

Growth and Yield Potential of Green Pepper as Affected by Nitrogen at Transplanting

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ABSTRAK

Anak benih cili hijau (*Capsicum annuum* L. cv. Lady Bell) yang berumur 7 minggu diubah ke ladang. Kadar N berikut telah digunakan: 112, 224, 336 dan 448 kg/ha. Kadar N yang tinggi diberikan ketika mengubah tidak merangsangkan pertumbuhan tampang sebaliknya telah merencatkan pertumbuhan pokok terutama sekali pada jangkamasa awal pertumbuhan. Pertambahan kadar N menyebabkan hasil buah awal dan jumlah buah yang kurang. Hasil awal berkorelasi positif dengan berat kering pokok. Menggandakan kadar N dari 112 kepada 224 kg/ha menambahkan 21% jumlah kudup bunga dikeluarkan tetapi peratus kejadian buah berkurangan dengan pertambahan kadar N. Kejadian buah mempunyai korelasi negatif dengan kandungan N dalam daun dan korelasi positif dengan berat kering pokok, menunjukkan bahawa kandungan N yang tinggi dalam pokok dan berat kering pokok yang rendah akan menjejaskan kejadian buah dan hasil cili hijau.

ABSTRACT

Green pepper (*Capsicum annuum* L. cv. Lady Bell) was grown for 7 weeks and transplanted into the field. The following rates of N were applied: 112, 224, 336 and 448 kg/ha. High N rates at transplanting did not stimulate vegetative growth but suppressed plant growth, particularly during the early growing period. As N rates increased, plants exhibited poor early growth and produced lower early and total fruit yields. Early yield positively correlated with plant dry weight. Doubling the N rate from 112 to 224 kg/ha resulted in a 21% increase in flower buds, but the percentage of fruit set decreased as N rates increased. Fruit set correlated negatively with total leaf N and positively with plant weight, suggesting that a high leaf N content and a lower plant weight were detrimental to fruit set and yield of green pepper.

INTRODUCTION

The problems of low fruit yield of green pepper are often related to poor fruit set. Poor fruit set may be due to incomplete pollination or effects of environmental factors such as moisture and nutrient stress. Nitrogen is known to be the most important nutrient affecting fruit yield in pepper. Nitrogen influences flower development of several vegetable crops including pepper, tomato and cucumber (Kinet *et al.* 1985). In tomato, high N increases flower formation but not fruit set (Garrison *et al.* 1967). However, the effect of N fertilizer upon flowering and fruit set of green pepper has produced contradictory results. Higher rates of N in-

creased the number of blossoms formed and fruit set (Cochran 1933), but Maynard *et al.* (1962) found that although high N rates increased fruit set, flower production decreased as the plant reached physiological maturity. Schmidt (1983) found that increased N did not affect the number of flower buds or fruit set.

Early N availability appears necessary for plant growth, fruit size and yield of pepper. The yield was greater with a single N application than split applications when plants were grown under mulch (Locascio *et al.* 1985). Similarly, fruit weight was heavier with preplant than with split applications when slow-release N fertilizers were applied (Wiedenfeld 1986). Improved N

availability during early growth increased fruit size. However, plants receiving excess N produced excess foliage and decreased yield (Stroehlein and Oebker 1979). Thus, the purpose of this experiment was to determine the effects of high nitrogen rates at transplanting on growth, fruit set and yield of green pepper.

MATERIALS AND METHODS

Green pepper (*Capsicum annuum* L. cv. Lady Bell) seeds were sown in 5 cm² cell size containing peat:vermiculite (2:1 v/v) in the glasshouse. Seedlings received no supplemental light and were fertilized 4 weeks after emergence with 3g of 20:20:20 (N:P:K). When the plants were 5 weeks old, they were hardened for 2 weeks. Uniform, 7-week-old seedlings were transplanted into a Flanagan silty clay loam (fine Montmorillonitic Mesic, 5% organic matter, cation exchange capacity of 23.5 meq/100 g, and a pH of 6.1). Plants were spaced 1.2 m apart in and between rows in a randomized complete block design, with four replications consisting of four rows of 40 plants. Prior to planting, 50 kg/ha of P and 300 kg/ha of K were broadcast and incorporated by disking. Urea was applied in a single application 3 days after transplanting at 112 (the recommended rate, (Gerber and Swiader 1985)), 224, 336 and 488 kg N/ha. Plots were irrigated with 1.25 cm of water immediately after fertilizer application.

Weeds were controlled with a preplant application of trifluralin (α -trifluoro-2,6-dinitro-N, N-dipropyl-p-toluidine) at 0.75 kg a.i./ha, with mechanical and manual cultivation as needed. Plots were sprinkler irrigated when necessary during the growing season.

The above-ground parts of 4 plants were sampled from each plot at three sampling dates during the growing season to determine plant growth response. Sampling dates were: 40 days after transplanting (40 DAT) when plants were setting fruits; after the second fruit harvest (70 DAT); and one week before the last harvest (100 DAT). Fresh weight and dry weight of plants (24 h, 70°C) were measured. At each sampling date, newly-expanded leaves were randomly collected for total N analysis. Leaves were washed with distilled water, dried, ground (100mg used), and total N (duplicate samples) determined by the method of Nelson and Sommers (1973).

Mature green fruits were harvested five times at 10-14 day intervals. The marketable fruits were counted, weighed and recorded. Diseased, chlorotic and small fruits were recorded as culls. Fruit yield data were based on 20 plants from each replication.

Three plants per replication were randomly selected to determine the number of flower buds produced and fruit set. Flower buds 3-4 mm in diameter were tagged and recorded for eight weeks. The number of marketable fruits, cull and small fruits left on the plant at last harvest were harvested and counted.

Data were analyzed by analysis of variance to test the effect of N levels on the various parameters. Comparisons between means were made by application of Fisher's least significant difference (LSD), where the F test indicated significant effects at 5% level. The relation between variables was determined using correlation coefficients.

RESULTS AND DISCUSSION

Plant Growth.

The effect of high N during early plant growth is critical. Once early growth was retarded, the plants did not recover very well as the season progressed. Plants grown with high N generally were relatively small at 3 sampling dates (Table 1), indicating that high N did not stimulate vegetative plant growth. Early plant growth, as shown by the first sampling date, was significantly suppressed by high N. At N rates higher than 224 kg/ha, the plant dry weights were significantly lower than those at lower N rates. Although plant height was not measured, we observed visually that plants grown with high N were short, bushy and very dark. Some leaves, particularly the lower ones, were chlorotic. Locascio *et al.* (1981) found that yield and dry weight of pepper plants were reduced when soluble N sources were broadcast at 308 kg/ha. A large amount of highly soluble N, when applied at transplanting, can be harmful to seedlings and reduce plant stand and early plant growth. Excessive N can result in excess soil salts, which probably is the major cause of plant growth reduction.

Plant dry weight increased as the season progressed (Table 1). There was no significant difference in plant dry weight measured at 100 days after transplanting at N rates lower than

336 kg/ha, indicating a slow recovery in growth for plants with high N at transplanting. Nitrogen may have been limiting at the lower N rates as the season progressed, whereas at higher N rates, more N was still available during the later part of the growing season.

TABLE 1
Effect of nitrogen levels at transplanting on dry weight of green pepper plants (g/plant)

N (kg/ha)	Days after transplanting		
	40	70	100
112	8.7 a	39.6 a	77.5 a
224	8.0 ab	39.8 a	76.5 a
336	7.9 b	34.2 b	75.6 ab
448	6.6 c	30.6 b	73.6 b

Values in a column followed by the same letter do not differ significantly at 5% by LSD test.

Fruit Yield.

Early fruit yield, as indicated by harvest 1 and 2, was significantly reduced by high N (Table 2). The number of marketable fruit decreased by 54 and 62% for the first harvest and by 26 and 53% for the second harvest as N was increased from 112 to 336 and 448 kg/ha, respectively.

Total fruit yield was significantly affected by N rates. Total marketable fruit weight per plant

decreased by 0.5 kg per plant (Table 2) as N levels were increased from 112 to 448 kg/ha. Total fruit weight correlated positively with the number of fruit ($r = 0.98$). The low total fruit weight at high N was due to fewer fruit per plant. Although no statistical differences were observed, pepper fruits were smallest in size at the highest N levels. However, fruits were darker green as N levels increased. High N levels are known to increase N content in plant tissues and improve fruit colour (Miller 1960).

The reduction in pepper fruit yield was influenced by the effect of N levels on early plant growth. In general, plants which showed vigorous early growth produced greater yields. When early growth was vegetatively affected due to high N at transplanting, less fruit was produced at early harvests and consequently less total yield was realized. When large amounts of highly soluble N fertilizer were applied early, plant growth was retarded and fruit yield was low (Locascio *et al.* 1981; Wiedenfeld 1986; Hochmuth *et al.* 1987). Total fruit number from harvest 1 and 2 correlated positively ($r = 0.73$) with plant dry weight (Table 2). This indicates that more fruits were produced by plants which had greater dry weight.

Flowering and Fruit Set

Nitrogen rates influenced flower bud production (Table 3). Doubling the N rate from 112 to 224 kg/ha resulted in increased flower buds from 118.4 to 143.5 (or 21%) per plant. Nitrogen rates greater than 224 kg/ha did not result

TABLE 2
Effect of nitrogen levels at transplanting on marketable fruit yield of green pepper

N (kg/ha)	No. of fruits/plant		Total marketable fruits/plant		Av wt/ fruit
	Harvest 1	Harvest 2	No.	Wt(kg)	(g)
112	1.6 a	1.9 a	16.7 a	2.1 a	125.7 a
224	1.4 a	1.7 ab	16.9 a	2.2 a	130.2 a
336	0.7 b	1.4 b	15.8 ab	2.1 a	132.9 a
448	0.6 b	0.9 c	13.3 b	1.6 b	120.3 a

Values in a column followed by the same letter do not differ significantly at 5% by LSD test.

TABLE 3
Effects of nitrogen levels at transplanting on number of flower buds and fruits and fruit set per plant of green pepper

N (kg/ha)	Flower buds/plant (no.)	Fruits/plant (no.)	Fruit set (%)
112	118.4b	41.8a	35.3a
224	143.5a	38.4ab	26.9b
336	129.4b	35.0b	27.1b
448	144.6a	33.1c	22.8c

Values in a column followed by the same letter do not differ significantly at 5% by LSD test. Total fruit includes marketable, cull and small fruits left on the plant after harvest.

in a further increase in the number of flower buds.

Fruit set is defined as fruit number relative to flower bud number. The number of fruits produced did not increase as flower buds increased. The number of buds increased with increased N rates. However, fruit number and fruit set per plant significantly decreased as N rates were increased from 112 kg/ha to 448 kg/ha. This is a 35 % reduction in fruit set. A similar result was also found with tomato where flower formation (but not fruit set) increased with high N rates (Garrison *et al.* 1977).

The difference between flower bud formation and fruit production induced by high rates of N indicates that excessive N at transplanting promotes bud production but is detrimental to fruit set. A large number of flowers was lost at higher N rates. However, these losses may have been compensated for by plants producing more flower buds initially. The plants are capable of utilizing the additional N by producing more flower buds, but cease to produce fruit set and develop. Furthermore, since fruits were allowed to grow until they reached the mature green stage, the strong sink effects from developing fruits caused more flower abscission before fruits were set or induced more young fruits to abort.

Leaf N Content. Regardless of N treatment, total leaf N was high at early plant growth stage and gradually decreased over the season (Table 4).

TABLE 4
Effect of nitrogen levels at transplanting on total leaf nitrogen in green pepper

N (kg/ha)	Days after transplanting		
	40	70	100
	%N		
112	4.6c	4.4c	2.7d
224	4.7b	4.6b	2.8c
336	4.9a	4.9a	3.0b
448	4.9a	4.9a	3.1a

Values in a column followed by the same letter do not differ significantly at 5% by LSD test.

Total N ranged from 4.6 to 4.9% at 40 days and 2.7 to 3.1% at 100 days after transplanting. As the season progressed, plants increased in size, and N concentration declined due to its dilution with rapidly accumulating carbohydrate products of photosynthesis (Knavel 1977).

Thomas and Heilman (1964) reported that the critical level of leaf N was about 4% and N deficiency symptoms were observed when leaf N concentration was 3.8 to 4%. Leaf N was greater than 4.4% at the first two sampling dates for all treatments. However, it decreased markedly towards the end of the growing season. Some N deficiency symptoms were observed on plants at the low N rates at the final sampling date.

A negative correlation was found between leaf N concentration and the total number of fruits per plant ($r = -0.69$). The number of fruit at the first ($r = 0.65$) and second ($r = -0.64$) harvests correlated negatively but significantly with leaf N concentration sampled at 40 days. Fruit set correlated with leaf N content ($r = -0.57$) negatively and positively with plant dry weight ($r = 0.78$). This suggests that N concentration during early plant growth influenced early fruit production. External N levels were effective in modifying the internal N levels which apparently influenced the fruit set.

CONCLUSION

The study shows that application of high amounts of N at transplanting is not recommended for

pepper fruit production and could be a concern for pepper growers. Providing high N at the early plant growth stage was detrimental to fruit set and yield.

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