

Response of growth, productivity and oil composition of fenugreek plants to foliar application of complete fertilizer, dry yeast and L- tryptophan under sandy soil conditions

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ABSTRACT

The present investigation was conducted at the Experimental Farm of the Agriculture Faculty, Sebha University, Libya, during the two consecutive seasons of 2013/2014 and 2014/2015 to study the effect of complete fertilizer named Irral (0.0, 4000 and 8000 ppm) and 100 ppm of L- Tryptophan, dry yeast (3, 6 and 9 g/l) plus L- Tryptophan (Trp.) as well as control on growth and productivity of fenugreek plants (*Trigonella foenum-graecum*). The effect of complete fertilizer and foliar spray with Tryptophan plus dry yeast on the growth parameters and yield components were measured and quantitative analysis of some chemical constituents and active ingredients were performed. The most effective rate was 4000 ppm of complete fertilizer with foliar application 9 g/l dry yeast plus 100 ppm L- Tryptophan. interaction treatment, resulting in a positive increase in vegetative growth compared to control. The highest values of yield components were 46, 45 /plant (pods); 10.65, 9.24 g /plant (seed yield); 745.50, 646.80 kg/feddan (seed yield); 1.28, 1.11ml /plant (fixed oil yield); 89.73, 77.44 l/feddan (fixed oil yield) during the first and second seasons respectively. Moreover, the same trend was found in most chemical constituents as nitrogen percentage, total carbohydrates, total chlorophyll and trigonilline seed content of fenugreek plants.

Keywords: Fenugreek, Complete fertilizer, Tryptophan, Growth, yield, Active ingredients

Introduction

Fenugreek (*Trigonella foenum graecum*) is an annual plant belongs to the family Leguminosae (Apiaceae). It is commonly growing in the Mediterranean regions of the world. Its seeds and leaves are primarily used as a culinary spice. In Egypt, Greece, Italy, and South Asia it is also used to treat some healthy problems (Acharya *et al.*, 2008). These beneficial physiological effects including the antidiabetic and hypocholesterolemic effects of fenugreek are mainly attributable to the intrinsic dietary fiber constituent which has promising nutraceutical value (Srinivasan, 2006). Fenugreek seed contains 20% protein, 50% carbohydrate, 5% fat and 25% dietary fibers lipids, cellulose starch, ash, calcium, iron and β -carotene (USDA, 2001). Also it has been found to contain vitamin C, niacin, potassium, and diosgenin (which are a compound that has properties similar to estrogen). Other active constituents in fenugreek are alkaloids (lysine and L-tryptophan) as well as steroidal saponins (Acharya *et al.*, 2007a and b). Additionally, green fenugreek is a good source of iron (Fe) for human (Chhibba *et al.*, 2000). *Trigonella foenum-graceum* L. is a medicinally important plant possessing anti-diabetic, anti-cancerous, anti-microbial and hypocholesterolaemic properties (Nagananda *et al.*, 2010).

Macronutrients play a very important role in plant growth and development. On the basis of elements' quantity and their requirement on the earth crust, they have been classified in many other ways such as macronutrients, i.e., N, P, K, Ca, and Mg, and micronutrients or trace nutrients which consist of B, Cl, Cu, Fe, Mo, Mn, Ni, Na, and Zn. Studies suggested that these elements enhance the growth and yields, besides performing different dynamic functions to protect the internal or external integrity of plant life (White and Brown, 2010).

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Zahir *et al.* (2000) reported that addition of L-Trp as precursor of auxin substantially enhanced auxin production by microbes present in soil. The amount of auxins resulted from the precursor, required for better productivity, which varies with crop type and variety. In higher plants, it has been found that L-TRP has better effects on seed germination percentage, growth characteristics, nutrient concentration and yield components as compared to pure auxin (Frankenberger and Arshad, 1991).

Active dry yeast is a natural safety biofertilizers causes various promotive effect on plants. It is considered as a natural source of cytokinins which simulates cell division and enlargement as well as the synthesis of protein, nucleic acid and B-vitamin (Amer, 2004). It also releases CO₂ which reflected in improving net photosynthesis (Kurtzman and Fell, 2005).

The main aim of this work is to study the effect of complete fertilizer, L-Tryptophan plus dry yeast and their combination treatments on growth, yield components, some chemical constituents and active ingredients and fixed oil fraction of fenugreek plants.

Materials and Methods

The present investigation was conducted at the Experimental Farm of the Agriculture Faculty, Sebha University, Libya, during the two seasons of 2013/2014 and 2014/2015 to study the effect of complete fertilizer (Irral), dry yeast and L- Tryptophan on fenugreek plants (*Trigonella foenum-graecum*)

Irral was produced and imported from Tecniterra Company, Italy. Irral is soluble in water and contains many macroelements, i.e., nitrogen 20 %, phosphorus 8 % as P₂O₅, potassium 16 % as K₂O and magnesium 1 %, while microelements, i.e., manganese 1%, zinc 0.1%, copper 0.1%, iron 0.03 %, sulphur 1% and boron 0.5 % are pronounced in organic phase to avoid precipitation or inversion to unavailable form.

The soil of the experimental site is sandy, comprising of 92.52% sand, 5.48% silt and 3.0% clay, with pH of 7.8 and EC.1.2 dsm⁻¹.

On October 8th 2013 and 2014 in the first and second seasons respectively, the seeds of fenugreek were sown into plots 5 x 3 meter. The distance between rows 60 cm apart and spaced in hills 20 cm in between. After complete germination (at 20 days after sowing) plants were thinned to tow plant per hill. Every plot contained 250 plants.

The normal agricultural treatments of growing fenugreek plants were practiced. Fenugreek plants were fertilized with different fertilizers at rates of 20 m³ cattle manure, 300 kg calcium superphosphate (15.5 % P₂O₅), 75 kg potassium sulphate (50 % K₂O) and 150 kg ammonium nitrate (33 % N) per feddan. Cattle manure, phosphorus and potassium fertilizers were applied during soil preparation. While, nitrogen fertilizer was divided into three equal doses and were added to the soil at 25, 50 and 75 days after sowing. Drip irrigation system was used in this experiment.

The experimental design in the experiments was a split-plot in complete randomized blocks design. The experiments included fifteen treatments and three replicates. Plants were sprayed with complete fertilizers with Irral, dry yeast and L- Tryptophan three times of each concentration at 21 days intervals. The first one was applied after month from planting. Control plants were spray distilled water. All other horticultural practices needed by the plants were conducted.

Data recorded:

1. Growth parameters: Plant samples were taken at random in April 27th in both seasons, the following data were recorded: Plant height (cm), number of branches per plant and dry weight of plant (g) nodule number /plant and fresh weight of nodules /plant (g).

2. Yield and its components: At harvest date (4th of May) in the first seasons and (6th of May) in the second season respectively, the following data were recorded: Number of pods per plant, seed weight per pod and per plant (g) and seed yield per feddan (kg).

3. Fixed oil production:

Fixed oil percentage in the dried seeds was determined according to the method of A.O.A.C. (1980). The fixed oil content per plant and per feddan were calculated.

4. Chemical constituents:

4.1. Nitrogen percentage: Total nitrogen percentage in the dried seeds of fenugreek was determined according to **Chapman and Pratt (1978)**.

4.2. Carbohydrates percentage: Total carbohydrate percentage in fenugreek seeds was determined according to the method reported by Dubois *et al.* (1956).

4.3. Total chlorophyll content: As leaf green color degree (SPAD unit) was determined in fenugreek fresh leaves by using SPAD- 502 meter (Markwell *et al.*, 1995).

5. Active ingredients:

5.1. Trigonelline content: The alkaloids trigonelline percentage was estimated in the seeds by the method of Gorham (1986) then, the trigonelline content per plant was recorded.

5.2. Mucilage content: Mucilage percentage in seeds was conducted according the method of Amer (1978). The mucilage content per plant was calculated by multiplying mucilage percentage in the seed weight per plant.

Amino acids analysis:

Total amino acids composition of control and treated fenugreek seed by (9gm/L.) of dry yeast combined with tryptophan (100 ppm) during the second season were determined by amino acid analyzer apparatus model "Eppendorf LC3000" (Simpson *et al.*, 1976) using the following steps: A known weight (0.2 g) of each sample was received 10 ml 6 N hydrochloric acid in a sealing tube, and then placed in oven at 110°C for 24 hr. Hydrolysates were transferred quantitatively into a porcelain dish and the hydrochloric acid was then evaporated to dryness at 50-60°C on a water bath. Distilled water (5 ml) was added to the hydrolysate and then evaporated to dryness to remove the excess of hydrochloric acid and finally the residue was dissolved in 10 ml distilled water and filtrate through 0.45 mm filter. The filtrate was dried under vacuum with a rotary evaporator, then 10 ml of distilled water were added and the samples were dried a second time. One ml of 0.2 N sodium citrate buffer at pH 2.2 was added and the samples were stored frozen in a sealed vial until separation of amino acids by amino acid analyzer (Column : hydrolysate column Eppendorf LC 3000 (250 × 4.6). The temperature of amino acid analyzer was 47°C; Sample: 20 µl; Buffer system: Sodium acetate, buffer A (pH 3.3), buffer B (pH 3.6), buffer C (pH 4.3) and buffer D (pH11.0); Flow rate: 0.2 ml/min.). Ninhydrin was used for the detection of amino acids at 440 nm for proline and 570 nm for the other amino acids through an oxidative decarboxylation reaction. The peak area and percentage of each amino acid were calculated by computer software AXXIOM CHROMATOGRAPHY- 727.

Statistical analysis:

Statistical analysis was conducted for collected data of both experiments under study. The analysis of variance was calculated according to Snedecor and Cochran (1980). Mean separation was done according to L.S.D at 0.05 level by using Statistix 9 computer program (Analytical Software, 2008).

Results and Discussion

Effect on growth parameters:

Data in Table 1 show that spraying fenugreek plants with complete fertilizer at different rates (0, 4000 and 8000 ppm) reflect significant effect on plant height, number of leaves/plant, total dry weight/plant, nodule number/plant and fresh weight nodules/plant in both seasons. Foliar spray with mixture nutrient at 4000 and 8000 ppm increased growth parameters compared to the control.

Spraying with complete fertilizer at 4000 ppm increased plant height, number of leaves/plant, dry weight/plant, nodule number/plant and fresh weight of nodule/plant with no significant differences with the highest concentration with respect to plant height and dry weight/plant in both

seasons and nodule number and fresh weight of nodule/plant in the 2nd season. The increases in total dry weight/plant were about 0.68 and 0.54 g/plant for complete fertilizer at 4000 ppm and 0.92 and 0.53 g/plant for complete fertilizer at 8000 ppm over the control in the 1st and 2nd seasons, respectively. These results are in harmony with those found by Alizadeh *et al.* (2010) on *Satureja hortensis* plant and Boroomand and Grouh (2012) on medicinal and aromatic plants (basil, turmeric, black pepper, cardamom, fennel and fenugreek).

Table 1: Effect of complete fertilizer (Irral) treatments on vegetative growth parameters of fenugreek plants during both seasons

Complete fertilizers (ppm)	Growth parameters					
	Plant height (cm)	No. of branches / plant	No. of leaves / plant	Dry weight of plant (g)	Nodule number / plant	Fresh weight of nodules / plant (g)
First season (2015/2016)						
0 (Control)	70.40	6.67	44.13	6.79	16.53	1.11
4000	73.33	7.00	46.33	7.47	26.00	1.33
8000	72.93	6.93	45.27	7.71	23.20	1.27
LSD at 5 %	0.92	N.S.	0.40	0.32	2.65	0.04
Second season (2016/2017)						
0 (Control)	72.60	7.00	44.27	6.94	17.73	1.16
4000	74.53	7.13	47.40	7.48	24.67	1.25
8000	73.87	7.20	46.13	7.47	23.73	1.23
LSD at 5 %	1.31	N.S.	2.64	0.36	1.06	0.03

Spraying fenugreek plants with dry yeast and L-tryptophan had significant effect on plant height, number of leaves and branches/plant, dry weight/plant, nodule number/plant and fresh weight of nodule/plant in both seasons (Table 2).

Table 2: Effect of dry yeast (DY) and L-tryptophan (Trp.) on vegetative growth parameters of fenugreek plants during both seasons

Treatments	Growth parameters					
	Plant height (cm)	No. of branches/plant	No. of leaves / plant	Dry weight of plant (g)	Nodule number /plant	Fresh weight of nodules /plant (g)
First season (2015/2016)						
0.0 (Control)	61.00	5.22	39.78	6.19	17.89	1.08
Trp. at 100 ppm	71.22	6.44	42.89	6.51	19.11	1.16
DY at 3 g/l + Trp.	73.33	7.00	45.33	7.19	21.00	1.22
DY at 6 g/l + Trp.	75.67	7.11	47.33	7.68	24.00	1.28
DY at 9 g/l + Trp.	79.89	8.55	50.89	9.03	27.56	1.45
LSD at 5 %	1.59	0.75	2.98	0.29	1.55	0.05
Second season (2016/2017)						
0.0 (Control)	64.89	5.78	41.67	6.24	16.33	1.04
Trp. at 100 ppm	72.11	6.33	43.56	6.76	18.78	1.14
DY at 3 g/l + Trp.	74.89	7.22	46.56	7.33	21.67	1.24
DY at 6 g/l + Trp.	76.56	7.55	48.22	7.64	24.78	1.27
DY at 9 g/l + Trp.	79.89	8.67	49.67	8.53	28.67	1.37
LSD at 5 %	1.64	0.52	2.18	0.37	1.58	0.04

Foliar spraying with tryptophan and dry yeast + tryptophan increased growth parameters compared to the control. Spraying with dry yeast at 9 g/l + tryptophan at 100 ppm gave the tallest plants and recorded maximum values of number both leaves and branches, total dry weight/plant, nodule number/plant and fresh weight of nodule/plant compared to the over treatments. The increases in total dry weight/plant were about 1 and 1.09 g/plant for dry yeast at 3 g/l + tryptophan at 100 ppm, 1.49 and 1.40 g/plant for dry yeast at 6g/l + tryptophan at 100 ppm and 2.84 and 2.29 g/plant for dry yeast at 3 g/l + tryptophan at 100 ppm over the control in the 1st and 2nd seasons, respectively, (Ezz El-Din and Hendawy, 2010) on borage plant regarding dry yeast and (Hassan and Bano, 2015) on wheat regarding L-Trp found similar results.

Foliar application of yeast bread might be due to that yeast induces nutrient minerals absorption through general improvement due to the ability of yeast to increase the production of stimulants for plant growth, especially gibberellins, auxins and cytokinins which act to improve the plant cell division and its growth. Additional, micronutrients often act as co-factors in enzyme systems and participate in redox reactions, in addition to having several other vital functions in plants (Amer, 2004).

The obtained results in Table 3 indicate that the interaction between spraying with complete fertilizer at different rates (0, 4000 and 8000 ppm) and spraying with dry yeast and tryptophan had significant effect on growth parameters of fenugreek plants in both seasons. The interaction between complete fertilizer at 4000 or 8000 ppm and dry yeast at 9 g/l + tryptophan at 100 ppm increased plant height, number of both branches and leaves /plant, total dry weight/plant, nodule number/plant and fresh weight of nodule/plant with no significant differences with the interaction between 0 micronutrients mixture and dry yeast at 9 g/l + tryptophan at 100 ppm with respect to plant height and number of branches/plant in both seasons and number of leaves/plant in the 1st season.

Effect on seed yield and its components:

Data presented in Table 4 indicated that, spraying with complete fertilizer at 4000 and 8000 ppm had significant effect on No. of pods/plant, seed yield/plant and seed yield/fad. with no significant differences with complete fertilizer at 8000 ppm with respect to No. of pods/plant in the 2nd season. The increases in seed yield / fad. were about 114.5 and 77.47 kg/fad. for complete fertilizer at 4000 ppm and about 73.78 and 45.32 kg/fad. for complete fertilizer at 8000 ppm over the control in the 1st and the 2nd seasons, respectively.

Chaurasia *et al.* (2005) reported that the maximum fruit length, yield components and net profit of tomato plant were recorded foliar sprays of water soluble liquid fertilizers 19:09:19 NPK. In addition, Farahani and Khalvati (2011) found significantly higher seed yield of coriander at 70 kg ha⁻¹ P₂O₅ which was superior over all other P levels.

Respecting the effect of foliar spray with dry yeast and tryptophan, data in Table 5 illustrate that spraying with dry yeast and tryptophan increased No. of pods/plant, seed yield/plant and seed yield/fed. compared to the control. Spraying with dry yeast at 9 g/l + tryptophan at 100 ppm significantly increased No. pods/plant, seed yield and seed yield/fad. in both seasons. The increases in seed yield /fed. were about 136.49 113.86 kg/fad. for dry yeast at 3 g/l + tryptophan at 100 ppm, 213.11 and 186.35 kg/fed. for dry yeast at 6 g/l + tryptophan 100 ppm and 294.16 and 216 kg/fad. for dry yeast at 9 g/l + tryptophan at 100 ppm over the control in the 1st and 2nd seasons, respectively.

However, these results coincided with those found by Zahir *et al.* (2000) on rice and Rao *et al.* (2010) on maize regarding L- tryptophan. In the mean time, El-Tohamy and El-Greadly (2007) on snap beans regarding yeast foliar spray at 10 g/l.

Table 3: Effect of combination between complete fertilizer (Irral), dry yeast and L-tryptophan treatments on vegetative growth parameters of fenugreek plants during both seasons

Complete fertilizers (ppm)	DY and Trp.*	Growth parameters					
		Plant height (cm)	No. of branches /plant	No. of leaves/plant	Plant dry weight (g)	Nodule number /plant	Nodule fresh weight /plant (g)
First season (2015/2016)							
0 (Control)	1	57.67	4.67	39.33	5.99	13.00	0.93
	2	67.67	6.33	40.00	6.00	15.33	1.13
	3	71.33	6.67	43.67	6.60	14.33	1.12
	4	76.00	7.00	47.00	7.14	17.00	1.15
	5	79.33	8.67	50.67	8.23	23.00	1.22
4000	1	60.00	5.67	39.67	6.22	19.00	1.14
	2	74.67	6.67	45.33	6.46	23.00	1.19
	3	74.00	7.00	46.67	7.35	26.67	1.33
	4	76.00	6.67	47.00	7.77	30.00	1.40
	5	82.00	9.00	53.00	9.55	31.33	1.60
8000	1	65.33	5.33	40.33	6.37	21.67	1.18
	2	71.33	6.33	43.33	7.08	19.00	1.16
	3	74.67	7.33	45.67	7.62	22.00	1.22
	4	75.00	7.67	48.00	8.13	25.00	1.29
	5	78.33	8.00	49.00	9.32	28.33	1.53
LSD at 5 %		2.63	1.22	4.63	0.54	3.53	0.09
Second season (2016/2017)							
0 (Control)	1	61.33	5.33	39.33	6.05	12.33	0.99
	2	69.33	6.67	41.00	6.23	16.00	1.13
	3	72.67	7.33	46.67	7.29	16.33	1.15
	4	78.67	7.33	47.67	7.19	19.00	1.20
	5	81.00	8.33	46.67	7.96	25.00	1.32
4000	1	65.33	5.67	43.33	6.25	17.67	1.06
	2	73.00	5.67	44.00	7.01	20.67	1.17
	3	76.00	7.33	47.33	7.43	24.67	1.30
	4	77.00	7.67	49.67	7.84	29.33	1.32
	5	81.33	9.33	52.67	8.90	31.00	1.42
8000	1	68.00	6.33	42.33	6.43	19.00	1.09
	2	74.00	6.67	45.67	7.03	19.67	1.12
	3	76.00	7.00	45.67	7.28	24.00	1.27
	4	74.00	7.67	47.33	7.89	26.00	1.29
	5	77.33	8.33	49.67	8.75	30.00	1.37
LSD at 5 %		2.85	1.06	4.25	0.67	2.65	0.08

* 1= 0.0 (Control), 2= Trp. at 100 ppm, 3= DY at 3 g/l + Trp., 4= DY at 6 g/l + Trp. and 5= DY at 9 g/l)+ Trp.

Table 4: Effect of complete fertilizer (Irral) treatments on yield components and fixed oil production of fenugreek plants during both seasons

Complete fertilizers (ppm)	Yield components			Fixed oil production		
	No. of pods/plant	Seed yield/plant (g)	Seed yield/feddan (kg)	Seed oil percentage	Seed oil yield/plant (ml)	Seed oilyield/feddan (liter)
First season (2015/2016)						
0 (Control)	29.53	6.31	441.56	9.67	0.61	43.11
4000	35.73	7.94	555.71	10.31	0.84	58.52
8000	33.53	6.88	481.93	10.36	0.72	50.76
LSD at 5 %	2.02	0.46	32.38	0.23	0.04	2.70
Second season (2016/2017)						
0 (Control)	30.00	6.43	449.82	9.55	0.62	43.23
4000	35.93	7.53	527.29	10.46	0.80	56.11
8000	34.40	6.88	481.97	10.29	0.72	50.27
LSD at 5 %	0.94	0.30	20.81	0.09	0.03	1.95

Table 5: Effect of dry yeast and L-tryptophan on yield components and fixed oil production of fenugreek plants during both seasons

Treatments	Yield components			Fixed oil production		
	No. of pods/plant	Seed yield/plant (g)	Seed yield/feddan (kg)	Seed oil percentage	Seed oil yield/plant (ml)	Seed oilyield/feddan (liter)
First season (2015/2016)						
0.0 (Control)	23.44	4.95	346.81	9.31	0.46	32.33
Trp. at 100 ppm	30.00	6.19	433.69	9.37	0.58	40.65
DY (3 g/l)+ Trp.	32.78	6.91	483.93	9.83	0.68	47.68
DY (6 g/l)+ Trp.	36.11	8.00	559.92	10.49	0.84	58.86
DY (9 g/l)+ Trp.	42.33	9.16	640.97	11.57	1.06	74.48
LSD at 5 %	1.86	0.43	30.18	0.28	0.05	3.23
Second season (2016/2017)						
0.0(Control)	25.11	5.32	372.56	9.33	0.50	34.76
Trp. at 100 ppm	29.22	6.07	424.67	9.46	0.57	40.20
DY (3 g/l)+ Trp.	34.00	6.95	486.42	9.77	0.68	47.69
DY (6 g/l)+ Trp.	37.22	7.98	558.91	10.50	0.84	59.03
DY (9 g/l)+ Trp.	41.67	8.42	589.24	11.44	0.97	67.68
LSD at 5 %	1.31	0.35	24.90	0.14	0.04	2.76

The interaction between spraying with complete fertilizer and dry yeast + tryptophan reflect significant effect on No. of pods/plant, seed yield/plant and seed yield/ fad. in both seasons (Table 6). The interaction between complete fertilizer at 4000 ppm and dry yeast at 9 g/l + tryptophan at 100 ppm significantly increased No. of pods/plant, seed yield/plant and seed yield/ fad. in both seasons compared to control.

Moreover, Matter and El Sayed (2015) showed that the treated caraway plants with NPK fertilizer combined with spraying active dry yeast led to improve number of umbels plant⁻¹, diameter of umbel, fresh and dry weights of umbels plant⁻¹ and weight of fruits plant⁻¹. Also, Abbas *et al.* (2010) found that the L-TRP improved the crop vegetative and reproductive growth that consequently increases pod weight per chickpea plant.

Table 6: Effect of combination between complete fertilizer (Irral), dry yeast (DY) and L-tryptophan (Trp.) treatments on yield components and fixed oil production of fenugreek plants during both seasons

Complete fertilizers (ppm)	DY and Trp.*	Yield components			Fixed oil production		
		No. of pods/plant	Seed yield/plant (g)	Seed yield/feddan (kg)	Seed oil %	Seed oil yield/plant (ml)	Seed oilyield/feddan (liter)
First season (2015/2016)							
0 (Control)	1	18.33	4.31	301.70	9.16	0.39	27.62
	2	26.67	5.90	413.23	9.20	0.54	38.02
	3	30.67	6.21	434.93	9.31	0.58	40.49
	4	34.00	7.13	498.87	9.93	0.71	49.52
	5	38.00	7.99	559.07	10.73	0.86	59.92
4000	1	26.33	5.31	371.47	9.36	0.50	34.78
	2	32.00	6.53	457.10	9.42	0.61	43.05
	3	36.33	8.12	568.17	10.07	0.82	57.18
	4	38.00	9.09	636.30	10.67	0.97	67.87
	5	46.00	10.65	745.50	12.04	1.28	89.73
8000	1	25.67	5.25	367.27	9.42	0.49	34.60
	2	31.33	6.15	430.73	9.49	0.58	40.88
	3	31.33	6.41	448.70	10.10	0.65	45.36
	4	36.33	7.78	544.60	10.86	0.85	59.18
	5	43.00	8.83	618.33	11.93	1.05	73.79
LSD at 5 %		3.49	0.80	56.39	0.49	0.08	5.66
Second season (2016/2017)							
0 (Control)	1	21.00	5.14	359.57	9.14	0.47	32.85
	2	27.67	6.01	420.47	9.22	0.55	38.78
	3	31.67	6.24	436.57	9.34	0.58	40.79
	4	33.33	7.08	495.37	9.59	0.68	47.50
	5	36.33	7.67	537.13	10.47	0.80	56.24
4000	1	27.67	5.45	381.73	9.40	0.51	35.89
	2	30.00	6.15	430.73	9.60	0.59	41.37
	3	36.33	8.01	560.70	10.15	0.81	56.88
	4	40.67	8.80	616.47	11.19	0.99	68.98
	5	45.00	9.24	646.80	11.97	1.11	77.44
8000	1	26.67	5.38	376.37	9.44	0.51	35.53
	2	30.00	6.04	422.80	9.57	1.58	40.45
	3	34.00	6.60	462.00	9.83	1.65	45.40
	4	37.67	8.07	564.90	10.73	1.86	60.61
	5	43.67	8.34	583.80	11.89	0.99	69.38
LSD at 5 %		2.22	0.62	43.55	0.23	0.07	4.67

* 1= 0.0 (Control), 2= Trp. at 100 ppm, 3= DY at 3 g/l + Trp., 4= DY at 6 g/l + Trp. and 5= DY at 9 g/l)+ Trp.

Effect on fixed oil production in seeds

Foliar spraying with complete fertilizer at 4000 ppm significantly increased seed oil %, seed oil yield/plant and seed oil yield/fed. with no significant differences with complete fertilizer at 8000 ppm with respect to seed oil % in both seasons (Table 4). The increases in seed oil yield/fed. were about 15.41 and 12.88 kg/fed. for complete fertilizer at 4000 ppm and 7.65 and 7.04 kg/fed. for complete fertilizer at 8000 ppm over the control in the 1st and 2nd seasons, respectively. Shishu and Vinay

(2005) stated that significantly higher oil content of mustard which was superior over all other levels including control.

Foliar spray with dry yeast at 9 g/l + tryptophan at 100 ppm significantly increased seed oil %, seed oil yield/plant and seed oil yield/fad. in both seasons (Table 5). The increases in seed oil yield/fed. were about 15.35 and 12.93 l/fed. for dry yeast at 3 g/l + tryptophan at 100 ppm, 26.63 and 24.27 l/fad. for dry yeast at 6g/l + tryptophan at 100 ppm and 42.15 and 32.92 l/fed. for dry yeast at 9g/l + tryptophan at 100 ppm over the control in the first and second seasons, respectively. Ezz El-Din and Hendawy (2010) reported that increasing the dose of dry yeast from 2 g/l to 4 g/l showed significant differences in the mean values of fixed oil % of *Borago Officinalis* Plant.

The interaction between foliar spray with complete fertilizer at 4000 ppm and foliar spray with dry yeast at 9 g/l + tryptophan at 100 ppm significantly increased seed oil %, seed oil yield/plant and seed oil yield/ fed. (Table 6). Furthermore, Matter and El Sayed (2015) on caraway reported that NPK fertilizer interacted with active dry yeast increased volatile oil percentage compared to untreated plants.

Effect on nitrogen, total carbohydrates in seeds and total chlorophyll in leaf tissues

The data calculated in Table 7 show that spraying with complete fertilizer at 4000 ppm significantly increased total carbohydrates percentage in seeds and total chlorophyll in leaf tissues with no significant differences with complete fertilizer at 8000 ppm. Khalid and Shedeed (2015) indicated that foliar nutrition by agronal as complete fertilizer led to higher biochemical contents than the control. The highest values of chemical contents were total carbohydrate and nitrogen percentages.

Table 7: Effect of complete fertilizer (Irral) treatments on some chemical constituents and active ingredients of fenugreek plants during both seasons

Complete fertilizers (ppm)	Chemical constituents			Active ingredients	
	Seed nitrogen (%)	Seed total carbohydrates (%)	Leaf total chlorophyll (SPAD unit)	Trigonelline seed content (mg/100 g)	Seed mucilage (%)
First season (2015/2016)					
0 (Control)	3.43	36.98	40.87	0.343	32.75
4000	3.43	37.15	43.00	0.363	34.31
8000	3.42	37.86	41.93	0.366	34.38
LSD at 5 %	N.S.	0.42	0.41	0.002	0.57
Second season (2016/2017)					
0 (Control)	3.40	37.22	39.87	0.351	32.91
4000	3.40	38.06	42.67	0.359	34.23
8000	3.46	37.74	42.53	0.358	33.95
LSD at 5 %	0.14	0.65	1.07	0.006	0.74

Also, spraying dry yeast at 9 g/l + tryptophan at 100 ppm increased N (%) and total carbohydrates (%) in seeds and total chlorophyll in leaf tissues as SPAD-unit during both seasons (Table 8). In addition, the increases in the content of total carbohydrates, N, P and K as a result of the tryptophan treatments may be attributed to its conversion of to IAA (Phillips, 1971).

Also, the treatment of L-tryptophan at 100 part per million showed significant increase in nitrogen, phosphorus and carbohydrates contents per plant when compared to control or the other ones under study in the two seasons. The interaction between spraying with complete fertilizer at 4000 and 8000 ppm and dry yeast at 9 g/l + L-tryptophan at 100 ppm significantly increased N and total carbohydrates in seeds and total chlorophyll in leaf tissues (Table 9).

Effect on active ingredients in seeds:

Spraying fenugreek plants with complete fertilizer at 4000 ppm increased trigonelline content and mucilage (%) in seeds with no significant differences with complete fertilizer at 8000 ppm (Table 7). Foliar spray with dry yeast at 9 g/l + tryptophan at 100 ppm significantly increased trigonelline content and mucilage (%) in seeds in both seasons (Table 8). In addition, Abdelkader and Hamad (2015) demonstrated that trigonelline content of fenugreek plant was gradually increased with increasing NPK foliar fertilization levels. The highest concentration of foliar fertilization gave the maximum values of this parameter.

Data in Table 9 show that the interaction between foliar spray with complete fertilizer at 4000 or 8000 ppm and dry yeast at 9 g/l + tryptophan at 100 ppm gave the higher trigonelline contents and mucilage % in seeds in both seasons.

Table 8: Effect dry yeast and L-tryptophan on some chemical constituents and active ingredients of fenugreek plants during both seasons

Treatments	Chemical constituents			Active ingredients	
	Seed nitrogen (%)	Seed total carbohydrates (%)	Leaf total chlorophyll SPAD unit	Trigonelline seed content (mg/100 g)	Seed mucilage (%)
First season (2015/2016)					
0.0 (Control)	3.36	35.85	37.56	0.300	31.27
Trp. at 100 ppm	3.38	36.69	40.00	0.341	32.80
DY (3 g/l) + Trp.	3.41	37.34	42.33	0.364	33.47
DY (6 g/l)+ Trp.	3.42	37.96	43.78	0.383	35.10
DY (9 g/l)+ Trp.	3.58	38.81	46.00	0.400	36.43
LSD at 5 %	0.03	0.51	0.70	0.009	0.48
Second season (2016/2017)					
0.0 (Control)	3.35	36.33	37.67	0.294	31.18
Trp. at 100 ppm	3.38	36.93	40.22	0.344	32.27
DY (3 g/l)+ Trp.	3.42	37.44	41.22	0.362	33.69
DY (6 g/l)+ Trp.	3.34	38.38	43.11	0.382	34.92
DY (9 g/l)+ Trp.	3.59	39.27	46.22	0.397	36.42
LSD at 5 %	0.15	0.314	0.85	0.010	0.63

Effect on total protein and amino acids in seeds:

A total of 17 amino acids were listed in fenugreek seed before and after treatment by (9 g/l) of dry yeast combined with tryptophan (100 ppm) (Table 10). The contents of the hydrophobic amino acids residues (Pro, Gly, Ala, Val, Ile, Leu, Phe) are 26.18% and 31.69% for fenugreek seed before and after treatment, respectively. The contents of the acidic amino acid residues (asp + glu, are 29.22% and 31.4% for fenugreek seed before and after treatment, respectively) and there are higher than that of the basic amino acids (arg + lys + his) which represented 14.79% and 17.85% for fenugreek seed before and after treatment, respectively). Amino acid analysis of fenugreek seed show only slight increases in the essential amino acids (27.1% and 35.66% before and after treatment, respectively) and non-essential amino acids (52.89% and 58.01% before and after treatment, respectively).

Matter and El Sayed (2015) reported that GLC analysis of the volatile oil of caraway seed revealed the presence of Carvone, Limonene, Linalool, Pinene, Carveol and Dihydrocarvone. The mean values of Carvone (major compound) in the essential oil showed gradually increase due to increasing NPK dose from 50 to 100 then 150 kg / fed. the same trend was attained with active dry yeast.

Table 9: Effect of combination between complete fertilizer (Irral), dry yeast and L-tryptophan treatments on some chemical constituents and active ingredients of fenugreek plants during both seasons

Complete fertilizers (ppm)	DY and Trp.*	Chemical constituents			Active ingredients	
		Seed nitrogen (%)	Seed total carbohydrates (%)	Leaf total chlorophyll SPAD unit	Trigonelline seed content (mg/100 g)	Seed mucilage (%)
First season (2015/2016)						
0 (Control)	1	3.35	35.41	37.67	0.297	30.07
	2	3.38	36.24	39.00	0.327	31.18
	3	3.44	36.84	40.33	0.347	32.78
	4	3.45	38.00	44.00	0.357	34.07
	5	3.53	38.39	43.33	0.390	35.63
4000	1	3.36	35.62	37.33	0.303	31.59
	2	3.38	36.53	41.67	0.340	33.97
	3	3.39	37.00	44.00	0.370	33.82
	4	3.43	37.86	44.00	0.397	35.36
	5	3.61	38.73	48.00	0.403	36.81
8000	1	3.36	36.52	37.67	0.300	32.14
	2	3.39	37.28	39.33	0.357	33.25
	3	3.39	38.19	42.67	0.377	33.81
	4	3.39	38.03	43.33	0.400	35.88
	5	3.60	39.30	46.67	0.400	36.84
LSD at 5 %		0.04	0.89	1.15	0.017	0.93
Second season (2016/2017)						
0 (Control)	1	3.32	35.83	36.67	0.290	30.99
	2	3.36	36.61	39.00	0.347	31.77
	3	3.40	36.65	39.33	0.357	32.96
	4	3.42	38.11	41.67	0.367	33.78
	5	3.50	38.89	42.67	0.393	35.03
4000	1	3.38	36.85	37.67	0.287	31.40
	2	3.39	37.16	40.33	0.353	32.37
	3	3.44	37.88	42.67	0.373	34.11
	4	3.12	38.67	45.00	0.380	36.17
	5	3.64	39.74	47.67	0.403	37.12
8000	1	3.36	36.33	38.67	0.307	31.15
	2	3.41	37.03	41.33	0.333	32.66
	3	3.41	37.79	41.67	0.357	34.01
	4	3.49	38.36	42.67	0.400	34.82
	5	3.62	39.19	48.33	0.393	37.12
LSD at 5 %		0.27	0.80	1.68	0.017	1.21

* 1= 0.0 (Control), 2= Trp. at 100 ppm, 3= DY at 3 g/l + Trp., 4= DY at 6 g/l + Trp. and 5= DY at 9 g/l)+ Trp.

Table 10: Effect of dry yeast (9 g/l) combined with tryptophan (100 ppm) on amino acids composition (%) of fenugreek seed during second season

Amino acid	Concentration (%)	
	(0) Control	Irral 4000 ppm + DY (9 gm/L) + Trp. (100 ppm)
Valine*	3.35	4.12
Lysine*	5.34	6.04
Threonine*	2.81	4.37
Methionine*	0.81	1.41
Histidine*	1.74	2.56
Phenylalanine*	2.53	3.92
Leucine*	5.93	7.13
Isoleucine*	4.59	6.11
Glycine	3.85	4.37
Alanine	2.83	2.85
Proline	3.1	3.19
Tyrosine	1.75	1.99
Arginine	7.71	9.24
Aspartic acid	10.99	12.1
Glutamic acid	18.23	19.3
Cysteine	0.79	0.85
Serine	3.64	4.12
Total essential	27.1	35.66
Total non-essential	52.89	58.01

*Essential amino acids

Recommendation

Finally, it could be recommended that the treating fenugreek plant by applying 4000 ppm complete fertilizer named (Irral) interacted with spraying with 9 g/l dry yeast + 100 ppm L-Trptophan gave the best results regarding growth parameters, seed yield components, chemical constituents, seed fixed oil% and fixed oil constituents of *Trigonella foenum-graecum* plant under sandy soil conditions.

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