EFFECT OF NITROGEN FERTILIZER ON VEGETATIVE AND REPRODUCTIVE GROWTH OF PEPPER PLANTS UNDER FIELD CONDITIONS

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The present research was carried out to evaluate response of paprika pepper (Capsicum annum L.) to nitrogen (N) fertilizer under field conditions. Nitrogen was supplied in four levels (0, 50, 100 and 150 kg ha\(^{-1}\)). Plant height, leaf chlorophyll content, fruit weight, yield, seed number, 1000 seed weight and vitamin C were assessed at immature and mature stages. The results showed that plant height, lateral stem length and leaf chlorophyll content were influenced by N fertilizer. Data indicated that fertilization with 50 g N ha\(^{-1}\) resulted to the best yield and quality components at ripening stage. Although, there was no significant difference in vitamin C content among treated plants with different nitrogen levels at mature stage, but significant differences were shown between treated plants and control. Thus, these results showed that fertilization with 50 kg N ha\(^{-1}\) had strong impact on vegetative and reproductive growth of paprika pepper under field conditions.

Keywords: nitrogen, vegetative growth, yield, fruit quality, pepper

INTRODUCTION

Pepper (Capsicum annum L.) which belongs to Solanaceae, is known as a vegetable, and consumed both as fresh and dehydrated spices (Bosland and Vostava, 2000). Paprika pepper is good source of vitamins A, C, E, B\(_1\) and B\(_2\), potassium (K), phosphorus (P), and calcium (Ca). Moreover, it is one of the valuable medicinal plants in pharmaceutical industries because of high amounts of antioxidant, capsaicin and capsantin as main active substances.

Practical managements such as transplant age, plant nutrition, plant population, and harvest time influence pepper yield (Dennis et al., 1994).
Nitrogen (N) is a major constituent of several of the most important substances which occur in plants. It is of outstanding importance among the essential elements in the N compounds comprise from 40 to 50% of the dry matter of the protoplasm, the living substance of plant cells (Togun et al., 2003). Nitrogen is known to promote production, partitioning and accumulation of dry matter in crop plant (Akanbi et al., 2007). Law-Ogbomo and Egharevba (2009) observed that N fertilizer is an essential component for good yield and fruit production of tomatoes. Tumbare et al. (2004) reported that N fertilizer increased fruit weight, yield and fruit number of chilli peppers. Aroiee and Omidbaigi (2004) reported that N fertilizer increased leaf chlorophyll and had a linear relationship between leaf chlorophyll content and leaf nitrogen concentration. It is well known that adequate N is required by pepper for satisfactory growth, development and yield. Thus the main aims of this experiment were to find the best nitrogen level for paprika pepper cultivation under field status.

MATERIALS AND METHODS

Plant Preparation

The field experiment was conducted in 2005 at Birjand University of Iran (latitude 32°53’ N, longitude 59°13’ E and 1470 m elevation). Soil sample (0–30 cm depth) was taken with an auger for some physical and chemical analysis after the site had been prepared for cultivation. Soil texture was determined by hydrometric method (Bouyoucous, 1951). Total N was determined by sulfuric acid digestion using copper sulfate (CuSO₄) and potassium sulfate (K₂SO₄) as catalyst. Total N in the digest was determined by the regular Kjeldahl distillation method and the available phosphorus was measured by atomic absorption spectroscopy (Chapman and Pratt, 1961). Also the soil K was measured by a flame photometer (PEP7 and PEP7/C, Jenway, Stone, UK). The pH of soil samples were measured in distilled water [soil: water, 1:2.5 (v/v) ratio] after shaking the solution for 30 min by means of a pH Meter (CD 510, WPA) fitted with a glass electrode and soil data analysis shown in Table 1. Paprika pepper seeds were established in a greenhouse in large trays with a 1:1 mixture of sand and peat (1:1 v/v)

<table>
<thead>
<tr>
<th>Soil factors</th>
</tr>
</thead>
</table>
| N (ppm)      | 630  
| P (ppm)      | 14   
| K (ppm)      | 290  
| pH           | 7.1  
| Clay (%)     | 19   
| Silt (%)     | 41   
| Sand (%)     | 40   

TABLE 1 Soil characteristics of experimental field
Effects of Nitrogen on Pepper

on the 26th March, 2005. Irrigation was done after sowing when necessary. After four weeks, the seedlings were transplanted to well-prepared beds in the field. The plants spaced at 75 and 25 between rows and plants on row, respectively. All practical managements included mulching; weeding, staking and other horticultural operations were done traditionally.

**Treatments**

Treatments consisted of four levels of N (0, 50, 100 and 150 kg ha\(^{-1}\)) that were split into three equal parts and applied at ten days after transplanting (DAP) as basal and remaining portions were used as top dressing at 30 and 50 DAP.

**Measurements**

Five plants in each replication were used to assess plant height, leaf number, number and length of lateral stems at three growing stages including vegetative, flowering and fruiting. Leaf chlorophyll content was measured by a portable chlorophyll meter (SPAD – 502, Minolta Corporation, Ramsey, NJ, USA). Leaf samples were oven dried at 70\(^{\circ}\)C for 48 h and leaf dry weight for each plant was obtained. Days to 50\% flowering were estimated for each plot and number of flowers per plant was evaluated based on the method by Remison (1997). Mature fruits were harvested at weekly intervals to assess the number and volume of fruits (cm\(^{3}\)), average fruit weight (g) and fruit yield per plant (g plant\(^{-1}\)). Vitamin C was determined by titration of fruit juices with Indophenol Method and indicated as mg ascorbic acid per 100 mL (AOAC, 2000).

**Experimental Design and Statistical Analysis**

The experiment was arranged in a completely randomized block design (CRBD) with four treatments and three replications, each replication with five plants. Data were analyzed using MSTAT-C (Michigan State University, East Lansing, MI, USA) and means were compared by Duncan’s multiple range test (DMRT) at 5\% level of confidence.

**RESULTS AND DISCUSSION**

Data (Tables 2–5) showed that N fertilization significantly affect pepper growth, yield and fruit quality.

**Vegetative Growth**

Results indicated the lowest plant height by control plants at vegetative, flowering and fruiting stages (Table 2); however, no significant difference
### TABLE 2: Effect of nitrogen fertilizer on vegetative characteristics of paprika pepper

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>Lateral stem length (cm)</th>
<th>Lateral stem no. (veg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (control)</td>
<td>18.59  b</td>
<td>26.42 b</td>
<td>37.84 c</td>
</tr>
<tr>
<td>50 kgN</td>
<td>20.00  a</td>
<td>29.26 a</td>
<td>40.17 b</td>
</tr>
<tr>
<td>100 kgN</td>
<td>19.92  a</td>
<td>29.76 a</td>
<td>40.42 ab</td>
</tr>
<tr>
<td>150 kgN</td>
<td>20.09  a</td>
<td>28.34 ab</td>
<td>41.67 a</td>
</tr>
</tbody>
</table>

No.: number, veg.: vegetative stage; flower: flowering stage; rep.: reproductive stage. Within each column, same letter indicates no significant difference between treatments at 5% levels.

### TABLE 3: Effect of nitrogen fertilizer on leaf number and leaf chlorophyll content of paprika pepper

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Leaf number</th>
<th>Leaf chlorophyll (SPAD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (control)</td>
<td>23.92 b</td>
<td>82.76 c</td>
</tr>
<tr>
<td>50 kgN</td>
<td>25.42 ab</td>
<td>86.09 b</td>
</tr>
<tr>
<td>100 kgN</td>
<td>25.76 a</td>
<td>87.51 b</td>
</tr>
<tr>
<td>150 kgN</td>
<td>26.09 a</td>
<td>90.76 a</td>
</tr>
</tbody>
</table>

Veg.: vegetative stage; flower: flowering stage; rep.: reproductive stage. Within each column, same letter indicates no significant difference between treatments at 5% levels.

### TABLE 4: Effect of nitrogen fertilizer on leaf dry matter content of paprika pepper

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Leaf dry matter content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Veg.</td>
</tr>
<tr>
<td>0 (control)</td>
<td>16.61 b</td>
</tr>
<tr>
<td>50 kgN</td>
<td>17.55 a</td>
</tr>
<tr>
<td>100 kgN</td>
<td>18.03 a</td>
</tr>
<tr>
<td>150 kgN</td>
<td>18.29 a</td>
</tr>
</tbody>
</table>

Veg.: vegetative stage; flower: flowering stage; rep.: reproductive stage. Within each column, same letter indicates no significant difference between treatments at 5% levels.

### TABLE 5: Effect of nitrogen fertilizer on reproductive characteristics of paprika pepper

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Node number to first flower</th>
<th>Days to 50% flowering</th>
<th>Flower number at lateral stem</th>
<th>Fruit number at lateral stem</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (control)</td>
<td>9.84 b</td>
<td>47.84 a</td>
<td>4.09 c</td>
<td>1.84 b</td>
</tr>
<tr>
<td>50 kgN</td>
<td>10.84 a</td>
<td>45.26 b</td>
<td>4.92 a</td>
<td>2.17 ab</td>
</tr>
<tr>
<td>100 kgN</td>
<td>11.09 a</td>
<td>43.76 b</td>
<td>4.76 ab</td>
<td>2.51 a</td>
</tr>
<tr>
<td>150 kgN</td>
<td>11.00 a</td>
<td>46.76 ab</td>
<td>4.42 bc</td>
<td>2.00 b</td>
</tr>
</tbody>
</table>

Within each column, same letter indicates no significant difference between treatments at 5% levels.
was found between three treatments: 50, 100 and 150 kg N ha\(^{-1}\) (at vegetative, flowering stages). The obtained results were in agreement with Bar-Tal et al. (2001), Bowen and Frey (2002), and Aroiee and Omidbaigi (2004). The lowest of height and number of lateral stem were observed in control (Table 2). The highest lateral stem length (12.17cm) and the number of lateral stems (11.17) were obtained at 100 kg N ha\(^{-1}\) (at vegetative stage), but there was no significant between three treatments: 50, 100, and 150 kg N ha\(^{-1}\) (Table 2). Height and growth rate of plant can be considered as one of the indices of plant vigor and it is clear that nutrients such as N have an important role increasing vegetative growth (Pervez et al., 2004).

As data shown, N fertilization increased leaf number (Table 3). The highest leaf number was related to the fourth treatment (150 kg N ha\(^{-1}\)) with 26.09 leaves (at vegetative stage) and 90.76 leaves (at reproductive stage), while the lowest was related to the control treatment with 23.92 and 82.76 leaves at vegetative and reproductive stages, respectively, which were in agreement with findings of Ayodele (2002) and Boroujerdnia and Alemzadeh Ansari (2007).

Data showed the lowest leaf chlorophyll content by control plants at all stages (vegetative, flowering and reproductive stages), but there was no significant between N levels at the mentioned stages (Table 3). Similar results have been reported by Bowen and Frey (2002), Aroiee and Omidbaigi (2004). A promotion effect of inorganic fertilizers on chlorophyll content might be attributed to the fact that N is a constituent of chlorophyll molecule and participate in amino acid constructions to make proteins that has a structural role in chloroplast (Basela and Mahadeen, 2008).

Nitrogen fertilizer at different levels increased leaf dry matter content (at all stages) compared with control (Table 4). The highest leaf dry matter content at all stages was obtained at 150 kg N ha\(^{-1}\) application (18.29%, 23.29% and 24.02%, respectively) while the least leaf dry matter content was related to control (16.61%, 19.46% and 20.42%, respectively). Similarly, Magdatena (2003) and Tei et al. (2000) reported that leaf dry matter content increased as N rate increased. Takebe et al. (1995) reported that increments in leaf dry weight may be due to a combination of N with plant matter produced during photosynthesis such as glucose, ascorbic acid, amino acids and proteins.

**Reproductive Growth**

The effect of N levels on the days to 50% flowering was significant (Table 5), which ranged from 45.26 to 47.84 days under different treatments. Thus N application accelerated the appearance of first flower and treated plants flowered earlier than control. The highest and lowest node numbers up to the first flower appearance were obtained at 100 kg N/ha with 11.09 nodes and control with 9.84 nodes, respectively (Table 5). Nitrogen
deficiency retarded the vegetative as well as reproductive growth, which resulted in longer periods needed to flowering and fruit setting. Similarly, the highest N level (150 kg ha\(^{-1}\)) also increased the day numbers up to flowering and fruit setting. It means N enhanced vegetative growth and reduced reproductive growth, therefore, a fertilizer dose of 50 kg N ha\(^{-1}\) proved better for minimum days to flowering, which leads to early fruit setting that were in agreement with findings of Satpal and Saimbhi (2003) and Law-Ogbomo and Egharevba (2009).

The highest flower and fruit numbers at lateral stems were obtained in 50 and 100 kg N ha\(^{-1}\), respectively compared with others (Table 5), which were in agreement with findings of Solvadore et al. (1997), Guohua et al. (2001) and Olaniyi (2008). Ali and Kelly (1992) suggested that the maintenance of vigorous vegetative growth from flower bud formation throughout fruit development might ensure sufficient assimilate supply to alleviate stress on growing processes in the developing buds. Increase of soil fertility delayed at the beginning of flowering and fruit set of sweet pepper, but increased total fruit yield (Shrivastava, 1996).

Total seed weight and 1000-seed weight significantly increased by N treatments compared with control; however, no significant difference was found between N levels (Table 6). Adequate supply of N is essential for vigorous vegetative growth, seed formation and increase 1000 seed weight and optimum yield of pepper which were in agreement with findings of Akanbi et al. (2007) and Olaniyi (2008).

Data showed the highest fruit weight (72.52 g) and the fruit volume (157.9 cm\(^3\)) from 50 and 100 Kg N treatments, respectively (Table 6), which were in agreement with Magdatena (2003), Akanbi et al. (2007) and Aujla et al. (2007). N fertilization significantly increased fruit number, yield per plant and total yield comparing to control, that were in agreement with Tumbare et al. (2004) and Law-Ogbomo and Egharevba (2009); however, these variables reduced by the highest level of N compared with others (Table 6). The highest (1120 g plant\(^{-1}\)) and lowest (944 g plant\(^{-1}\)) yield were obtained after application of 100 kg N ha\(^{-1}\) and with control,

### Table 6: Effect of nitrogen fertilizer on yield and fruit quality characteristics of paprika pepper

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Fruit f. w. (g)</th>
<th>Fruit vol. (cm(^3))</th>
<th>Seed no./fruit</th>
<th>1000 seed w. (g)</th>
<th>Vit-C (mg/100 g)</th>
<th>Yield/ fruit plant (g)</th>
<th>Fruit no./ plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (control)</td>
<td>64.59 c</td>
<td>141.7 c</td>
<td>125.3 b</td>
<td>5.02 b</td>
<td>131.7 c</td>
<td>198.3 b</td>
<td>944.0 c</td>
</tr>
<tr>
<td>50 kgN</td>
<td>72.52 a</td>
<td>152.1 ab</td>
<td>138.5 a</td>
<td>5.40 a</td>
<td>135.1 a</td>
<td>203.2 a</td>
<td>1111 a</td>
</tr>
<tr>
<td>100 kgN</td>
<td>72.51 a</td>
<td>157.9 a</td>
<td>139.7 a</td>
<td>5.42 a</td>
<td>135.5 a</td>
<td>204.2 a</td>
<td>1129 a</td>
</tr>
<tr>
<td>150 kgN</td>
<td>69.92 b</td>
<td>147.1 bc</td>
<td>141.3 a</td>
<td>5.26 a</td>
<td>133.0 b</td>
<td>201.2 ab</td>
<td>1029 b</td>
</tr>
</tbody>
</table>

F.w.: fresh weight; vol.: volume; w.: weight; no.: number; vit.: vitamin. Within each column, same letter indicates no significant difference between treatments at 5% levels.
respectively. The marked effect of N on fruit weight and yield might be due to its cumulative stimulating effect on vegetative growth, which forms the base for flowering and fruiting.

Although the lowest vitamin C was observed in control at green and red fruit stages, however it increased by different levels of N compared with control (Table 6). As the data shows, although N fertilizer affected fruit vitamin C content, the highest level of N reduced this variable at green and red stages compared with the lower levels (Table 6). This is in disagreement with Anita et al. (2009), who reported that increasing the rate of N increased vitamin C of pumpkin. Moreover, Mozafar (1993) reported the positive and negative effects of N on vitamin C contents by fruits.

CONCLUSION

Vegetative growth and yield components of pepper were affected by different N levels. Although there were no significant differences between N levels on almost all cases of variables, however, reproductive growth was improved with lower nitrogen levels. Thus, our study shows that application of low amounts of N (50 kg ha\(^{-1}\)) is recommended for paprika pepper production and could be a concern for growers.

REFERENCES


