Correlation of Tuber Yield with Yield Components of Potato Affected by Nitrogen Application Rate in Different Plant Density

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ABSTRACT

To investigate the study of effect nitrogen application rate in different plant density on correlation of tuber yield with yield components (Agria cultivar), a field experiment was carried out in Ardebil during 2009. The experimental design was factorial in the base of complete random block in three replication. Factors included nitrogen fertilizer rate (0, 80, 160 and 200 kg N ha$^{-1}$ as urea) and plat density (5.5, 7.5 and 11 plants m$^{-2}$). The resulted showed that the highest yield, number of stolon, harvest index, number of tuber and dry weight of tuber were obtained from application of 80 and 160 kg N ha$^{-1}$ (commonly). Increasing of plant density resulted in higher tuber yield, number of stolon, dry weight of tuber and total dry matter yield and decreased harvest index. Elevation of nitrogen fertilizer rate to 160 kg N ha$^{-1}$ mean tuber weight and total dry matter yield improved. Too, There were significantly positive correlation between tuber yield and whole treats, than, harvest index. To obtain highest yield and avoidance of environments pollution use of 80 kg N ha$^{-1}$ chemical fertilizer and density of 11 plants m$^{-2}$ are recommended.

Key words: Correlation, nitrogen fertilizer, plant density, potato, yield and yield components.

Introduction

Potato (Solanum tuberosum L.) is grown and eaten in more countries than any other crops, and in the global economy it is the fourth most important crop after the three cereals including maize, rice and wheat [16]. With increasing nitrogen application and plant density, potato yield is increases [4]. Plant density in potato affects some of important plant traits such as total yield, tuber size distribution and tuber quality [15]. Increase of plant density led to decrease of mean tuber weight but number of tuber and yield per unit area, was increased [13]. Increase of plant density decreases mean tuber size probably because of plant nutrient elements reduction, increase of interspecies competition and large number of tubers produced by high numbers of stems [9].

Marguerite et al. [12] showed that the mean maximum increase in total tuber yield, generated by N fertilizer against the zero-N treatment, was 34.3% and ranged from 10.5% to 54.7%, and in regard to potato, the improvement of N efficiency should be also achieved by splitting N fertilizer applications and by monitoring the crop N needs to match crop N requirements and mineral N supply throughout the growing season. Georgakis et al. [6] concluded that by increasing plant density, the tuber yield was increased. Karafyllidis et al. [8] reported that plant density strongly affected yield, both by number and by weight, and more tubers and yield per square meter were expected in higher plant densities. Alvin et al. [2] reported that with increasing plant density, yield of potato was increased. On the other hand, increase of plant density, probably is the reason of lack of nutrient elements for each plant or production of more tubers per unit area and reduction of their

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The aim of this study was to evaluate the effect of nitrogen application rate in different plant density on correlation of tuber yield with yield components in a potato crop (Agria cultivar) in order to determine the most suitable density and nitrogen level to achieve the highest yields.

Material and methods

In order to investigate the effect of plant density and nitrogen fertilizer on yield and yield components of potato tuber Agria cultivar, a factorial experiment based on randomized complete block design with three replications was conducted in the research Field of University of Mohaghegh Ardabili, Ardabil, Iran, in 2009. The first factor was nitrogen level (0, 80, 160, and 200 kg ha⁻¹), and the second was plant density (5.5, 7.5, and 11 plants m⁻²). It was given as urea form at two stages (namely, planting date and date of earthing up).

According to soil analysis results, the total nitrogen content was 0.56%, and the soil texture was sandy loam. The rows were spaced 60 cm apart, and the plots contained 6 rows each 3 meters long. In order to prevent nitrogen effects in adjacent plots (border effects), a 1.5 m border was made. Tubers of 60-70 grams were sown on 13 May 2009. The sowing depth was 12-13 cm. The last harvest was assigned for yield. To promote storage capability, ten days before harvest, the aerial parts were removed.

Sampling was done from 2 m² plot area, and then, tubers were transferred to the laboratory. Before measurements, tubers were washed along with roots and stolons. Different plant tissues were dried separately for 48 hours at 75°C and weighed. The harvest index was calculated as shown by:

\[
\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biologic yield}} \times 100
\]

Also, the total dry matter yield was calculated from the sum of dry matter of aerial and sub-ground parts. Results were analyzed by SAS software, and mean comparisons were done via Duncan's multiple range test and graphs were drawn by Excel software.

Results and discussion

Correlation:

The correlation (Table 1), it became clear that, except harvest index, there was a positive correlation between yield and other traits with each other and function. Among these traits, respectively, the average tuber weight, number and number of stolons and tuber had the highest correlation with yield and this result represents a very positive impact on these traits, which is increased tuber. Saeidi et al. [14] and Mahmoodi and Hakimian [11] also, quite similar to the test results were reported.

Number of Stolons:

Effects of plant density, nitrogen and their interaction effect on number of stolons per unit area was significant (P<0.01). Results (Table 2) showed that increase in number of stolons per unit area up to some points. The highest value of this trait for nitrogen levels jointly was observed at 80 and 160 kg ha⁻¹ and the lowest value, at control level. Increase in nitrogen application increases stolons including tuber but over increase reversely decreases them. In some studies, it was shown that number of stolons in favorite nitrogen levels was significantly more than other levels [9]. Also, increase in plant density significantly caused an increase in number of stolons per unit area (Table 2).

The most and the least number of stolons were gained at 11 and 5.5 plants m⁻², respectively. The most rate of this trait as affected by plant density × nitrogen levels was obtained at 80, 160 kg ha⁻¹ nitrogen and 11 plants m⁻² and the least one, at 5.5 plants m⁻² and control nitrogen level (Fig 1).

Number of Tubers:

Number of tuber per unit area for nitrogen level and plant density was significant (P<0.05). As shown in Table 2, nitrogen level up to definite point had the incremental effect of this trait and then, led to decrease of it. Khajehpour [9] approved increase in number of tuber with increasing nitrogen fertilizer. According to the Table 2, increase in plant density resulted in an increase in number of tuber so, densities of 7.5 and 11 plants m⁻² jointly were at highest value and 5.5 plants m⁻² placed after them. Increase in number of tuber occurred as a result of increase in number of stolons and increase of density, increasing stolons, eventually increased tuber yield. It was cleared that with increasing plant number, number of stems grown from the planted. Tuber, and consequently, number of produced tuber per stem, is increased. Thus, increase of plant density leads to increase of produced tubers [9].

Tuber Yield:

Effect of plant density and nitrogen level was significant (P<0.01) on tuber yield. Results showed that increase in nitrogen rates up to some point led to an increase in tuber yield per unit area. The highest valued of this trait affected by nitrogen were obtained at 80 and 160 kg ha⁻¹ and the lowest one
was belonged to control. With increasing nitrogen application, number of stolons including tuber, number of tubers and consequently, yield were increased. Over application of tuber and consequently, yield were increased over application of nitrogen may resulting decrease of yield. This may attributed to fact that in such conditions, vegetative growth of the aerial parts can increase and hence, prevented transferring photosynthetic matters in to the storage parts (tubers). Marguerite et al. [12] and Alam et al., [1] revealed that tuber yield per unit area was increased with increasing nitrogen fertilizer up to suitable level. Also, increase in density led to significant increase in tuber yield so that, the most and the least tuber yield was achieved at 11 plant m⁻² and at 5.5 and 7.5 plant m⁻², respectively (Table 2). According to the Arsenault et al. [4], in at high densities, number of tuber and yield of potato is increased.

**Tuber Dry Weight:**

Effect of plant density and nitrogen level on this trait was significant (P<0.01). Based on the results, area. This trait is changed under various nitrogen applications [13]. Increase of tuber dry weight is probably because of increase in number in number of stolon, number of tuber and tuber yield. About plant density, it was observed that increase in density caused significant increase in tuber dry weight, as well. The highest and the lowest tuber dry weight was gained at 11 plant m⁻², and jointly at 5.5 and 7.5 plant m⁻², respectively (Table 2). With regard to the matter that with increasing plant density, it number of produced tubers is increased [8] it can be said that increase of tuber may result in increase of tuber dry weight per unit area.

**Mean Tuber Weight:**

Effect of nitrogen (P<0.01) and plant density (P<0.01) was significant on mean tuber weight. With increasing nitrogen up to definite point, this trait was increased so, the highest value was obtained with application of 160 kg ha⁻¹ nitrogen. Meanwhile, control and 200 kg ha⁻¹ rates had significant effect on mean tuber weight. Also, it was seen that the lowest mean tuber weight was achieved at 7.5 and 11 plant m⁻² and the highest one was achieved at 5.5 plant m⁻² (Table 2). Increase of density probably causes the increase of in competition between and within plants and hence, leads to decrease in availability of nutrients to each plant and consequently, results in decline of mean tuber weight (karafyllidis et al., 1997). Applied nitrogen less affects number of tuber but more affects tuber size and increases it so, directly increases mean tuber weight but in case of excess rates of nitrogen, in applied, mean tuber weight is decreased [10].

![Fig. 1: Number of stolon in m² under interaction effect of nitrogen and plant density levels](image-url)
Table 1: Simple correlation coefficients between traits measured

<table>
<thead>
<tr>
<th>Traits</th>
<th>Tuber yield</th>
<th>Number of stolon</th>
<th>Number of tuber</th>
<th>Mean tuber weight</th>
<th>Total plant dry matter yield</th>
<th>Tuber dry weight</th>
<th>Harvest index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of stolon</td>
<td>0.652**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of tuber</td>
<td>0.629**</td>
<td>0.652**</td>
<td>1.00</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean tuber weight</td>
<td>0.761**</td>
<td>0.598**</td>
<td>0.426*</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total plant dry matter yield</td>
<td>0.368*</td>
<td>0.792**</td>
<td>0.426*</td>
<td>0.747**</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuber dry weight</td>
<td>0.442**</td>
<td>0.519**</td>
<td>0.426*</td>
<td>0.685**</td>
<td>0.722**</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Harvest index</td>
<td>0.292</td>
<td>0.567**</td>
<td>0.446*</td>
<td>0.409*</td>
<td>0.453*</td>
<td>0.500**</td>
<td>1.00</td>
</tr>
</tbody>
</table>

* and ** significant in 5 and 1% respectively.

Table 2: Effects of plant density and nitrogen levels on measured traits.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Number of stolon in m²</th>
<th>Number of tuber in m²</th>
<th>Mean tuber weight (g)</th>
<th>Total plant dry matter yield (kg m⁻²)</th>
<th>Dry weight of tuber (g m⁻²)</th>
<th>Tuber yield (g m⁻²)</th>
<th>Harvest index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen fertilizer doses (kg ha⁻¹)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>72.52c</td>
<td>63.86b</td>
<td>23.29b</td>
<td>0.9c</td>
<td>498.79b</td>
<td>2024.6b</td>
<td>68.79b</td>
</tr>
<tr>
<td>80</td>
<td>94.56a</td>
<td>93.35a</td>
<td>30.21ab</td>
<td>1.17b</td>
<td>669.95a</td>
<td>2994.1a</td>
<td>70.83a</td>
</tr>
<tr>
<td>160</td>
<td>96.83a</td>
<td>100.9a</td>
<td>33.67a</td>
<td>1.29a</td>
<td>728.18a</td>
<td>3174.6a</td>
<td>72.51a</td>
</tr>
<tr>
<td>200</td>
<td>86.98b</td>
<td>80.23ab</td>
<td>24.85b</td>
<td>1.12b</td>
<td>498.23b</td>
<td>2457.0b</td>
<td>67.49b</td>
</tr>
<tr>
<td>Plant density (plant m⁻²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.5</td>
<td>66.94c</td>
<td>77.12b</td>
<td>30.55x</td>
<td>0.91c</td>
<td>525.35b</td>
<td>2440.3b</td>
<td>72.24c</td>
</tr>
<tr>
<td>7.5</td>
<td>83.81b</td>
<td>81.62b</td>
<td>27.36ab</td>
<td>1.05b</td>
<td>580.32b</td>
<td>2473.8b</td>
<td>69.07b</td>
</tr>
<tr>
<td>11</td>
<td>112.42a</td>
<td>95.0a</td>
<td>26.11ab</td>
<td>1.4a</td>
<td>742.45a</td>
<td>3116.6a</td>
<td>68.4b</td>
</tr>
</tbody>
</table>

*Numbers with same words in each column, have no significant differences to each other.

Total Plant Dry Matter Yield:

Total plant dry matter significantly was affected by plant density and nitrogen (P<0.01). Results (Table 2) showed that application of nitrogen up to 160 kg ha⁻¹ resulted in increase of this trait and over rates caused decrease. Plant density had very positive effect. As seen in majority of traits, increase of nitrogen up to a distinct rate led to increase of total plant dry matter yield and afterwards. Alvin et al. [1] showed that with increasing density, plant dry matter was decreased in each plant but was increased per unit area. Approximately it can be said that all factors affecting tuber yield, affect total plant dry matter, as well [7].

Harvest Index:

Plant density and nitrogen level had the significant effect (P<0.01) on harvest index. With increasing plant density and nitrogen level, harvest index was decreased so that, density of 5.5 plant m⁻² caused the highest and densities of 7.5 and 11 plant m⁻² jointly, caused the lowest harvest index. Nitrogen levels of 80 and 160 kg ha⁻¹ made the highest and control and 200 kg ha⁻¹ mad the lowest harvest index (Table 2). Cox and Cherry [5] stated that with increasing density, harvest index was decreased. Another factor affecting harvest index is nitrogen.

Effect of this factor on harvest index is significant so that with increasing nitrogen application, this trait in increased. Effect of nitrogen on biological yield is higher than economical yield and this reason; harvest index is decreased [13].

Conclusions:

Totally it was observed that nitrogen rate of 160 kg ha⁻¹ caused increase of tuber yield. Since, 80 and 160 kg ha⁻¹ nitrogen had no significant difference to each other producing the highest tuber yield and number of tuber, so in order to prevent environmental pollutions and excessive costs, utilize of 80 kg ha⁻¹ nitrogen is recommended. Also, 11 plant m⁻² densities' producing the highest yield makes it suitable for planting.

REFERENCES