

**EFFECT OF NITROGEN FERTILIZATION
AND ITS APPLICATION SYSTEMS ON VEGETATIVE
GROWTH, FRUIT YIELD AND QUALITY
OF SWEET PEPPER**

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ABSTRACT

Two field experiments were conducted on sweet pepper plants (cv. California Wonder) during the successive summer seasons of 2000 and 2001, in the Agricultural Experimental station, Alexandria University, at Abies. The objective of these experiments was to determine the effects of nitrogen rates (60, 90 and 120 kg fed⁻¹) and their application systems (three, four, five and six split applications), on vegetative growth, fruit yield and quality of sweet pepper. The obtained results indicated that increasing N applied rate was accompanied with significant increases in plant height, number of leaves, leaf area and dry mass plant⁻¹. Moreover, higher yield potential (yield plant⁻¹, number of fruits plant⁻¹ and average fruit weight⁻¹) and better fruit quality (fruit dry matter, total soluble solids, ascorbic acid and k content) seemed to be associated with the application of 90 kg N fed⁻¹.

Increasing number of split N applications up to six split doses, significantly, increased vegetative growth characters; plant height, number of leaves, leaf area and dry mass plant⁻¹. Leaf's N content, total fruit yield plant⁻¹, number of fruits plant⁻¹ and average fruit weight and some fruit quality characteristics were positively and significantly responded to the frequent N applications up to 5 or 6 doses. However, early yield was significantly decreased. Leaf's mineral contents (P and K) were not significantly affected. The interaction between N rates and their application systems reflected significant differences for most of the studied characters, and revealed that the rate of 90 Kg N fed⁻¹ when applied at six split doses; at transplanting, 4, 6, 8, 10, and 12 weeks after transplanting, appeared to be the most efficient combination treatment, which favored the production of high yield with acceptable fruit quality.

INTRODUCTION

Nutrition of pepper plants in general and with nitrogen in particular have been focused by many investigators (Russo, 1991; Johnson and Decoteau, 1996; Fattah – Allah *et al.*, 1997). A positive relationship has been emphasized between the available amount of N in the soil and the vegetative growth and some fruit quality characteristics of pepper (Mishriky and Alphonse, 1994; Shahin *et al.*, 1999; Hartz *et al.*, 1999; Gabr *et al.*, 2001). However, there is no consensus on an optimal N fertilization level, but varying N rates ranged between 50-225 kg N fed⁻¹ were documented (Mishriky and Alphonse, 1994; Johnson and Decoteau, 1996; Fattah – Allah *et al.*, 1997; Shahin *et al.*, 1999; Gabr *et al.*, 2001). Johnson and Decoteau (1996) showed that biomass of pepper plant and fruit production responded linearly to N fertilizer rate. Working on pepper, Shahin *et al.* (1999) and Gabr *et al.* (2001) demonstrated true increases on total fruits yield and its components when N applications ranged between 80-120 kg N fed⁻¹. However, super optimal N application led to enhancing vegetative growth at the expense of early and total fruit yield and quality (Somos, 1984; Bosland and Votava, 1999; Hartz *et al.*, 1999; Hochmuth, 2001).

Pepper plants, during the vegetative and fruit development stages, are sensitive to nutritional balance. Maynard (1962) concluded that a little requirement of N supply, through the 1st period of plant growth, was responsible for accelerating the flowering of pepper plants meanwhile, the higher the rate of N application the higher was the percentage of fruit set. On the other side, Somos (1984) reported that N requirement of pepper plants seemed to be the highest within the flowering period and gradually diminish starting from fruit ripening. In addition, excessive N application after the appearance of 1st flower greatly favored fruits development. Pajero *et al.* (1990) mentioned that N applied rate during the vegetative growth stage was a function of early flower initiation and flower production. The greatest absorption of nutrients occurs through the first 8 to 14 weeks of growth and again after the removal of first fruit. So, the application of high N levels early during the vegetative growth period of pepper with supplemental applications after the initiation of fruit set are required (IFA, 1992). However, in Egypt, soil N application, to the grown pepper plants, generally, achieved at three equal applications after 3, 6 and 9 weeks of transplanting while, harvesting of fruits achieved 45 days later of the final N application (Mishriky and Alphonse, 1994).

Addition the proper amount of N at the suitable time is of a great interest to enhance yield and/or quality features. Therefore, the current study was proposed to clarify the effects of three different N levels and four various systems of N application on vegetative growth, yielding ability, chemical constituents and quality of sweet pepper.

MATERIALS AND METHODS

Two field experiments were carried out during the summer seasons of 2000 and 2001 at the Experimental Station Farm, Faculty of Agriculture, Alexandria University. Prior to the initiation of each experiment, soil samples of 25 cm depth were collected and analyzed for some important physical and chemical properties according to the published procedures (Black, 1965). Results of the analyses are presented in Table (1).

Table 1. Some important physical and chemical characteristics of the experimental site in 2000 and 2001 seasons

Season	Physical properties				Chemical properties					
	Sand (%)	Silt (%)	Clay (%)	Texture	EC (dsm ⁻¹)	pH	T.N (%)	P (ppm)	K (%)	O.M (%)
2000	19.60	33.30	47.10	Silty loam	3.36	7.88	0.09	13	.0072	0.14
2001	19.40	32.40	48.20	Silty loam	3.32	8.01	0.10	15	0.078	0.15..

Sweet pepper seeds (Sun Seed Company, USA) of California Wonder cultivar were sown in the nursery on February 3, 2000 and February 8, 2001. Uniform seedlings of 45 days old were transplanted into the field in rows 4 meters long. The inter- and intra-row spacing was 40 and 70 cm, orderly.

The treatments comprised three different N levels and four various systems of N application. The N rates and their application systems are shown in Table (2).

Table 2. The schedule of nitrogen doses and their application systems to sweet pepper plants, in the two growing summer seasons of 2000 and 2001

Treatments		Amount of N (kg fed ⁻¹) applied at					
		Vegetative growth stage			Flowering and fruiting stages		
N Rates (Kg. fed ⁻¹)	Application systems	At Transplanting	4 WAT*	6 WAT	8 WAT	10 WAT	12 WAT
60	3 doses	10	20	30	-	-	-
	4 doses	10	10	20	20	-	-
	5 doses	10	10	10	10	20	-
	6 doses	10	10	10	10	10	10
90	3 doses	15	30	45	-	-	-
	4 doses	15	15	30	30	-	-
	5 doses	15	15	15	15	30	-
	6 doses	15	15	15	15	15	15
120	3 doses	20	40	60	-	-	-
	4 doses	20	20	40	40	-	-
	5 doses	20	20	20	20	40	-
	6 doses	20	20	20	20	20	20

*WAT :Weeks after transplanting.

The first N application, in all treatments, was in the form of ammonium sulphate (20.6% N) whereas; the later ones were in the form of ammonium nitrate (33.5% N). Identical dose of phosphorous and potassium fertilizers at the rate of 50 kg P₂O₅ and 72 kg K₂O fed⁻¹, orderly was applied. Phosphorous fertilizer was applied during soil preparation while, potassium fertilizer was added at three equal applications; 6, 8 and 10 weeks after transplanting. The experimental layout was a split-plot system in a randomized complete blocks design with three replications. The main plots were allocated to N rates meanwhile; the sub-plots were assigned to the system of N application. Each experimental unit contained 4 rows to cover an area of 11.2 m². Each two adjacent experimental plots were separated by 1.4 m alley to protect against border effects. All other recommended agro- managements for the production of sweet pepper were followed whenever it was necessary. In each experimental unit, the outer two rows were allocated to record the vegetative growth features and determination the chemical constituents of leaves while, the inner two

rows were preserved to record the flowering traits and fruits yield and its components.

Data recorded

1-Vegetative growth characters

A random sample, consists of 5 plants from each experimental unit, 95 days after transplanting, was collected and the following vegetative measurements were recorded; plant height, number and area of leaves plant⁻¹ and foliage dry mass plant⁻¹.

2- Chemical constituents of leaves

The 5th upper leaf of 5 randomly chosen plants, from each plot, was collected, at 95 days old after transplanting. The following chemical determinations were achieved; total nitrogen and phosphorous contents using Microkjeldahal and ammonium stannous chloride procedures, respectively (A.O.A.C., 1992) while, potassium content was estimated using Flame photometer as outlined by Black (1965).

3- Fruits yield and its components

Picking of the fruits in 2000 and 2001 seasons started on June 12 and June, 16 with interval of 6 days and terminated 56 and 63 days later, orderly. The following measurements included early fruits yield plant⁻¹(weight of the first four pickings), number and weight of fruits plant⁻¹ and average fruit weight.

4- Fruit quality characteristics

A random fruit samples, taken from each experimental unit, from the six picking was utilized to achieve the following determinations: dry matter content, total K content using the same aforementioned analytical procedure, total soluble solids content using a hand refractometer, ascorbic acid and total titratable acidity contents as illustrated in A.O.A.C. (1992).

All obtained data were subjected to statistical analysis using Costat Software (1985). Revised Least Significant Difference Test introduced by EL-Rawy and Khalf-Allah (1980) was utilized to verify the differences among treatment means.

RESULTS AND DISCUSSION

Vegetative growth characters

Data in Table (3) showed that increasing the application of N fertilizer from 60 to 90 and fatherly to 120 kg N fed⁻¹ resulted in corresponding and significant increases in all studied vegetative growth characters, i.e. plant height, number of leaves, leaf area and dry mass plant⁻¹, in 2000 and 2001 seasons. The exception was in 2001 season, where the difference between the application of 90 and 120 kg N fed⁻¹ for foliage dry mass and number of leaves plant⁻¹ was not significant. Such a positive effect of N could be explained on the ground that the determined amounts of available N in the soil were between 0.09 and 0.10% in 2000 and 2001 seasons, respectively (Table 1) which were not sufficient to meet the elevated requirements of pepper plants. The enhancing effect of applied N on plant growth may be attributed to its beneficial effects on stimulating the meristemic activity for producing more tissues and organs. Moreover, N plays a major role on protein and nucleic acids synthesis, and protoplasm formation (Marschner, 1986). These findings, generally, agreed with those obtained by Mishriky and Alphonse (1994) Johnson and Decoteau (1996), Shahin *et al.* (1999). Gabr *et al.* (2001) reported that increasing N applied to pepper plants from 40 to 150 kg N fed⁻¹. was accompanied with significant increases in plant height, leaf area, number of leaves and dry mass plant⁻¹.

Concerning the effect of N application systems, the results shown in Table (3) indicated that increasing the split applications of N fertilizer, to the growing pepper plants, up to six doses caused successive significant increases in plant height, number of leaves, leaf area and foliage dry mass plant⁻¹ in 2000 and 2001 seasons. The six splits application of N; at transplanting and after 4,6,8,10 and 12 weeks of transplanting, prove to be the best, as it associated with the highest mean values for all test characters. On the other extreme, the triple splits application; at transplanting, 4 and 6 weeks after transplanting, significantly, attained the lowest mean values for all studied vegetative characters. The obtained results seemed to be in

Table 3. Vegetative growth characters of sweet pepper plants as affected by N level and its application systems during the summer seasons of 2000 and 2001

Treatments		2000 season				2001season			
N rates (Kg N fed ⁻¹)	Systems of N application	Plant height (cm)	No. leaves plant ⁻¹	Leaf area (dm ²)	Foliage dry mass plant ⁻¹ (g)	Plant height (cm)	No. leaves plant ⁻¹	Leaf area (dm ²)	Foliage dry mass plant ⁻¹ (g)
60		50.3C*	74.2B	36.0C	55.4C	54.1C	78.4B	36.6C	60.5B
		60.3B	79.8A	40.6B	73.4B	63.3B	83.3A	45.2B	78.7A
		64.4A	79.5A	45.7A	75.9A	66.5A	85.5A	48.4A	77.2A
		49.9D	67.5D	36.5D	59.3D	53.0D	72.5D	38.5D	63.5D
60	3 doses	54.8C	74.1C	39.2C	64.6C	57.7C	80.3C	42.1C	70.6C
	4 doses	62.6B	82.9B	42.7B	72.8B	65.5B	86.1B	45.6B	76.5B
	5 doses	65.9A	86.8A	44.6A	76.2A	69.0A	90.6A	47.4A	78.0A
	6 doses	43.3j	62.7j	31.6h	49.5k	46.4i	66.3i	31.9i	51.6i
90	3 doses	47.0i	73.9g	33.5g	52.6j	52.6h	76.3g	35.2h	56.6h
	4 doses	54.2g	78.9f	39.0f	56.2i	56.3f	83.3e	38.2g	65.4g
	5 doses	56.5e	81.3e	39.9e	63.4g	61.2d	87.6cd	41.0f	68.4f
	6 doses	51.1h	68.4i	38.1f	61.9h	54.9g	73.9h	41.0f	67.7f
120	3 doses	56.5e	79.4f	40.3de	68.3e	58.1 e	81.8f	43.8d	80.6c
	4 doses	66.1c	83.3d	41.0d	81.2bc	68.9c	86.3d	47.0c	82.9ab
	5 doses	67.6b	88.2b	42.9c	82.2ab	71.0b	91.0b	48.9b	83.7a
	6 doses	55.3f	71.3h	39.9e	66.5f	57.6ef	77.3g	42.7e	71.2e
120	3 doses	61.0d	69.1f	43.6c	73.0d	62.4 d	82.7ef	47.3c	74.7d
	4 doses	67.7b	86.4c	48.0b	81.1c	71.2b	88.7c	51.6a	81.2c
	5 doses	73.5a	91.0a	51.0a	83.1a	74.9a	93.1a	52.2a	81.9bc
	6 doses								

* Values marked with the same alphabetical letter (s), within a comparable group of means, do not significantly differ, using revised L.S.D. test at 0.05 level.

general agreement with those reported by Kumar and Cheeran (1981), who pointed out that the application of N to the grown pepper plants as split dose was more beneficial than the single one. Recently, Feleafel (2005), on eggplant, reported that increasing number of split N applications up to six split doses, significantly, increased plant height, number of branches and leaves, leaf area and dry weight plant⁻¹. Such a result could be interpreted on the basis that the greatest absorption of nutrients by sweet pepper plants occurs through the first 8 to 14 weeks of growth and again after the removal of first fruit. Therefore, high N levels are required by the plant early in the growth season with supplemental applications after the fruit initiation stage (IFA, 1992).

The interaction effects of N rates and their application systems on the vegetative growth characters of pepper plants were significant, in both seasons (Table, 3). At any N rate, increasing number of split applications up to six doses, generally, increased plant height, number of leaves, leaf area and dry mass plant⁻¹. The combined treatment which included 120 kg N fed⁻¹ plus six splits doses can be considered the best choice as it attained the highest significant mean values for all vegetative growth characters. Similar results were obtained by Feleafel (2005) on eggplant.

Leaf's mineral content

Data recorded in Table (4) showed that the application of N fertilizer with successive amounts caused significant increases on leaf's N content. The highest rate of N (120 kg N fed⁻¹) recorded the highest mean values of nitrogen content of leaves, in the two studied seasons. However, leaf's P content did not reflect any significant response. Nevertheless, the K-content of leaves gradually decreased by increasing the nitrogen applied rate. Such a result concerning the effect of N rates on leaf's K content seemed to suggest the presence of an antagonistic effect between the level of applied N and K concentration in leaves. Somos (1984) stated that an increase in N doses applied to the grown pepper diminished the K uptake. Results of the effects of N

rates on leaf's N and P contents confirmed previous findings of Shahin *et al.* (1999), who reported positive influences of leaf's N and P contents of pepper plants as a result of increasing N dose. Similar results were recorded by Gabr *et al.* (2001), who stated positive and significant effects on leaf's N and P contents due to N application.

Regarding the effect of application systems of N on leaf mineral contents, data in Table (4) indicated that leaf's N content increased by partitioning N application until 12 week after transplanting. Phosphorous and potassium concentrations did not affect by splitting N amount during the growing season. The obtained results are, generally, in accordance with those found by Feleafel (2005) on eggplants.

Table (4): Leaf's mineral contents of sweet pepper plants as affected by N level and its application systems during the summer seasons of 2000 and 2001.

Treatments		2000 season			2001 season		
N rates (Kg N fed ⁻¹)	Systems of N application	N (%)	P (%)	K (%)	N (%)	P (%)	K (%)
60		3.70C*	0.378A	3.45A	3.81C	0.386A	3.56A
90		3.82B	0.379A	3.40B	3.86B	0.389A	3.49B
120		3.85A	0.378A	3.30C	3.92A	0.389A	3.46B
	3 doses	3.69D	0.378A	3.38A	3.77D	0.387A	3.49A
	4 doses	3.77C	0.378A	3.38A	3.84C	0.389A	3.50A
	5 doses	3.82B	0.379A	3.39A	3.90B	0.388A	3.49A
	6 doses	3.88A	0.379A	3.38A	3.94A	0.388A	3.51A
60	3 doses	3.60i	0.378a	3.44a	3.72g	0.378a	3.52a
	4 doses	3.68h	0.377a	3.46a	3.78f	0.389a	3.56a
	5 doses	3.72gh	0.378a	3.46a	3.84e	0.387a	3.55a
	6 doses	3.78ef	0.380a	3.44a	3.90d	0.390a	3.59a
90	3 doses	3.71h	0.378a	3.38a	3.77f	0.392a	3.51a
	4 doses	3.80ef	0.380a	3.39a	3.84e	0.387a	3.49a
	5 doses	3.86cd	0.380a	3.40a	3.89d	0.391a	3.45a
	6 doses	3.91ab	0.378a	3.41a	3.94bc	0.388a	3.49a
120	3 doses	3.76fg	0.378a	3.31a	3.28e	0.391a	3.45a
	4 doses	3.82de	0.376a	3.29a	3.91cd	0.392a	3.45a
	5 doses	3.88bc	0.378a	3.32a	3.96ab	0.385a	3.48a
	6 doses	3.94a	0.379a	3.28a	3.96a	0.387a	3.45a

The interaction effect of N rate by N application system on N content of pepper leaves was significant, but leaf's P and K contents did not appear to be significantly affected, in both seasons (Table, 4). At any N level, splitting N application until 12 weeks after transplanting, gave the highest leaf content of N, in both seasons. The treatment combination of 120 kg N fed⁻¹ applied as 6 split applications until 12 weeks after transplanting seem to be the best on leaf's N

content. These findings confirmed the results obtained by FeleafeL (2005), who indicated that the interaction effects of N rates and their application systems on the percentages of K and P in the eggplant leaves were not significantly affected.

Fruit yield and its components

Data in Table (5) exhibited that application of N at 90 and 120 kg N fed⁻¹, significantly, increased early yield plant⁻¹, yield plant⁻¹, number of fruits plant⁻¹ and average fruit weight relative to 60 kg N fed⁻¹, in both seasons. The only exception was noticed with number of fruits plant⁻¹ in the first season, where, the difference between 60 and 120 kg N fed⁻¹ was insignificant. It is worthy to mention that raising N level above 90 kg N fed⁻¹ was not associated with a corresponding increase in most yield and its components characters; but instead a pronounced decrease was observed. Such a result seemed to suggest that 90 kg N fed⁻¹ was sufficient to meet sweet pepper requirements. The plants that were received the rate of 90 kg N fed⁻¹ gave the highest early yield plant⁻¹, total yield plant⁻¹ number of fruits plant⁻¹ and average fruit weight. The exceptions were observed with average fruit weight, in the first season and early yield plant⁻¹, in the second season; where the plants were fertilized with 120 kg N fed⁻¹ produced the heaviest fruit weight and earliest yield. The beneficial effect of N, particularly, the moderate level (90 kg N fed⁻¹), on fruit yield potential could be related to the role of N in activating the vegetative growth as shown earlier in Table(3) which probably promote the production of more photosynthetic substance required for fruit formation and development. Similar results were recorded by Mishriky and Alphonse (1994), Shahin *et al.* (1999) and Gabr et al. (2001), who reported that yield potential; number of green fruits plant⁻¹, average fruit weight , early and total fruit ,and yield plant⁻¹ increased as a result of N application.

Table 5. Fruit yield and its components of sweet pepper plants as affected by N level and its application systems during the summer seasons of 2000 and 2001

Treatments		2000 season				2001 season			
N rates (Kg N fed ⁻¹)	Systems of N application	Early yield plant ⁻¹ (g)	yield plant ⁻¹ (g)	No. of fruits plant ⁻¹	Average fruit weight (g)	Early yield plant ⁻¹ (g)	yield plant ⁻¹ (g)	No. of fruits plant ⁻¹	Average fruit weight (g)
60		131.2C	806.3C	13.7B	58.5C	149.0C	845.4C	14.0B	60.3C
90		147.7A	947.4A	15.1A	62.5B	161.4B	1037.6A	15.2A	68.3A
120		143.4B	918.1B	14.3B	65.0A	165.1A	990.0B	15.4A	64.1B
	3 doses	152.7A	723.1D	12.7C	57.0D	163.7A	817.6C	13.4C	61.1C
	4 doses	143.7B	841.8C	14.7B	61.0C	159.9B	921.8B	14.6B	63.0B
	5 doses	136.3C	960.1B	15.1A	63.6B	156.4C	1057.7A	15.9A	66.5A
	6 doses	130.4D	1037.3A	15.6A	66.3A	154.1D	1033.4A	15.5A	66.4A
60	3 doses	142.7c	640.8j	12.0g	53.4f	155.7g	753.9j	12.8d	58.9g
	4 doses	132.7e	713.0i	12.8f	55.7e	150.4h	786.0i	13.1d	60.0fg
	5 doses	127.7f	893.5f	14.6d	61.2d	147.2i	954.0f	15.0bc	63.6de
	6 doses	121.9g	977.9d	15.4bc	63.5c	142.8i	887.7g	15.1bc	58.8b
90	3 doses	158.9a	741.5h	13.1f	56.6e	168.5a	889.6g	13.9d	64.0de
	4 doses	150.1b	908.5e	14.7d	61.8d	163.4de	996.6d	15.1bc	66.0c
	5 doses	143.2c	1024.0b	16.0ab	64.0c	157.6f	1130.5a	15.9af	71.1a
	6 doses	138.7d	1115.4a	16.5a	67.6a	156.1g	1133.5a	15.7ab	72.2a
120	3 doses	156.6a	786.9g	12.9f	61.0d	166.8b	809.4h	13.4d	60.4f
	4 doses	148.3b	903.9e	14.7d	65.5b	165.8c	982.8e	15.6b	63.0e
	5 doses	138.1d	962.9d	14.7d	65.5b	164.5d	1088.6b	16.8a	64.8d
	6 doses	130.6e	1018.5c	15.0cd	67.9a	163.3	1079.1c	15.8ab	68.3b

** Values marked with the same alphabetical letter (s), within a comparable group of means, do not significantly differ, using revised L.S.D. test at 0.05 level.

Table (5) shows that splitting the amounts of N applications to five or six doses led to significant increases in total fruit yield plant-1, number of green fruits and average fruit weight relative to triple or fourth applications, in both growing seasons. This result means that the effectiveness of N being better with, more than less frequent N applications. On the other side, partitioning N application until 12 weeks after transplanting caused a reduction in early yield plant-1 which might be due to the enhancement in vegetative growth at the expense of early yield in both seasons. The favorable effects of split application of N fertilizer on fruit yield and its components except early yield plant-1 could be attributed to the ideal distribution of N throughout growing season, especially with a relatively heavy feeder plant such as sweet pepper. It is, also, possible that the sufficient quantity and perhaps the efficient absorption of N coupled together to promote the production of more photosynthetic required for fruit formation and development. It was reported that the greatest absorption of nutrients occurs in the first 8 and 14 weeks of growth and again after the first fruit removal. Therefore, high N levels are required early in the growth season with supplemental application after the fruit initiation stage (IFA, 1992). Oliveira et al. (1971) stated that sweet pepper plants grow slowly for the first 60 days. These results agreed, more or less, with those reported by Dod et al (1983), who found that the highest pepper yield was obtained by applying N in four split doses. EL-Shobaky (2002) showed that N application at five or six times, significantly, increased fruit yield plant-1 and total yield fed-1 of tomato plants. The results reported by Feleafel (2005), on eggplant, confirmed our findings concerning the enhancing effects of application systems on yield and its components.

The interaction effects between N levels and their application systems on yield and its components appeared significant in both seasons (Table, 5). At any N level, increasing number of split applications, significantly, increased, with different degrees, total yield

plant⁻¹, number of fruits plant⁻¹ and average fruit weight while decreased early yield plant⁻¹, in both seasons. The comparisons between the twelfth treatment combinations, generally, indicated that pepper plants were received 90 kg N fed⁻¹ added at five or six split applications seemed to be the most economical and beneficial treatment for total yield plant⁻¹, number of fruits plants⁻¹ and average fruit weight relative to 60 kg N and /or 120 kg N fed⁻¹ at the varying application systems, in both seasons. However, the differences between five and six split applications for total yield plant⁻¹ and average fruit weight were not significant in the second season. Such a result suggests that 90 kg N fed⁻¹ was sufficient to attain economical fruit yield potential when added at five split application. On the other extreme, the combination treatment of 90 kg fed⁻¹ added at triple doses, significantly, produced the highest early yield plant⁻¹, in both seasons. The noticed reduction in early yield plant⁻¹ at the highest level of N 120 kg N fed⁻¹ at varying application systems might be due to the increased vegetative growth at the expense of the earliness of flowering. Bosland and Votava (1999) reported that super optimal N application can stimulate growth, resulting in large plants with fewer early yields.

Fruit Quality characteristics

Results in Table (6) illustrated that the application of N at 90 and 120 Kg N fed⁻¹, significantly, enhanced the fruit contents of dry matter, total soluble solids (TSS), ascorbic acid and potassium relative to 60 Kg N fed⁻¹, in both seasons. The fruits which produced from plants that were fertilized with 90 kg N fed⁻¹. characterized by the highest contents of dry matter, TSS, ascorbic acid and K content. Raising N level to 120 kg N fed⁻¹ was associated with corresponding inferior in the aforementioned later quality traits, in both experiments. On the other hand, fruit's titratable acidity content did not appear to be significantly affected. These results, in general, were compatible with

Table 6. Fruit quality characteristics of sweet pepper as affect by N level and its application systems during the summer seasons of 2000 and 2001.

Treatments		2000 season					2001 season				
N rates (Kg N fed ⁻¹)	Systems of N application	Dry matter (%)	Total soluble solids (%)	K (%)	Ascorbic acid (mg/100g f. w.)	Titratable acidity (g citric acid/100 ml juice)	Dry matter (%)	Total soluble solids (%)	K (%)	Ascorbic acid mg/100g f. w.)	Titratable acidity (g citric acid /100 ml juice)
60		7.40C*	5.45C	2.74C	158.8C	0.232A	8.07C	5.65C	2.85C	172.8C	0.241A
90		10.17A	6.24A	2.94A	190.0A	0.240a	10.33A	6.63A	3.01A	192.8A	0.241A
120		8.67B	5.83B	2.78B	175.0B	0.242A	8.85B	6.09B	2.95B	181.1B	0.245A
	3 doses	9.03A	5.73B	2.80A	168.6A	0.238A	9.58A	5.85B	7.93A	173.8A	0.241A
	4 doses	8.75B	5.86A	2.81A	173.7A	0.238A	9.06B	6.04A	2.94A	178.3A	0.243A
	5 doses	8.71B	5.91A	2.83A	177.4A	0.239A	8.93B	6.17A	2.94A	186.3A	0.243A
	6 doses	8.47C	5.86A	2.83A	178.7A	0.237A	8.75C	6.07A	2.93A	190.4A	0.243A
60	3 doses	7.60g	5.21e	2.76a	155.4j	0.233a	8.82g	2.42f	2.86a	163.3l	0.240a
	4 doses	7.49g	5.44d	2.69a	158.8i	0.232a	7.87h	5.61e	2.90a	168.1k	0.241a
	5 doses	7.30h	5.62c	2.71a	160.5h	0.234a	7.77h	5.83d	2.82a	178.4h	0.241a
	6 doses	7.19h	5.52cd	2.78a	160.4h	0.238a	7.82h	5.74de	2.80a	181.3g	0.243a
90	3 doses	10.70a	6.17a	2.92a	181.1d	0.238a	10.77a	6.22bc	2.97a	185.3e	0.241a
	4 doses	10.17b	6.22a	2.96a	188.3c	0.240a	10.50b	6.41a	3.01a	185.9d	0.242a
	5 doses	10.10b	6.332a	2.95a	193.1b	0.241a	10.32c	6.46a	3.04a	197.0b	0.244a
	6 doses	9.70c	6.23a	2.94a	197.4a	0.240a	9.80d	6.35ab	3.00a	199.0a	0.240a
120	3 doses	8.80d	5.80b	2.73a	169.4g	0.243a	9.16e	5.90d	2.96a	173.0j	0.245a
	4 doses	8.60ef	5.91b	2.79a	173.9f	0.243a	8.80f	6.11c	2.90a	177.0i	0.246a
	5 doses	8.73de	5.81b	2.82a	178.5e	0.244a	8.80f	6.22bc	2.94a	183.4f	0.245a
	6 doses	8.53f	5.82b	2.76a	178.2e	0.242a	8.63f	6.11	2.98a	191.0c	0.245a

* Values marked with the same alphabetical letter (s), within a comparable group of means, do not significantly differ, using revised L.S.D. test at 0.05 level.

those reported by Shahin et. al. (1999), who clarified significant increments on ascorbic acid and K contents in pepper fruits as a result of N fertilization. Gabr et. al. (2001) reported that application of N at 40, 80 Kg N fed⁻¹, significantly, increased fruit dry weight, K, total soluble solids and ascorbic acid contents over the unfertilized control. It was evident that the higher the application of N to sweet pepper plants, the lower was the fruit quality. The negative relationship between N application and some quality characteristic could be attributed to that, under high N conditions greater amount of carbohydrates probably directed and utilized in maintaining vigorous vegetative growth and a little proportions may be left to supply the growing fruits with sufficient carbohydrates. Such a result could be supported by the findings obtained by Somos (1984), Gabr et. at. (2001) and Bosland and Votava (1990), who reported that super optimal N application produce large plants and cause clear reduction in fruit quality.

Respecting the effect of N application system on fruit quality, data in Table (6) shows, clearly, that splitting the amount of N applied up to six doses did not reflect any significant differences on fruit K, ascorbic acid and titratable acidity contents, in both seasons. Increasing split applications of N fertilizer more than 3 doses, significantly, increased fruit TSS content. However, the differences among 4, 5 and 6 doses with respect to TSS content were not significant, in both seasons. On the other hand, the highest significant mean values for fruit dry matter were recorded from the plants which received three N doses whereas, the lowest fruit dry matter content was produced from the application of N at six doses. These results, in general, were compatible with those obtained by Dod et. al. (1983), who showed that the highest fruit ascorbic acid content was obtained by applying N in 4 equal split doses; at transplanting and 30, 51 and 72 days later. Frontela and Morejon(1988) reported that the highest fruit ascorbic acid content was obtained by applying 25% of N at sowing followed

by six after 40 – 45 days and after 70 – 75 days. Recently, Feleafel (2005) reported that split application of N fertilizer did not reflect any significant effect on TSS and firmness of eggplant fruits.

Data in Table (6) revealed also that the interaction effects between N rates and application systems exhibited significant differences on some quality characters of pepper fruits, in the two seasons. The exceptions were for both K and titratable acidity contents, where the differences were not so high enough to be significant. The treatment combination (90 kg N fed⁻¹ added at 3 doses) recorded the highest significant fruit dry matter content. In the case of TSS, the highest content was resulted from the treatment 90 Kg N fed⁻¹ added at five doses, in both seasons. However, plants received 90 Kg N at six doses produced fruits with highest ascorbic acid content. The obtained result, in general, agreed with those recorded by Feleafel (2005) on eggplant.

In conclusion, the present investigation clearly indicated that, the combination treatment of 90 kg N fed⁻¹ when applied at 6 applications; at transplanting, 4, 6, 8 , 10 and 12 weeks after transplanting was the most efficient combination treatment, which favored the production of high total yield with acceptable fruit quality under the conditions of this experiment.

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الملخص العربي تأثير التسميد النيتروجيني ونظم إضافته على النمو الخضري ومحصول وجودة ثمار الفلفل الحلو

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أجريت دراسة حقلية خلال الموسم الصيفي لعام 2000 – 2001 بالمزرعة التجريبية لكلية الزراعة جامعة الإسكندرية بهدف دراسة تأثير ثلاث معدلات من التسميد النيتروجيني (60، 90، 120 كجم ن / فدان)، وطريقة إضافة كل منها إما على ثلاث دفعات (عند الشتل و بعد 4 و6 أسابيع من الشتل) أو على أربعة دفعات (عند الشتل وبعد 4 و6 و8 أسابيع من الشتل) أو على خمسة دفعات (عند الشتل وبعد 4، 6، 8، 10 أسابيع من الشتل) أو ستة دفعات (عند الشتل وبعد 4، 6، 8، 10، 12 أسبوع من الشتل) على صفات النمو الخضري ومحصول وجودة الثمار لنباتات فلفل الحلو صنف كاليفورنيا وندر. أوضحت النتائج أن زيادة معدل السماد النيتروجيني المضاف قد صاحبه زيادة معنوية في صفات النمو الخضري معبرا عنها بارتفاع النبات وعدد الأوراق والمساحة الورقية والوزن الجاف للمجموع الخضري للنبات، هذا بالإضافة إلى أن أعلى جهد محصولي معبرا عنه بمحصول النبات وعدد الثمار للنبات ومتوسط وزن الثمرة وأفضل جودة للثمار معبرا عنها بمحتوى الثمار من المواد الصلبة الذائبة الكلية وحمض الاسكوربيك ومحتوى الثمار من البوتاسيوم والوزن الجاف للثمار كان متلازما مع إضافة السماد النيتروجيني حتى 90 كجم ن / للفدان ولقد أدى زيادة عدد مرات الإضافة للمعدل الواحد من التسميد النيتروجيني خلال موسم النمو حتى ستة دفعات إلى زيادة معنوية في صفات النمو الخضري معبرا عنها بارتفاع النبات وعدد الأوراق والمساحة الورقية والوزن الجاف للمجموع الخضري للنبات، ولقد استجاب معنويا بصورة موجبة كل من المحصول الكلي للنبات وعدد الثمار للنبات ومتوسط وزن الثمرة ومحتوى الأوراق من النتروجين وبعض صفات الجودة للثمار بينما لم يتأثر محتوى الأوراق من الفوسفور والبوتاسيوم في حين انخفض المحصول المبكر بزيادة عدد مرات الإضافة للنتروجين، أما بالنسبة لتأثير التداخل بين التسميد النيتروجيني وطرق إضافته فقد عكس اختلافات معنوية لمعظم الصفات المدروسة، ويعتبر معدل التسميد الازوت 90 كجم ن للفدان عند إضافته على ستة دفعات (عند الشتل وبعد 4، 6، 8، 10، 12 أسبوع من الشتل) أفضل المعاملات العاملة كفاءة والتي أعطت أفضل محصول من الفلفل الحلو ذو صفات جودة مقبولة.