Kinetin and Tryptophan Enhance Yield and Production Efficiency of Lupine (*Lupinus Termis* L.) Plants

Amin, A.A.[1], M. E. Awadi [1], M. G. Dawood[1], F. A. E. Gharib[2] and Esmat, A. Hassan[1]

[1] Botany Dept., National Research Centre, Dokki, Cairo, Egypt
[2]Botany & Microbiology Dept., Faculty of Science, Helwan University, Cairo, Egypt
el_awadi@yahoo.com

Abstract: Two field experiments were carried out in Research and Production Station, Nubaria, Egypt during the two successive seasons of 2011/2012 and 2012/2013. This study aimed to investigate the response of yield and its components as well as oil content and some metabolites of lupine (*Lupinus termis* L. cv. Giza 2) seeds to foliar application of kinetin (Kin; 20, 40 and 60 mg L^{-1}) and the amino acid tryptophan (Trp; 25, 50 and 100 mg L^{-1}) either alone, or combination. Kin or Trp either alone, or combination, significantly increased yield of lupine plants at harvest stage (i.e. plant height, number of (branches, pods and seeds/plant), pod length (cm) and DW/plant, seed index (100 seed weight), seed and straw yield (per plant and per fed), biological yield/fed., crop and harvest index). Kin was more effective than Trp in increasing lupine yield and its contributing characters.
Nitrogen, phosphorus, potassium, crude protein, total soluble sugars, free amino acids as wells oil content (oil percent, yield per plant and fed) in lupine seeds were significantly promoted by increasing Kin and/or Trp concentrations up to 60 or 100 mg/L, respectively alone or combination. Generally, foliar application of Kin at 60 mg L^{-1} and Trp at 100 mg L^{-1} singly or combined, effectively produced larger numbers of pods which resulted in substantially higher seed yield and quality. The most promising results of seed, straw, biological and oil yield/fed (ton) was observed at 60 mg L^{-1} Kin + Tryp at 100 mg L^{-1}, followed by 60 mg L^{-1} Kin alone.
[Amin, A.A., M. E. Awadi, M. G. Dawood, F. A. E. Gharib and Esmat, A. Hassan. Kinetin and Tryptophan Enhance Yield and Production Efficiency of Lupine (*Lupinus Termis* L.) Plants. *World Rural Observ* 2014;6(4):50-56]. ISSN: 1944-6543 (Print); ISSN: 1944-6551 (Online). http://www.sciencepub.net/rural. 8

Key words: lupine plants; kinetin; tryptophan; yield; protein, total soluble sugars, amino acids , oil content

1. Introduction

Lupine (*Lupinus termis*) is one of the oldest agricultural crops widely used in the world as a protein source in fodder production and for soil improvement (Maknickiene, 2001). The seeds of lupine cultivars have been used with increasing frequency as a source of proteins replacing proteins of animal origin or soybean in feed compounds. It contains 33-40% crude protein, 5-13% oil and relatively beneficial amino acids profile (Písaříková, and Zralý (2009). Further, proximate analysis for dehulled lupin flour gave 43.57% protein, 9.75% oil, 3.16% total ash, 12.45% crude fibre and 29% carbohydrate (Khalid and Elharadallou, 2013). Saturated fatty acids (11.35%) of bitter lupin (*Lupinus termis*) seed oil was lower than unsaturated fatty acids (88.65) with oleic acid (52.22 %) as a predominant fatty acid. Bitter lupin seed oil is suitable for utilization in different food products due to presence of high antioxidants content (α- and δ-tocopherol (5.41 and 4.23 mg/100g oil, respectively) (Alamri, 2012). In Egypt, the cultivated lupine area is about 1482 ha producing 2881 t with a productivity of 19, 439 kg·ha^{-1} (FAO, 2009). Despite large acreage of these crops, the total productivity remains low owing to physiological and biological constrains. Exhaustive efforts are being made to improve lupine quality and productivity (Dawood and Taie (2009): Ayad and Gamal El-Din, 2011; El-Saeid *et al*., 2011; Alamri 2012).

Amino acids foliar spray increased total soluble sugars and total free amino acids in *Antholyza aethiopica* (Wahba *et al*., 2002). Tryptophan application increased the growth of several species may be due to its conversion into IAA (Russell, 1982). Spraying tryptophan, increased growth and photosynthetic pigments of *Iberis amara* L (Attoa *et al*., 2002); *Chatharanthus roseus* L (Talaat *et al*., 2005) and *Philodendron erubescens* L (Abou Dahab and Abd El-Aziz, 2006) and *Brassica napus* L (Dawood and Sadak, 2007).

On the other hand, plant growth regulators (PGRs) representing one of the controlling factors regulate growth; biosynthesis of chemical constituents and yield. The uses of Plant growth regulators to improve growth character and productivity of various economic crops have yielded very encouraging results; application of PGRs at correct rate and date significantly increased pod number, shortening of off shoots and seed yields of yellow and narrow-leaved lupine (*Lupinus luteus* and *L. angustifolius*, resp.) plants (Gromadzinski *et al*., 1990).

Ammanullah *et al*. (2010) mentioned that plant growth substances are known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates to sink thereby helping in effective flower formation, fruit and seed development and ultimately enhancing the productivity of crops.

Kinetin is synthetic cytokinins known to significantly improve plant growth and development even grown under environmental stress. It stimulates leaf expansion, development of reproductive organs and delays senescence (Shah, 2007).

Spraying yellow lupine cultivar with cytokinin (6-benzyloaminopurine) and auxin (indole-3-butyric acid) significantly increased seed yield and limited the unfavourable abscission of generative organs (Prusinski *et al*., 1999.). Kinetin treatments increased the level of IAA, gibberellins and cytokine's in lentil plants (Khalil *et al*. 2006) and faba bean plants (Sadak *et al*., 2013). Exogenous application of IAA, NAA and kinetin at 25, 50 and 100 mg·dcm-3 significantly increased seed number and yield per pod and per plant as well as endogenous PGRs, particularly, GA and IAA, protein and total carbohydrates content but decreased oil percent in white lupine seeds (El-Saeid *et al*., 2011).

Considering the positive benefit that Kin and Trp have had on productivity of several crop plants and to ascertain the possibility of increasing production efficiency and nutritive value of seeds, by spraying lupine plants with different concentrations of kinetin and tryptophan, individually or in combination. Agronomic traits, yield, oil content and some metabolite profiles of lupine (*Lupinus termis* L.) cv. Giza 2 seeds were assessed.

2. Materials and Methods

Two field experiments were carried out at the Experimental Station of the National Research Centre (Research and Production Station, Nobaria region, Behira Governorate), Egypt during the two successive seasons of 2011/2012 and 2012/2013 to study the effect of foliar application of different concentrations of kinetin and tryptophan, individually or in combination on some growth criteria, yield and its components as well as some metabolic constituents of lupine seeds.

Inoculated lupine (*Lupinus termis* L. c,v. Giza 2) seeds with nitrogen fixing bacteria (Rhizobia) obtained from Agriculture Research Centre, Egypt, were sown on 10th and 12th November 2011 and 2012 season, respectively in Nobaria region.

The experimental design was a split plot design with four replications. The kinetin treatments occupied the main plots and tryptophan treatments were allocated at random in sub-plots. The plot area was 10.5 m^2 (3.0 m x 3.5 m) and consisted of four rows 70 cm apart and the distance between hills along the row 20 cm apart.

Pre-sowing, 30 kg/fed. Calcium super-phosphate (15.5% P_2O_5) was applied to the soil. While, ammonium nitrate (33.5% N) was applied in two equal doses; thirty days after sowing and before second irrigation respectively.

In both seasons, a foliar spray was applied twice to lupine plants during vegetative growth (at 45 and 60 days after sowing), with kinetin (6-furfuryi amino purine) (obtained from (Sigma Company, USA) at 20, 40 and 60 mgL^{-1} and/or tryptophane (Try, aldrich) at 25, 50 and 100 mgL^{-1} (i.e. singly and in combination, in all possible permutations). Solutions were sprayed evenly over the entire surface of plant, including the adaxial and abaxial surfaces of leaves. No additives or surfactant such as Tween were added. The interaction of different concentrations of both compounds was also assessed, in addition to untreated plants (control) which were sprayed only with tap water.

At the time of harvest, ten guarded plants were taken out at random from the middle two ridges of each plot to determine the mean values of yield and its related parameters, i.e., plant height, number of (branches, pods and seeds/plant), pods length (cm), DW of pods/plant, seed index (100 seed weight), seed and straw yield (per plant and per fed), biological yield/fed., crop and harvest index.

Plant samples were taken from each treatment and dried in an electric oven with a fan at 70°C for 48 h until constant DW was achieved. Samples of grains for determination of oil percentage by Soxhlet apparatus according to (A.O.A.C, 1981) and oil yield/plant and per fed were calculated. Dry samples of seeds were taken to determine total soluble sugars using the phenol sulphuric method (Dubois *et al*., 1956). Crude protein percentage was calculated by multiplying the values of total nitrogen by 6.25 (A.O.A.C, 1988). Phosphorus was determined according to Watanab and Olsen (1965) and potassium by Jackson, (1965). The method of Rosen (1957) was used for estimation of total free amino acids (g/100g dry weight).

Data for both growing seasons was carried out according to Snedecor and Cochran (1990). Data was combined since CV% was <5%. Treatments means were compared using Fisher's least significant differences (LSD) at 5%.

3. Results

3.1. Yield and its components

Data presented in Tables 1 and 2 show that foliar application of kinetin either separately at 20, 40 and 60 mg L^{-1} and Trp at 25, 50 and 100 mg L^{-1} or their combination, significantly increased lupine height and yield (i.e., number of (branches, pods and seeds/plant), length (cm) and dry weight of pods/plant, seed index (100 seed weight), seed and straw yield (per plant and per fed) and biological yield/fed.). On the other hand, crop and harvest index percent were nearly similar to control plants.

Kinetin application was superior to tryptophan in increasing lupine yield and its contributing characters at harvest stage. The most promising results, obtained with 60 mg L^{-1} kinetin. Since, seed, straw and biological yield 1.24, 1.74 and 2.98 ton/fed, respectively. (Table 1).

Furthermore, lupine yield was more sensitive to the interaction between Kin and Trp. The highest increase in lupine height and yield (i.e. number of (branches, pods and seeds/plant), dry weight of pods/plant, seed index (100 seed weight), as well as seed and straw yield (per plant and per fed.) were obtained by foliar application with 60 mg L^{-1} kinetin + 100 mg L^{-1} Trp, followed by 60 mg L^{-1} kinetin for all previous parameters. Moreover, both previous treatments showed nearly similar seed, straw and biological yield (per fed) as well as harvest index (Tables 1 and 2).

3.2. Chemical constituents

Data presented in Tables 3 and 4 show that foliar application of either Kin or Trp at any concentration as well as their combination significantly increased the nitrogen, phosphorus, potassium, crude protein, total soluble sugar percentages as well as oil content (oil percent, yield per plant and per fed.) in the seeds of lupine compared with their controls.

Table (1): Effect of kinetin and tryptophan on yield characters of lupine plants (Combined analysis of two seasons)

Treatments (mgL^{-1})		Yield characters													
		Plant height (cm)	No. of branches $plant^{-1}$	No. of pods $plant^{-1}$	No. of seeds $plant^{-1}$	Pod length (cm)	Pods dry weight (g) $plant^{-1}$	Seed index (g) $plant^{-1}$	Seeds yield (g) $plant^{-1}$	Straw yield (g) $plant^{-1}$	Seeds yield/fed (ton)	Straw yield/fed (ton)	Biological yield/fed (ton	Crop index	harvest index
Kinetin	0.0	90.31	22.09	19.08	49.22	6.61	23.59	34.81	20.16	31.56	0.98	1.41	2.39	0.41	0.69
	20.0	102.25	26.23	24.39	55.41	7.20	29.90	39.72	24.23	37.90	1.18	1.69	2.87	0.41	0.70
	40.0	112.63	29.43	29.44	59.60	7.53	34.88	43.33	27.39	39.88	1.21	1.72	2.93	0.41	0.70
	60.0	122.43	33.39	31.12	64.89	8.43	37.05	49.49	31.40	42.09	1.24	1.74	2.98	0.42	0.71
L.S.D. at 5%		8.01	2.66	1.59	3.26	0.31	2.12	3.67	3.01	1.87	0.04	0.02	0.05	n.s.	n.s.
Tryptophan	0.0	87.52	21.69	18.59	48.81	6.50	22.92	33.59	19.51	30.11	0.96	1.36	2.32	0.41	0.70
	25.0	100.61	24.80	22.64	53.27	6.68	28.37	37.60	22.60	34.93	1.10	1.59	2.69	0.42	0.71
	50.0	110.70	27.53	26.39	57.36	7.37	31.01	41.71	26.72	38.26	1.16	1.65	2.81	0.41	0.70
	100.0	118.89	30.44	29.09	60.45	7.80	35.90	46.80	29.68	41.51	1.23	1.73	2.96	0.42	0.71
L.S.D. at 5%		6.32	2.23	1.39	2.76	0.25	2.56	2.91	2.87	1.29	0.03	0.03	0.11	n.s.	n.s.

Table (2): Effect of interaction between kinetin and tryptophan on yield characters of of lupine plants (Combined analysis of two seasons)

Treatments (mgL^{-1})				Yield characters											
Tryp	Kinetin	Plant height (cm)	No. of branches $plant^{-1}$	No. of pods $plant^{-1}$	No. of seeds $plant^{-1}$	Pod length (cm)	Pods dry weight (g) $plant^{-1}$	Seed index (g) $plant^{-1}$	Seeds yield (g) $plant^{-1}$	Straw yield (g) $plant^{-1}$	Seeds yield/fed (ton)	Straw yield/fed (ton)	Biological yield/fed (ton)	Crop index	harvest index
0.0	0.0	89.11	20.17	18.21	49.78	5.12	22.29	33.51	19.31	30.42	0.91	1.32	2.23	0.40	0.69
	20.0	97.23	22.82	20.29	52.69	6.30	25.40	35.42	21.39	34.31	0.96	1.41	2.37	0.41	0.69
	40.0	103.39	23.93	21.32	55.50	6.49	26.51	37.39	21.50	38.01	1.02	1.52	2.54	0.41	0.67
	60.0	106.45	25.40	23.44	57.41	6.58	28.38	39.54	22.67	39.49	1.09	1.59	2.68	0.41	0.69
25.0	0.0	97.54	22.51	20.55	51.32	6.71	24.30	35.56	20.62	32.68	0.98	1.36	2.34	0.42	0.72
	20.0	101.63	25.62	23.67	54.42	6.60	26.41	37.76	22.44	36.70	1.11	1.60	2.71	0.41	0.69
	40.0	107.72	27.73	25.37	57.31	7.55	29.62	40.68	24.67	39.63	1.13	1.69	2.82	0.40	0.68
	60.0	112.81	29.84	27.84	59.60	7.34	31.34	42.69	25.58	40.45	1.15	1.72	2.87	0.41	0.67
50.0	0.0	100.90	24.59	22.90	53.38	6.83	26.44	37.64	22.39	33.48	1.03	1.39	2.42	0.43	0.74
	20.0	109.01	28.60	24.09	56.47	7.62	29.54	39.59	25.40	38.61	1.16	1.64	2.80	0.42	0.71
	40.0	115.41	31.71	26.51	59.56	7.71	33.66	42.69	27.55	40.34	1.19	1.70	2.89	0.41	0.70
	60.0	118.21	33.28	29.31	61.50	7.69	35.57	46.77	29.64	41.52	1.21	1.74	2.95	0.41	0.70
100.0	0.0	102.30	26.93	24.20	55.64	6.89	28.48	39.80	24.70	35.70	1.11	1.61	2.72	0.41	0.70
	20.0	110.49	29.40	28.39	58.37	7.67	31.69	42.09	27.81	39.61	1.15	1.69	2.84	0.40	0.68
	40.0	119.58	32.51	29.40	62.28	7.74	35.70	46.41	29.93	41.50	1.18	1.70	2.88	0.41	0.69
	60.0	127.67	34.62	31.56	65.91	8.89	39.81	50.32	32.66	42.39	1.25	1.75	2.99	0.41	0.71
L.S.D. at 5%		7.29	2.11	2.03	1.88	0.13	2.89	1.76	0.87	0.71	0.02	0.03	0.11	n.s.	0.01

Table (3): Effect of kinetin and tryptophan on some chemical constituents and oil content of lupine seeds (Combined analysis of two seasons).

Treatments (mgL^{-1})		Chemical Constituents						Oil content		
		N %	P %	K %	Crude protein %	Total soluble sugar %	Amino acids (g 100 g^{-1} dry weight)	Oil %	Oil yield (g) plant^{-1}	Oil yield fed^{-1} (ton)
Kinetin	0.0	5.30	3.44	1.29	33.12	25.08	3.69	12.60	2.54	0.123
	20.0	5.85	5.39	2.03	36.56	27.26	4.72	13.56	3.29	0.160
	40.0	6.83	5.48	2.11	42.69	29.50	5.89	14.39	3.94	0.174
	60.0	7.63	6.21	2.19	47.70	30.26	6.77	15.10	4.74	0.187
L.S.D. at 5%		0.39	1.78	0.49	2.42	2.01	0.82	0.67	0.20	0.010
Tryptophan	0.0	5.26	3.29	1.11	32.90	24.90	4.02	11.89	2.32	0.114
	25.0	5.58	4.38	1.39	34.87	26.56	5.81	12.96	2.93	0.143
	50.0	6.30	5.47	2.09	39.38	28.44	6.33	13.76	3.68	0.160
	100.0	6.98	5.56	2.12	43.62	29.96	7.52	14.88	4.42	0.183
L.S.D. at 5%		0.29	0.89	0.23	1.80	1.56	1.02	0.59	0.20	0.012

Table (4): Effect of interaction between kinetin and tryptophan on some chemical constituents and oil content of lupine seeds (Combined analysis of two seasons).

Treatments (mgL^{-1})		Chemical Constituents						Oil content		
Tryptophan	Kinetin	N %	P %	K %	Crude protein %	Total soluble sugar %	Amino acids (g 100 g^{-1} dry weight)	Oil %	Oil yield (g) plant^{-1}	Oil yield fed^{-1} (ton)
0.0	0.0	5.19	3.30	1.21	32.46	24.11	3.54	11.20	2.16	0.102
	20.0	5.53	3.38	1.39	34.58	25.29	4.16	11.39	2.44	0.109
	40.0	5.70	4.01	1.44	35.60	27.30	5.29	12.01	2.58	0.123
	60.0	6.04	4.39	2.09	37.74	27.44	5.79	12.33	2.80	0.134
25.0	0.0	5.52	3.48	1.43	34.52	25.35	4.44	11.43	2.36	0.112
	20.0	5.86	4.26	1.51	36.61	26.46	5.59	12.29	2.76	0.136
	40.0	6.16	4.41	2.26	38.49	28.27	5.60	12.37	3.05	0.140
	60.0	6.51	5.20	2.34	40.68	29.38	6.77	13.11	3.35	0.151
50.0	0.0	5.87	4.35	1.49	36.67	26.19	5.09	12.39	2.77	0.128
	20.0	6.15	5.12	2.31	38.46	27.21	6.18	12.58	3.20	0.146
	40.0	6.49	5.39	2.39	40.55	29.31	6.29	13.38	3.69	0.159
	60.0	7.00	6.06	2.42	43.74	30.22	7.32	14.44	4.28	0.175
100.0	0.0	6.19	4.44	1.55	38.68	27.23	5.49	12.47	3.08	0.138
	20.0	6.81	5.43	2.39	42.59	29.34	6.67	13.50	3.75	0.155
	40.0	7.17	6.23	2.54	44.84	30.25	7.16	14.56	4.36	0.172
	60.0	7.65	6.34	2.64	47.79	30.46	7.59	15.21	4.97	0.189
L.S.D. at 5%		0.25	0.11	N.S	1.59	1.01	1.09	0.13	0.01	0.002

Generally, kinetin treatments were superior than tryptophan in increasing chemical constituents and oil content in lupine seeds. The most effective treatment in this concern was 60 mg L^{-1} of Kin or 100 mg L^{-1} of Trp and their combination.

Furthermore, the results obtained indicate that the highest level of nitrogen (7.63, 6.98 and 7.65%), phosphorus (6.21, 5.56 and 6.34%), potassium (2.19, 2.12 and 2.64 %), crude protein (47.70, 43.62 and 47.79%), total soluble sugars (30.26, 29.96 and 30.46 %), total free amino acids (6.77, 7.52 and 7.59 g /100 g dry weight) and oil yield/ fed (ton) (increased 51.64, 60.34 and 85.05 % more than their control, respectively) was obtained at 60 mg L^{-1} of Kin, 100 mg L^{-1} Trp and their combination, respectively compared with their controls.

4. Discussion

The present study indicated that application of Kin up to 60 and Trp up to 100 mg L^{-1}, individually or in combination greatly promoted the growth by enhancing cell division and consequently improved yield and quality of seed; number of (branches, pods and seeds/plant), length (cm) and dry weight of pods/plant, seed index (100 seed weight), seed and straw yield (per plant and per fed) and biological yield/fed. In other studies, application of PGRs significantly increased pods number, and seed yield of yellow and narrow-leaved lupines (*Lupinus luteus* and *L. angustifolius*, resp.) plants (Gromadzinski *et al*., 1990) Cytokinin (6-benzylaminopurine) significantly increased seed yield and limited the unfavourable abscission of generative organs (Prusinski et al., 1999) of yellow lupine cultivar. Kinetin also stimulated growth by increasing the amount of endogenous promoters (IAA, gibberellins and cytokinins) in lentil plants (Khalil *et al*., 2006) and white lupine (El-Saeid *et al*., 2011) and in faba bean plants (Sadak *et al*., 2013). In our study, kinetin (60 mg L^{-1}) has shown a much better ability than Trp (100 mg L^{-1}) in promoting growth and yield of lupine plants due to increasing the amount of endogenous promoters, metabolic processes and hence increased the growth and dry matter accumulation. On the other hand, Stoddart, (1986) and Wilkins(1989) mentioned that Trp increased the content and activity of endogenous PGRs which promote linear growth of plant organs Trp increased the growth of several species due to its conversion into IAA (Russell, 1982). Auxins promote growth, increase building metabolites, retard senescence, enhance cell division, chlorophyll accumulation and stimulate dry matter production as a result of higher photosynthetic activity and consequently increased translocation and accumulation of microelements in plant organs **(Shafey *et al*., 1994 and Chhun *et al*., 2004)**. amino acids treatments caused significant increase in growth, flowering parameters and quality of inflorescences in lemon grass (Gamal El-Din *et al*., 1997), basil (Talaat and youssef , 2002), *Pelargonium graveolens* (Mahgoub and Talaat, 2005), *Dianthus caryophyllus* (Bekheta and Mahgoub, 2005), and *Salvia farinacea* plants (Abd El-Aziz and Balbaa, 2007). Also, Trp applicatopn up to 100 ppm increased growth of *Iberis amara* L (Attoa *et al*., 2002); *Chatharanthus roseus* L (Talaat *et al*., 2005), *Philodendron erubescens* (Abou Dahab and Abd El-Aziz, 2006) as well as length, number, fresh and dry weights of inflorescences per *Antirrhinum majus* L. plants (Abd El-Aziz, *et al*., 2009). Dawood and Sadak (2007) mentioned that the possibility of using tryptophan as a tool to increase the yield of canola seeds/plant as well as its oil, protein and carbohydrate content. Sadak *et al.* (2013) concluded that kinetin treatments had an enhancement effect on growth, some chemical constituents as well as yield quantity and quality of the two tested faba bean cultivars.

Consequently, Kin + Trp combination was more effective than Kin and Trp alone for increasing yield of lupine plants by enhancing translocation and accumulation of certain metabolites in plant organs which affected yield and quality.

In our study, foliar application of either Kin or Trp and their combination affect the abundance of some metabolite and change the metabolic networks due to their bioregulatory effect. Such changes influence the morphology, physiology, enzymatic activity of plants and consequently affect the translocation and accumulation of building metabolites to seeds. Kin and/or Trp increased the nitrogen, phosphorus, potassium, crude protein, total soluble sugars percent, total free amino acids and oil content (oil percent, yield per plant and per fed.) of lupine compared with their controls at the harvest stage. The combined treatments of Kin at 60 and Trp at 100 mg L^{-1} was very effective for enhancing nitrogen, phosphorus, potassium, crude protein, total sugar content, total free amino acids and oil content and consequently increased nutritional value of lupine seeds as a cereal-based diet more than Kin and Trp used alone. Cytokinins are among the factors which determine the selectivity of ion uptake; they regulate the absorption of K^+ and affect the distribution and redistribution of K^+ in the shoot cells of the intact plant (Ilan *et al*., 1971). Spraying chamomile plant with kinetin or amino acids (ornithine, proline or phenylalanine) increased oil %, total nitrogen% and crude protein (Gamal El-Din and Abd El-Wahed, 2005; Reda *et al*., 2010). Benzyladenine up to 60 mgL^{-1} increased oil %, total phenols, alkaloid%, total nitrogen% and crude protein in *L. termis* seed (Ayad and Gamal El-Din, 2011). Amino acids increased total soluble sugars and total free amino acids in *Antholyza aethiopica* (Wahba *et al*., 2002), *Philodendron erubescens* (Abou Dahab and Abd El-Aziz (2006) and onion (Amin *et al*., 2011). Tryptophan and phenylalanine up to 100 ppm significantly increased photosynthetic pigments, total sugar content in *Iberis amara* L (Attoa *et al.,* 2002), *Catharanthus roseus* L (Talaat *et al*., 2005), *Salvia farinacea* (Abd El-Aziz and Balbaa, 2007) and *Antirrhinum majus* L. due to their important role in the biosynthesis of chlorophyll molecules which in turn affected total soluble sugars content (Abd El-Aziz *et al*., 2009). Amino acids can serve as a source of carbon and energy when carbohydrates become deficient in the plants. Amino acids are determinate, releasing the ammonia and organic acid form which the amino acid was originally formed. The organic acids then enter the Kerb's cycle, to be broken down and release energy through respiration (Goss 1973). Amino acids provide plant cells with an immediately available source of nitrogen, which generally can be taken by the cells more rapidly than inorganic nitrogen (Thon *et al*., 1981).

In conclusion, Kin and Trp can be easily applied to lupine plants in the field. Application of Kin and Trp singly or in combination, resulted in a significant increase in every morphological attribute and nutritional value. They improved the yield contributing characters and quality of seeds as a promising potential source of low-cost protein, minerals, amino acids and oils for possible use as food/feed supplements.

5. References

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11/15/2014