Evaluation of Tomato Yield Using Statistical Tests

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Abstract

The main objective of this study is to calculate the correlation existed between the NPK mineral fertilization doses on tomato yield using statistical tests (multiple regression analysis of variance, the F-test, value of R and R^2, Durbin–Watson test). A field experiment was using two tomatoes samples in different precocity steady (Export II and Ace Royal) cultivated in Romanian west area. Multiple regression analysis of variance on the influence of fertilization on the yield of Export II cultivar show that 90.28% of the production variability is due to the influence of these three macronutrients (NPK) while the yield of Ace Royal cultivar the percentage is 97.78%. The tomato yield increases with the fertilization doses and nitrogen fertilization has a major influence distinctly significant on achieving production, while the fertilization with potassium is lower but superior to phosphorus fertilization for two tomato cultivar.

Introduction

Consumption of vegetables and fruits is very important for human nutrition [2]. Tomato (*Lycopersicum esculentum*) is one of the popular and most consumed vegetable in the world. Romania produces about 745 thousands tons tomatoes/year, current average productivity is 16 - 18 tons per hectare (t/ha) [9]. Multiple regresion analiysis model provides not only a statistical test of the models ability to predict the outcome variable (the F-test), but also the value of R and the adjusted R^2 [1]. The Durbin-Watson statistic (DW) is a commonly used and routinely reported diagnostic test for the presence of first-order auto or serial correlation in the error of a time-series regression model [3]. Its value always lies between 0 and 4. A value of 2 indicates there appears to be no autocorrelation. If the Durbin-Watson statistic is substantially less than 2, there is evidence of positive serial correlation [3, 4].

Experimental

Fertilization was control (without fertilizers) and mineral fertilizers (NPK) in variable doses: $N_{30}P_{30}K_{30}$, $N_{45}P_{45}K_{45}$, $N_{60}P_{60}K_{60}$, $N_{120}P_{60}K_{60}$. Were use dry/granulated fertilizers NPK 15:15:15 and the nitrogen high dose supply with urea application. The fertilization doses and the application methods in tomatoes fertilization were to determine in correlations between agro chemistry factors [8].

Regression analysis is defined as another technique for measuring the linear association between x (independent variable) and y (dependent variable) and shown as ($Y=a+b_1X_1+b_2X_2+b_3X_3...+b_nX_n$) which is used extensively in forecasting. Multiple regresion analiysis model provides not only a statistical test of the models ability to predict the outcome variable (the F-test), but also the value of R and the adjusted R^2 [1, 7]. Data collected was subjected to analyses using statistical package ANOVA.

Results and discussions

The experience was done in a cambic cernosium soil, with low acidity reaction and the high natural fertility potential favorable vegetables cultivation. The analysis show that soil its favorable for tomatoes cultivation [6]. Liptay and al. [5] has showed that with increasing nitrogen fertilization doses increased tomatoes production. As can be observed from Figure 1, the tomato yield increases from control to highest fertilization doses for both varieties.

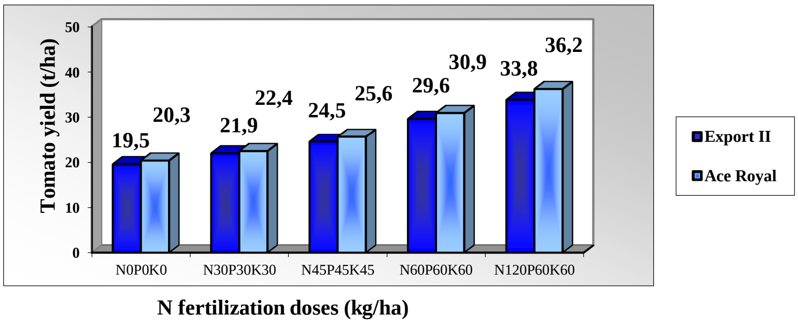

Figure 1. Tomato yield

Multiple regression analysis of variance on the influence of the three macronutrients on the yield of Export II tomato cultivar (Table 1) show that 90.28% of the production variability is due to the influence of the macroelements. Of these, it is observed that nitrogen fertilization has a major distinctly significant contribution (82.98%) to achieving the high yield, while potassium (15.15%) and phosphorus (1.87%) fertilization has small and very small influence on the production. Other sources, were not significant, and did not have much contribution to the tomato yield.

Table 1. The multiple regression analyses of variance between Export II cultivar production and nitrogen, phosphorus and potassium fertilization doses

Variability source	SP	GL	S^2	F test
Regression	168.22 (100%)	3	56.07	F = 65.20**
N dose (x_1)	139.59 (82.98%)	1	139.59	F = 162.31**
P dose (x_2)	3.12 (1.87%)	1	3.12	F = 3.62ns
K dose (x_3)	25.51 (15.15%)	1	25.51	F = 29.66**
Other sources	18.10	21	0.86	
Sum	186.32	24		

ns: non significant; *: significant; **: distinct significantly; ***: major distinct significantly

$y = 23.407 + 0.032x_1 + 2.546\ x_2 - 2.525\ x_3$; $R^2 = 0.9028$; R = 0.9501; SDE = 2.206 t/ha; DW = 3.06

The regresion model adopted for the analysis of relationships between production and different macroelements, shows a strong statistical assurance, assessing the production with an error of ±2.206 t/ha, while the estimated production without fertilization is about 23 t/ha. Because the DW index is 3.06, the any errors that accompanying experimental results are not autocorrelation and the macroelements order in the regression equation not affect the estimated production.

Eliminating the effect of phosphorus fertilization, on the results of multiple regression analysis of variance with two independent variables (Table 2) shows that 76.38% of Export II tomato yield is influenced by the effect of nitrogen and potassium doses applied.

In Figure 2 was noted that there is a linear relationship, positive and highly significant between the nitrogen doses applied and Export II tomato yield, such as the production increases proportionally with the nitrogen applied to 272.5 kg/ha, where obtaining the highest estimated tomato yield of 31 t/ha.

Table 2. The multiple regression analyses of variance between Export II cultivar production and nitrogen and potassium fertilization doses

Variability source	SP	GL	S^2	F test
Regression	142.30 (100%)	2	71.15	F = 35.52**
N dose (x_1)	139.58 (98.08%)	1	139.58	F = 69.79**
K dose (x_3)	2.722 (1.92%)	1	2.72	F = 1.36ns
Other sources	44.02	22	2.00	
Sum	186.32	24		

$y = 23.428 + 0.033x_1 + 0.019x_2$; $R^2 = 0.7638$; R = 0.8739; SDE = 2.887 t/ha; DW = 3.15

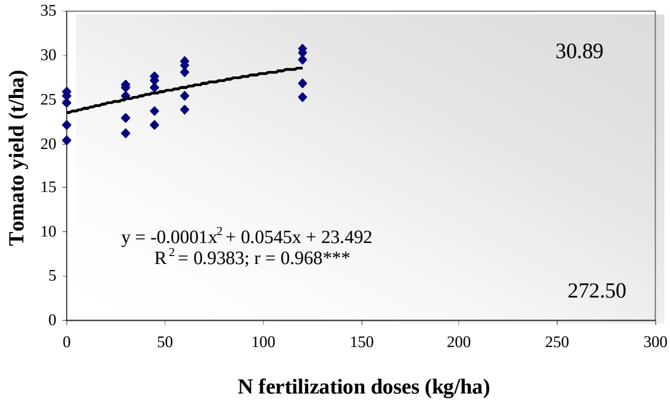

Figure 2. Regression between the production and nitrogen dose of Export II tomato variety

In Table 3 it is noted that 98% of the Ace Royal tomato yield can be explained as the result of NPK fertilization. The fertilization with nitrogen has a major influence distinctly significant on achieving production (78.64%), following the contribution with potassium (20.32%) and phosphorus (0.98%) fertilization.

Table 3. The multiple regression analyses of variance between Ace Royal cultivar production and nitrogen, phosphorus and potassium fertilization doses

Variability source	SP	GL	S^2	F test
Regression	203.69 (100%)	3	67.89	F = 188.60**
N dose (x_1)	160.20 (78.64%)	1	160.20	F = 445**
P dose (x_2)	1.97 (0.98%)	1	1.97	F = 5.47ns
K dose (x_3)	41.52 (20.32%)	1	41.52	F = 115.33**
Other sources	7.66	21	0.36	
Sum	211.35	24		

$y = 24.422 + 0.039x_1 + 2.686x_2 – 2.67x_3$; $R^2 = 0.9778$; R = 0.9888; SDE = 2.268 t/ha; DW = 2.99

According to the distinct significantly regression model, the control samples obtain a production about 24 t/ha, by an error about ±2.26 t/ha. DW coefficient values (2.99) indicate that the order of the three variables does not affect the results of estimated tomato yield [1].

Table 4. The multiple regression analyses of variance between Ace Royal cultivar production and nitrogen and potassium fertilization doses

Variability source	SP	GL	S^2	F test
Regression	177.84 (100%)	2	88.92	F = 58.50**
N dose (x_1)	176.20 (99.07%)	1	176.20	F = 115.92***
K dose (x_3)	1.64 (0.93%)	1	1.64	F = 1.08ns
Other sources	33.51	22	1.52	
Sum	211.35	24		

$y = 24.444 + 0.039x_1 + 0.015x_2$; $R^2 = 0.8414$; R = 0.9173; SDE = 2.359 t/ha; DW = 3.13

Considering only fertilization with nitrogen and potassium (Table 4), shows that these macrolements influenced by 84% the Ace Royal tomato yield, under a major distinct significant contribution of nitrogen (99.07%).
Figure 3 illustrates the result of the correlation between nitrogen fertilization doses and productions; the highest estimated Ace Royal tomato yield (35 t/ha) is obtained at the optimal dose of about 274 kg/ha.

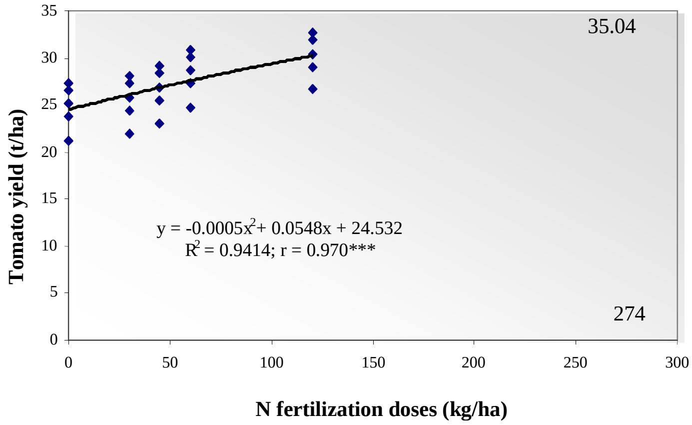

Figure 3. Regression between the production and nitrogen dose of Ace Royal tomato variety

Nitrogen was more efficiently exploited by Ace Royal tomato variety compared with the Export II variety, which on the optimal fertilization dose has achieved an increase of 4.0 t tomato/ha.

Conclusion

The tomato yield increases with the fertilization doses. The fertilization with $N_{120}P_{60}K_{60}$ determinate maximum tomato yield (34 t/ha for Export II variety and 36 t/ha for Ace Royal variety).
Using statistical methods show that the highest tomato yield (31 t/ha) is obtained at the optimal nitrogen dose of 272 kg/ha for Export II variety and for Ace Royal variety the highest estimated tomato yield (35 t/ha) is obtained at the optimal nitrogen dose of 274 kg/ha.
The nitrogen fertilization has a major influence on tomato yield, followed by fertilization with potassium and phosphorus by two tomato cultivars.

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