International Journal of PharmTech Research
CODEN (USA): IJPRIF, ISSN: 0974-4304, ISSN(Online): 2455-9563
Vol.9, No.7, pp 24-32, 2016

Comparison of yeast extract and Nicotinaminde foliar applications effect on quinoa plants grown under sandy soil condition

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Abstract : Two field experiments were conducted at the Research and Production Station, National Research Centre, El-Nubaria Province, El-Behira Governorate, Egypt, during the two successive winter seasons of 2013/2014 and 2014/2015, to study the foliar application with either dry bread yeast (DBY) fungi or Nicotinaminde on growth characteristics, yield and yield attributes and some chemical constituents of quinoa plants grown under sandy soil condition. The plants were sprayed twice during vegetative growth at 45 and 60 days after sowing with yeast (5, 10 and 15 g/l) or Nicotinaminde (50, 75 and 100 mg/l), while control plants were sprayed with distilled water. The obtained results show that increasing the concentration either yeast extract or nicotinamide treatments were significantly differ in the studied characters i.e., number of leaves /plant, length of shoot /plant, weight of fresh shoot/plant, dry weight of shoot/plant, fresh weight of root /plant except, dry weight of root/plant. The results of photosynthetic pigments parameters illustrate that different photosynthetic pigments as chlorophyll a, b, carotenoids as well as total pigments were positively significance responses to the different foliar application with nicotinamide and yeast extract foliar application at 45 and 60 days after sowing during the both assigned seasons. Increasing of yeast foliar application concentrations from 0 to 15 g/l increased shoot length, fruiting branches number /plant, shoot weight/ plant and seed weight /plant by 81.21, 75.90, 69.05 and 91.09 %, respectively compared to control treatment while increasing the nicotinamide foliar application concentrations from 0 to 100 mg/l increased the studied characters by 71.67, 50.11, 55.77 and 77.00 % for shoot length, fruiting branches number /plant, shoot weight/ plant and seed weight /plant, respectively. Significant differences among different treatments on the studied characters of chemical constituents were observed except, seed oil content, filavonoids % and DPPH.
Kay words: Quinoa – dry bread yeast – nicotinamide- growth characters- photosynthetic pigments- chemical constituents.

Introduction

Production of food situation as well as allocation in Egypt illustrates challenges of great quantity to the four pillars of food security: availability, arrival, consumption and biological utilization. In this context quinoa considers a promising crop with potential to give a share in food security as well as sovereignty to adverse climate and soil conditions, also low cost of production. The cultivation of quinoa provides a substitutional crop for countries, like Egypt. Quinoa (*Chenopodium quinoa* Willd.) is pseudograin and it is an important food

source in the Andean region where local people domesticated it since ancestral times [1]. Quinoa is grown under a wide range of environmental conditions in the South American region, at latitudes from 20°N to 40°S [2]. Quinoa is drought resistant; it is able to develop even in regions with a low annual rainfall [3]. It has lately become particular popular, due to its high nutritional value properties as well as gluten-free, protein percentage, 13.81 to 21.9% depending on variety and an extraordinary balance between oil, protein and starch [4]. Proteins of quinoa have a balanced composition of essential amino acids similar to the composition of milk protein. As a result to high content of essential amino acids in protein, the protein is the only food that provides all essential amino acids, which are quietly related to human nutrition standards. Seed carbohydrates of quinoa contain between 58 and 68% starch as well as 5% sugar also high fibre content, these making an ideal source for energy that is slowly released [5].

Nicotinamide (NIC) is a well-characterized constituent of the pyridine dinucleotide coenzymes NADH and NADPH, it is contributory in many enzymatic systems. Nicotinamide is efficiently and effectively taken up by plant tissue cultures (Heeger *et al.* 1976). The transformation of Nicotinamide to trigonelline involves deamidation of Nicotinamide to nicotinic acid (vitamin B3/niacin) which is methylated to trigonelline in an S-adenosyl-methionine (SAM)-consuming process. The main source of NIC in plant cells show to be NAD, Nicotinamide can be released as the result of NAD glycohydrolase[6]. Stimulate the effect of Nicotinamide on various metabolic systems related to protection in plant tissue cultures. NIC induces a pronounced and long-lasting increase in reduced and oxidized glutathione[7,8], and it improves the accumulation of secondary metabolites, e.g., anthocyanins[8] and alkaloids as well as induces a long-lasting increase in the activity of the key enzyme of the phenylpropanoid pathway[9]. The Nicotinamide -induced increase in anthocyanin accumulation in plant tissue cultures may depend on use the NIC as a key enzymes within the phenylpropanoid/flavonoid pathway. In contrast to the Nicotinamide caused a decrease in the steroid accumulation in *D. lanata* tissue culture[9]. The nicotinamide contents may increase in plants after treatments known to cause oxidative stress and induction metabolism defensive[10].

Yeast (*Saccharomyces cerevisiae*) (dry bread yeast, DBY) is an enriched source of phytohormones especially cytokinins, vitamins, enzymes, amino acids and minerals as well as has a stimulatory effect on the cell division and enlargement, protein and nucleic acids synthesis, chlorophyll formation and protective role from different stresses[11]. Yeast extracts contain trehalose-6-phosphate syntheses which had a key enzyme for treadles bio synthesis[12]. Active (DBY) application resulted in increasing growth characters, chemical constituents, total carbohydrates and also, increased yield characters[13]. Dry bread yeast is a kind of the biofertilizers used in soil or foliar application for crops fertilization[14]. It's content of many nutrients and being productive compounds of semi growth regulator compounds like auxins and gibberellins, and it was capable of increasing the simulative growth compounds that act to improve plant cell division and growth[15]. Dry bread yeast was participate in a beneficial role during vegetative and reproductive growth stages through improving flower formation and their set in plants and enhancement accumulation of carbohydrates[16]. Its stimulatory effects on cell division and enlargement, protein and nucleic acid synthesis and chlorophyll formation[17,18]. The aim of this investigation to study the foliar application with either yeast fungi or Nicotinaminde on growth characteristics, yield and yield attributes and some chemical constituents of quinoa plants grown under sandy soil.

Materials and methods

Two field experiments were carried out at the experimental Station of National Research Centre, Nubaria district El-Behrea Governorate, Egypt, during two successive winter seasons of 2013/2014 and 2014/2015, to study the foliar application with either yeast fungi or Nicotinaminde on quinoa plants grown under sandy soil conditions. The soil physical and chemical analysis of experimental site (0-30 depth) were carried out according to[19] as follow: sand 91.2%, silt 3.7%, clay 5.1%, PH 7.3, organic matter 0.3%, CaCO3, 1.4%, EC 0.3 ds.m-1, soluble N 8.1 g /kg and available P 3.2 g /kg. The experimental design was randomized complete block design with four replications, quinoa seeds were sown in mid of November in both cultural seasons. During seed preparation, 150 kg/fed calcium superphosphate (15.5% P_2O_5) and 50 kg/fed potassium sulphate (48 % K_2O) were applied. 75 kg N/fed as ammonium sulfate (20.6% N) was added in five equal doses began after two weeks from sowing and the other doses were applied weekly. Irrigation was carried out using sprinkler irrigation system where water was added every 7 days. The plants were sprayed twice during

vegetative growth at 45 and 60 days after sowing with dry bread yeast (DBY) (5, 10 and 15 g/l) or Nicotinaminde (50, 75 and 100 mg/l), while control plants were sprayed with distilled water.

Data Recorded

Growth characteristics: 10 plant samples from the middle of each plot were collected two weeks after the second foliar spraying in (75 DAS) to determine plant height/plant, number of leaves/plant, fresh and dry weight of shoot and root/plant.

Yield and yield attributes: At harvest, 10 plants from the middle of each plot were collected and the following items were estimated: shoot length/plant, fruiting branch numbers/plant, shoot weight/plant, seeds weight/plant and 1000 seed weight.

Chemical analysis

Photosynthetic pigments: Total chlorophyll a and b and carotenoids contents in fresh leaves were estimated using the method of[20]**.** Indole acetic acid content were extracted and analyzed by the method described of[21]. Total phenol content, the extract was extracted as IAA extraction, and then measured as described by[22]. Air dried seeds were ground into fine powder and kept in desiccators for analysis. Free amino acid was determined with the ninhydrin reagent method[23]. Determination of total carbohydrates was carried out according to[22]. Total protein concentration of the supernatant was determined according to the method described by[23]. The oil was extracted according to[25]. Total flavonoids were determined using the method reported by[26]**.** The antioxidant activity (DPPH radical scavenging) was determined using the method of [27]**.**

Statistical analysis:

Data were analyzed using an ANOVA randomized complete block design[28]. Since the trend was similar in both seasons, Bartlett's test was applied and the combined analysis of the two growing seasons was done. LSD ($P<0.05$) was used to compare means.

Results and Discussion

Growth characteristics

Data presented in Table (1) illustrated the effect of foliar application with either DBY or nicotinamide on some morphological characters of quinoa plants grown in sandy soil conditions. All plaa increased by increasing concentration ach tested materials with exception of root dry weight/plant. Gradual increase of DBY concentrations from 0 to 15 g/l increased leaves/plant, shoot length/plant, shoot fresh weight/plant, shoot dry weight/plant, root fresh weight/plant and root dry weight/plant by 31.05, 50.47, 65.37, 77.24, 80.10 and 65.89 %, respectively. Increasing the nicotinamide concentrations from 0 to 100 mg/l increased the all studied characters by 25.33, 32.54, 45.93, 18.92, 23.42 and 34.68 % for leaves/plant, shoot length/plant, shoot fresh weight/plant, shoot dry weight/plant, root fresh weight/plant and root dry weight/plant, respectively. Treatment 15 g/l yeast foliar application surpassed other treatments with significance differences in different studied characters. On the other hand, the lowest values of the studied characters were recorded by the control treatment with significant differences with other treatments except, 5 g/l yeast foliar application treatment in characters shoot dry weight/plant, root dry weight/ plant and root dry weight, and 50 mg/l nicotinamide foliar application treatment in characters leaves number/plant, shoot dry weight/plant, root fresh weight/plant and root dry weight/plant. These results are in agreement with these obtained by[29]**.**

All the above mentioned characters were increased with increasing the foliar application of yeast treatments. Improving of vegetative growth characters in response to the foliar application of yeast may be attributed to its content of different nutrients, higher percentage of proteins, higher values of vitamins, especially vitamin B which may play an important role in improving growth and controlling the incidence of fungi diseases[30]. It is used as a kind of biofertilizers in foliar application on the shoots of some crops [31]. This is because it's content of many nutrient elements and being productive compounds of semi growth regulator compound like auxins, gibberellins and cytokinins[15]. The positive effects of DBY application were reflected on its considered as a natural source of cytokinins that stimulates cell division and enlargement as well as the

synthesis of protein, nucleic acid and chlorophyll[32,33]. Foliar application of yeast solution significantly increased plant height, number of branches/plant, dry matter of vegetative growth[34]. It also contains sugar, proteins, amino acids and vitamins (Shady, 1978). In addition, yeast extract treatments were suggested to participate beneficial role during vegetative and reproductive growths through improving flower formation and their set in some plants due to its high auxins and cytokinins content and its beneficial effect on carbohydrates accumulation[16]. Also, its contents of cryoprotective agents i.e. sugars and amino acids as well as, several vitamins[35,36].

Table (1): Effect of dry bread yeast (DBY) or Nicotinamide foliar application on morphological criteria of quinoa plant grown in sandy soil condition at 75 days after sowing.

Material mg/l		Leaves number /plant	Shoot length (cm) /plant	Shoot FW (gm) /plant	Shoot DW (gm) /plant	Root FW (gm) /plant	Root DW (gm) /plant
Control		13.30	16.90	28.30	8.35	3.97	1.47
Yeast (g/l)	5	15.67	19.77	35.20	9.50	4.75	1.77
	10	16.27	21.37	44.50	12.40	6.83	1.83
	15	17.43	25.43	48.80	14.80	7.15	NS
Nicotinaminde (mg/l)	50	13.97	18.75	34.35	9.14	3.95	1.57
	75	15.30	21.00	36.60	11.29	5.33	1.78
	100	16.67	22.40	41.30	12.93	6.90	1.98
LSD 5%		1.32	1.24	2.20	1.36	0.83	NS

Photosynthetic pigments

Data in Table (2) indicate that different photosynthetic pigments as chlorophyll a, b, carotenoids and total pigments were significantly increased in response to foliar application of nicotinamide or DBY at 45 and 60 days after sowing during both assigned seasons. The highest values of chlorophyll a (16.74 µg/g), chlorophyll b (5.78 µg/g), carotenoids (5.30 µg/g) and total pigments (27.82 µg/g) were recorded by 15 g/l yeast foliar application treatment followed by 100 mg/l nicotinamide foliar application, where it records 14.71, 4.88, 4.85 and 24.44 µg/g for chlorophyll a, chlorophyll b, carotenoids and total pigments, respectively with significant difference between both treatments, while the lowest values of the studied characters were recorded by the control treatment. The increase of chlorophyll a, chlorophyll b, carotenoids content and total pigments may be enhanced photosynthesis efficiency and that is a good explain to the increasing of dry matter production. Also, this enhancement could be an indicator for expectable high yielded fruits. The treatments of yeast suspension caused gradual significant increase in total chlorophyll [37]. Its stimulatory effects on cell division and enlargement, protein and nucleic acid synthesis and chlorophyll formation [17,18]. These results are in agreement with those obtained by [38,39].

Table (2): Effect of DBY or Nicotinamide foliar application on photosynthetic pigment of quinoa plant grown in sandy soil condition at 75 days after sowing.

Material mg/l		Chlorophyll a (µg/g)	Chlorophyll b (µg/g)	Carotenoids (µg/g)	Total pigments
Control		9.73	1.86	2.17	13.76
Yeast (g/l)	5	11.69	3.47	3.38	18.54
	10	12.93	4.55	4.23	21.71
	15	16.74	5.78	5.3	27.82
Nicotinaminde (mg/l)	50	10.81	3.33	3.01	17.15
	75	11.55	3.65	3.75	18.95
	100	14.71	4.88	4.85	24.44
LSD 5%		1.15	0.39	0.48	1.17

IAA, Phenol and free amino acid contents:

Results presented in Table 3 reveal that, using DBY or nicotinamide as foliar treatments at different concentrations (5, 10 and 15 mg/l) and (50,75 and 100 mg/l), respectively were significantly increased free amino acid contents, IAA and total phenol of quinoa plant as compared with control treatment. Data clearly shows that the effect of DBY was more pronounced than nicotinamide particularly at 15 mg/l, where the treatment 15 g/l yeast records the highest values of free amino acids, 362.91 mg/g dry weight, IAA, 75.35 µg/g fresh weight and total phenol, 194.45 mg/100g fresh weight with significant differences with the other treatments this treatment follow by nicotinaminde, 100 mg/l where it records 324.52 mg/g dry weight, 64.45 µg/g fresh weight and 163.07 mg/100g fresh weight for free amino acid contents, IAA and total phenol, respectively. The increases in IAA in shoot tissues treated with using DBY or nicotinamide as foliar treatments parallel with the increase in growth rate (Table 1) could be attributed to the stimulation in cell division and / or cell enlargement. These results may be due to the yeast extract is an enriched source of phytohormones especially IAA, cytokinins, vitamins, enzymes and free amino acids [11]. These results are in agreement with those obtained by [38].

Table (3): Effect of DBY or Nicotinamide foliar application on free amino acid, IAA and total phenol of quinoa plant grown in sandy soil condition at 75 days after sowing.

Material mg/l		Free amino acids (mg/g dry weight)	IAA (µg/g fresh weight)	Total phenol (mg/100g fresh weight)
Control		219.59	35.36	112.20
Yeast (g/l)	5	265.15	45.68	145.14
	10	351.24	61.32	154.76
	15	362.91	75.35	194.45
Nicotinaminde (mg/l)	50	240.31	42.60	134.33
	75	298.28	59.32	142.73
	100	324.52	64.45	163.07
LSD 5%		6.21	1.96	3.24

Yield components:

Data presented in Table (4) show effect of either DBY or Nicotinamide foliar application on some yield components of quinoa plants. As treatments concentration increased the yield component increased except for 1000 seed weight. Increasing of yeast foliar application concentrations from 0 to 15 g/l increased shoot length, fruiting branches number /plant, shoot weight/ plant and seed weight /plant by 81.21, 75.90, 69.05 and 91.09 %, respectively compared with the control treatment. Meanwhile increasing the nicotinamide foliar application concentrations from 0 to 100 mg/l increased the studied characters by 71.67, 50.11, 55.77 and 77.00 % for shoot length, fruiting branches number /plant, shoot weight/ plant and seed weight /plant, respectively compared with the control treatment. The positive effects of applying DBY foliar application may be attributed to its own contents of different nutrients, protein, different vitamins especially vitamin B and natural plant growth regulators such as cytokinins these tend to increase the growth characters (Table 1) consequently these have positive effects on different yield and yield attributes characters [15,33]; physiological roles of vitamins and amino acids in the yeast extract which increased the metabolic processes role and endogenous hormones levels, i.e., IAA and GA3 which may promoted the vegetative growth characters which in turn reflected on increasing the yield. Foliar application of yeast was found to increase growth, yield and quality of many vegetable crops [40,41,42,43]. Active dry yeast application resulted in increasing yield characters[13,44,45]. Yeast extract was participating in a beneficial role during vegetative and reproductive growth stages through improving flower formation and their set in plants[16].

Table (4): Effect of either DBY or Nicotinamide foliar application on yield components of quinoa plants grown under sandy soil conditions.

Material mg/l		Shoot length (cm)	Fruiting branches number /plant	Shoot Weight (gm)	Seed Weight (gm)	1000 seed weight (gm)
Control		47.90	13.57	39.00	5.87	0.35
Yeast (g/l)	5	66.73	19.73	57.72	11.33	0.45
	10	73.36	21.97	63.80	13.37	0.50
	15	86.80	23.87	65.93	16.95	0.53
Nicotinaminde (mg/l)	50	59.73	17.87	54.55	9.39	0.40
	75	71.88	18.35	58.30	12.3	0.43
	100	82.23	20.37	60.75	15.7	0.49
LSD 5%		2.21	1.27	3.15	1.94	NS

Chemical constituents

Data in Table (5) illustrate the effect of foliar application by either yeast extract or Nicotinamide on some chemical constituents i.e. carbohydrates %, protein %, oil %, filavonoids and DPPH of quinoa seed. Significant differences among different treatments on the studied characters were observed except, seed oil %, filavonoids % and DPPH. Increasing the DBY foliar application from 0 to 15 g/l records the highest values and tends to significant increase in most studied characters except, seed oil content, filavonoids % and DPPH. No significant differences between 15 g/l yeast foliar application and 100 mg/l Nicotinaminde foliar application in carbohydrates %, oil %, Filavonoids % and DPPH %. This is may be attributed to its content of many nutrient elements and being productive compounds of semi growth regulator compounds like auxins, gibberellins and cytokinins. The yeast was capable of increasing the simulative growth compounds like gibberellins, auxins and cytokinins that act in improving plant cell division and growth[15]. Also, these results may be due to the physiological roles of vitamins and amino acids in the yeast extract which increased the metabolic processes rate and levels of indigenous hormones, i.e. LAA and GA3[46]. These results are in harmony with those obtained by [38]. Foliar application of yeast increasing cytokinins content especially at the high level of yeast (10 g/l.)[41].

Table (5): Effect of DBY or Nicotinamide foliar application on some chemical constituents of quinoa plant grown in sandy soil condition.

Material mg/l		Carbohydrates %	Protein %	Oil %	Filavonoids %	DPPH %
Control		45.30	13.38	6.10	61.55	44.10
Yeast (g/l)	5	49.89	14.52	6.90	69.62	49.01
	10	53.00	16.89	7.63	72.24	51.20
	15	54.56	18.24	7.84	74.65	52.82
Nicotinaminde (mg/l)	50	47.90	13.92	6.59	63.92	46.20
	75	50.39	14.61	6.83	65.32	48.17
	100	53.00	15.23	7.50	70.55	50.00
LSD 5%		1.91	1.19	NS	NS	NS

Acknowledgement

This work was funded by The National Research Centre through the project entitled "Raising agronomic performance of Quinoa plant under environmental stress using antioxidant and organic fertilizer. Project No. 10120111 during 2013-2016.The principal investigator Ass. Pro. Dr/ Maha Mohamed Shater Abdallah- Botany Department.

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