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# Survey Changes of Nitrate and Tuber Production of Potato under Integrated Management of Manure and Chemical Fertilizer in Different Locations of Isfahan, Iran

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## ABSTRACT

Nitrogen fertility management is a key component in potato (*Solanum tuberosum* L.). Production To investigate the effects of manure fertilizer and chemical fertilizer (Urea) on potato yield and nitrate content (Arinda cultivar), an experiment was conducted in 2014-2015 at two regions of Khorsgan and Faridan, Isfahan, Iran. A split plot layout in a randomized complete block design with four replications was used in each location. Manure fertilizer (0, 30 and 60 ton/ha) considered as main plots, and chemical fertilizer (0, 175, 350 and 525 kg/ha Urea) was used as sub-plots. Increasing the N fertilizer application rate from 0 to 60 kg Urea per ha generally resulted in increase of fresh and dry tuber yields, percentage of large tubers, and increase nitrate content of tuber. In most cases, tuber yield was significantly different between treatment of 60 kg/ha Urea and the other tow treatments. The maximum dry tuber yield was obtained in Faridan region with application of 60 ton/ha manure fertilizer and 525 kg/ha Urea. The number tuber and fresh tuber yield in Faridan region was higher than those values in Khorasgan region. The results of this research suggested that the use of animal manure not only reduces the deleterious effects of chemical fertilizer, but also increases the yield and yield components of potato. Applying 60 ton/ha manure fertilizer along with chemical fertilizer is necessary to achieve the highest performance and to protect the soil from degradation.

***Keywords***: Nitrate, Tuber production, Potato, Manure fertilizer, Chemical fertilizer.

## INTRODUCTION

Potato is one of the main and strategic agricultural products and stands in fourth position after wheat, rice, and corn. It has also a special role in feeding people of under developed and

developing countries (Liu *et al*., 2006; Ahmadi *et al*., 2011; Ploae *et al*., 2012; Ranjbar *et al*., 2012). Nitrogen as an essential nutritious element in plant structure has a vital role and among the essential elements for potato crop growth, has one of the most important role in LAI (Jalali, 2013; Soleymani *et al*., 2013; Arshadi *et al*., 2014; Shahrajabian and Soleymani, 2017). Excess N fertilizer can negatively impact tuber formation while also resulting in N leaching, leading to economic waste and environmental pollution (Soleymani and Shahrajabian, 2011; Soleymani *et al*., 2011; Soleymani *et al*., 2012; Shahrajabian and Soleymani, 2017). Accumulation of nitrates in plants is a complex process and depends on a number of factors, such as: genetic of the traits, soil and climatic conditions, fertilization and period of crop cultivation. The agronomic factor which mostly affects the accumulation of nitrates in plants is fertilization. High content of these compounds occurs mainly after excessive fertilization with nitrogen, introduction to soil with minerals or natural fertilizers (Shahrajabian *et al*., 2011; Zakikhani *et al*., 2016). Jafari (2014) reported the significant effect of manure fertilizer on tuber yield, average weight of tuber, number of tubers per plant, tuber weight per plant and nitrate content. Organic source of nitrogen can have more advantage than chemical fertilizers and also play an important role in maintaining soil organic compounds and improve plant health (Soleymani and Shahrajabian, 2012). So many researchers have reported the importance of animal manures as an appropriate source of nitrogen to provide nutrition to the growing crops (Nyiraneza and Snapp, 2007; Baghdadi *et al*., 2016). The aim objective of this research was to study the effects of different amount of nitrogen fertilizer from chemical source and organic manures on yield and nitrate content of potato in two regions of Isfahan in center of Iran.

## MATERIALS AND METHODS

In order to evaluate the influence of both chemical fertilizer (Urea) and cow manure fertilizer on yield, yield components and nitrate content of potato crop (Arinda cultivar), an experiment was conducted in 2014-2015 at two regions of Khorsgan and Faridan, Isfahan, Iran. The average mean temperature and rainfall in Khorsagan region (Latitude $32^{o}40^{/}$N, Longitude $51^{o}58^{/}$E, 1570 m elevation above sea level), is 17 $^{o}$C and 220 mm and for Faridan (Latitude $33^{o}10^{/}$N, Longitude $50^{o}29^{/}$E, 2300 m elevation above sea level) is $9^{o}$C and 335 mm. Soil texture at Khorasgan and Faridan field research stations were silt clay and clay loam, respectively. A split plot layout in a randomized complete block design with four replications was used, in each location. Manure fertilizer (0, 30 and 60 t/ha) considered as main plots and chemical fertilizer (0, 175, 350 and 525 kg Urea/ha) was used as sub-plots. The previous crop on the field in both location was barley. Each 4×6 m plot had six rows. On the basis of soil analysis manure fertilizers, and one third of nitrogen and were used before planting. One third of nitrogen was used with soil cultivation after planting and one third was applied at flowering stage. Seeds were hand planted. The distance between tubers in each row was 25 cm. The first irrigation was two days before plantation, the second irrigation was after planting and other irrigation intervals were 14 days. The normal agricultural practices took place whenever it was necessary according to the recommendations of

Iranian Ministry of Agriculture. Different phonological and morphological traits and components of yield were determined. Total fresh weight of the tubers and dry weight of sliced tubers were determined after drying at 85$^{o}$C for 24 h. Nitrate content (%) was measured for the tubers. Data were subjected to variance analysis by SAS statistical software. Duncan ,s multiple range tests at p=0.05 probability level was applied to compare the means.

## RESULTS AND DISCUSSION

The highest number of days from planting to germination, flowering and tuber formation was obtained for Faridan region. Except for the number of days from planting to tuber formation, for the other phonological data there was no significant difference between the two experimental locations. The maximum plant height (58.35 cm) and leaf area index (LAI) (2.89) was obtained in Faridan region, but no significant difference was observed between the two experimental locations. The highest number of stem per $m^2$ (47.52), the number of tuber per $m^2$ (39.64), fresh tuber yield (38157.3 g/$m^3$) and dry tuber yield (757.43 g/$m^3$) was related to Faridan region and their differences with Khorasgan region were significant (Table 1). The highest number of days from planting to germination, and tuber formation, plant height (58.31 cm), number of stem per $m^2$, and LAI (2.88) was obtained in application of 60 ton/ha of manure fertilizer, but this treatment had no significant differences with other treatments. The maximum and minimum number of days from planting to flowering was related to control treatment (0 ton/ha), and application 60 ton/ha manure fertilizer, how aver, they had no significant difference. Usage of 60 ton/ha manure fertilizer had the highest LAI (2.88), number of tuber per $m^2$ (40.50), fresh tuber yield (37859.4 g/$m^2$), and dry tuber yield (775.53 g/$m^2$). These values were significantly other treatments; however, there were no significant differences between control treatment and application of 30 to/ha for these traits. No significant differences was found among treatments for the number of days from planting to germination. The highest number of days from planting to flowering and tuber formation was achieved in application of 525 kg/ha Urea, followed by 350 kg/ha, 175 kg/ha and control treatments. Application of 525 kg/ha the highest values of plant height (59.79 cm), and the number of stem per $m^2$ (47.20). There were significant differences among chemical fertilizer treatments in both experimental station for most of the characters. The maximum LAI and the number of tuber per $m^2$ which were 3.11 and 42.79, respectively were obtained for application of 525 kg Urea per ha, which had significant differences with other treatments. The highest and the lowest fresh tuber yield were applied for application of 39697.9 kg/ha Urea and control treatment, which had significant differences with other treatments. The maximum dry tuber yield was related to application of 525 kg/ha Urea, followed by 350 kg/ha, 175 kg/ha and control treatments. All differences between treatments were significant (Table 1). Hosseini *et al*. (2017) reported that the increase in the application of N fertilizer up to certain level increases the potato yield, but since then, it has no effect on the increase in yield.

Table 1. Mean comparison of different traits for experimental factors.

| Experimental factors | Number of days from planting to Germination | Number of days from planting to flowering | Number of days from planting to potato tuber formation | Plant height (cm) | Number of stem per $m^2$ | LAI | Number of tuber per $m^2$ | Fresh tuber yield ($g/m^2$) | Dry tuber yield ($g/m^2$) |
|---|---|---|---|---|---|---|---|---|---|
| Location | | | | | | | | | |
| Khorasgan | 23.87a | 55.39a | 50.83b | 57.37a | 42.41b | 2.62a | 37.25b | 35562.5b | 737.97b |
| Faridan | 25.58a | 57.50a | 55.50a | 58.35a | 47.52a | 2.89a | 39.64a | 38157.3a | 757.43a |
| Manure fertilizer (ton/ha) | | | | | | | | | |
| 0 | 24.62a | 56.62a | 52.90b | 57.56a | 44.65a | 2.67b | 36.96b | 36185.9b | 729.87b |
| 30 | 24.71a | 56.43a | 52.93b | 57.71a | 44.75a | 2.73b | 37.87b | 36535.9b | 737.71b |
| 60 | 24.84a | 56.28a | 53.65a | 58.31a | 45.50a | 2.88a | 40.50a | 37859.4a | 775.53a |
| Urea (Kg/ha) | | | | | | | | | |
| 0 | 24.70a | 55.00b | 52.54c | 55.29c | 42.12c | 2.35d | 35.12c | 33966.7d | 698.33d |
| 175 | 24.70a | 56.58b | 52.91bc | 57.83b | 44.37b | 2.65c | 25.37b | 35833.3c | 729.66c |
| 350 | 24.75a | 57.25a | 53.37ab | 58.54ab | 46.16a | 2.91b | 38.62b | 37943.8b | 753.83b |
| 525 | 24.75a | 57.95a | 53.83a | 59.79a | 47.20a | 3.11a | 42.79a | 39697.9a | 809.00a |

For each experimental factor means within each column common letters do not differ significantly ($p<5\%$)

The highest value for tuber nitrate content (124.22 mg/kg), number of tuber with less than 35 mm diameter (16.12), number of tuber with 35-70 mm diameter (16.68), number of tuber with more than 70 mm diameter (15.58), weight of tuber with less than 35 mm diameter (71.16 $g/m^2$) and weight of tuber with more than 70 mm diameter (435.83 $g/m^2$) was obtained in Faridan region which were significantly different from the values for Khorasgan region. Yazadn Doust Hamedani (2003) concluded that increased nitrogen fertilizer led to increased nitrogen concentration in tuber which corresponds to findings of this experiment. Although, the highest value for tuber weight between 35-70 mm diameter which was 263.16 $g/m^2$ was related to Faridan region, it had significant difference with Khorasgan region. Application of 60 ton/ha manure fertilizer resulted in the maximum nitrate contact (147.81 mg/kg), number of tuber with less than 35 mm diameter (14.40), number of tuber with 35-70 mm diameter (16.90), number of tuber with more than 70 mm diameter (16.12), weight of tuber with 35-70 mm diameter (270 $g/m^2$) weight of tuber more than 70 mm diameter (435.83 $g/m^2$) followed by the values for application of 30 ton/ha manure fertilizer and control treatment. Furthermore, all differences for those experimental characteristics were meaningful. Although, the highest and the lowest weight for tuber with less than 35 mm diameter was achieved in application of 60 ton/ha and control treatment, there was no meaningful difference between treatments. The maximum nitrate (184.12 mg/kg), the number of tuber less than 35 mm diameter (15.16), the number of tuber between 35-70 mm diameter (17.75), the number of tuber more than 70 mm diameter (16.54), tuber weight less than 35 mm diameter (70.37 $g/m^2$), tuber weight between 35-70 mm diameter (280.58 $g/m^2$) and tuber weight more than 70 mm diameter (474.54 $g/m^2$) was obtained for usage of 525 kg/ha Urea fertilizer, followed 350 kg/ha, 175 kg/ha and control treatment. Jamaati *et al*. (2009) concluded that nitrogen was effective on tuber size and increased tuber weight, but excessive increase in nitrogen caused the reduction of tuber weight. Ankumah *et al*. (2003) reported that

the tuber size was effective on the growth period of potato, time tuber formation and nitrogen levels. Like results of other experiments, the content of nitrate affected by application of nitrogen fertilizer (Pussemier *et al*., 2006; Irena, 2009; Poberezny *et al*., 2012; Poberezny *et al*., 2015). All differences between chemical fertilizer treatments for all experimental characteristic were meaningful (Table 2).

Table 2. Mean comparison for experimental characteristics

| Experimental factors | Nitrate (mg/kg) | Number of tuber less than 35 mm diameter | Number of tuber between 35-70 mm diameter | Number of tuber more than 70 mm diameter | Tuber weight less than 35 mm diameter ($g/m^2$) | Tuber weight between 35-70 mm diameter ($g/m^2$) | Tuber weight more than 70 mm diameter ($g/m^2$) |
|---|---|---|---|---|---|---|---|
| Location | | | | | | | |
| Khorasgan | 107.25b | 11.37b | 14.45b | 11.58b | 63.60b | 261.27a | 412.56b |
| Faridan | 124.22a | 16.12a | 16.68a | 15.58a | 71.16a | 263.16a | 435.83a |
| Manure fertilizer (ton/ha) | | | | | | | |
| 0 | 92.31c | 13.31b | 14.31c | 11.96c | 66.43a | 257.75b | 404.34c |
| 30 | 107.09b | 13.53b | 15.50b | 12.65b | 67.43a | 258.90b | 427.71b |
| 60 | 147.81a | 14.40a | 16.90a | 16.12a | 68.28a | 270.00a | 440.53a |
| Urea (Kg/ha) | | | | | | | |
| 0 | 46.37d | 12.00c | 13.58d | 11.45c | 65.12b | 243.95c | 382.25d |
| 175 | 96.54c | 13.75b | 15.08c | 12.87b | 66.83b | 260.62b | 413.79c |
| 350 | 135.91b | 14.08b | 15.87b | 13.45b | 67.20b | 263.70b | 426.20b |
| 525 | 184.12a | 15.16a | 17.75a | 16.54a | 70.37a | 280.58a | 474.54a |

Common letters within each column do not differ significantly.

## CONCLUSION

Potato is known as a favorite crop and regarded as one of the most important vegetable crops as human food. Potato is highly responsive to N fertilizer which is usually the most specific essential nutrient for potato plant growth on all soils. The excessive use of nitrogen can lead to increase vegetative growth rather than tuber production and delay potato maturity. The main part of required nitrogen for plant is absorbed in nitrate from $NO_3^-$ and excessive accumulation of nitrogen in products such as potato can be deleterious consumer 's health. Our results indicated that location had significant influence on LAI, number of tuber per $m^2$, fresh and dry tuber yield, tuber nitrate content, number of tuber and tuber weight. Manure fertilizer also had significant effect on plant height, the number of tuber per $m^2$, fresh and dry tuber yield, nitrate content, tuber weight between 35 to more than 70 mm diameter. Chemical fertilizer had significant effect on the number of stem per $m^2$, LAI, fresh and dry tuber yield, tuber nitrate content and tuber weight.

Increase of N fertilizer application rate from 0 to 60 kg Urea per ha generally resulted in increase of fresh and dry tuber yield, percentage of large tubers, and nitrate content. In most cases, tuber yeild was significantly different between 60 kg Urea / ha treatment and the other tow treatments. On the basis of the results obtained the maximum dry tuber yield was achieved in Faridan region with application of 60 ton/ha manure fertilizer and 525 kg/ha Urea. The number of tuber and fresh tuber yield in Faridan region was higher than those values in Khorasgan, that may be due to better climatic condition of Faridan region compare to Khorasgan. Application of 60 ton/ha manure fertilizer resulted in the maximum nitrate (147.81 mg/kg), number of tuber less than 35 mm diameter (14.40), number of tuber between 35-70 mm diameter (16.90), number of tuber more than 70 mm diameter (16.12), weight of tuber with 35-70 mm diameter (270 $g/m^2$) and weight of tuber with more than 70 mm diameter (435.83 $g/m^2$) followed by values for treatment of application of 30 ton/ha manure fertilizer and control treatments. Evaluation of the results of this research suggested that use of animal manure not only reduces the deleterious effect of chemical fertilizer, but also increase yield and yield components of potato. Application of 60 ton/ha manure fertilizer along with chemical fertilizer can lead to successful results.

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