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EFFECT OF N-FORMS AND K-LEVELS ON THE PRODUCTIVITY OF LONG WHITE RADISH

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ABSTRACT

Two field experiments were carried out during both successive winter seasons of 2008/2009 and 2009/2010 in a private farm near Gamasa city, Dakahlia Governorate to evaluate the effect of Nitrogen fertilization forms (NH_4 : NO_3) and Potassium fertilization levels on plant growth, chemical composition, yield and quality of radish plants (*Raphanus sativus*, L., cv. Radish early 40 days).

Factorial experiment in a randomized complete block design was used. The experiment included 15 treatments: First factor: 5 treatments of N-forms (NH_4 : NO_3), i., N1=100% NH_4, N2=75% NH_4+25% NO_3, N3=50% NH_4 + 50% NO_3, N4=25% NH_4+75% NO_3 and N5=100% NO_3. Second factor 3 treatments of K-levels: K1 = 40, K2 = 70 and K3 = 100 Kg K_2O/fed.

The results obtained from this work could be summarized as follow:

- The maximum values of vegetative growth parameters, total chlorophyll, N%, K%, yield and its components and quality parameters were recorded for the plants supplied with N-forms as N3 treatment (50%NH_4 + 50%NO_3) and N4 treatment (25% NH_4 + 75% NO_3). Whereas, the lowest one were produced when 100% NH_4 was the only N-form. This trend was true in the two seasons.
- The highest values of these parameters were realized for the treatments of K2 (70 kg K_2O/fed) or K3 (100 kg K_2O/fed).
- With regard to the effect of interaction between N-forms and K-levels, it can be observed that the best vegetative growth parameters, chemical constituents, yield and quality parameters were documented for the plants received the N forms as N3 (50%NH_4 + 50%NO_3) followed by N4 (25% NH_4 + 75% NO_3) of N-fertilizers at the rate of 100 kg N/fed combination with K2 level (70kg K_2O/fed). Whereas, the lowest one were produced when 100% NH_4 was the only N-form with all levels of potassium during the both seasons under the conditions of new sand cultivated area of Dakahlia Governorate, Egypt.

Keywords: Radish, *Raphanus sativus*, N-forms, N-sources, N-fertilizers, K-levels, vegetative growth, yield, quality parameters, chemical composition, total sugars, free NO_3.

INTRODUCTION

Radish (*Raphanus sativus* L.) is both annual and biennial and belongs to the Cruciferae, or Brassicaceae or mustard family.

Plants absorb N only as inorganic nitrate ions (NO_3^-), or ammonium (NH_4^+) and or amino (NH_2^+) ions. Available N is often a more limiting factor influencing plant growth than in any other nutrient. In the same line, Hartman *et al.* (1986) studied the influence of nitrate: ammonium ratios on tomato plants. They reported that vegetative growth prior to fruit set was increased significantly by adding 25% of the N as NH_4, although higher NH_4 ratios reduced vegetative growth. Talaat (1995) pointed out that the dry weight of shoots was higher in radish plants supplied with ammonium nitrate than those supplied with ammonium sulphate due to the stimulatory effect of this N source. Also, Naguib *et al.* (2003) studied the response of three radish cultivars (Japanese, White and Red radish) to urea, ammonium sulfate and ammonium nitrate applied singly or in combination with chelated zinc sprays. Japanese radish was superior in terms of growth parameters and yield of roots. Urea-N fertilizer proved highly significant simulation of the growth and roots parameters compared to the other two N-sources. In addition, Shafeek *et al.* (2004) supplied radish plants with three nitrogen forms (ammonium nitrate, ammonium sulfate and urea) with three nitrogen rates (30, 60 and 90 kg N/feddan). Nitrogen fertilizer in the form of ammonium sulfate resulted in the best growth characters and chemical constituents, followed in descending order by urea and ammonium nitrate forms. Fallovo *et al.* (2009) observed the growth, yield, nitrate content, total N and S concentration in shoots, and water uptake of hydroponically grown *Brassica rapa* and *Brassica juncea* in greenhouses. Plants were supplied with nutrient solutions having equal N concentrations of 11 mM in different forms: 100% NH_4, 50% NH_4+50% NO_3, and 100% NO_3. Nitrogen supplied as 100% NH_4 reduced fresh and dry shoot biomass, leaf area, and leaf number in both *Brassica* species. Fresh shoot biomass was maximized in *Brassica rapa* when photosynthetically active radiation level was above the medium value and nitrate was supplied in the nutrient solution as NO_3 or as a mixture of 50% NO_3 and 50% NH_4. In the same line, Bybordi (2010) found that the biomass production of canola plants at 75% NH_4: 25% NO_3 was lower than that of plants at 0 % NH_4 : 100 NO_3.

Potassium is one of essential nutrients required for plant growth and reproduction. It is essential for plant respiration and development of photosynthesis processes and chlorophyll content and also, it plays a vital role in promoting the assimilation rate of CO_2 and photosynthesis capacity (Mengel and Kirkby, 1982). In the same line, Bokhatiar *et al.* (2001) showed that the yield increased with every increase in the level of K up to a certain limit, thus signifying that higher dose of K fertilizer is required in this soil for obtaining the satisfactory radish yield. The highest yield was noted in K3 treatment (160 kg K_2O/ha) which was closely followed by K2 treatment (120 kg K_2O/ha). Patnaik and Sadhu (2006) observed that K rates had slight effects on the vegetative growth of radish plants. Moreover, Lukacs and Sardi (2009) suggested that increases in fresh and dry matter production of radish plants strongly responded to increasing rates of potassium fertilizer. The highest values in dry matter production were observed at the highest rates of K supply.

The aims of this investigation are to evaluate the effect of nitrogen form ratio, the optimum level of potassium and their interaction effect on growth, chemical composition, yield and quality of radish plants.

MATERIALS AND METHODS

Materials:

Two field experiments were carried out during both successive winter seasons of 2008/2009 and 2009/2010 in a special farm near Gamasa city, Dakahlia Governorate to evaluate the effect of Nitrogen fertilization forms and

Potassium fertilization levels on plant growth, chemical composition, yield and quality of radish plants (*Raphanus sativus*, L.) cv. Radish early 40 days.

The experimental design and treatments:

Factorial experiment in a randomized complete block design was used with four replicates for each treatment. The experiment included 15 treatments: 5 treatments of N-form combinations (NH_4: NO_3 ratio) and 3 treatments of K-levels:

First factor (N-forms):

N1=100% NH_4 = 500 kg/fed $(NH_4)_2SO_4$.
N2=75% NH_4+25% NO_3= 375 kg/fed $(NH_4)_2SO_4$) + 166 kg/fed Ca $(NO_3)_2$.
N3=50% NH_4 + 50% NO_3 = 303 kg/fed NH_4NO_3.
N4=25% NH_4+75% NO_3 = 125 kg/fed $(NH_4)_2SO_4$) + 500 kg/fed Ca $(NO_3)_2$.
N5=100% NO_3 = 666 kg/fed Ca $(NO_3)_2$.

Second factor (K-levels):

K1 = 40 Kg K_2O /fed.
K2 = 70 Kg K_2O/fed.
K3 = 100 Kg K_2O/fed.

Cultivation:

Radish seeds were sown in lines by hand in hills on November 25 in both seasons of 2008/2009 and 2009/2010, respectively. Row-to-row and plant-to-plant distances were 20 cm and 20 cm, respectively. There were 5 rows in each plot with 10 plants per row. The plot area was 2 m^2, i.e., 2m x 1m. Thinning of seedlings was done after two weeks from sowing. The seedlings were diminished to one plant per hill.

The physical and chemical properties of the experimental soil have presented in Table (1).

Table (1): Physical and chemical properties of the experimental soil during both seasons of the experiment.

O.M %	$CaCO_3$ %	Total sand %	Silt %	Clay %	Texture class	E.C (soil paste) dS/m	pH	S.p
4.6	3.22	83.0	9.0	8.0	sandy	1.25	7.70	32.0

Table 1: continue

Available (ppm)			Ions meq/100 g soil							
N	P	K	Ca^{++}	Mg^{++}	K^+	Na^+	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}
43.0	11.0	280	2.00	1.44	0.11	2.44	0.00	0.63	1.10	4.55

Fertilization:

Nitrogen fertilizer was added in the forms of NH_4 and NO_3 of Ammonium sulphate ($(NH_4)_2SO_4$; 20% N) and Ammonium nitrate (NH_4NO_3, 33% N) are residually acid forming whereas Calcium nitrate (Ca $(NO_3)_2$, 15.5% N) is residually basic forming. These fertilizers added at the level 100 kg N/fed. Potassium fertilizer was added in the form (K_2SO_4) at three levels (40, 70 and 100 kg K_2O/fed.)

N and K fertilizers were divided into two equal parts; the first addition was done after 20 days from planting and the second one at 30 days later. The other agricultural practices were done as the farmers do in the experimental area.

Sampling dates and data recorded:

Three plants were randomly taken from each plot at harvest (after 90 days after planting; DAP) to determine the following parameters:

Plant growth parameters:

1-Leaf length.
2- Leaf width.
3-Number of leaves /plant.
4-Leaves fresh weight /plant.
5-Leaves dry weight /plant
6- Leaf area/ plant: It was calculated according to the method mentioned by (Koller, 1972).

Chemical composition:

1- Total chlorophyll was determined in radish leaves at harvest (90 DAP).
2- N, P and K contents were determined in the leaves and roots of radish at harvest (after 90 DAP).

Roots yield and its components:

1-Root length.
2-Root fresh weight /plant.
3-Root dry weight /plant.
4- Shoulder diameter of root.
5-Middle diameter of root.
6- Roots yield: At harvesting stage; yield of radish roots was calculated as kg/m^2 by multiplying the average weight of root /plant * 25 plants.

Quality parameters:

1-NO_3-N and NO_2-N contents were determined in the leaves and roots of radish plants at harvest (after 90 DAP).
2-Total sugars % and TSS % were determined in the roots of radish plants at harvest (after 90 DAP).

Methods of analysis:

Soil analysis:

Soil samples were collected and mechanical analysis was determined using the international pipette method (Kilmer and Alexander, 1949). For chemical analysis, the soil samples were digested as described by Jackson (1967) using a modified Kjeldahl procedure to determine chemical properties as follows:

- pH was measured in 1: 2.5 soil water suspensions as described by Jackson (1967). EC of the 1: 5 and soil paste extracts were measured by EC meter according to the method of US Salinity Lab (1954). O.M %: it was determined using Walkely's rapid titration method (Jackson, 1967).
- Calcium carbonate was determined using Collin's calcimeter method (Piper, 1950).
- Available N was measured using the conventional method of Kjeldahl as described by Bremner and Mulvany (1982). Available P was determined using Spectrophotometer as described by Olsen and Sommers (1982). Available K was determined by using Flam photometer according to Black (1965).

Plant analysis:

- Chlorophyll content, it was determined according to the method described by Goodwine (1965).
- N, P and K:

  The oven dry materials of plant samples were ground and wet digested by a sulfuric-percloric acid mixture as described by Peterburgski (1968). The total N, P and K were determined using the following technique: Total nitrogen (%) was determined according to the methods described by Pregle (1945), using micro-Kjeldahl. Total phosphorus (%) was estimated colourimetrically as described by Jackson (1967). Potassium (%) was determined using a flame photometer according to Black (1965).

- Nitrate and nitrite, were determined according to the method described by Singh (1988).
- Total soluble solids (TSS %), it was estimated using Gali 110 Refractometer.
- Total sugars %, it were determined according to the method described by Frosee (1938).

Statistical analysis:

The obtained data were subjected to statistical analysis as factorial experiment in a randomized complete block design with four replicates in the both growing seasons according to Gomez and Gomez, (1984). Means of treatments were compared using Duncan Multiple Range test at 0.05% probability according to Duncan (1955).

RESULTS AND DISCUSSION

Vegetative growth characteristics.

The parameters used for measuring the vegetative growth in this study are length and width of leaves, number of leaves per plant, leaf area, fresh and dry weight of leaves.

Effect of N-forms:

Regarding the effect of N-forms, data presented in Table (2) indicated that addition of the combinations of NH_4 and NO_3 produced the greatest of vegetative growth parameters in comparison to addition of NH_4 or NO_3 alone. The maximum values of these parameters were observed for the plants supplied with N3 treatment (50%NH_4 + 50%NO_3) and N4 (25% NH_4 + 75% NO_3) at 90 DAP. On the other hand, the lowest one was produced when 100% NH_4 was used. This trend was true in the two seasons.

This could be attributed to, in most cases plants grown in ammonium medium without nitrate generally that contain lower concentrations of potassium, calcium and magnesium than those supplied with nitrate alone because of the 100 % NH_4 treatment reduced uptake of these elements. This effect led to the reduction of vegetative growth (Haynes and Goh 1978; El-Gamiely, 1988). However, excess NH_4 can reduce plant growth by depleting carbon reserves required for growth, particularly during the seedling stage when photosynthesis capacity is low or when environmental conditions severely limit photosynthesis. In contrast, nitrate assimilation results in less carbon translocation from leaves to roots, providing less potential for either reducing "feedback" inhibition of photosynthesis or depleting carbon reserves required for growth. This is because nitrate assimilation occurs to large extent in shoots and significant quantities of nitrate are stored as N reserves before being assimilated (Tsai *et al.*, 1982).

NH_4: NO_3 ratio available to roots affects physiological process by number of mechanisms: 1- The NH_4: NO_3 ratio in roots medium affects N absorption rates by roots. Relative rates of NH_4: NO_3 absorption are affected by the stage of plant growth, pH and ionic composition of the soil solution. 2- The rhizosphere tends to become acidic when NH_4 is the dominant N-form absorbed by roots and tends to become alkaline when nitrate is the dominant N form absorbed. These pH changes indirectly affecting the availability of plant nutrients or toxic elements to plant roots. 3- Since N is absorbed in relatively large quantities compared with other inorganic plant nutrients, the ionic form of N absorbed affects uptake of other cations and anions. This affects on the level of inorganic nutrients absorbed by plant roots and also the metabolic requirements for regulating ionic balance and pH within the plant (Hageman, 1984).

These results on growth parameters agree with results obtained by others on different crops such as Talaat (1995), Naguib *et al.* (2003), Shafeek *et al.* (2004), Al-Obeid (2008), Salem (2009) on radish; Hartman *et al.* (1986) on Tomato; Fallovo *et al.* (2009) and Bybordi (2010) on *Brassica spp.*

Regarding the effect of K-levels, data in Table (2) showed that significant differences were found among the values of vegetative growth parameters at 90 DAP. The highest values of these parameters were realized for the treatment of K2 (70 kg K_2O/fed) or K3 (100 kg K_2O/fed). Higher K levels, i.e., 70 or 100 kg K_2O /fed led to produce maximum mean values without significant differences between both treatments. This trend was true during the two seasons.

In this respect, the enhancement effect of potassium on the vegetative growth may be due to not only promoting the translocation of newly synthesized photosynthesis but, also it has a beneficial effect on the metabolism processes which reflected on plant growth (Mengel and Kirkby, 1982). Potassium has a beneficial effect in water consumption. Also, K is essential for plant respiration and development of photosynthesis processes and chlorophyll content and also, it plays a vital role in promoting the assimilation rate of CO_2 and photosynthesis capacity. In addition, the enhancing effect of potassium application by using on the dry matter content might be due to the increase in the photosynthetic capacity to which the number of leaves per plant could be a reliable index and might contribute much for the superiority in the dry weight content of radish plants (Gardener *et al.*, 1985).

These results were in accordance with those obtained by Bokhtira *et al.* (2001), Bilekudari *et al.* (2005), Patniak and Sadhu (2006) and, Lukacs and Sardi (2009) and Zhao *et al.* (2010) on radish.

Effect of interaction:

With regard to the effect of interaction between N-forms and K-levels (Table, 2), it can be observed that plants fertilized by 50%NH_4+50%NO_3 followed by N4 treatment (25%NH_4+75%NO_3) combined with K2 (70kg K_2O/fed) had the highest values of all aforementioned traits. Whereas, the lowest values were produced when 100% NH_4 was the only used N-form with all levels of potassium during the both seasons.

Table (2): Effect of N- forms, K-levels and their interaction on vegetative growth parameters of radish plants at harvest during both seasons of 2008/2009 and 2009/2010.

Characters / Treatments	Seasons	Leaf length (cm) 1st	Leaf length (cm) 2nd	Leaf width (cm) 1st	Leaf width (cm) 2nd	Number of leaves / plant 1st	Number of leaves / plant 2nd	Leaf area (cm^2) 1st	Leaf area (cm^2) 2nd	Fresh weight of leaves (g/plant) 1st	Fresh weight of leaves (g/plant) 2nd	Dry weight of leaves (g/plant) 1st	Dry weight of leaves (g/plant) 2nd
A: N-forms (100 unit N)													
N1 = 100% NH_4		35.5 d	37.7 e	13.9 e	14.1 e	16.00 b	16.33 b	2887.6 c	2919.4 d	267.01 d	271.26 d	24.36 d	24.53 d
N2=75%NH_4+ 25%NO_3		36.7 c	38.9 d	14.4 d	14.5 d	16.11 b	16.44 b	2896.7 c	2925.1 d	274.81 c	278.79 c	25.45 c	25.59 c
N3=50%NH_4+ 50%NO_3		39.8 a	42.0 a	15.7 a	15.8 a	16.56 a	16.89 a	2976.1 a	3006.7 a	291.27 a	295.61 a	27.76 a	27.91 a
N4=25%NH_4+ 75%NO_3		39.5 a	41.6 b	15.5 b	15.6 b	16.67 a	17.11 a	2951.7ab	2978.7 b	292.11 a	296.10 a	27.88 a	28.00 a
N5 = 100% NO_3		38.5 b	40.6 c	15.0 c	15.2 c	16.56 a	17.00 a	2933.4 b	2958.2 c	285.57 b	289.31 b	26.96 b	27.08 b
B: K-levels (K_2O kg/fed)													
K1 = 40		33.0 c	35.2 c	12.8 c	13.0 c	15.33 c	15.67 c	2839.7 b	2875.4 b	249.07 c	253.51 c	21.85 c	22.01 c
K2 = 70		37.7 ab	39.9 ab	14.6 ab	14.7 ab	16.20 ab	16.60 ab	2857.7 ab	2889.2 ab	277.39 ab	281.77 ab	25.81 ab	25.99 ab
K3 = 100		43.3 a	45.4 a	17.3 a	17.4 a	17.60 a	18.00 a	3090.0 a	3108.2 a	320.00 a	323.36 a	31.78 a	31.87 a
C: Interaction (A * B)													
N1	K1	30.6 l	32.9 m	12.0 n	12.1 n	15.00 f	15.33 d	2883.3ef	2921.4 fg	235.23 o	239.70 o	19.91 o	20.10 o
	K2	40.0 e	42.2 e	15.9e	16.1e	17.00 ab	17.33 b	2963.6de	2985.9 e	300.33 e	304.00 e	29.03 e	29.15 e
	K3	35.9 h	37.9 i	13.9 j	14.0 j	16.00 de	16.33 c	2815.9 f	2851.0 hi	265.47 j	270.07 j	24.14 j	24.33 j
N2	K1	32.5 k	34.7 l	12.6 m	12.7 m	15.00 f	15.33 d	2880.1ef	2916.8 fg	245.43 n	249.90 n	21.34 n	21.50 n
	K2	41.1 d	43.3 d	16.4 d	16.6 d	17.33 ab	17.67 b	3019.4cd	3036.7 d	308.77 d	311.93 d	30.21 d	30.29 d
	K3	36.5 h	38.7 h	14.2 i	14.3 i	16.00 de	16.33 c	2790.6 f	2821.8 i	270.23 i	274.53 i	24.81 i	24.97 i
N3	K1	33.2 jk	35.4 k	13.0 l	13.1 l	15.33 ef	15.67 d	2810.2ef	2845.2 hi	249.67m	254.07m	21.93 m	22.07 m
	K2	47.4 a	49.6 a	19.0 a	19.2 a	18.00 a	18.33 a	3218.9 a	3240.2 a	340.77 a	344.57 a	34.69 a	34.79 a
	K3	38.7 f	40.9 f	15.0 g	15.1 g	16.33 d	16.67 c	2899.1ef	2934.9 f	283.37 g	288.20 g	26.64 g	26.86 g
N4	K1	33.9 j	35.9 k	13.1 l	13.2 l	15.33 ef	15.67 d	2788.7 f	2824.2 i	255.33 l	259.87 l	22.73 l	22.88 l
	K2	44.9 b	47.0 b	17.8 b	18.0 b	18.00 a	18.33 a	3150.0ab	3168.1 b	330.67 b	334.03 b	33.27 b	33.35 b
	K3	39.8 e	42.0 e	15.4 f	15.6 f	16.67 cd	17.33 b	2916.5ef	2943.8 f	290.33 f	294.40 f	27.63f	27.78 f
N5	K1	34.8 i	36.9 j	13.5 k	13.6 k	16.00 de	16.33 c	2836.1 f	2869.6g-i	259.67 k	264.03 k	23.33 k	23.49 k
	K2	42.9 c	45.0 c	17.1 c	17.3 c	17.67 a	18.33 a	3097.9bc	3110.2 c	319.47 c	322.27 c	31.70 c	31.77 c
	K3	37.8 g	39.9 g	14.5 h	14.7 h	16.00 de	16.33 c	2866.4ef	2894.8f-h	277.57 h	281.63 h	25.84 h	26.00 h

Means followed by the same letter within each column do not significantly differed using Duncan's Multiple Rang Test at the level of 5%.

Chemical composition

Effect of N-forms:

As for the effect of N-forms, data presented in Table (3) indicated that the greatest contents of chlorophyll, N and K contents in both leaves and roots were achieved at 90 DAP for the plants received the N-forms as N3 (50%NH_4 + 50% NO_3) and N4 (25%NH_4 + 75% NO_3) treatments. On the other hand, the lowest one was obtained for the plants given the N-form as N1 (100% NH_4). Generally, these results stated that the greatest contents of chlorophyll were recorded when NO_3 was the dominant in the combination of N-forms (NH_4^+:NO_3^-). This trend was the same in both seasons. These results are in the same line with those reported by Shafeek *et al.* (2004) on radish.

N uptake increased when NO_3^- was the dominant N-form while, the 100% NH_4^+ treatment reduced the uptake of nitrogen. Also, the addition of NO_3^- as a part of N-form resulted in maximum nitrogen percentage in both leaves and roots. Moreover, these results stated that, the K uptake in both leaves and roots were decreased for the plants supplied with N-form as 100% NH_4 only while, the combinations of NH_4 and NO_3 increased potassium uptake. These results are in the same line with those reported by Hartman *et al.* (1986). Generally, the positive response of the chemical constituents could be attributed to the source of N-fertilizer for the plants treated with N3 treatment (ammonium nitrate). It is residually acid forming. Whereas, the sources of N fertilizers for the plants treated with N4 treatment were ammonium sulfate and calcium nitrate. These N-fertilizers are residually acid and basic forming. Continued use of these N fertilizers can affect pH of soil and increasing these elements in rooting zone soluble and availability form encouraged the plant to absorb more of them, consequently the uptake of the elements was increased (Hartmann *et al.*, 1988).

Effect of K-levels:

Data presented in the same Table showed that the application of K-levels had a marked effect on these contents of radish leaves and roots. Additionally, the highest values in this respect were recorded in K2 or K3 treatments (70 or 100 kg K_2O/fed). The values in both treatments were not significant differences with each other. These results were true during both seasons.

Generally, it could be concluded that N and K uptake were gradually increased in tissues of radish plants with increasing the level of potassium addition. This may be attributed to that increasing the level of K addition raised the availability of N and P to maintain the nutritional balance in soil media, consequently their uptakes were increased.

These results are in the same line with those reported by Chang (2002) and Patnaik and Sadhu (2006) on radish.

Effect of interaction:

With regard to the combined effect between the two factors studied on the contents of chlorophyll, N% and K% in both leaves and roots of radish plants, the maximum values of chlorophyll, N% in both leaves and roots were realized by using the treatment of N3 (50%NH_4+50%NO_3) followed by N4 treatment (50%NH_4+50%NO_3) combined with K2 (70 kg K_2O/fed) treatment.

Table (3): Effect of N- forms, K-levels and their interaction on chemical composition of radish plants at harvest during both seasons of 2008/2009 and 2009/2010.

Characters		Total chlorophyll (Mg/g FW)		N% (Leaves)		N% (Roots)		K% (Leaves)		K% (Roots)	
Treatments	Seasons	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
A: N-forms (100 unit N)											
N1 = 100% NH_4		1.907 d	1.993 e	2.70 c	2.70 d	1.63 b	1.64 c	2.77 d	2.53 c	1.54 b	1.55 c
N2 = 75%NH_4 + 25%NO_3		1.962 c	2.049 d	2.77 b	2.77 c	1.68 a	1.69 b	2.82 c	2.83 b	1.53 b	1.54 c
N3 = 50%NH_4 + 50%NO_3		2.044 a	2.130 b	2.84 a	2.85 b	1.72 a	1.73 a	2.97 a	2.99 a	1.65 a	1.67 a
N4 = 25%NH_4 + 75%NO_3		2.053 a	2.139 a	2.89 a	2.89 a	1.72 a	1.73 a	2.95 a	2.96 a	1.59 ab	1.60 b
N5 = 100% NO_3		2.021 b	2.107 c	2.86 a	2.86 b	1.71 a	1.72 a	2.90 b	2.91 a	1.64 a	1.65 a
B: K-levels (K2O kg/fed)											
K1 = 40		1.788 c	1.875 c	2.53 c	2.54 c	1.56 c	1.57 c	2.63 c	2.49 c	1.47 c	1.48 c
K2 = 70		1.987 ab	2.073 ab	2.80 ab	2.81 ab	1.69 ab	1.70 ab	2.87 ab	2.89 ab	1.58 ab	1.59 ab
K3 = 100		2.217 a	2.303 a	3.09 a	3.10 a	1.83 a	1.84 a	3.14 a	3.16 a	1.73 a	1.74 a
C: Interaction (A * B)											
N1	K1	1.673 l	1.760 o	2.39 h	2.40 l	1.47 f	1.49 i	2.49 g	1.75 d	1.38 i	1.40 i
	K2	2.132 d	2.218 e	3.01 c	3.02 d	1.81 a	1.83b	2.74 ef	2.75 a-c	1.55 e-g	1.56 f
	K3	1.915 gh	2.002 j	2.69 f	2.69 h	1.60 e	1.61 g	3.09 b	3.10 ab	1.70 bc	1.71 c
N2	K1	1.763 k	1.849 n	2.47 g	2.48 k	1.52 f	1.53 h	2.50 g	2.51 c	1.39 i	1.40 i
	K2	2.178 cd	2.265 d	3.06 c	3.07 c	1.82 a	1.83 b	2.79 e	2.81 a-c	1.49 gh	1.51 g
	K3	1.945 fg	2.032 c	2.77 e	2.77 g	1.70 b-d	1.71 de	3.16 ab	3.17 ab	1.70 bc	1.71 c
N3	K1	1.802 jk	1.889 m	2.52 g	2.53 j	1.53f	1.55 h	2.67 f	2.68 bc	1.51 fg	1.52 g
	K2	2.297 a	2.383 a	3.18 a	3.18 a	1.88 a	1.89 a	2.97 c	2.98 a-c	1.64 cd	1.65 d
	K3	2.033 e	2.119 g	2.83 e	2.84 f	1.75 b	1.76 c	3.22 a	3.23 a	1.81 a	1.83 a
N4	K1	1.830 ij	1.917 l	2.62 f	2.63 i	1.61 e	1.63 g	2.69 f	2.71 bc	1.43 hi	1.45 h
	K2	2.262 ab	2.348 b	3.14 ab	3.14 b	1.83 a	1.84 b	2.99 c	3.01 ab	1.58 d-f	1.60 e
	K3	2.067 e	2.153 f	2.90 d	2.90 e	1.72 bc	1.73 d	3.23 a	3.24 a	1.75 ab	1.76 b
N5	K1	1.873 hi	1.960 k	2.66 f	2.66 h	1.64 de	1.65 f	2.80 e	2.81 a-c	1.62 c-e	1.63 d
	K2	2.215 bc	2.301 i	3.08 bc	3.09 c	1.81 a	1.83 b	2.88 d	2.90 a-c	1.62 c-e	1.63 d
	K3	1.975 f	2.061 h	2.82 e	2.83 f	1.68 cd	1.69 e	3.02 c	3.03 ab	1.67 cd	1.68 c

Whereas, the maximum values of K % in both leaves and roots were realized by using the treatment of N3 followed by N4 treatment combined with K3 (100 kg K_2O/fed) treatment.

While the same data stated that the lowest effect were more achieved with N1 (100% NH_4) combined with all levels of potassium treatments on these parameters for radish plants. This trend was confirmed in both seasons of the study.

Yield and its components:

The parameters used for measuring the yield and its components in this study are root length, shoulder and middle diameters of root, fresh and dry weights of roots and yield/m2 (Table, 4).

Effect of N-forms:

Referring to the effect of N-forms, the maximum values of these Referring to the effect of N-forms, the maximum values of these parameters were observed for the plants supplied with treatment N3 (50%NH_4+50%NO_3) and N4 (25%NH_4+75%NO_3) combinations. On the other side, the lowest one of these parameters were produced when 100%NH_4 was the only form.

The obtained increment of yielo and its components may be due to more vigor of plant growth and strong rooting system as a result of residually acid forming and availability form of most nutrients to the plants supplied with N3 as ammonium nitrate and as a result of residually neutral (acid + basic) forming and availability form of most nutrients to the plants treated with N4 (ammonium sulfate and calcium nitrate).

These results were agreeable with those reported by other workers such as Naguib *et al.* (2003), Kovacik *et al.* (2004) and Shafeek *et al.* (2004) on radish.

Effect of K-levels:

As respect of K-levels, data in Table (4) indicated that the highest mean values of these parameters of radish roots were recorded in K2 or K3 (70 or 100 kg K_2O/fed) treatments during the two seasons.

The yield increase was mainly due to increases in root weight, and length and diameter of the roots. The promoting effect of potassium fertilizer on yield and its components may be due to that K a part of promotes the enzymes system and it is needed in formation of protoplasm and translocation of the carbohydrates (Mengel and Kirkby, 1982) consequently, increased the roots yield of radish plants.

These results agree with the results obtained by Bokhtiar *et al.* (2001), Patnaik and Sadhu (2006), Wang *et al.* (2006), Yulin *et al.* (2007) and Zhu *et al.* (2007) on radish.

Effect of interaction:

The highest mean values of these parameters were documented for the plants received N3 treatment (50%NH_4+50%NO_3) followed by N4 treatment (25%NH_4 + 75%NO_3) combined with K2 (70kg K_2O/fed). In addition, the results stated that with 100%NH_4 these parameters were less than the other combinations of NH_4 and NO_3 or 100%NO_3 (Table, 4).

Table (3): Effect of N- forms, K-levels and their interaction on chemical composition of radish plants at harvest during both seasons of 2008/2009 and 2009/2010.

Characters		Total chlorophyll (Mg/g FW)		N% (Leaves)		N% (Roots)		K% (Leaves)		K% (Roots)	
Treatments	Seasons	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
A: N-forms (100 unit N)											
N1 = 100% NH_4		1.907 d	1.993 e	2.70 c	2.70 d	1.63 b	1.64 c	2.77 d	2.53 c	1.54 b	1.55 c
N2 = 75%NH_4 + 25%NO_3		1.962 c	2.049 d	2.77 b	2.77 c	1.68 a	1.69 b	2.82 c	2.83 b	1.53 b	1.54 c
N3 = 50%NH_4 + 50%NO_3		2.044 a	2.130 b	2.84 a	2.85 b	1.72 a	1.73 a	2.97 a	2.99 a	1.65 a	1.67 a
N4 = 25%NH_4 + 75%NO_3		2.053 a	2.139 a	2.89 a	2.89 a	1.72 a	1.73 a	2.95 a	2.96 a	1.59 ab	1.60 b
N5 = 100% NO_3		2.021 b	2.107 c	2.86 a	2.86 b	1.71 a	1.72 a	2.90 b	2.91 a	1.64 a	1.65 a
B: K-levels (K2O kg/fed)											
K1 = 40		1.788 c	1.875 c	2.53 c	2.54 c	1.56 c	1.57 c	2.63 c	2.49 c	1.47 c	1.48 c
K2 = 70		1.987 ab	2.073 ab	2.80 ab	2.81 ab	1.69 ab	1.70 ab	2.87 ab	2.89 ab	1.58 ab	1.59 ab
K3 = 100		2.217 a	2.303 a	3.09 a	3.10 a	1.83 a	1.84 a	3.14 a	3.16 a	1.73 a	1.74 a
C: Interaction (A * B)											
N1	K1	1.673 l	1.760 o	2.39 h	2.40 l	1.47 f	1.49 i	2.49 g	1.75 d	1.38 i	1.40 i
	K2	2.132 d	2.218 e	3.01 c	3.02 d	1.81 a	1.83b	2.74 ef	2.75 a-c	1.55 e-g	1.56 f
	K3	1.915 gh	2.002 j	2.69 f	2.69 h	1.60 e	1.61 g	3.09 b	3.10 ab	1.70 bc	1.71 c
N2	K1	1.763 k	1.849 n	2.47 g	2.48 k	1.52 f	1.53 h	2.50 g	2.51 c	1.39 i	1.40 i
	K2	2.178 cd	2.265 d	3.06 c	3.07 c	1.82 a	1.83 b	2.79 e	2.81 a-c	1.49 gh	1.51 g
	K3	1.945 fg	2.032 c	2.77 e	2.77 g	1.70 b-d	1.71 de	3.16 ab	3.17 ab	1.70 bc	1.71 c
N3	K1	1.802 jk	1.889 m	2.52 g	2.53 j	1.53f	1.55 h	2.67 f	2.68 bc	1.51 fg	1.52 g
	K2	2.297 a	2.383 a	3.18 a	3.18 a	1.88 a	1.89 a	2.97 c	2.98 a-c	1.64 cd	1.65 d
	K3	2.033 e	2.119 g	2.83 e	2.84 f	1.75 b	1.76 c	3.22 a	3.23 a	1.81 a	1.83 a
N4	K1	1.830 ij	1.917 l	2.62 f	2.63 i	1.61 e	1.63 g	2.69 f	2.71 bc	1.43 hi	1.45 h
	K2	2.262 ab	2.348 b	3.14 ab	3.14 b	1.83 a	1.84 b	2.99 c	3.01 ab	1.58 d-f	1.60 e
	K3	2.067 e	2.153 f	2.90 d	2.90 e	1.72 bc	1.73 d	3.23 a	3.24 a	1.75 ab	1.76 b
N5	K1	1.873 hi	1.960 k	2.66 f	2.66 h	1.64 de	1.65 f	2.80 e	2.81 a-c	1.62 c-e	1.63 d
	K2	2.215 bc	2.301 i	3.08 bc	3.09 c	1.81 a	1.83 b	2.88 d	2.90 a-c	1.62 c-e	1.63 d
	K3	1.975 f	2.061 h	2.82 e	2.83 f	1.68 cd	1.69 e	3.02 c	3.03 ab	1.67 cd	1.68 c

Obtained results were confirmed during both seasons. It can concluded that root elongation (root length), root expansion (root diameters), fresh and dry weights of roots and roots yield of radish plants were affected by both N-forms and K-levels application.

Generally, these results may be due to excess ammonium can reduce plant growth and consequently decreased yield by depleting carbon reserves required for growth (Tasi et al., 1982).

Quality parameters:

Nitrate and Nitrite accumulation in the leaves and roots:

Effect of N-forms:

As for the effect of N-forms, data in Table (5) stated that in most cases, the lowest values of NO_2-N and NO_3-N were recorded for the plants supplied with N1 treatment (100% NH_4), N2 (75% NH_4 + 25%NO_3) and N3 treatments (50% NH_4 + 50%NO_3) followed by N4 treatment (25% NH_4 + 75%NO_3). But the highest contents of NO_2 and NO_3 in leaves and roots of radish plants were produced when 100 % NO_3 was used through the growth cycle during both seasons. This evident that NO_2 and NO_3 contents decrease when NO_3 was not the dominant in the combinations of N-form (NH_4 / NO_3 ratio).

These findings are good accordance with data recorded by the previous investigators such as Al-Obeid (2008), Salem (2009), Wang *et al.* (2010) on radish; Angelino *et al.* (2007) on turnip; Fallovo *et al.* (2009) on *Brassica spp.*

Effect of K-levels:

It is evident from the effect of K-levels that the lowest values of NO_2-N and NO_3-N contents in leaves and roots were realized through the growth cycle with the treatment of K3 (100 kg K_2O / fed) followed by K2 (70 kg K_2O / fed). This trend was true during the two seasons. That, the contents of NO_2-N and NO_3-N decreased with rise in the level of potassium application.

Obtained results are in accordance with those reported by Amelin (1999) and Chang (2002) on radish.

Effect of interaction:

Regarding the effect of interaction between N-forms and K-levels on NO_2-N and NO_3-N of both leaves and roots, data in Table (5) showed a significant differences. The results stated that the lowest accumulation of NO_2-N and NO_3-N were recorded for the plants supplied with N-form as N1, N2 and N3 X K3 (100kg K_2O/fed) followed by N4 with the same level of K. But, the highest mean values of these parameters were achieved for the plants which supplied with N-form as 100% NO_3 only combined with K1 (40kg K_2O/fed). This trend was true in the two seasons of the experiment.

Total soluble sugars and TSS % of roots:

Effect of N-forms:

The highest mean values of total sugars were fulfilled for the treatment of N1 or N4 followed by the N2 and N3 treatments during the two seasons (Table, 5). However, the maximum values of TSS obtained at 90 DAP for the plants treated with the treatment of N3 (50%NH_4+50%NO_3) followed by N4 treatment (25%NH_4+ 75%NO_3). This trend was true in the two seasons of the experiment.

Table (4): Effect of N- forms, K-levels and their interaction on yield and its components of radish plants at harvest during both seasons of 2008/2009 and 2009/2010.

Characters		Root length (cm)		Shoulder diameter (cm)		Middle diameter (cm)		Fresh weight of root (g/plant)		Dry weight of root (g/plant)		Yield Kg/ m^2	
Treatments / Seasons		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
A: N-forms (100 unit N)													
N1 = 100% NH_4		35.8 e	35.8 e	3.21d	3.26 d	1.89 e	1.99 e	358.70 d	361.42 d	23.29 d	23.45 d	8.968 d	9.036 d
N2=75%NH_4+ 25%NO_3		38.1 d	38.2 d	3.35 c	3.40 c	2.01 d	2.10 d	366.33 c	369.33 c	24.43 c	24.65 c	9.158 c	9.233 c
N3=50%NH_4+ 50%NO_3		42.0 a	42.0 a	3.53 a	3.58 a	2.23 a	2.32 a	374.59 a	377.65 a	25.67 a	25.88 a	9.365 a	9.441 a
N4=25%NH_4+ 75%NO_3		41.1 b	41.2 b	3.49 ab	3.54 ab	2.18 b	2.27 b	374.26 a	377.42 a	25.62 a	25.85 a	9.357 a	9.435 a
N5 = 100% NO_3		39.6 c	39.7 c	3.43 bc	3.48 bc	2.10 c	2.19 c	371.00 b	374.01 b	25.13 b	25.36 b	9.275 b	9.350 b
B: K-levels (K_2O kg/fed)													
K1 = 40		31.2 c	31.3 c	2.96 c	3.01 c	1.68 c	1.77 c	344.93 c	347.86 c	21.22 c	21.38 c	8.623 c	8.696 c
K2 = 70		38.6 ab	38.6 ab	3.38 ab	3.43 ab	2.01 ab	2.10 ab	369.20 ab	372.50 ab	24.86 ab	25.16 ab	9.230 ab	9.313 ab
K3 = 100		48.2 a	48.2 a	3.86 a	3.91 a	2.56 a	2.65 a	392.80 a	395.54 a	28.40 a	28.58 a	9.820 a	9.889 a
C: Interaction (A * B)													
N1	K1	28.0 n	28.1 o	2.74 bc	2.79 bc	1.51 n	1.60 n	332.11 m	334.59 o	19.30 m	19.34 o	8.303 m	8.365 o
	K2	43.9 e	43.9 e	3.67 cd	3.72cd	2.33 e	2.42 e	382.78 e	385.41e	26.90e	27.06 e	9.570 e	9.635 e
	K3	35.5 j	35.5 j	3.21 gh	3.26 gh	1.84 j	1.93 j	361.22 i	364.26 j	23.67 i	23.95 j	9.031 i	9.107 j
N2	K1	30.0 m	30.1 n	2.89 j	2.94 j	1.65 m	1.74 m	341.11 l	344.13 n	20.65 l	20.83 n	8.528 l	8.603 n
	K2	45.8 d	45.9 d	3.76 bc	3.81 bc	2.40 d	2.49 d	388.67 d	391.47 d	27.78 d	27.98 d	9.717 d	9.787 d
	K3	38.5 h	38.5 h	3.41 ef	3.46 ef	1.99 h	2.08 h	369.22 h	372.39 h	24.87 i	25.13 h	9.230 h	9.310 h
N3	K1	31.1 m	31.2 m	2.98 ij	3.03 ij	1.71 lm	1.80 l	344.00 l	347.17 m	21.08 l	21.26 m	8.600 l	8.679 m
	K2	53.0 a	53.1 a	4.05 a	4.10 a	2.77 a	2.86 a	402.11 a	404.75 a	29.80 a	29.95 a	10.053 a	10.119 a
	K3	41.9 f	41.8 f	3.55 de	3.60 de	2.21 f	2.30 f	377.67 f	381.03 f	26.13 f	26.42 f	9.442 f	9.526 f
N4	K1	32.8 l	32.9 l	3.06 h-j	3.11 h-i	1.75 kl	1.84 kl	351.33 k	354.48 l	22.18 k	22.34 l	8.783 k	8.862 l
	K2	50.5 b	50.6 b	3.93 a	3.98 a	2.69 b	2.79 b	398.11 b	400.72 b	29.20 b	29.38 b	9.953 b	10.018 b
	K3	40.0 g	40.0 g	3.48 e	3.53 e	2.09 g	2.18 g	373.33 g	377.06 g	25.48 g	25.82 g	9.333 g	9.426 g
N5	K1	34.1 k	34.2 k	3.12 g-i	3.17 g-i	1.80 jk	1.89 jk	356.11 j	358.92 k	22.90 j	23.10 k	8.903 j	8.973 k
	K2	47.7 c	47.7 c	3.88 ab	3.93 ab	2.59 c	2.68 c	392.33 c	395.33 c	28.33 c	28.55 c	9.808 c	9.883 c
	K3	37.1 i	37.1 i	3.27 fg	3.32 fg	1.90 i	2.00 i	364.56 i	367.78 i	24.17 h	24.45 i	9.114 i	9.194 i

Generally, the increment of total sugars may be due to arising from enhanced sucrose movement from leaves to roots with NH_4 assimilation compared with that for nitrate assimilation (Tasi *et al.*, 1982). These results on agree with the results obtained by Naguib *et al.* (2003) and Shafeek *et al.* (2004) on radish.

Effect of K-levels:

As for the effect of K-levels, the highest contents of total sugars and TSS % were realized for the plants treated with K3 (100 kg K_2O / fed) followed by K2 (70 kg K_2O/fed) treatments (Table, 5). On the other hand, the lowest percentage of total sugars and TSS were happened for the plants fertilized with K1 (40 kg K_2O / fed). These results may be due to that potassium enhances translocation of sugars and starch. Sugars produced in photosynthesis must be transported through the phloem to other parts of the plant for utilization and storage. The plants transport system uses energy in the form of ATP. If K is inadequate, less ATP is available, and the transport system breaks down. This causes photosynthesis to build up in the leaves and the rate of photosynthesis is reduced. An adequate supply of K helps to keep all of these processes and transportation systems functioning normally (Armstrong, 1998).

Effect of interaction:

It is also observed that, plants fertilized with N-form as N1 (100%NH_4) combined with K3 (100kg K_2O/fed), followed by N2 or N3 treatments with same level of potassium, had the highest mean values of total sugars (Table, 5). Whereas, the highest mean values of TSS were recorded for the treatments of N3 (50%NH_4+50%NO_3) followed by N4 (25%NH_4+75%NO_3) combined with K2 (70 kg K2O/fed) at 90 DAP. The same trend was true in the both seasons of this study.

Conclusion

From the abovementioned results, it was noticed that, the vegetative growth, chemical constituents, yield and quality parameters are affected by both N-forms and K levels. Also, with 100% NH_4 or 100 %NO_3, these parameters were less than the other combinations of NH_4 and NO_3.

Generally, this investigation suggested that, the best vegetative growth, chemical constituents, yield and quality parameters were documented for the plants received the N-forms as N3 (50%NH4 + 50%NO3) followed by N4 (25%NH4 + 75%NO3) of N-fertilizer at the rate of 100 kg N/fed combined with K2-level (70 kg K2O/fed.) under the conditions of new sandy cultivated area in Egypt.

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تأثير صور النيتروجين ومعدلات البوتاسيوم على إنتاجية الفجل الأبيض الطويل

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اجريت تجربتان حقليتان خلا ل موسمي النمو الشتويين (٢٠٠٨- ٢٠٠٩) و(٢٠٠٩-٢٠١٠) في مزرعة خاصة بالقرب من مدينه جمصه - محافظة الدقهلية- مصر للتعرف على تأثير بعض صور النيتروجين (NH_4^+ : NO_3^-) ومستويات التسميد البوتاسي على صفات النمو والتركيب الكيماوي والمحصول ومكوناته وصفات الجودة لنباتات الفجل الأجنبي الأبيض الطويل صنف Radish 40 days.

تم تحليل النتائج المتحصل عليها تبعا للتحليل الإحصائي (تجربة عامليه في قطاعات كاملة العشوائية). اشتملت التجربة على ١٥ معاملة تمثل كل التفاعلات الممكنة بين خمس معاملات من صور التسميد النيتروجينى (NH_4^+ : NO_3^-) وثلاث مستويات من التسميد البوتاسى اضافه إلى التفاعل بينهما على النحو التالي:

العامل الأول: صور النيتروجين (NH_4^+ : NO_3^-):

N1 = ١٠٠% لمونيوم . N2 = ٧٥% امونيوم + ٢٥% نترات . و N3 =٥٠% امونيوم + ٥٠% نترات . و N4 = ٢٥% امونيوم + ٧٥% نترات . و N5 = ١٠٠% نترات .

العامل الثاني: مستويات البوتاسيوم

K1 = ٤٠ و K2 =٧٠ و K3 =١٠٠ كجم بو٢أ للفدان.

ويمكن تلخيص النتائج التي تم الحصول عليها من هذه التجربة على النحو التالي:

❖ سجلت أعلى القيم لكل من صفات النمو الخضري ومحتوى النبات من الكلوروفيل الكلي و النسبة المئوية من النيتروجين والبوتاسيوم والمحصول ومكوناته وصفات الجودة في النباتات التي تم إمدادها بالنيتروجين في صورة (٥٠% لمونيوم + ٥٠% نترات) و(٢٥%أمونيوم +

٧٥% نترات). في حين أنه تحققت أقل القيم عند إمداد النباتات بالنيتروجين فى صورة (١٠٠% أمونيوم) في كلا الموسمين.

- ❖ فيما يتعلق بتأثير مستويات البوتاسيوم، تحققت أعلى القيم لهذه الصفات السابق ذكرها عند المعاملة بالمستوى الثاني (٧٠ كجم بو٢أ للفدان) و المستوى الثالث (١٠٠كجم بو٢أ للفدان).
- ❖ فيما يتعلق بالتفاعل بين صور النيتروجين ومستويات البوتاسيوم لوحظ أن النباتات التي تم تسميدها بالنيتروجين على صورة (٥٠% أمونيوم + ٥٠% نترات) و (٢٥% أمونيوم + ٧٥% نترات) بالتفاعل مع المستوى الثاني للبوتاسيوم (٧٠ كجم بو٢أ للفدان) أعطت أعلى القيم للصفات السابق ذكرها. في حين أنه تم الحصول على أقل القيم عند استخدام ١٠٠% أمونيوم كصورة للنيتروجين بالتفاعل مع كل المستويات المختلفة من البوتاسيوم وذلك في كلا الموسمين وذلك تحت ظروف الأراضي الجديدة بمحافظة الدقهلية- جمهورية مصر العربية.

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