Assiut J. of Agric. Sci., 39 (3) (51-61)

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

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Abstract: Two field experiments were conducted on sweet pepper plants (cv. California Wonder) during the consecutive summer seasons of 2006 and 2007, at El-Qaten region, Hadramout Governorate, Yemen. The objective of these experiments was to determine the effects of nitrogen fertilization rates (60, 90 and 120 Kg fed^{-1}) and their application systems (three, four, five and six split doses), on vegetative growth, and fruit yield 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}) seemed to be associated with the application of 9o 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 $^{-1}$. Total fruit yield plant^{-1}, number of fruits plant^{-1} and average fruit weight characteristics were positively and significantly responded to the frequent N applications up to 5 or 6 doses. However, early yield was significantly decreased. The interaction between N rates and their application systems reflected significant differences for most of the studied characters, and revealed that the rate of 9o kg N fed^{-1} applied at six split doses; at transplanting, 4,6,10 and 12 weeks after transplanting, appeared to be the most effective combination treatment, which favored the production of high yield.

Key words: pepper, nitrogen, application systems, vegetative growth, fruit yield.

Introduction

Nutrition of pepper plants in general and with nitrogen in particular have been focused by Johnson and Decoteau, (1996). A positive relationship has been emphasized between the available amount of N in the soil and the vegetative growth characteristics of pepper (Mishriky and Alphonse, 1994; Shahin *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 Alponse, 1994; Johnson and Decoteau ,1996; 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 (Bosland and Votava, 1999).

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, 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).

However, addition the proper amount of N at the suitable time is of a great interest to enhance yield 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, and yielding ability of sweet pepper.

Materials and Methods

Two field experiments were carried out during the summer seasons of 2006 and 2007 at El-Qaten region, Hadramout governorate. 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 physical and chemical characteristics of the experimental site in 2006 and 2007 seasons.

Season	Physical properties				Chemical properties					
	Sand (%)	Silt (%)	Clay (%)	Texture	EC (dsm^{-1})	pH	T.N (%)	P K(ppm) (%)		O.M (%)
2006	59.0	33.0	8.0	Sa.Loom	6.1	7.8	0.08	2.71	1.3	0.33
2007	55.0	32.0	12.0	Sa.Loom	6.7	7.5	0.13	2.81	1.4	0.29

Sweet pepper seeds of California Wonder cultivar were sown in the nursery on January 3, 2006and January 8, 2007. Uniform seedlings of 45 days old were transplanted into the field in rows 4 meters long. The inter- and intra-row spacings were 40 and 70 cms, 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 2006 and 2007.

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	-
		20	20	20	20	20	20

***WAT :Weeks after transplanting.**

The N application, in all treatments, was in the form of urea (46% N) whereas; the phosphorous and potassium fertilizers at the rate of 50 kg P_2O_5 and 50 kg K_2O fed^{-1}, orderly was applied during soil preparation. 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 m^2 .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 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, 5 plants were taken from each experimental unit, 95 days after transplanting, was collected and the following vegetative measurements were recorded and averaged to obtain; plant height (cm), number and area of leaves $plant^{-1}$ (cm^2) and foliage dry mass $plant^{-1}$(g)

2- Fruits yield and its components

Picking of the fruits in 2006 and 2007 seasons started on July 12 and July 16, respectively at 6 days interval and terminated 56 and 63 days later, orderly. The following measurements were included early fruits yield $plant^{-1}$(weight of the first four pickings), number and weight of fruits $plant^{-1}$ and average fruit weight.

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 to120 kg N fed^{-1} resulted in corresponding and significant increases in all of studied vegetative growth characters, i.e. plant height, number of leaves, leaf area and dry mass $plant^{-1}$, in 2006 and 2007 seasons. The exception was in 2007 season, where the differences between the application of 90 and 120 kg N fed^{-1} regarding foliage dry mass and number of leaves $plant^{-1}$ were not significant. Such a positive effect of N could be explained on the basis that the determined amounts of available N in the soil were between 0.08 and 0.13% in 2006 and 2007 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 2006 and 2007 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 resulted in 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 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 the 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 split 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.

Fruits yield and its components

Data in Table (4) 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. Also, in the 2nd season the difference between 90 and 120 kg N fed^{-1} regarding no. of fruits plant^{-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 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 (4) 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 three or four doses of 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, 4). At any N level, increasing number of split applications, significantly, incr-eased, 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 among the twelve treatment combinations, generally, indicated that pepper plants receiving 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 /or120 kg N fed^{-1}at the varying application systems, in both seasons. However, the differences between five and six spilt 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 three split doses, significantly, produced the highest early yield plant^{-1}, in both seasons. The noticeable 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.

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 fruit yield under the conditions of this experiment.

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تأثير التسميد النيتروجينى ونظم إضافته على النمو الخضري ومحصول ثمار الفلفل الحلو

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أجريت دراسة حقلية خلال الموسم الصيفي لعامي 2006 – 2007بمنطقة القطن محافظة حضرموت بهدف دراسة تأثير ثلاث معدلات من التسميد النيتروجينى (60،90،120كجم ن / فدان)، وطريقة إضافة كل منها إما على ثلاث دفعات (عند الشتل و بعد 4و6 أسابيع من الشتل) أو على أربعة دفعات (عند الشتل وبعد 4و6و8 أسابيع من الشتل) أو على خمسة دفعات(عند الشتل وبعد 4 و6 و 8و 10 أسابيع من الشتل) أو ستة دفعات(عند الشتل وبعد4 و6 و 8و 10و 12 أسبوع من الشتل) على صفات النمو الخضري ومحصول الثمار لنباتات الفلفل الحلو صنف كاليفورنيا وندر. أوضحت النتائج أن زيادة معدل السماد النيتروجينى 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 كان متلازما مع إضافة السماد النيتروجينى حتى 90 كجم ن / للفدان.

ولقد أدى زيادة عدد مرات الإضافة للمعدل الواحد من التسميد النيتروجينى 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 الكلى للنبات وعدد الثمار للنبات ومتوسط وزن الثمرة في حين انخفض المحصول المبكر بزيادة عدد مرات الإضافة للنتروجين ، أما بالنسبة لتأثير التداخل بين التسميد النيتروجينى وطرق أضافته فقد عكس اختلافات معنوية لمعظم الصفات المدروسة، ويعتبر معدل التسميد الازوتى 90 كجم ن للفدان عند إضافته على ستة دفعات(عند الشتل وبعد 4و6و8و10و12اسبوع من الشتل) أفضل المعاملات العاملية كفاءة والتي أعطت أفضل محصول من الفلفل الحلو.