of organic carbon rate that material necessities further decomposition. During the current examination, the assessment of organic carbon rate in 90 days. Generally, the value of C/N ratio would decrease throughout the composting progress. The most extreme decline, 30.4% in organic carbon was seen at 90 days. The bringing down of the amount carbon during the method of composting is because of the serious microbial activity that has been inoculated as inoculum. Microorganisms in their regular environments are basic to the working of the world's biological systems and they play a significant role in the biochemical cycles. Advantageous microbes in the soil are associated in decay of organic matter and in expanded nutrient availability leading to developed soil fertility and yield efficiency [9]. Degradation rate was influenced by the nature of the organic matter according to its biodegradability. The use of peroxidases, xylanases and cellulases has been fundamentally considered for the bioconversion of lignocellulosic materials, particularly agriculture wastes to produce higher value products such ethanol fuel and different synthetics materials. Cellulase is as a significant enzyme for carbon catabolism and its activity can be an indicator of organic matter degradation during the composting of agricultural residues [29]. An examination by [30], analyzed lignocellulose corruption to survey the impact of actinomycetes (four cellulolytic organisms) was inoculated into composting of dairy waste. The outcomes showed that actinomycetes inoculation sped up creation of the enzymes, including CMCase, xylanase, lignin peroxidase etc. and expanded the rate of decomposition of compost. The outcomes revealed improved cellulase activities and sped up cellulose degradation, increased of the amount humic substances [31]. Likewise, noticed a decrease in the C/N proportion at the finish of composting from 36 to 14 by the addition of solid of cattle slurry [32].Creation excellent quality compost could be ready from Paddy straw through 3 months by *Paecilomyces fusisporou, Aspergillus awamori* and *Trichoderma viride* as inoculum.

3.2. Pot experiment

3.2.1. Plant dry weight and seed yield

Quinoa plants inoculated with various bacterial inoculum either solely or in combination has the advantage to grow well comparing to the uninoculated plants (Table 3). This was true under various rates of organic fertilization. Dry weight per plant values were improved by combined inoculum rather than individuals. The best plant dry weight was induced by addition of organic compost at dose of 200 kg N ha^{-1} but it nearly closed to those recorded with 100 kg N ha^{-1} in case of combined inoculum. The treatment combinations of the bacterial inoculation *B. polymxa and A. chroococum* revealed numerically the most seed yield in the plant. Seed yield per plant after collect was great

Table 2: Estimation of cellulase and xylanase enzymes, organic carbon%, nitrogen%, P% and C: N ratio during compositing periods

Incubation period (days)	Property					
	Cellulase activity mg kg^{-1}	Xylanase activity mg kg^{-1}	Organic carbon %	Nitrogen %	C:N ratio	P %
0	5.96	8.0	60.2	0.75	78.67	0.012
30	127.8	88.9	51.8	1.04	51.33	0.059
60	212.0	124.3	42.3	1.70	25.00	0.156
90	156.3	55.3	30.4	1.91	15.00	0.170
L.S.D 0.05	2.190	1.036	4.064	0.063	2.238	0.089

when nitrogen was applied at higher dose 200 kg N ha^{-1}. This demonstrated that bacterial inoculation increased the availability of nitrogen from the soil. The least seed yield was recorded from control (Table 3). If there is a balanced provide of nitrogen and bacterial inoculation the impact is consistently synergetic for seed yield. Expansion in plant growth parameters may have worked and accessibility of plant nutrients and hence give a good condition for better reproductive development. Then again, there was no significant difference between two doses of 100 and 200 kg N ha^{-1} with inoculated plant. Quinoa plant developed for consumable reason. For instance, leaves can be eaten as green vegetable with a fantastic wellspring of nutrients, similar to spinach [33]. Result from different investigations showed the beneficial effect of the organic farming on dry matter yield in quinoa reaching 8650 kg ha^{-1} and 8800 kg ha^{-1} for compost and cow manure, respectively [34]. A few investigations have demonstrated that the utilization of organic fertilizers can possibly build the dry weight and usefulness of a large scope of yields [35]. Many authors had pointed the beneficial outcome of utilizing farmyard manure and biofertilizers on yield qualities and its substance parts at quinoa plants [35-37]. The utilization of nitrogen fertilizer at rate of 50, 100 and 150 kg N fad^{-1} expanded grain and biological yields of quinoa compared with non-fertilized control by about 52.3, 58.6 and 61.9% and 52.9, 59.7 [39] . These augmentations may be attributed to the role of nitrogen in improving quinoa growth by improvement meristematic cell division and expansion [40], activity and metabolic, photosynthesis processes and forming filled grains as result producing heavier grains [41 and 42]. The nitrogen fertilizer levels influenced seed yield of quinoa in light of the fact that nitrogen fertilizer had advancing vegetative development [14, 41-43]. Therefore, had expanded capacity for photosynthesis and photosynthate movement to advance seeds quantity and quality.

3.2.2. Nitrogen percentage and crude protein content of seeds:

The consequences of the present examination appear to suggest that a significant dry weight plant increase is conceivable with expanding use of nitrogen. The expanded nitrogen seeds by compost may be a direct result of the way that the nitrogen uptake of plants and the resultant improvement increases that expanded essentially all parts. The most amount of nitrogen in seed, 5.52 % was recorded because of the combination of dual inoculation with 200 kg N ha^{-1} and the least amount of nitrogen in seeds, 0.34 % was recorded from unfertilized with inoculated Table (4). A comparable pattern was seen with both nitrogen content and crud protein, so the positive reaction of quinoa plants to the increase of nitrogen fertilizer rates and its effect on increasing crud protein content [39].

Table 3: Plant dry weight g $plant^{-1}$ and seed yield g $plant^{-1}$ in quinoa plants under different levels of organic compost and bacterial inoculation.

Inoculation	**Plant dry weight g $plant^{-1}$**				**Seed yield g $plant^{-1}$**			
	Compost-N added kg ha^{-1}							
	0	**50**	**100**	**200**	**0**	**50**	**100**	**200**
Control (uninoculated)	2.30	15.6	19.2	20.5	0.55	0.89	0.92	0.96
B. polymxa	2.37	23.1	29.4	30.1	1.45	2.45	3.74	3.75
A. chroococcum	3.60	21.9	30.2	30.2	1.14	3.57	4.62	4.73
B. polymxa+ A. chroococcum	4.37	24.2	35.7	36.4	1.57	4.65	8.26	8.33
L.S.D at 0.05	0.827				0.405			

Table 4: Nitrogen percentage and crude protein content in mature dried seeds in quinoa plants under different bacterial inoculation and different levels of organic compost.

Inoculation	**N %**				**Crude Protein content %**			
	Compost-N added kg ha^{-1}							
	0	**50**	**100**	**200**	**0**	**50**	**100**	**200**
Control (uninoculated)	0.34	1.27	1.52	1.84	2.15	7.92	9.51	11.5
B. polymxa	0.39	1.30	1.75	2.89	2.46	8.14	10.91	18.1
A. chroococcum	0.44	2.43	2.91	3.47	2.73	15.42	18.21	21.7
B. polymxa+ A. chroococcum	0.62	2.99	3.43	5.52	3.92	18.73	21.47	34.5
L.S.D at 0.05	0.087				0.204			

The large increase of protein in quinoa fertilizer with soluble inorganic nitrogen (23%) compared with cow manure (21%) [46]. The significant reality that decides the seed protein content is nitrogen accessibility, and quinoa is exceptionally receptive to nitrogen fertilizer [40]. The gradual expansion in the protein amount of quinoa seed with the expanding nitrogen dose was likewise announced by [41]**.** The quinoa yield may be expanded when treated by dissolvable inorganic nitrogen as fast as available [47].

3.2.3. Phosphorus and potassium contents in seeds:

Phosphorus and potassium contents were significantly increased with increasing N doses up to 200 kg N ha^{-1}. This was valid under all inoculation treatments (Table 5). The two of them were significantly increased with bacterial inoculation with changed qualities as per inocula. In this regard, the best P and K percentages were recorded with dual inoculum followed by *A. chroococum* inoculum. Generally, inoculation with either individuals or dual inoculum had enhanced P and K content contrasting with the uninoculated plants. All nitrogen doses were significant in phosphorus content in seeds. The most phosphorus content in seed was recorded at the dose of 200 kg N ha^{-1} which was followed by 100 kg N ha^{-1} with dual inoculation. On the other hand, there was no significant difference between two doses of nitrogen fertilizer 200 and 100 kg N ha^{-1} . The most reduced content of phosphorus in seed was recorded in the uninoculated and unfertilized Table 5. The mineral content (i.e P, K, Ca and Fe) in the seeds of fertilized plants with N-levels were higher than those of the non-fertilized control and at the same time, gradually increased with increasing N rates [39] . Comparable results were accounted for before by [48], [14] and [49]. In the same direction, a slight increment of P and K in grains along with an increased nitrogen dose from 60 to 180 kg N ha^{-1}[50], estimated higher P and K in seeds when quinoa plants treated with high level 150 kg ammonium nitrate fed^{-1} in combination with nitrobin (commercial biofertilizer) [14].

4. CONCLUSION

B. polymxa and A. chroococum were assessed for their single and dual impacts on the growth advancement of quinoa and the expanded of seed yield. As far as anyone is concerned, this is the principal record that arrangements with the investigation of *B. polymxa and A. chroococum* related to quinoa that grows in Egypt. The enormous scope definition steps, we acquired compost in a common and efficient way, which will an environmentally friendly production of organic quinoa for markets, simultaneously keeping the microorganisms populations in the soil. This investigation showed that quality production of quinoa yields high seed quality in Egypt. Quinoa crop was just fundamentally influenced by bacterial inoculation and nitrogen fertilization. Compost can be utilized to develop soil properties when applied to the soil. In light of the plant dry biomass, seed yield and nutrient concentrations. Concerning application doses, their effect on the parameters again, except for 0 kg N ha^{-1} (control), 200 kg N ha^{-1}

Table 5: Potassium and phosphorus content in mature dried seeds in quinoa plants under different bacterial inoculation and different levels of organic compost.

Inoculation	**K % contents of the seed**				**P % contents of the seed**			
	N added kg ha^{-1}							
	0	**50**	**100**	**200**	**0**	**50**	**100**	**200**
Control (uninoculated)	0.21	0.55	0.57	0.65	0.12	0.24	0.26	0.32
B. polymxa	0.33	0.76	0.93	0.95	0.23	0.42	0.45	0.50
A. chroococcum	0.45	1.23	1.34	1.35	0.32	0.65	0.70	0.71
B. polymxa+ A. chroococcum	0.58	1.54	1.65	1.65	0.38	0.69	0.78	0.81
L.S.D at 0.05	0.127				0.049			

with dual inoculation *A. chroococcum* and *B. polymxa* demonstrate to be adequate for quinoa growth and availability nutrition in this soil condition.

CONFLICT OF INTEREST STATEMENT

Authors declare that there are no conflicts of interest.

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مساهمة الكمبوست العضوي والتلقيح البكتيري في تحسين جودة بذور الكينوا

عبير موسى ، رباب إبراهيم ، يحيى جلال

هيئة الطاقة الذرية، مركز البحوث النووية، قسم بحوث الأراضي والمياه، أبو زعبل 13759 مصر

الملخص

تعتبر الأسمدة الحيوية والكمبوست العضوي مصدرًا مهمًا أثناء نمو النبات. تم استخدام الكمبوست فى تجربة أصص في الصوبة الزراعية بجرعات الاتية 0 و 50 و 100 و 200 كجم هكتار على أساس محتواها من النيتروجين. تم استخدام السلالات البكتيرية من Azotobacter chroococcumكبكتيريا مثبتة لنيتروجين غير تكافلية و Bacillus polymyxa كبكتيريا معززه لنمو النبات (PGPR) كأسمدة حيوية. تم إجراء اختبار قدرة وجودة الكمبوست العضوي مع التلقيح البكتيري. بشكل عام ، أدى الكمبوست العضوي والأسمدة الحيوية إلى تحسين نمو وجودة بذور الكينوا. وكذلك ، كان التعاون بين التلقيح البكتيريى وجرعات الكمبوست المختلفة كبديل للسماد النيتروجيتى تأثير معنوي على جميع الصفات المدروسة. وكانت جرعة النيتروجين 200 كجم نيتروجين /هكتار مع التليقح المزدوج من Bacillus & Azotobacter chroococcum polymyxa هي أفضل معاملة فى المحتوى البروتين٪ وP ٪ وK ٪ للنباتات تم تسجيل أعلى محتوى من النيتروجين (5.52٪) والبروتين الخام (34.5٪) والفوسفور (0.81٪) والبوتاسيوم (1.65٪) من الاستخدام جرعة النيتروجين 200 كجم نيتروجين /هكتار مع التليقح المزدوج . وكان الجمع بين جرعة النيتروجين البالغة 200 كجم نتروجين /هكتار 1 مع التلقيح المزدوج وادى إلى انتاجية أعلى وزن جاف للنبات 36.4 جم / نبات وأعطى أعلى محصول بذور 8.33 جم/ نبات مع زيادة المحصول بنحو 88.48٪ عن غير الملقح. . وأخيرًا ، كفاءة الكمبوست التي تم الحصول عليها على نمو وتغذية لنبات الكينوا ، والتي تعتبر انتاج كينوا بمفهوم الزراعة العضوية فى الأسواق.