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ORIGINAL ARTICLES

Effect Of Nitrogen Fertilization Rates And Potassium Sources On Broccoli Yield, Quality And Storability

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ABSTRACT

A field experiment was conducted at the Experimental Station of the Faculty of Agriculture, Cairo University during the winter seasons of 2010/2011 and 2011/2012 to study the effects of nitrogen rates and potassium sources on broccoli(*Brassica oleracea var.italica*) head yield, quality ,storability and some associated characters. The experiment was laid in split plot design with three replications. The treatments consisted of the combination of two rates of nitrogen (40 and 60 kg/fed.), two potassium sources (Mort K and Faster). The uniform dose of P 30 kg P_2O_5 $fed.^{-1}$was applied in all plots. Results showed that increasing N rates did not gave significant difference in number of leaves, chlorophyll content, head diameter, average head weight , head yield/fed., head dry matter (after storage), P and K % and give significantly decrease N% accumulation in the head. Nitrogen rate 60kg/fed. had significantly the highest average leaf area (978.8 and849.7cm^2,respectively), in both seasons. The maximum average leaf area per plant (1168.5and 952.6 cm^2) was recorded in first and second season respectively under 60 kg N/fed. with Mort K, which was significantly superior over all the other treatments. The maximum head yield (7.88 ton) was recorded under treatment of 60 kg N /fed. with Faster in the first season while, the maximum head yield (8.62 and 8.33 ton, respectively) were recorded under treatments 40 kg N /fed. with Mort K and 60 kg N /fed. with Faster in the second season. . In both season the maximum harvest index (37.2, 35.8 and 38.5, 35.0 %, respectively) were recorded with treatments 40 kg N /fed. with Mort K and 60 kg N /fed. with Faster , which was significantly superior over all other treatments. the maximum N accumulation in the head (4.19 and 4.08%, respectively) were recorded under treatment of 40 kg N /fed. with Mort K. In all treatments broccoli heads stored for a month with- out change in color (acceptable color) L*, a*, and b* values.

Key word: Broccoli- *Brassica oleracea var.italica*- N- K- Yield- Color measurements

Introduction

Among the vegetable crops native to the Mediterranean region, broccoli (*Brassica oleracea* L. var *italica* Plenk) is a unique nutritious cole crop. The commercial product of the broccoli plant is its inflorescence, harvested before the flower buds begin to open, and often including about 10cm of the crisp fleshy stem. The inflorescence is green and rich in chlorophyll, vitamin A, ascorbic acid and is a good source of calcium, niacin and riboflavin. Nowadays, broccoli attracted much attention due to its multifarious use and great nutritional value (Rangkadilok *et al*., 2004). In addition, broccoli is consumed for richness in bioactive compounds such as phenolics, flavonoids and gluconsinolates that possess antioxidant and anticancer effects (Yoldas *et al*., 2008) In Egypt, broccoli still grown in limited areas. The optimal temperatures for broccoli growing are between 18 and 27 $^{\circ}$C (George, 1999).Synthetic N sources play an essential role for world food supply because they are readily available for plant uptake and allow arable land to be continuously farmed(Eickhout *et al*.,2006). Broccoli is a rapidly growing crop that takes up little N in its first 40days of growth, and most N accumulation may occur during the final 30 to 50 days preceding harvest (Doerge *et al*., 1991).Chemical fertilizer is considered a major source of plant nutrients, but excessive N supply reduce storability, and also increase the occurrence of physiological disorders like hollow stem in broccoli (Rahn 2000, Naeem *et al*., 2006).Among plant nutrients K has the strongest influence on crop quality parameters that determine consumer preference (Jifon and Lester, 2009).The efficiency of K application may be improved further by foliar application .Foliar-applied nutrients, reduce nutrient loss and enhancing yield (Brahma and Phookan, 2006). Singh and Singh (2000) indicated that K fertilization improved the utilization of N. The extractions of K by broccoli under fertigation were 83.8% higher than those under conventional management (Martinez *et al*., 2006)

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Little research has evaluated the effects of foliar potassium application on broccoli. The objective of this experiment was to determine the effects and interactions of foliar potassium application sources and nitrogen fertilization rates on crop yield, quality and storability.

Materials And Methods

Experimental site:

The experimental site lies at 31.13 longitude and 30.03 latitude at attitude of 19 m above sea level in the Experimental Field Station belonging to Faculty of Agriculture, Cairo University, Giza. The experiment was carried out to study the effect of N fertilization rates and K sources on broccoli yield and storability and some associated characters. Field trail was executed during the two successive winter seasons of 2010/2011 and 2011/2012. The soil of the experimental area was clay loam. The Physical and chemical analysis of the experimental soil is presented in Table 1. After applying the traditional agricultural practices including ploughing and compacting, the experimental area was divided into plots of 8.4 m^2 with 3 rows, each 4.0 m long and 0.7 m width. Land preparation encompassed the introduction of 30 kg P_2O_5 $fed.^{-1}$ as well.

Table 1: Physical and chemical analysis of the experimental soil.

Physical analysis		Chemical analysis					
Soil texture	clay loam	Ca^{++} meq/l	7.11	CO_3^{--} +HCO_3meq/l	10.39	Zn ppm	0.39
Clay %	36.55	K^{+} meq/l	0.31	SO_4^{--} meq/l	2.42	Mn ppm	0.59
Silt%	35.31	Na^{+} meq/l	6.1	P ppm	21.0	Cu ppm	0.54
Fine sand%	24.5	Mg^{++} meq/l	2.94	N ppm	30.0	EC(dSm^{-1})	1.63
Coarse sand%	3.55	Cl^{-} meq/l	3.65	Fe ppm	1.13	pH	7.96

Broccoli seeds:

Seeds of broccoli (*Brassica oleracea* L. var *italica* Plenk) hybrid Centauro (Takii Co., Japan) were sown in the nursery in foam trays filled with a mixture of peat moss and vermiculite (1:1, w/w) on 5th of September. Forty day-old seedlings were field transplanted. Seedlings were set on one side of the row at 50 cm spacing. Harvested plants were those grown in the central row of each plot.

Experimental treatments:

The experiment was laid in split plot design with three replications. The treatments consisted of the combination of two rates of nitrogen (40 and 60 kg/fed.), two potassium sources Mort K(K_2O 60%) and Faster(K_2O 30% ,P_2O_5 5%, free amino acids 12%, citric acid 1%, ascorbic acid 0.1%) (Arabian Group for Agriculture Service CO.).

Nitrogen was incorporated into soil in the form of ammonium nitrate (33% N). This was done in three equal portions at 2, 4and 6 week intervals after transplanting. The two types of K foliar fertilizer were applied three times at 2, 4 and 6 weeks after transplanting (Mort K applied at 2.5 g/l and Faster applied at 2.5 ml/l).

At harvest, 90 days after transplanting, three healthy plants were randomly taken representing the plot and for the following measurements:

Vegetative characteristics:

Plant height from cotyledonary scar to shoot tip, number of leaves more than 1cm long (including scares), chlorophyll content (SPAD readings) in the most recent fully expanded leaf and average leaf area (Portable area meter, model LI 3000).

Yield:

A head was considered mature at the time before it started to lose compactness or just before buds started to break up. Yield of top head was recorded in the central row of the plot. Five heads were taken from each plot for measuring: head diameter in two directions, head dry matter percent, average head weight and total head yield.

Growth parameter"

Economic yield (EY) = yield of economic part of the plant.
Harvest index (HI) = (EY/W) ×100 was measured at harvest.

Where W is biological yield = total plant dry matter at harvest.

Head chemical composition:

Nitrogen, Phosphorus and Potassium percentage were determined according to the method described in AOAC (1990)

Head storage:

Three heads from every plot were stored at 0 °C for five weeks, at harvest and every week color was measured by chromameter.

Color measurement:

Color was quantified using CR-400 chromameter with an 8 mm diameter viewing aperture. The instrument was calibrated with white sheet .Reading were taken on three sites on the head. Color was expressed as L*, a*, and b*, indicating luminosity, chromaticity on a green (-) to red (+) axis, and chromaticity on a blue (-) to yellow (+) axis, respectively. Based on the visual quality of broccoli head, threshold values of L*,a*, and b* were defined to determine the acceptability limit of broccoli .

Statistical analysis:

Data were subjected to the statistical analysis according to Snedicor and Cochran (1980) and the means were compared using L.S.D test at 5% significance level

Results and Discussion

The effect of nitrogen fertilization rates and potassium sources on broccoli plant height, number of leaves, average leaf area and chlorophyll content during the 2010/2011 and 2011/2012 seasons is presented in Table 2.

Nitrogen rates:

Nitrogen rate 60 kg/fed. had significantly the highest plant height in the first season. while, the differences did not reach the significance level in the second season. In both seasons increasing N rates did not give significant difference in number of leaves and chlorophyll content. In both seasons nitrogen rate 60kg/fed. had significantly the highest average leaf area (978.8 and849.7cm^2,respectively). Plants grown under limiting nitrogen supply have smaller leaves than grown at optimum N supply (Lambers *et al*. 1998).

Increase nitrogen fertilizer produced healthy plants with large vegetative growth (leaf area) which reflected in the yield (Arisha *et al*., 2003). The area of the leaf determines the photosynthetic area, which has important role in head production (Khatun *et al*. 2012).

Potassium sources:

Mort K had the superior plant height in the first season. Meanwhile, the difference did not reach the significance level in the second season. In both seasons there were no significant differences among the K sources in number of leaves. In the first season the differences did not reach the significance level in average leaf area and chlorophyll content. Opposite to the first season Mort K had the highest average leaf area and chlorophyll content in the second season.

Nitrogen rates× Potassium sources interaction:

The highest plant height was recorded in treatment of 60 kg N/fed. with Mort K (82 cm) in the first season. while, no differences between treatments in the second season. There were no significant differences between treatments in number of leaves per plant in both seasons. The maximum average leaf area per plant (1168.5and 952.6 cm^2) was recorded in first and second season respectively under 60 kg N/fed. with Mort K, which was significantly superior over all the other treatments. Singh and Singh (2000) indicated that K fertilization improved the utilization of N.

The difference did not reach the significance level in the first season in chlorophyll content while, 40kg N/fed. with Faster had the lowest chlorophyll content in the second season and no differences between other treatments in chlorophyll content.

Table 2: Effect of nitrogen fertilization rates (Kg N/ fed.) and potassium source on Broccoli plant height , leaf number, average leaf area and chlorophyll content(SPAD) during 2010/2011 and 2011/2012 seasons.

2010/2011 season				
Treatments	Plant height	leaves no.	Average leaf area(cm^2)	chlorophyll content(SPAD)
Nitrogen level				
40kgN/fed.	75.50b	25.33a	776.0b	74.33a
60kgN/fed.	78.66a	24.17a	978.8a	76.03a
Potassium source				
Mort K	80.00a	24.83a	937.5a	75.45a
Faster	74.16b	24.66a	817.3a	74.92a
Interaction				
40kgN/fed.× Mort K	78.00b	25.66a	706.6b	75.96a
40kgN/fed.× Faster	73.00d	25.00a	845.4ab	72.70a
60kgN/fed.× Mort K	82.00a	24.00a	1168.5a	74.93a
60kgN/fed.× Faster	75.33c	24.33a	789.3b	77.13a
2011/2012 season				
Nitrogen level				
40kgN/fed.	76.00a	24.33a	738.5b	75.52a
60kgN/fed.	78.58a	24.50a	849.7a	77.60a
Potassium source				
Mort K	76.25a	24.83a	862.6a	78.50a
Faster	78.25a	24.00a	725.6b	74.62b
Interaction				
40kgN/fed.× Mort K	76.00a	24.66a	772.5b	79.00a
40kgN/fed.× Faster	76.00a	24.00a	704.5b	72.05b
60kgN/fed.× Mort K	76.50a	25.00a	952.6a	78.00a
60kgN/fed.× Faster	80.66a	24.00a	746.7b	77.20a

Values followed by a letter in common are not significantly different at the 0.05 level

The effect of nitrogen fertilization rates and potassium sources on broccoli head diameter, average head weight, head yield per fed., economic yield and harvest index during the 2010/2011 and 2011/2012 seasons is presented in Table 3.

Nitrogen rates:

In both seasons increasing N rates did not gave significant increment in head diameter, average head weight and head yield per fed. Vagen (2005) found that no significant difference from 120(50kg/fed.) to 240kg N ha^{-1}(100kg/fed.) in broccoli biomass. In both seasons nitrogen rate 60kg/fed. had significantly the highest economic yield which increased 11.18 and 6.12%,respectively by increasing N rate from 40 to60 kg/fed.

Kumar and Sharms(2001) concluded that the maximum values for broccoli growth, yield and quality characteristics were obtained at N 150 kg/ha (62.5 kg/fed.).

The difference did not reach the significance level in the harvest index in the first season. While, nitrogen rate 60kg/fed. had the highest harvest index in the second season.

Potassium sources:

In both seasons there were no significant differences among the K sources tested in the average head weight. The results indicated that K sources did not differed in there affect in head diameter in the first season. while, Mort K was the superior in head diameter in the second season. Faster potassium source had the highest head yield and economic yield in the first season. while, Mort K had the highest head yield and no differences in economic yield in the second season. Potassium sources did not differ in their effects on harvest index in the first season. meanwhile, Mort K had the highest harvest index in the second season. Wall *et al*. (1989) found that there was little yield response to added K fertilizer.

Nitrogen rates× Potassium sources interaction:

There was only a limited effect of the interaction on head diameter. The maximum head diameter (25.5 and 25.7 cm, respectively) were recorded under treatment 40kg N/fed. with Mort K. There were no differences between treatments in average head weight in the first season. while, the maximum average head weight (754.5 and 729.1g) were recorded under 40 kg N /fed. with Mort K and 60 kg N /fed. with Faster, followed by 60 kg N /fed. with Mort K the treatment 40 kg N /fed. with Faster showed the minimum head weight in the second season. The maximum head yield (7.88 ton) was recorded under treatment of 60 kg N /fed. with Faster in the first season . while, the maximum head yield (8.62 and 8.33 ton, respectively) were recorded under treatments 40 kg N /fed. with Mort K and 60 kg N /fed. with Faster, which was significantly superior over all the other

treatments in the second season . The minimum head yield (6.39 ton) was found in treatment 40 kg N /fed. with Faster. Raising the nitrogen rate to broccoli is generally associated with higher yield (Babik and Elkner, 2002). Thompson *et al*. (2002) found that maximum broccoli yields associated with the N rates and quality parameters were highly responsive to N input. By increasing application of N, P, K fertilizer head yield significantly increased (Brahma and Phookan, 2006). The maximum economic yield (71.9g) was recorded under treatment of 60 kg N /fed. with Faster in the first season. while, the maximum economic yield (72.8 and 72.7 g, respectively) was recorded with treatments 40 kg N /fed. with Mort K and 60 kg N /fed. with Faster , which was significantly superior over all the other treatments in the second season. The minimum economic yield (54.2g) was found in 40 kg N /fed. with Faster. In both season the maximum harvest index (37.2, 35.8 and 38.5, 35.0 %, respectively) were recorded with treatments 40 kg N /fed. with Mort K and 60 kg N /fed. with Faster , which was significantly superior over all other treatments. The harvest index (HI) increased by approximately 50% from the zero to the maximum N rate 240kg N ha^{-1}(100kgN/fed.) (Vagen 2005) .Other studies found no effect of N rate on HI (Everaarts 1994).

Table 3: Effect of nitrogen fertilization rates (Kg N/ fed.) and potassium source on Broccoli head diameter, average head weight, head yield, economic yield and harvest index 2010/2011 and 2011/2012 seasons.

2010/2011 season					
Treatments	head diameter(cm)	average head weight(g)	Head yield (ton/fed.)	Economic yield(g)	Harvest index (%)
Nitrogen level					
40kgN/fed.	25.10a	620.88a	7.09a	59.34b	33.76a
60kgN/fed.	24.00a	647.41a	7.55a	65.98a	33.65a
Potassium source					
Mort K	24.90a	628.58a	7.18b	60.57b	33.03a
Faster	24.85a	639.71a	7.47a	64.75a	34.38a
Interaction					
40kgN/fed.× Mort K	25.58a	624.50a	7.13b	61.09b	37.28a
40kgN/fed.× Faster	24.62ab	617.25a	7.05b	57.59b	30.23b
60kgN/fed.× Mort K	24.22b	632.66a	7.23b	60.06b	28.77b
60kgN/fed.× Faster	25.08ab	662.16a	7.88a	71.90a	38.53a
2011/2012 season					
Nitrogen level					
40kgN/fed.	24.60a	657.04a	7.50a	63.50b	31.14b
60kgN/fed.	25.25a	689.25a	7.87a	67.39a	32.99a
Potassium source					
Mort K	25.50a	701.91a	8.02a	67.44a	33.39a
Faster	24.35b	644.37a	7.36b	63.45a	30.74b
Interaction					
40kgN/fed.× Mort K	25.70a	754.50a	8.62a	72.80a	35.87a
40kgN/fed.× Faster	23.50b	559.58c	6.39c	54.20c	26.42c
60kgN/fed.× Mort K	25.30a	649.33b	7.42b	62.08b	30.91b
60kgN/fed.× Faster	25.20a	729.16a	8.33a	72.70a	35.06a

Values followed by a letter in common are not significantly different at the 0.05 level

The effect of nitrogen fertilization rates and potassium sources on broccoli head dry matter percentage (before storage), head dry matter percentage (after storage), N,P and K % in the head during the 2010/2011 and 2011/2012 seasons is presented in Table 4.

Nitrogen rates:

The increasing N rates did not give significant difference in head dry matter (before storage) in the first season. while, nitrogen rate 60kg/fed. had significantly the highest head dry matter in the second season. This result was in disagreement with that obtained by Csizinszky (1995) who found that dry matter in green cauliflower head decreased with increasing N rate. The actual N uptake of the crop appeared to be more critical for fresh weight yield than was the dry matter amount produced in broccoli heads (Vagen 2005). In both season increasing nitrogen rates did not give significant increment in head dry matter (after storage), P and K %. P content was not significantly affected by increasing nitrogen fertilizer (Ouda and Mahadeem, 2008).

In both season increasing N rate gave significantly a decrease in N% accumulation in the head. Nitrogen may be used in increasing vegetative growth. Increase nitrogen fertilizer produced healthy plants with large vegetative growth (leaf area) (Arisha *et al*., 2003).

Potassium sources:

The results indicated that there were no differences among the K sources tested in there effect in head dry matter percent (before storage),head dry matter(after storage), N and P% in the first season and head dry matter

(before storage), P and K % in the second season. Mort K had the superior K accumulation in the head in the first season and the superior N accumulation in the head in the second season. while, had the lowest head dry matter (after storage) in the second season. There was little difference in plant N uptake from different K sources in cauliflower plants (Gunadi and Asandhi, 1988).

Nitrogen rates× Potassium sources interaction:

The maximum dry matter before and after storage was recorded with treatments 40 kg N /fed. with Mort K and 60 kg N /fed. with Faster, Which was significantly superior over all the other treatments in the first season. while, the maximum dry matter before and after storage was recorded under treatment of 60 kg N /fed. with Faster in the second season. In both seasons, the maximum N accumulation in the head (4.19 and 4.08%, respectively) were recorded under treatment of 40 kg N /fed. with Mort K. The amount of nitrogen in broccoli head increased by increasing nitrogen fertilization and the highest amount was detected in the cv. Marathon fertilized with 120kg/ha (50kg/fed.) while, at 240kg/ha (100kg/fed.)the nitrogen accumulation was decreased. (Fabek *et al*., 2012).

There were no differences between treatments in P accumulation in the first season. meanwhile, 60 kg N /fed. with Mort K had the highest P and no differences between the other treatments in the second season. The maximum K accumulation (3.42%) was recorded under treatment of 60 kg N /fed. with Mort K in the first season, while, the maximum K (3.35 and3.38%, respectively) was recorded under treatments 40 kg N /fed. with Faster and 60 kg N /fed. with Mort K in the second season. In disagreement with those obtained by Fabek *et al*. (2012) they indicated that nitrogen fertilizer had a negative impact on potassium accumulation.

Table 4: Effect of nitrogen fertilization rats (Kg N / fed.) and potassium source on Broccoli head dry matter percentage before and after storage, nitrogen, phosphors and potassium content 2010/2011 and 2011/2012 seasons.

2010/2011 season					
Treatments	Head dry matter percent(before storage)	Head dry matter percent(after storage)	N (%)	P (%)	K (%)
Nitrogen level					
40kgN/fed.	9.55a	9.38a	3.99a	0.54a	3.21a
60kgN/fed.	9.85a	9.46a	3.47b	0.53a	3.22a
Potassium source					
Mort K	9.73a	9.37a	3.71a	0.49a	3.35a
Faster	9.67a	9.47a	3.75a	0.58a	3.08b
Interaction					
40kgN/fed.× Mort K	9.78a	9.50a	4.19a	0.50a	3.28ab
40kgN/fed.× Faster	9.32b	9.27b	3.80b	0.58a	3.14bc
60kgN/fed.× Mort K	9.68ab	9.25b	3.24c	0.48a	3.42a
60kgN/fed.× Faster	10.02a	9.68a	3.71b	0.58a	3.03c
2011/2012 season					
Nitrogen level					
40kgN/fed.	9.67b	9.38a	3.73a	0.53a	3.32a
60kgN/fed.	9.93a	9.54a	3.47b	0.62a	3.19a
Potassium source					
Mort K	9.82	9.27b	3.79a	0.66a	3.17a
Faster	9.77a	9.65a	3.42b	0.49a	3.34a
Interaction					
40kgN/fed.× Mort K	9.65b	9.72b	4.08a	0.57b	3.30ab
40kgN/fed.× Faster	9.68b	9.49b	3.39b	0.50b	3.35a
60kgN/fed.× Mort K	9.89ab	9.27b	3.50b	0.76a	3.38a
60kgN/fed.× Faster	9.97a	9.81a	3.45b	0.48b	3.00b

Values followed by a letter in common are not significantly different at the 0.05 level

The effect of nitrogen fertilization rates and potassium sources on broccoli color measurement at storage during 2010/2011 and 2011/2012 seasons.

Nitrogen rates:

In both seasons increasing N rates did not gave difference in their effect on L*, a*, and b* except 40kg N /fed. which was superior in b* after one week of storage in the second season and after four weeks in the first season (data not shown).

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Potassium sources:

In both seasons there were no significant difference among the K sources in L*, a*, and b* except after one week of storage where Mort K was superior in L* in the first season (data not shown).

Nitrogen rates× Potassium sources interaction:

L* can express the level of luminosity on broccoli head surface. Low levels of luminosity indicate high levels of browning since darkness is related to browning(Martin-Diana *et al*.,2005).The effect of treatments on L* values are presented in Fig.1,2. The initial L* values in all treatments were similar. The difference between treatments did not reach the significant level in L* value from harvest to last of storage .but, there were limited differences appeared between the treatments after one and two weeks of storage. Treatment 40kg N/fed. with Mort K had the highest L* value (41.59) after one week and 60kg N/fed. with Mort K (39.80) after two weeks in the first season. while, treatment 40kg N/fed. with Mort K had the lowest L* after four weeks(36.80) of storage in the second season. L* value of all treatments remained above 35 through-out the storage period and remained acceptable.

a* was determined to evaluate the change of broccoli chromaticity on a green to red axis during storage. As shown in Fig.3, 4. The unacceptable level (a* value>2) the differences between treatment did not reach the significance level in a* value from harvest to last of storage in both seasons, suggesting a minor loss of green color for all treatments.

The b* value was used to be a measurement of yellowness.Fig.5,6. The unacceptable level (b* value>17) there were no differences between treatments in b* at harvest. There were limited different after one week of storage in the second season. Treatment 60 kg N/fed. with Faster had the lowest b* value (11.75). after two weeks of storage treatment 40kg N/fed. with Mort K and 60 kg N/fed. with Faster had the highest b* value (14.3 and14.7, respectively) in the first season and no significant differences between treatments in the second season. After three, four and five weeks of storage treatment 40 kg N/fed. with Faster was the highest b* value in the first season, limited significant differences between treatments after three weeks and no differences after four and five weeks in the second season. All treatments were acceptable except treatment 40 kg N/fed. with Faster was unacceptable after five weeks of storage where b* value was access 20. Toivonen *et al*. (1994) found no significant effect of N rates from 0 to 625 kg N ha^{-1} on the storage ability of broccoli.

Conclusion:

Increasing N rates give significantly the highest average leaf area and decrease N% accumulation in the head. The results clearly show that application of foliar K is beneficial for broccoli production and quality. Faster was more compatible with 60Kg N /fed. while, Mort K compatible with40 kg N/fed. Under treatments consisted of the combination of two rates of nitrogen (40 and 60 kg/fed.) and two potassium sources (Mort K and Faster) broccoli heads stored for a month with- out change in color (acceptable color) L*,a*, and b* values.

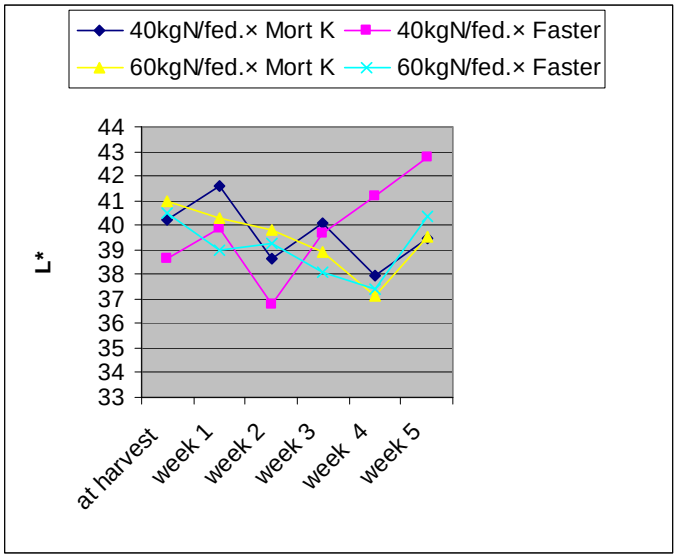

Fig. 1: Effect of nitrogen fertilization rats (Kg N / fed.) and potassium sources on L* for different storage times from harvest to 5 weeks 2010/2011season.

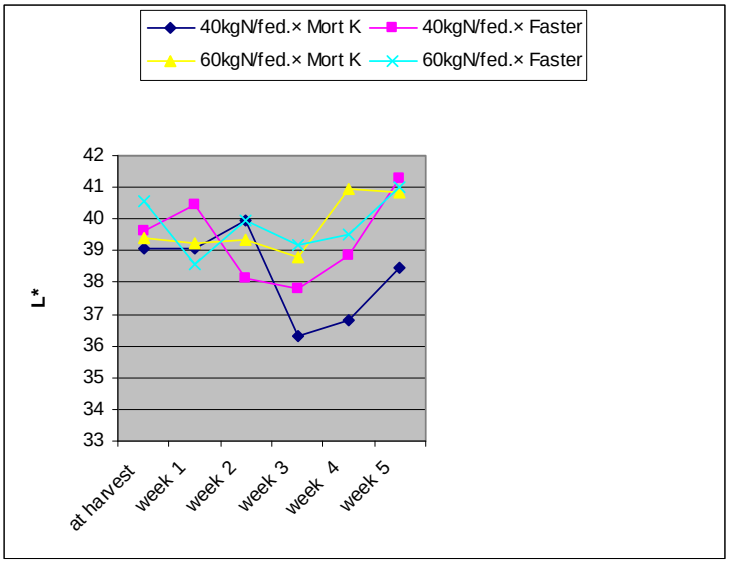

Fig. 2: Effect of nitrogen fertilization rats (Kg N / fed.) and potassium sources on L* for different storage times from harvest to 5 weeks 2011/2012season.

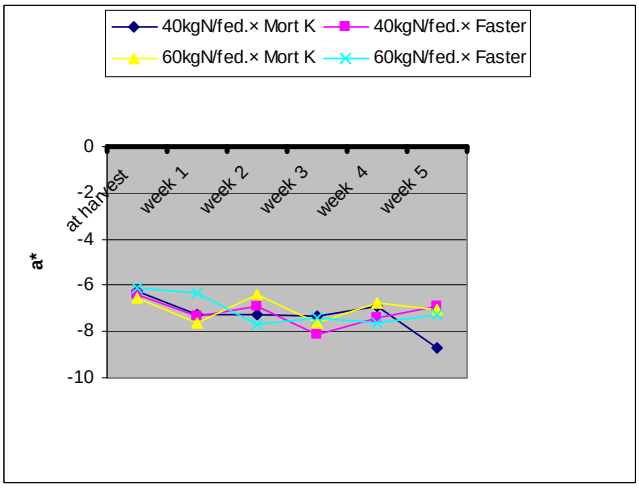

Fig. 3: Effect of nitrogen fertilization rats (Kg N / fed.) and potassium sources on a* for different storage times from harvest to 5 weeks 2010/2011season.

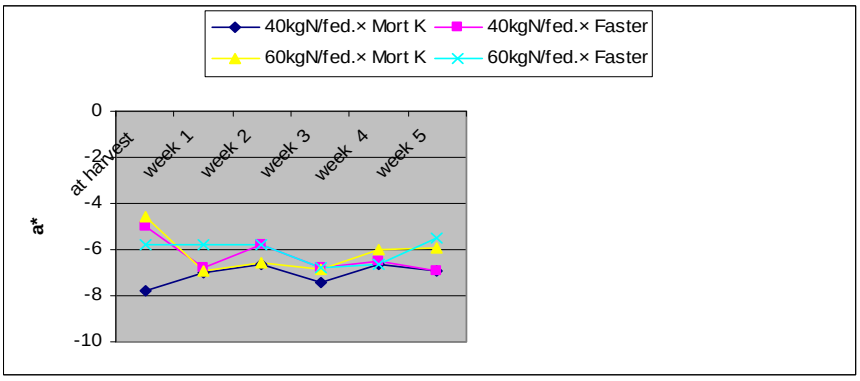

Fig. 4: Effect of nitrogen fertilization rats (Kg N / fed.) and potassium sources on a* for different storage times from harvest to 5 weeks 2011/2012season.

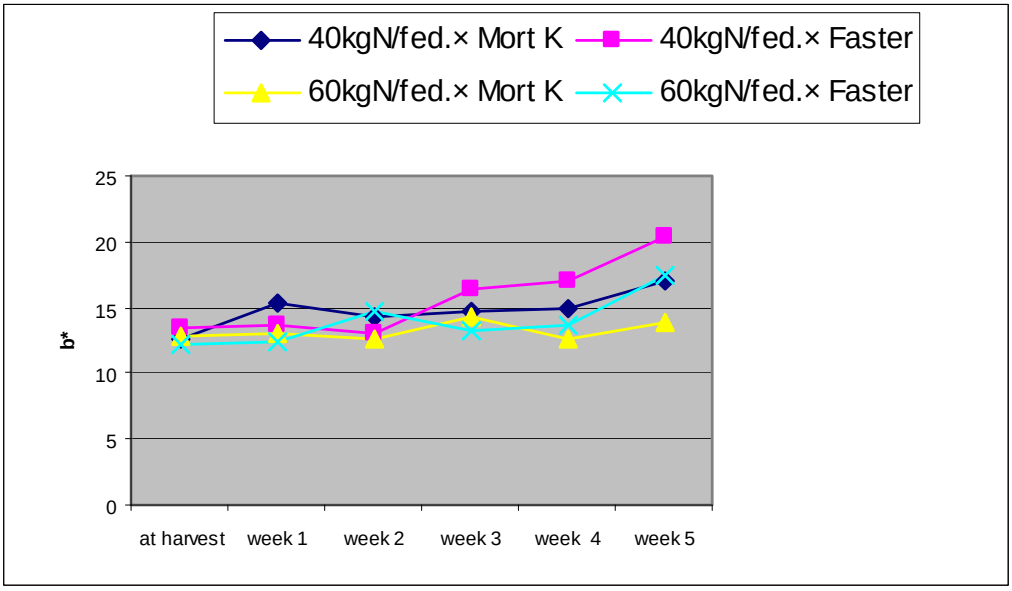

Fig. 5: Effect of nitrogen fertilization rats (Kg N / fed.) and potassium sources on b* for different storage times from harvest to 5 weeks 2010/2011season.

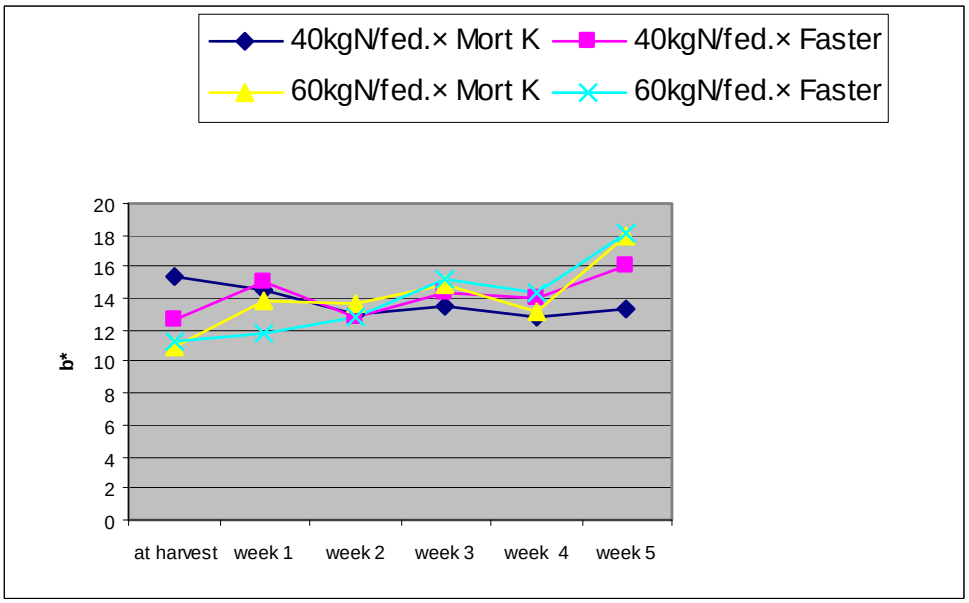

Fig. 6: Effect of nitrogen fertilization rats (Kg N / fed.) and potassium sources on b* for different storage times from harvest to 5 weeks 2011/2012season.

References

A.O.A.C., 1990. Official methods of analysis Association of Official Analytical Chemists. Washington. D.C. 13th ed.

Arisha, H.M.E., A.A. Gad and S.E. Younes, 2003. Response of some pepper cultivars to organic and mineral nitrogen fertilizer under sandy soil conditions. Zagazig journal of Agricultural Research, 30:1875-1899.

Babike, I. and K. Elkner, 2002.The of nitrogen fertilization and irrigation on yield and quality of broccoli. Acta Horticulturae., 571: 33-43.

Brahma, S. and D.B. Phookan, 2006. Effect of nitrogen ,phosphorus and potassium on yield of broccoli (*Brassica oleracea var. italica*).cv. Pusa broccoli .Research on Crops., 7(1): 261-262.

Csizinszky, A.A., 1995. Geen cauliflower (Broccoflower),Brassica oleracea L. Botrytis group,cv. Alverda, response to N and K rates and plant spacing on sand.Proceeding of the Florida State Horticultural Society, 108: 178-181.

Doerge, T.A., R.L. Roth and B.R. Gardner, 1991. Nitrogen fertilizer management in Arizona.Rep. No.191025. The Univ. of Arizona, College of Agriculture, Tuczon, AZ.

Eickhout, B., A.F. Bouwman and H. van Zeijts, 2006. The role of nitrogen in world food production and environmental sustainability. Agriculture Ecosystems& Environment., 116: 4-14.

Everaats, A.P., 1994. Nitrogen fertilization and head rot in broccoli. Netherlands journal of Agricultural Science., 42: 195-201.

Fabek, S., N. Toth I.R. Redovnikovic, M.H. Custic, B. Benko and I. Zutic, 2012. The effect of nitrogen fertilization on nitrate accumulation,and the content of minerals and glucosinolates in broccoli cultivars. Food Technology Biotechnology, 50(2): 183-191.

George, R.A.T., 1999. Vegetable seed production, Oxford University press, Oxford, UK.

Gunadi, N and A.A. Asandhi, 1988. Effects of urea and Chilean nitrate fertilizer application on nutrient uptake produce quality and the incidence of clubroot in cauliflowers. Buletin Penelitian Hortikultura, 16(3): 81-86.

Jifon, J.L. and G.E. Lester, 2009. Foliar potassium fertilization improves fruit quality of field-grown muskmelon on calcareous soils in south Texas.Journal of the Science of Food and Agriculture., 89(14): 2452-2460.

Khatun, K., F. Hossain and S.R. Saha, 2012. Effect of different transplanting dates on the growth and yield of broccoli. Journal of Experimental Bioscience, 3(1): 13-18.

Kumar, P. and S.K. Sharma, 2001. Performance of different sprouting broccoli (Brassica oleracea var. italica) cultivars under different combinations of nitrogen, phosphorus and potassium. Indian Journal of Agricultural Sciences,71(8): 558-560.

Lambers, H., I.F.S. Chapin and T.L. Pons,1998. Plant physiological Ecology, 540pp. Springer Verlag, New York.

Martin-Diana, A.B., D. Rico, C. Barry-Ryan, J.M. Frias, J. Mulcahy and G.T.M. Henehan, 2005. Calcium lactate washing treatments for salad- cut Iceberg lettuce: effect of tremperature and concentration on quality retention parameters. Food Research International., 38: 729-740.

Martinez,V.J.L., R.N.Escobar, L.I. Ferrat, E. J. D Barra and C.R. Gonzalez, 2006. Potassium nutrition of broccoli with conventional management and fertigation in a vertisol in greenhouse. Agrociencia, 40(1): 1-11.

Naeem, M., J. Iqbal and M.A.A. Bakhsh, 2006. Comparative study of inorganic fertilizers and organic manures on yield and yield components of mungbean (Vigna radiat L.).Journal of Agriculture. Society. Science., 2: 227-229.

Ouda, B.A. and A.Y. Mahadeem, 2008. Effect of fertilizer on growth, yield, yield components, quality and certain nutrient contents in broccoli (*Brassica oleracea var. italica*). International. Journal of Agriculture. Biology, 10: 627-632.

Rahn, C.R., 2000. Nitrogen and field production of vegetable crops. Acta Horticulturae., 533: 361-369.

Rangkadilok, N., M.E. Nicolas, R.N. Bennett, D.R. Eagling, R.R. Premier and W.J. Taylor, 2004. The effect of supher fertilizer on glucoraphanin levels in broccoli (*B. oleracea* L. var. *italica*) at different growth stages. Journal of Agriculture. Food Chemistry, 52: 2632-2639.

Singh, A.K. and A. Singh, 2000. Influence of nitrogen and potassium on growth and head yield of broccoli (Brassica oleracea var. italica) under low hills subtropical condition .Vegetable Science, 27(1): 99-100.

Snedicor, G.W. and W.G. Cochran, 1980. Statistical Methods. Oxford and J. PH. Publishing Co. 7th edition.

Thompson, T.L., T.A. Doerge and R.E. Godin, 2002. Subsurface drip irrigation and fertigation of broccoli:I. Yield, quality, and Nitrogen Uptake. Soil Science Society American Journal., 66: 186-192.

Toivonen, P.M.A., B.J. Zebarth, and P.A. Bowen, 1994. Effect of nitrogen fertilization on head size, vitamin C content and storage life of broccoli (Brassica oleracea var. italica). Canadian J. Plant Science,74: 607-610.

Vagen, I.M., 2005. Nitrogen uptake utilization in broccoli (*Brassica oleracea var. italica*) Ph D theses Norwegian University of life Sciences.

Wall,T.E., G.J. Hochmuth and E.A. Hanlon, 1989.Calibration of Mehlich and extractable potassium for polyethylene mulched, drip irrigated cauliflower.Proceedings Soil Crop Science Society of Florida., 48: 46-49.

Yoldas, F., S. Ceylan, B. Yagmur, and N. Mordogan, 2008. Effect of nitrogen fertilizer on yield quality and nutrient content in broccoli. Journal of Plant Nutration., 31: 1333-1343.