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Effect of Mineral Nitrogen Levels and Foliar Spray with Tryptophan Concentrations on Growth, Yield and Quality of Lettuce Plants

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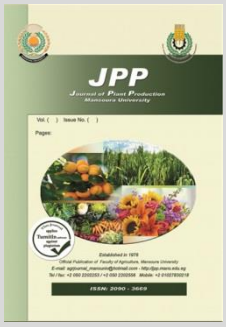

ABSTRACT

This experiment was carried out during the two successive winter seasons of 2018/2019 and 2019/2020 at El-Khattara Experimental Farm, Fac. Agric., Zagazig University, Sharkia Governorate, Egypt to study the effect of mineral nitrogen levels and foliar spray with tryptophan amino acid in different concentrations on the growth, yield and quality of lettuce plants cv. Dark green under sandy soil conditions. The best interaction treatment for increasing head weight, total yield and leaf area index was fertilizing plants with mineral nitrogen at 75% of recommended dose (RD) and spraying with tryptophan at 30 ppm. Moreover, fertilizing with 75% N (RD) and spraying with tryptophan at 45 ppm gave the highest values of total dry weight/ plant, N, K and dry matter percentage. In addition, fertilizing lettuce plants with 100% N (RD) and spraying with tryptophan at 30 (ppm) increased P%, whereas the highest nitrate concentration in leaves recorded by the interaction treatment with 100% N (RD) and all tested concentrations of tryptophan. Therefore, fertilizing with 75 % N (RD) and spraying with tryptophan at 30 ppm could be recommended for raising lettuce yield and giving moderate value of nitrate concentration in leaves under conditions of this study.

***Keywords*:** lettuce, mineral nitrogen, tryptophan, growth, yield and quality.

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is the most important leafy vegetable crop in Egypt and many regions of the world, and it is also considered as an excellent nutritive source of vitamins (A, E, C, and K), minerals, fiber and antioxidants such as quercetin and caffeic acid. In addition, lettuce leaves contain small amounts of lactucarium which is a mildsedative.

Nitrogen is an important factor for growth and productivity of lettuce plant, and enters in the content of many important components in plant like enzymes, nucleic acids, amino acids, chlorophyll and plays a key role in many metabolic reactions. Nitrogen also a structural constituent of cell walls (Marschner, 2012), but the increase in the nitrogen fertilization rate led to increase in nitrate content of the crop tissues without significant increase in yield and caused harmful effects on agricultural environment and human health. In addition, mineral fertilizers have the major cost in plant production (Custic *et al*., 1994).

Amino acids have function in the biosynthesis of other organic compounds i.e., enzymes, vitamins, terpenoids, alkaloids, coenzymes, purine and pyrimidine bases, also, amino acids are currently considered to be a regulator of plant growth and development as they affect cell division and differentiation and important function as antioxidant defense and regulation of photosynthesis processes (Ibrahem, 2016).

Tryptophan amino acid is a source of nitrogen in plant tissue that effect on plant growth criteria as shown by (Xu *et al.*, 2006) and L-tryptophan is known to be a physiological precursor of auxins in higher plants and it has an indirect role on the growth via its influence on auxin synthesis. Also, L-tryptophan is an amazing amino acid. It may act as an osmolyte, ion transport regulator and modulates stomatal opening (Rai, 2002).

This work was carried out to study the effect of different nitrogen fertilizer levels in combination with foliar spray by tryptophan on the growth, yield and chemical composition of lettuce plants under sandy soil conditions.

MATERIALS AND METHODS

This work was carried out during the two successive winter seasons of 2018/2019 and 2019/2020 at El-Khattara Experimental Farm, Faculty of Agriculture, Zagazig University, Sharkia Governorate, Egypt to study the effect of mineral nitrogen levels and foliar spray with tryptophan amino acid[(S) - 2 - Amino-3- (3-indolyl) propionic acid] in different concentrations on the growth, chemical composition and yield of lettuce plants (*Lactuca sativa*, L.) under the conditions of sandy soil using drip irrigation system. The experimental soil was sandy in texture and chemical properties were 7.90 and 7.69 pH, 0.98% and 0.96% organic matter, 2.10 and 2.30 ds/m for E.C., 0.027% and 0.032% total N, 13.69 and 14.98 ppm available N, 18.42 and 19.46 ppm available P and 64.08 and 75.10 ppm available K in the first and second seasons respectively.

This experiment was consisted of (16) treatments which were the combination among four mineral nitrogen levels (25%, 50%, 75% and 100% N) of recommended dose (60 kg N/fad.) and four concentrations of tryptophan amino acid [0 (control), 15, 30 and 45 ppm]. These treatments were randomly arranged in a split plot design system with three replicates, mineral nitrogen levels were randomly arranged in the main plots while tryptophan amino acid doses were randomly distributed in the sub plots of this experiment.

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Ammonium sulfate (20.5%N) was used as a source of mineral nitrogen and was added as a soil application according to treatments distribution in the experiment in three doses started after 15 days from transplanting. On the other hand tryptophan amino acid concentrations were added as a foliar application to the plants three times after 15, 30 and 45 days from transplanting.

All experimental units received equal amounts of botanical compost at the rate of $20m^3$/ fad. during soil preparation as well as one third of recommended amounts of the commercial P and K fertilizers which were calcium superphosphate (15.5% P_2O_2) and potassium sulphate (48% K_2O), respectively. The other two thirds of P and K fertilizers were added into equal doses around the season also as soil application. Transplants of lettuce cv. Dark green were transplanted in 30 November in the both seasons of the study. The area of the experimental unit was (12.6) m^2. It contained three lines each of 6 m length and 0.7 m width. Lettuce transplants were planted at 25 cm a part on both sides of the drippers. The other normal agricultural treatments for growing lettuce plants were practiced as commonly.

Data Recorded

1) Plant growth measurements: At 75 days from transplanting a random sample of (five) plants were taken from each experimental unit for measuring plant height, number of leaves per plant, fresh weight of different plant organs and total fresh weight per plant, also leaf area index (LAI) and dry weight of all studied different organs of lettuce plant and total dry weight per plant was determined (leaves were dried at 70ºC until constant weight then recorded). LAI was estimated by the following formula: Leaf area index =Leaf area per plant (cm^2) /Land area per plant (cm^2). Leaf chlorophyll content**:** Disc samples from the fourth outer leaf were randomly taken from every plot at the same time to determine total chlorophyll in both seasons, using chlorophyll meter (SPAD502, Osaka, Japan) which estimate SPAD value according to the method of Castelli *et al*. (1996).

2) Yield,head diameter and weight: At harvest time (100 days after transplanting) the fresh heads of lettuce plants in each experimental plot were harvested then weighted to determine head diameter (cm), head weight (kg) and total yield (ton/fad.).

3) N, P and K %:Nitrogen, phosphorus and potassium in leaves were determined at (75) days from transplanting in the dry matter of lettuce plants leaves according to the methods as described by to both methods described by AOAC (1995).

4) Nitrate content: Nitrate content in lettuce leaves was determined at 75 days from transplanting by using Brucine methods as described by Holty and Potworowski, (1972).

5) Dry matter (%): Known weight of fresh leaves (100 gm) was taken and dried at 105ºC to determine dry matter percentage.

Statistical analysis: All the obtained data were statistically analysis using the Statistix 9 program and means separation were done by least significant value (L.S.D.) at 0.05 level of probability according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

1. Vegetative characters and total chlorophyll

Effect of nitrogen levels

The presented data in Table (1) show the effect of mineral nitrogen levels on growth characters of lettuce plants expressed as, plant height (cm), number of leaves per plant and total chlorophyll in leaves during 2018/2019 and 2019/2020 seasons under the conditions of sandy soil. It is evident from such data that, adding mineral nitrogen at the rate of 75% of recommended dose to lettuce plants significantly enhanced the previous characters which tested in the two studied seasons compared to other rates and with no significant differences compared to 100% rate in the first season only.

As for total chlorophyll in leaves, the same data show that , total chlorophyll significantly enhanced in the leaves of lettuce plants which fertilized by mineral nitrogen at the rate of 75% of recommended dose followed by 100% of RD in the second season only with no significant differences between them. The increase in plant growth may be attributed to the beneficial effects of nitrogen on stimulating meristematic activity, cell division, protoplasm and chlorophyll formation (Marschner, 2012).

Table 1. Effect of mineral nitrogen levels and foliar spray with different tryptophan concentrations on vegetative growth at 75 days after transplanting of lettuce plants

Treatments	Plant height (cm)		Number of leaves / plant		Total chlorophyll (SPAD)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
			Nitrogen rates			
25 % RD*	36.05	36.40	51.57	51.86	29.85	29.70
50 % RD*	36.37	37.15	53.81	55.73	36.99	33.90
75 % RD*	40.22	43.31	60.33	63.97	38.71	36.41
100 % RD*	40.27	40.66	59.91	60.87	37.23	35.95
LSD at 0.05 level	0.57	0.97	1.11	0.83	1.14	0.79
			Tryptophan concentrations (ppm)			
0	36.55	37.74	52.57	55.37	32.15	31.80
15	37.85	38.28	55.27	56.67	35.43	33.53
30	39.32	41.00	58.98	60.13	37.37	35.58
45	39.20	40.51	58.80	60.27	37.82	35.06
LSD at 0.05 level	0.48	0.81	0.93	0.70	0.96	0.67

RD*= Recommended dose (60 kg N/fad.)

Additionally, Squire *et al*. (1987) established that, the main effect of nitrogen may be due to increase the rate of leaf expansion, leading to increased interception of daily solar radiation by the outer leaves, which enhanced more of head leaves formation. Many researches showed the effect of nitrogen on growth of lettuce plants such as Boroujerdnia and Ansari (2007), Hosseny and Ahmed (2009) and El-Bassyouni (2016).Moreover, the satisfactory effects of

nitrogen fertilizer enforcement on the content of chlorophyll may be referring to its memorable role in the chlorophyll pigment synthesis or chlorophyll molecule in the plant tissues. These findings are conformable to those reported by Abdel Nabi *et al*. (2017), Fu *et al*. (2017), Gioia *et al*. (2017) and Souza *et al*. (2017).

Effect of tryptophan

Such data in the same Table (1) revealed that, spraying lettuce plants with tryptophan at the rate of 30 ppm followed by 45 ppm significantly increased the previous characters with no significant differences between them. It is clear also from such data in this Table that, foliar spray with tryptophan at the rate of 45 ppm significantly improved total chlorophyll in lettuce plants leaves compared to other concentrations which tested followed by 30 ppm with no significant differences between them in the first season only. These results may be due to the physiological roles of tryptophan in plant growth which stimulate cell division in apical meristems, and it has an indirect role on the growth via its Influence on the natural plant auxin (indole acetic acid) synthesis. Also, tryptophan amino acid is a source of nitrogen in plant tissue that effect on plant growth as shown by Xu *et al*. (2006).

These results are harmony with those reported by Khan *et al*. (2019). They showed that treated lettuce plants with amino acid recorded the best results for increasing leaf length, width, and the number of leaves / plant than control treatment. Also, increasing in amino acid spraying rates from 250 to 500 ppm leads to an increase chlorophyll a, b in lettuce leaves (Abd El-Rheem, 2019).

Effect of the interaction

Results in Table (2) illustrate the effect of interaction between mineral nitrogen levels and foliar spray with tryptophan at different concentrations on vegetative growth of lettuce plants at 75 days after transplanting during seasons of 2018/2019 and 2019/2020.

Table 2. Effect of interaction between mineral nitrogen levels and foliar spray with different tryptophan concentrations on vegetative growth at 75 days after transplanting of lettuce plants

Treatments		Plant Height(cm)		Number of leaves / plant		Total chlorophyll (SPAD)	
Nitrogen levels	Tryptophan (ppm)	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
25 % RD*	0	35.60	34.00	46.40	47.00	23.90	27.55
	15	35.50	36.03	50.25	51.05	28.90	30.20
	30	36.30	36.89	54.45	53.34	32.00	30.95
	45	36.80	38.71	55.20	56.07	34.60	30.10
50 % RD*	0	34.00	36.78	51.00	55.17	35.11	31.30
	15	37.00	34.78	52.50	52.17	37.00	33.20
	30	37.20	39.03	55.80	58.55	38.40	34.20
	45	37.30	38.03	55.95	57.05	37.45	36.90
75 % RD*	0	36.40	41.38	54.60	62.07	33.70	34.00
	15	38.20	41.82	57.30	62.73	38.45	34.10
	30	43.40	47.04	65.10	66.56	41.85	40.05
	45	42.90	43.03	64.35	64.55	40.85	37.50
100 % RD*	0	40.20	38.83	58.30	57.25	35.90	34.35
	15	40.70	40.50	61.05	60.75	37.40	36.60
	30	40.40	41.04	60.60	62.07	37.25	37.10
	45	39.80	42.28	59.70	63.42	38.40	35.75
LSD at 0.05 level		0.96	1.63	1.87	1.40	1.93	1.34

RD*= Recommended dose (60 kg N/fad.)

It is interest to note that, adding mineral nitrogen at the rate of 75% from recommended dose and tryptophan at the level of 30 ppm as foliar application to lettuce plants was the best interaction treatment for enhancing vegetative growth characters which recorded, followed by adding mineral nitrogen at the same rate and tryptophan at 45 ppm with no significant differences between them in the first season only. In addition, adding mineral nitrogen at the rate of 75% of recommended dose with tryptophan at the rate of 45 ppm was the best interaction treatment which enhanced total chlorophyll in the leaves of lettuce plants in the two tested seasons followed by using mineral nitrogen at the same rate (75%) and tryptophan at 30 ppm level in the first season only compared to other interaction treatments.

In this respect, Abd El-wahed *et al*.(2016) found that, 30kgfad^{-1}nitrogen and 50 mg/l tryptophan caused the highest increases in all examined growth parameters of onion plants at both growth stages, while, enrichment nitrogen level and tryptophan amino acid concentration led to reduce the plant growth criteria .In addition, Yassen *et al*.(2010) reported that, foliar application of tryptophan (25 ppm) with nitrogen forms (ammonium nitrate and ammonium sulphate) fertilizer were more effective on anise plants compared tryptophan (50 ppm) with nitrogen forms.

2. Fresh weight

Effect of nitrogen levels

Results listed in Table (3) show the effect of mineral nitrogen levels on fresh weight of different plant organs as well as total fresh weight/plant during 2018/2019 and 2019/2020 seasons.

It is clear from such data that, adding mineral nitrogen at the maximum level (100%) significantly increased fresh weight of roots, leaves, stem as well as total fresh weight /plant (g) compared to other rates of nitrogen which tested in the two studied seasons except fresh weight of roots /plant in the first season only which didn't reflect any significant between 50 or 75 as well as 100% of mineral nitrogen rates which tested in this respect.

Effect of tryptophan

Also,data presented in Table (3) show the effect of foliar spray with tryptophan at different concentrations on the previous characters (fresh weight of different plant organs as well as total fresh weight/plant). Results indicated that, using tryptophan at the rate of 45 ppm as foliar application had significant effect on the abovementioned

characters. These results agree with those reported by Noroozlo, *et al.* (2019) on lettuce,they showed that shoot fresh were highest under 500 mg/l amino acid, whereas root fresh weight was highest under 250 mg/l amino acid spray.

Table 3. Effect of mineral nitrogen levels and foliar spray with different tryptophan concentrations on fresh weight of different plant organs at 75 days after transplanting of lettuce plants

Treatments	Fresh weight of roots / plant (g)		Fresh weight of leaves / plant (g)		Fresh weight of stem / plant (g)		Total fresh weight / plant (g)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Nitrogen levels								
25 % RD*	41.07	40.61	403.75	424.15	72.74	71.09	517.56	535.86
50 % RD*	43.75	41.78	438.12	467.35	89.39	91.71	571.27	600.85
75 % RD*	43.62	41.54	588.38	554.77	115.70	110.96	747.70	707.28
100 % RD*	44.01	43.49	599.12	603.72	122.34	122.01	765.48	769.23
LSD at 0.05 level	0.57	0.52	6.11	4.99	1.11	1.03	7.99	5.99
Tryptophan concentrations (ppm)								
0	38.95	38.72	473.75	479.22	93.76	89.34	606.46	607.29
15	40.83	40.16	502.75	501.75	97.31	97.09	640.89	639.00
30	45.28	43.43	519.88	531.30	103.23	103.78	668.39	678.52
45	47.40	45.11	533.00	537.72	105.87	105.56	686.27	688.40
LSD at 0.05 level	0.48	0.44	5.16	4.21	0.94	0.87	6.74	5.05

RD*= Recommended dose (60 kg N/fad.)

Effect of the interaction

Data presented in Table (4) show the effect of interaction between mineral nitrogen levels and foliar spray with tryptophan at different concentrations on fresh weight of different plant organs of lettuce plants at 75 days after transplanting during 2018/2019 and 2019/2020 seasons. Results showed that, there were no clear trends were observed on the effect of both mineral nitrogen levels as well as tryptophan at different concentrations on the fresh weight of different plant organs or total fresh weight of lettuce plants which treated.

We can say that, fertilizing lettuce plants with the maximum level of mineral nitrogen (100%) with tryptophan amino acid (as foliar spray) at the rate of 30 or 45 ppm were the best interaction treatments which significantly increased fresh weight of lettuce plant organs expressed as roots, leaves, stem as well as total fresh weight in the second season only compared with other interaction treatments which did not reflect any significant effect in most cases in this respect.

Table 4. Effect of interaction between mineral nitrogen levels and foliar spray with different tryptophan concentrations on fresh weight of different plant organs at 75 days after transplanting of lettuce plants

Treatments		Fresh weight of roots / plant (g)		Fresh weight of leaves / plant (g)		Fresh weight of stem / plant (g)		Total fresh weight /plant (g)	
Nitrogen levels	Tryptophan (ppm)	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
25 % RD*	0	37.50	36.68	356.00	372.00	63.20	50.40	456.70	459.08
	15	40.11	40.54	402.50	410.50	64.48	69.08	507.09	520.12
	30	40.68	41.86	424.50	453.40	80.88	80.72	546.06	575.98
	45	46.00	43.39	432.00	460.70	82.40	84.16	560.40	588.25
50 % RD*	0	38.57	40.11	410.00	451.70	84.00	83.32	532.57	575.13
	15	42.89	40.36	425.00	461.70	88.04	92.32	555.93	594.38
	30	46.64	42.07	458.00	485.50	92.60	97.12	597.24	624.69
	45	46.93	44.61	459.50	470.50	92.92	94.08	599.35	609.19
75 % RD*	0	38.29	39.11	546.00	520.70	109.20	104.16	693.49	663.97
	15	38.79	39.64	573.00	527.30	114.64	105.44	726.43	672.38
	30	48.50	42.82	591.00	565.60	118.24	113.12	757.74	721.54
	45	48.93	44.61	643.50	605.50	120.72	121.12	813.15	771.23
100 % RD*	0	41.46	39.00	583.00	572.50	118.64	119.48	743.10	730.98
	15	41.54	40.11	610.50	607.50	122.08	121.52	774.12	769.13
	30	45.32	47.00	606.00	620.70	121.20	124.16	772.52	791.86
	45	47.75	47.86	597.00	614.20	127.44	122.88	772.19	784.94
LSD at 0.05 level		0.96	0.88	10.32	8.42	1.88	1.75	13.48	10.18

RD*= Recommended dose (60 kg N/fad.)

On the other hand using mineral nitrogen at the rate of (75%) of recommended dose with tryptophan amino acid at 45 ppm was the best interaction treatment which significantly increased fresh weight of roots, leaves and total fresh weight/plant (g) in the first season only compared with other interaction treatments in this respect .

The favourable effect of mineral nitrogen levels and foliar spray with tryptophan on fresh weight of different plant organs of lettuce plants might be due to the fact that nitrogen and tryptophan effect on enzymes and hormones, in addition, nitrogen is an important macronutrient to ensure plant growth and development as it is a component of nucleic acids and proteins, and many co-factors and secondary metabolites or accumulation in the leaves. In this respect, Tsouvaltzis *et al.* (2014) indicated that fresh weight/plant of lettuce was increased when plants received supplemental fertilization with ammonium nitrate and spraying with amino acid.

3. Dry weight and LAI

Effect of nitrogen levels

It is clear from data in Table (5) that, dry weight of all studied different organs of lettuce plant and total dry weight/plant were significantly affected by the using of mineral nitrogen at the rate of 75% of recommended dose in the two studied seasons compared with other rates which studied except dry weight of roots which significantly enhanced by using a maximum rate of mineral nitrogen (100%) in the two tested seasons. In addition, adding

mineral nitrogen at the rate of 75% of recommended dose caused a significantly effect on leaf area index (LAI)in the second season with no significant differences between adding mineral nitrogen at the rate of 75% or 100% of RD in the first season.

Table 5. Effect of mineral nitrogen levels and foliar spray with different tryptophan concentrations on dry weight of different plant organs and leaf area index at 75 days after transplanting of lettuce plants

Treatments	Dry weight of roots / plant (g)		Dry weight of leaves / plant (g)		Dry weight of stem / plant (g)		Total dry weight/ plant (g)		Leaf area index (LAI)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Nitrogen levels										
25 % RD*	5.75	5.92	26.52	27.29	9.09	9.10	41.40	42.32	8661	9187
50 % RD*	6.69	6.63	31.29	31.13	10.95	11.43	48.95	49.19	9337	10462
75 % RD*	6.82	7.00	42.79	43.12	15.23	15.09	64.85	65.22	12506	14020
100 % RD*	7.70	7.49	38.02	36.37	14.46	13.87	60.19	57.73	12681	11970
LSD at 0.05 level	0.26	0.37	0.55	0.32	0.27	0.32	0.82	0.80	187.0	249.0
Tryptophan concentrations (ppm)										
0	5.87	6.03	32.05	30.97	11.59	10.98	49.55	47.98	9241	10333
15	6.27	6.52	34.16	33.58	12.07	12.29	52.50	52.40	10613	11552
30	7.28	7.01	35.99	36.45	12.87	13.03	55.88	56.50	11565	11674
45	7.55	7.48	36.42	36.91	13.20	13.19	57.45	57.58	11766	12081
LSD at 0.05 level	0.25	0.23	0.47	0.27	0.23	0.27	0.43	0.41	157.9	210.0

RD*= Recommended dose (60 kg N/fad.)

Increments in leaves dry weight may be due to a combination of nitrogen with plant matter produced during photosynthesis such as glucose, ascorbic acid, amino acids and protein (Magkos et al., 2003), in addition, nitrogen stimulates plant growth and increases leaf area; as a result increments in leaf area increase the rate of plant photosynthesis and thus higher dry matter production.

Boroujerdnia and Ansari (2007) found that, dry weight of leaves and LAI increased as the nitrogen dose increased. In addition, Mirdad (2016) reported that, plants receiving N fertigation rate up to 150 kg ha^{-1} were achieved the highest dry weight of outer leaves and head. In addition, dry weight of lettuce plants increased significantly in response to rate of 100% RD from NPK.

Effect of tryptophan

Data in the same Table(5) clearly indicate that , dry weight of all studied different organs of lettuce plant, total dry weight/plant and LAI were significantly affected by foliar spray with tryptophan at the rate of 45 ppm in the two studied seasons compared to other concentrations that tested which didn't reflect any significant effect except dry weight of leaves in the first season and dry weight of stem/plant in the second one , respectively which significantly affected also by adding tryptophan as foliar spray at the rate of 30 ppm. On the other hand control treatment (without tryptophan) was the lowest treatment in recorded values and didn't reach the level of significant at 0.05.Similar results were obtained by Abd El-Rheem et al. (2019) showed that the highest value of dry weight of lettuce leaves was found with amino acid at 500 ppm than 250 ppm.

Effect of the interaction

Data presented in Table (6) show that, fertilizing lettuce plants with mineral nitrogen at the rate of 75% of recommended dose in addition of tryptophan at the level of 45 ppm as foliar spray was the best interaction treatment which reflected a significant effect on the dry weight of all studied different organs of lettuce plant as well as total dry weight/plant in the two tested seasons except dry weight of leaves/plant which significantly affected by using mineral nitrogen at the rate of 75% of recommended dose and foliar spray with tryptophan at the level of 30 ppm followed by15 ppm in the first season only with no significant differences between them.

Table 6. Effect of interaction between mineral nitrogen levels and foliar spray with different tryptophan concentrations on dry weight of different plants organs and leaf area index at 75 days after transplanting of lettuce plants

Treatments		Dry weight of roots / plant (g)		Dry weight of leaves / plant (g)		Dry weight of stem / plant (g)		Total dry weight / plant (g)		Leaf area index (LAI)	
Nitrogen levels	Tryptophan (ppm)	Season1	Season2	Season1	Season2	Season1	Season2	Season1	Season2	Season1	Season2
25 % RD*	0	4.82	5.17	22.29	23.57	7.90	6.30	35.15	35.04	7751	8010
	15	5.52	5.60	25.75	26.32	8.06	9.26	39.33	41.18	7911	8944
	30	6.12	6.33	28.75	29.39	10.11	10.34	44.98	46.06	9920	9553
	45	6.55	6.60	29.29	29.91	10.30	10.52	46.14	47.03	9061	10242
50 % RD*	0	6.00	6.15	29.29	28.26	10.25	10.29	45.54	44.70	8459	10218
	15	6.79	6.42	30.36	30.98	10.63	11.54	47.78	48.94	9452	9531
	30	6.93	6.97	32.71	31.68	11.45	12.14	50.03	50.79	9318	11251
	45	7.07	6.99	32.82	33.61	11.49	11.76	52.48	52.36	10119	10848
75 % RD*	0	5.41	5.97	41.64	40.89	14.58	14.31	61.63	61.17	8769	13388
	15	5.51	7.07	43.61	43.39	15.26	15.19	64.38	65.65	12703	14207
	30	8.17	7.02	43.29	44.34	15.15	15.52	66.61	66.88	14278	14625
	45	8.22	7.96	42.64	43.87	15.93	15.36	66.79	67.19	14274	13858
100 % RD*	0	7.26	6.83	35.00	31.19	13.65	13.02	55.91	51.04	11985	9716
	15	7.27	7.02	36.93	33.66	14.33	13.18	58.53	53.86	12386	13524
	30	7.93	7.73	39.21	40.40	14.78	14.14	61.92	62.27	12743	11268
	45	8.36	8.38	40.96	40.25	15.09	15.14	64.41	63.77	13610	13374
LSD at 0.05 level		0.50	0.46	0.94	0.55	0.46	0.54	0.87	0.83	315.0	421.0

RD*= Recommended dose (60 kg N/fad.)

On the other hand using mineral nitrogen at the minimum level (25%) of recommended dose without foliar spray with tryptophan was the lowest interaction treatment in the recorded values and didn't reach the level of significant at 0.05. In addition, LAI significantly affected by using level of mineral nitrogen (75%) of recommended dose and foliar spray with tryptophan at the rate of 30 ppm in the two studied seasons compared with most interaction treatments which tested.

4.Yield, head diameter and weight

Effect of nitrogen levels

The presented data in Table (7) indicate that, both head diameter, head weight and total yield (ton/fad.) of lettuce plants significantly affected by using mineral nitrogen at the rate of 75% RD in the two studied seasons compared to other rates, with no significant differences between 100 % N RD regarding head diameter in the 1st season.

Table 7. Effect of mineral nitrogen levels and foliar spray with tryptophan concentrations on head diameter, head weight and total yield of lettuce plants

Treatments	Head diameter (cm)		Head weight (kg)		Total yield (ton/fed.)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Nitrogen levels						
25 % RD*	34.85	35.05	0.545	0.586	15.550	16.923
50 % RD*	37.67	39.01	0.748	0.738	22.443	22.134
75 % RD*	40.23	41.53	0.950	0.971	28.507	29.122
100 % RD*	40.19	41.11	0.891	0.871	26.737	26.116
LSD at 0.05 level	0.52	0.33	0.029	0.26	0.243	0.252
Tryptophan concentrations (ppm)						
0	36.30	38.01	0.720	0.706	21.459	21.034
15	37.69	38.17	0.771	0.764	22.974	22.682
30	39.29	40.59	0.817	0.855	24.271	25.411
45	39.66	39.94	0.826	0.839	24.532	25.169
LSD at 0.05 level	0.44	0.28	0.009	0.17	0.205	0.213

RD*= Recommended dose (60 kg N/fad.)

The positive response of lettuce yield to N rate may be attributed to remobilization of N and K from outer leaves to head that occurred over the last week of the growth period for lettuce as reported by Huett and Dettmann (1992). Many researches showed the effect of nitrogen on yield of lettuce plants such as Broadley *et al.* (2000),Tittonell *et al.* (2003), Boroujerdnia and Ansari (2007), El- Bassyouni (2016) , Mirdad (2016) and Gioia *et al.* (2017).

Effect of tryptophan

Such data in the same Table (7) show that also, head diameter and head weight significantly affected by foliar spray with tryptophan at the rate of 30 ppm followed by 45 ppm in the two studied seasons with no significant differences between them, as for head diameter in the 1st season only, in addition, total yield was significantly increased by foliar spray with tryptophan at the rate of 45 ppm in the 1st season and 30 or 45 ppm in the 2nd season , with no significant differences between them. Tryptophan affects plant growth and yield after its direct uptake by the plants and then its conversion into auxin within plant tissues (Frankenberger and Arshad, 1995). Results are harmony with those reported by Abd El-Rheem *et al.* (2019), Noroozlo, *et al.* (2019) and Khan *et al.* (2019) all showed that the highest value of total yield of lettuce was obtained with amino acid at the highest concentration.

Effect of the interaction

It is obvious from results listed in Table (8) that, fertilizing lettuce plants with mineral nitrogen at the rate of 75% of recommended dose with foliar spray with tryptophan at the level of 30 ppm was the best interaction treatment for enhancing all yield components, i.e., head diameter, head weight and total yield per faddan in the two studied seasons compared to other interaction treatments which did not reach the level of significant at 0.05.These results are accordance with Tsouvaltzis *et al.* (2014). They indicated that head yield of lettuce was substantially increased when plants received supplemental fertilization with ammonium nitrate and spraying with amino acid.

Table 8. Effect of interaction between mineral nitrogen levels and foliar spray with tryptophan concentrations on head diameter, head weight and total yield of lettuce plants

Treatments		Head diameter (cm)		Head weight (kg)		Total yield (ton/fed.)	
Nitrogen levels	Tryptophan (ppm)	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
25 % RD*	0	32.48	32.90	0.512	0.533	14.754	15.378
	15	35.18	33.74	0.528	0.584	15.234	16.514
	30	35.12	36.34	0.556	0.618	15.674	17.545
	45	36.64	37.25	0.585	0.609	16.538	18.257
50 % RD*	0	35.70	38.62	0.669	0.658	20.056	19.732
	15	36.75	36.52	0.765	0.734	22.935	22.011
	30	39.06	40.99	0.764	0.764	22.911	22.899
	45	39.17	39.94	0.796	0.797	23.870	23.895
75 % RD*	0	38.22	40.45	0.903	0.833	27.073	24.974
	15	39.11	41.91	0.903	0.940	27.073	28.189
	30	41.57	42.59	1.008	1.081	30.228	32.411
	45	42.05	41.19	0.989	1.031	29.652	30.912
100 % RD*	0	38.81	40.08	0.799	0.802	23.954	24.050
	15	39.74	40.53	0.889	0.801	26.653	24.014
	30	41.42	42.45	0.943	0.960	28.273	28.788
	45	40.79	41.39	0.936	0.921	28.069	27.613
LSD at 0.05 level		0.89	0.56	0.018	0.034	0.410	0.426

RD*= Recommended dose (60 kg N/fad.)

5. Mineral, nitrate content and dry matter

Effect of nitrogen levels

Results in Table (9) illustrate that, adding mineral nitrogen at the maximum rate (100%) reflected a significant effect on the mineral content of lettuce plants expressed as N, P, as well as nitrate content of lettuce leaves compared to other rates of mineral nitrogen which didn't reach the level of significant at 0.05 except content of K (%) in lettuce leaves which significantly enhanced also by using mineral nitrogen at the rate of 75% of recommended dose. Such results indicate that also, adding mineral nitrogen at the rate of 75% of recommended dose significantly increased the content of dry matter of lettuce leaves followed by 100% rate with no significant differences between them. Obtained results regarding the effect of mineral nitrogen on N , P and K (%) as well as nitrate content by Tei *et al*.(2000),Türkmen *et al*. (2004), Mahmoudi (2005),El- Bassyouni (2016), Fouda (2016) and Abdel Nabi *et al*. (2017) all on lettuce.

Effect of tryptophan

Data in the same Table (9) indicate that, mineral content of lettuce leaves from N, P and K% as well as nitrate content significantly affected by foliar spray with tryptophan at the high level (45 ppm) compared to other rates of tryptophan which didn't reach a level of significant at 0.05, except nitrate content in lettuce leaves which significantly increased also by foliar spray with tryptophan at 15 and 30 ppm with no significant differences among them in this respect. It is interest to note that also, the content of dry matter of lettuce leaves significantly increased by foliar spray with tryptophan at the rate of 30 or 45 ppm with no significant differences between them and compared with other concentrations which didn't reflect any significant effect. In this respect, Khan *et al*. (2019) revealed that treated lettuce plants with amino acid significantly increased the chemical constituents (N,P and K as well as dry matter contents) in lettuce plants. In this regard, Franzoni *et al.* (2020) found that spraying lettuce plants with amino acid reduced nitrate accumulation in leaves than unsprayed plants.

Table 9. Effect of mineral nitrogen levels and foliar spray with tryptophan concentrations on N, P, K, dry matter and nitrate contents in leaves of lettuce plants

Treatments	N (%)	P (%)	K (%)	Dry matter (DM) (%)	Nitrate contents (mg/kg DM)
Nitrogen levels					
25 % RD*	1.20	0.190	1.33	5.20	200.30
50 % RD*	1.26	0.182	1.43	5.35	207.07
75 % RD*	1.45	0.201	1.62	5.63	213.82
100 % RD*	1.51	0.214	1.59	5.60	219.65
LSD at 0.05 level	0.04	0.003	0.06	0.07	2.99
Tryptophan concentrations (ppm)					
0	1.32	0.191	1.33	5.24	203.43
15	1.34	0.188	1.39	5.36	213.00
30	1.35	0.196	1.58	5.57	211.07
45	1.40	0.211	1.67	5.60	213.35
LSD at 0.05 level	0.04	0.003	0.05	0.06	2.52

RD*= Recommended dose (60 kg N/fad.)

Effect of the interaction

Effect of the interaction between mineral nitrogen levels and foliar spray with different tryptophan concentrations on the dry matter and chemical composition of lettuce leaves are presented in Table (10).Such data revealed that, there were no clear trends observed among tested interaction treatments, but fertilizing lettuce plants with mineral nitrogen at the maximum dose (100%) with foliar spray with tryptophan at the rate of 30 ppm was the superior interaction treatment which reflected a significant effect on lettuce leaves content of P% as well as nitrate content in leaves with no significant differences with 15 and 45 ppm respect to nitrate content.

Table10. Effect of interaction between mineral nitrogen levels and foliar spray with tryptophan concentrations on N, P, K, dry matter and nitrate contents in leaves of lettuce plants

Treatments		N (%)	P (%)	K (%)	Dry matter (DM) (%)	Nitrate contents (mg/kg DM)
Nitrogen levels	**Tryptophan (ppm)**					
25 % RD*	0	1.10	0.189	1.25	5.03	196.80
	15	1.18	0.185	1.27	5.13	199.50
	30	1.25	0.191	1.37	5.32	199.20
	45	1.27	0.198	1.43	5.33	205.70
50 % RD*	0	1.25	0.181	1.25	5.15	204.50
	15	1.22	0.166	1.32	5.30	212.50
	30	1.25	0.166	1.55	5.47	205.70
	45	1.33	0.215	1.62	5.48	205.60
75 % RD*	0	1.43	0.196	1.52	5.35	205.10
	15	1.48	0.194	1.31	5.48	216.90
	30	1.39	0.202	1.71	5.82	215.10
	45	1.52	0.212	1.95	5.89	218.20
100 % RD*	0	1.51	0.199	1.30	5.43	207.30
	15	1.51	0.209	1.67	5.56	223.10
	30	1.51	0.228	1.69	5.70	224.30
	45	1.51	0.221	1.70	5.71	223.90
LSD at 0.05 level		0.07	0.006	0.11	0.13	5.05

RD*= Recommended dose (60 kg N/fad.)

On the contrary adding mineral nitrogen at the rate of 75% of recommended dose to lettuce plants with foliar spray with tryptophan at the rate of 45 ppm was the best interaction treatment which recorded the maximum value of K and N content (%) in lettuce leaves compared with other interaction treatments which didn't reflect any significant effect in this respect as well as it was the best interaction treatment which significantly increased the content of dry matter in lettuce leaves.

Obtained results are in accordance with those reported by Yassen *et al*. (2010) found that, the interaction between nitrogen forms and foliar spray with tryptophan at 25 and 50ppm increased N, P and K content in Anise plants compared to the use of nitrogen fertilizer alone .

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تأثير مستويات النيتروجين المعدنى والرش الورقى بتركيزات من التربتوفان على النمو والمحصول والجوده لنباتات الخس

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أجريت هذه التجربة خلال موسمي شتاء 2018 / 2019 ، 2019/ 2020 في مزرعة الخطارة التجريبية التابعه لكلية الزراعة جامعة الزقازيق بمحافظة الشرقية - مصر لدراسة تأثير معدلات النيتروجين المعدني والرش الورقي بتركيزات مختلفه من الحمض الأميني التربتوفان على النمو والمحصول وجوده نباتات الخس صنف دارك جرين تحت ظروف التربة الرملية. أظهرت النتائج أن أفضل معاملة تفاعل لزيادة وزن الرأس، المحصول الكلي، ودليل مساحة الورقة هي تسميد النباتات بالنيتروجين بمعدل 75٪ من المعدل الموصى به مع الرش بالتربتوفان بتركيز 30 جزء في المليون .علاوة على ذلك ، أدى إضافة النيتروجين المعدنى بمعدل 75٪ من الموصى به مع الرش بالتربتوفان بتركيز 45 جزء في المليون إلى زيادة الوزن الجاف الكلي للنبات ،ونسبة النيتروجين ،البوتاسيوم والماده الجافة فى الأوراق . بالإضافة إلى ذلك ، أدى إضافة النيتروجين بمعدل 100٪ من المعدل الموصى به مع الرش بالتربتوفان بتركيز 30 جزء في المليون إلى زيادة معنوية في محتوى الأوراق من الفوسفور ،بينما ازداد محتوى الأوراق من النترات عند إضافة النيتروجين بمعدل 100٪ من المعدل الموصى به مع الرش بأى من التركيزات الثلاثه من التربتوفان . وبناءاً على ماتقدم يمكن التوصيه بتسميد نباتات الخس بالنيتروجين بمعدل 75 % من الموصى به والرش بالتربتوفان بتركيز 30 جزء فى المليون لرفع إنتاجية محصول الخس والحصول على تركيزات متوسطة من النترات فى الأوراق تحت ظروف هذه الدراسة.