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Effects of Plant Density and Nitrogen Fertilizer on Nitrogen Uptake from Soil and Nitrate Pollution in Potato Tuber

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Abstract: In order to investigate plant density and nitrogen fertilizer on nitrogen uptake from soil and nitrate pollution in potato tuber cu. Agria, a factorial experiment based on randomized complete block design with three replications was carried out in Ardabil, Iran, in 2006. Factors were nitrogen levels (0, 80, 160 and 200 kg ha^{-1} net nitrogen) and plant densities (5.5, 7.5 and 11 plant m^{-2}). Results showed that the most nitrogen uptake by plant aerial parts and the most nitrate concentration in dry and fresh tuber weight were observed at 200 kg ha^{-1} nitrogen, 11 plant m^{-2} and 200 kg ha^{-1} nitrogen, 5.5 plant m^{-2}, respectively. At 160 kg ha^{-1} nitrogen (as equal to 80 kg ha^{-1} nitrogen) and 11 plant m^{-2}, the most tuber and yield of tuber were gained. With increasing nitrogen application up to 160 kg ha^{-1}, nitrogen uptake by tuber, number of tuber, tuber dry weight and mean tuber weight was increased. 160 and 80 kg ha^{-1} nitrogen jointly with density of 5.5 plant m^{-2}, caused the most mean tuber weight per plant. So, utilization of 80 kg ha^{-1} nitrogen to reach highest yield and less nitrate pollution, density of 11 plant m^{-2} to gain seed tuber (because of reduction in tuber weight and size) and density of 7.5 plant m^{-2} for eating usages, are recommended.

Key words: Nitrate pollution, plant density, nitrogen uptake and potato

INTRODUCTION

Potato (*Solanum tuberosum*) is grown and eaten in more countries than any other crop and in the global economy it is the fourth most important crop after the three cereals including maize, rice and wheat (Stephen, 1999). The fate of nitrogen fertilizers used in potato production is an important environmental concern (Meyer, 2002). Nitrogen is an essential element for plant growth and is a main part of proteins. When plant grows up in unfavorable environmental conditions, protein production is reduced and nitrogen accumulates as non-protein compounds. Belanger *et al*. (2000) reported that estimation of optimum fertilizer rates is of interest because of growing economic and environmental concerns. Usually, there is a close relationship between light intensity and nitrate reduction in green leaves. Also, Nutrient elements deficit has important effect on nitrate pollution. With increasing nitrogen application and plant density, potato yield increases (Arsenault *et al*., 2001). Plant density in potato affects some of important plant traits such as total yield, tuber size distribution and tuber quality (Samuel *et al*., 2004). Haase *et al*. (2007) found that tuber N uptake and nitrate concentration were significantly influenced by amounts of nitrogen fertilizer. Also, nitrogen uptake increases number of tuber, tuber weight, qualitative and quantitative aspects of tuber. But, over-usage of nitrogen delays tuber growth and reduces its qualitative and quantities aspects. Maher (1998) reported that with increasing plant density, mean tuber weight decreased and in low densities, number of harvested tubers, was decreased. Increasing plant density led to mean tuber weight decrease and number of tuber and

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yield per unit area, increase (Osaki *et al*., 1995). Increment of plant density decreases mean tuber size probably because of plant nutrient elements reduction, increment of interspecies competition and large number of tubers produced by high numbers of stems (Beraga and Caeser, 1990). Marguerite *et al*. (2006) showed that the mean maximum increase in total tuber yield, generated by N fertilization 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. Joern and Vitosh (1995) indicated that increasing nitrogen values resulted in increase of tuber nitrate concentration. Georgakis *et al*. (1997) concluded that by increasing plant density, the tuber yield was increased. Karafyllidis *et al*. (1997) 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. Wadas *et al*. (2005) reported that, with increasing the level of nitrogen fertilization, the nitrate content of tuber was increased and higher applications of nitrogen, caused higher nitrate content in tubers, too.

The aim of this study was investigation of different plant density and nitrogen level on nitrogen uptake by plant from soil, tuber nitrate pollution, yield and yield components in order to definition of the best nitrogen level and plant density in which the highest tuber yield with the lowest environmental pollution were gained in year 2006 in Ardabil region, Iran.

MATERIALS AND METHODS

In order to evaluation of plant density and nitrogen fertilizer on nitrogen uptake from soil and nitrate pollution of potato tuber Agria cultivar, a factorial experiment based on randomized complete block design was carried out with three replications in Ardabil, Iran, in 2006. First factor was nitrogen level (0, 80, 160 and 200 kg ha^{-1} net nitrogen) and second was plant density (5.5, 7.5 and 11 plant m^{-2}). Nitrogen was of urea source and applied in two stages, planting date and earthling up stage. Based on soil test pH depth of 0-30 cm, Total Saturated Electrical Conductivity (TSEC) was 3.68 mmhos cm^{-1}, soil pH was 8.09, total nitrogen was 0.56 % and soil texture was loamy sand. Rows were spaced 60 cm. Plots were included six rows each three meters. In order to preventing nitrogen effects in adjacent plots, they were placed 1.5 meters distance. Tubers of 60-70 g were sown in 13 May 2006. Sowing depth was 12-13 cm. Last harvest was assigned for yield. Promoting storage capability, 10 days before harvest, aerial parts were removed (Khajehpour, 2004). Sampling was done from 2 m^2 plot area, 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 h in 75°C and weighed. Tuber nitrate pollution was calculated by sulfosalicylic acid method using spectrophotometer device (Cecile, France). Calculation of nitrogen uptake rate was made according to the Hashemidezfooli *et al*. (1998):

$$NEU = DM \times EC$$

Where:
NEU = Nutrient element uptake
DM = Dry matter
EC = Element concentration

Results were analyzed by SAS software, mean comparisons were done via Duncan's multiple range test and graphs were drawn by Excel software.

RESULTS AND DISCUSSION

Nitrogen Uptake

Results showed that simple effects of plant density and nitrogen level on nitrogen uptake by aerial parts and tubers ($p<0.01$) and interaction effects of plant density×nitrogen level ($p<0.05$) only for nitrogen uptake by aerial parts, were significant. Since, increasing nitrogen application led to over-growth of aerial parts and consequently, increase of leaves and stems dry weight, so, it increased nitrogen uptake. The most nitrogen was uptaken at 200 kg ha^{-1} nitrogen and the less at control level, for all aerial parts. But in tuber, it was increased up to 160 kg ha^{-1} and then, decreased (Table 1). Increment of density increased dry matter of aerial parts per unit area. This led to more nitrogen uptake in aerial parts and tubers so, the most and the less uptake was observed in 11 and 5.5 plant m^{-2} (Table 1). With increasing plant density and constant rate of available nitrogen, competition for nitrogen, increased. In 200 kg ha^{-1} nitrogen and 11 plant m^{-2} treatments, the most uptake and in 80 kg ha^{-1} nitrogen and 5.5 plant m^{-2}, the less uptake was observed (Table 2). Haase *et al*. (2007) reported that with increasing N application, nitrogen uptake in tuber was increased and it is in accordance with present study. Also, they revealed more nitrogen uptake by tuber in case of increased nitrogen. Since, nitrogen uptake in tuber per unit area increased as a result of plant density and nitrogen level increment, so this increase, has affected positively tuber yield and yield components and probably, the best reason to yield increment.

Nitrate Pollution

Simple effect of plant density and nitrogen and their interaction effect on tuber nitrate pollution based on dry weight ($p<0.01$) and fresh weight ($p<0.05$) was significant. With increasing nitrogen level, nitrate content in tuber dry and fresh weight significantly increased. More nitrate content in tuber, as a result of increase nitrogen application, has been reported by Wadas *et al*. (2005). Increase of density, reduced tuber nitrate pollution, as well (Table 1). Perhaps, this is because of low fertilizer distribution between the large number of plants and consequently, the tubers. In 200 kg ha^{-1} nitrogen and 5.5 plant m^{-2}, the most nitrate pollution in fresh and dry weight, was observed (Table 2). In all nitrogen levels, Agria Cu. has accumulated the less nitrate rate in both fresh and dry tuber weight. Also, it could be found that nitrogen usage over the favorite range either caused to yield reduction or, increased nitrate accumulation in tuber.

Yield and Yield Components

Effects of plant density, nitrogen level ($p<0.01$) and their interaction effect ($p<0.05$) on tuber yield, were significant. Also, effects of plant density and nitrogen level ($p<0.01$) on tuber dry weight and tuber yield per unit area, were significant. Effects of plant density and nitrogen level ($p<0.05$) on

Table 1: Effect of plant density and nitrogen levels on measured traits

Experimental levels		N uptake by shoot (g m^{-2})	N uptake by tuber (g m^{-2})	Nitrate in tuber dry weight (ppm)	Nitrate in tuber fresh weight (ppm)	No. of tuber (m^{2})	Mean tuber weight (g)	Tuber yield per tuber (g m^{-2})	Dry weight of tuber (g m^{-2})	Tuber yield per plant (g)	Tuber yield (g m^{-2})
Nitrogen fertilizer (kg ha^{-1})	0	1125.0c	628.83c	78.94d	19.58d	63.86b	23.29b	498.79b	257.44c	2024.6b	
	80	1428.8b	879.29a	170.52c	33.88c	93.35a	30.21ab	669.95a	403.96a	2994.1a	
	160	1582.6b	924.54a	214.47b	50.82b	100.90a	33.67a	728.18a	420.76a	3174.6a	
	200	2012.6a	746.41b	273.70a	63.22a	80.23ab	24.85b	498.23b	318.63b	2457.0b	
Plant density (plant m^{-2})	5.5	1176.0c	674.85c	213.81a	46.46a	77.12b	30.55a	525.35b	449.79a	2346.3b	
	7.5	1472.44b	761.98b	180.29b	45.34a	81.62ab	27.36ab	580.32b	312.84b	2473.8b	
	11	1962.98a	974.48a	159.13c	37.58b	95.00a	26.11ab	742.45a	287.97b	3116.6a	

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

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

Interactions effects	N uptake by shoot (g m^{-2})	Nitrate pollution in tuber dry weight (ppm)	Nitrate pollution in tuber fresh weight (ppm)	Tuber yield per plant (g)
Control×5.5 plant	892.6f	94.87h	21.68fg	300.3bcd
Control×7.5 plant	976.3ef	75.4i	20.85fg	220.00d
Control×11 plant	13075.5def	66.55i	16.21g	252.01cd
80 kg×5.5 plant	1091.3ef	187.95e	38.69de	580.3a
80 kg×7.5 plant	1343.2de	171.02f	42.18cde	330.5bcd
80 kg×11 plant	1934.9bc	152.58g	35.78ef	301.1bcd
160 kg×5.5 plant	1258.8def	238.81c	50.21bcde	546.34a
160 kg×7.5 plant	1554.2cd	221.00d	58.81bc	387.58b
160 kg×11 plant	2050.7b	183.6e	43.44bcde	328.36bcd
200 kg×5.5 plant	1577.8cd	333.59a	75.26a	372.22bc
200 kg×7.5 plant	1901.2bc	253.74b	58.51b	313.26bcd
200 kg×11 plant	2558.8a	233.78c	54.88bcd	270.4bcd

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

mean tuber weight and number of tuber per unit area, were significant, as well. With increasing plant density, tuber yield was decreased per plant and increased per unit area (Table 1). This result has been reported by many of other researchers (Osaki *et al*., 1995; Georgakis *et al*., 1997; Karafyllidis *et al*., 1997). In 160 and 80 kg ha^{-1} nitrogen and density of 5.5 plant m^{-2}, the most tuber yield per plant was observed (Table 2). Increment of nitrogen application up to 160 kg ha^{-1}, led to increase of number, dry weight, tuber yield per unit area and mean tuber weight and then decreased. This is because of high growth of aerial parts as a result of over-usage of nitrogen (more than 160 kg ha^{-1}) and consequently, increases of intra competition to reach water, mineral elements and light that significantly reduced yield and yield components at 200 kg ha^{-1} nitrogen. In density of 5.5 plant m^{-2}, the most mean tuber weight was gained. Increase of plant density, decreased mean tuber size probably as a result of lack of available nutrient elements, intra competition or great number of produced tubers per plant (Beraga and Caeser, 1990).

CONCLUSIONS

In general, the most amount of nitrate in dry and fresh weight of tuber was observed in 200 kg ha^{-1} nitrogen, 5.5 plant m^{-2} treatments and the most tuber yield per plant was gained in jointly 80 and 160 kg ha^{-1} nitrogen, 5.5 plant m^{-2} treatments. Nitrate pollution at 80 and 160 kg ha^{-1} net nitrogen was 170.52 and 214.47 mg kg^{-1} tuber dry weight and 38.88 and 50.82 mg kg^{-1} tuber fresh weight, respectively. At these nitrogen levels especially 80 kg ha^{-1}, nitrate accumulated was lower than critical range so, application of 80 kg ha^{-1} nitrogen to gain most tuber yield with less nitrate pollution in tuber, is recommended for Agria Cu in Ardabil region. Noticing mean tuber yield in Ardabil region of 28.7 t ha^{-1} and its comparison with yield of 80 and 160 kg ha^{-1} nitrogen treatment (29.44 and 31.74 t ha^{-1}, respectively), it seems that can be recommended for this region. Also, density of 11 plant m^{-2} is suitable to obtain planting seed (according to reduction of tuber weight and size). But, density of 7.5 plant m^{-2} is recommended for eating usages.

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REFERENCES

Arsenault, W.J., D.A. Leblanc, G.C.C. Tai and P. Boswall, 2001. Effect of nitrogen application and seed piece spacing on yield and tuber size distribution in eight potato cultivars. Potato Assoc. Am., 78: 301-309.

Belanger, G., J.R. Walsh, J.E. Richards, P.H. Milburn and N. Ziadi, 2000. Comparison of three statistical models describing potato yield response to nitrogen fertilizer. Agron. J., 92: 902-908.

Beraga, L. and K. Caeser, 1990. Relationships between number of main stems and yield components of potato (*Solanum tuberesom* L. cv. erntestolz) as influenced by different day length. Am. J. Potato Res., 33: 257-267.

Georgakis, D.N., D.I. Karafyllidis, N.I. Stavropoulos, E.X. Nianiou and I.A. Vezyroglou, 1997. Effect of planting density and size of potato seed-minitubers on the size of the produced potato seed tubers. Acta Hort. (ISHS), 462: 935-942.

Haase, T., C. Schuler and J. Heb, 2007. The effect of different N and K sources on tuber nutrient uptake, total and graded yield of potatoes (*Solanum tuberosum* L.) for processing. Eur. J. Agron., 26: 187-197.

Hashemidezfooli, A., A. Koocheki and M. Banayanavval, 1998. Yield increment of crop plant (Translation). 1st Edn. Jehad daneshghahi Mashad Press, Mashad. Iran, ISBN 964-6023-05-3.

Joern, B.C. and M.L. Vitosh, 1995. Influence of applied nitrogen on potato. Part I: Yield, quality and nitrogen uptake. Am. Potato J., 72: 51-63.

Khajehpour, M., 2004. Production of Industrial Plants. 1st Edn. Jehad-e-Daneshgahi Isfahan Press, Isfahan. Iran, ISBN 961-6122-63-9.

Maher, M.J., 1998. The effect of planting density on the production of potato minituber under protection. Proc. Agric. Res. Forum, UCD., 4097(b): 1-13.

Marguerite, O., G. Jean-Pierre and L. Jean-Francois, 2006. Threshold value for chlorophyll meter as decision tool for nitrogen management of potato. Agron. J., 98: 496-506.

Meyer, K.M., 2002. Impact of nitrogen management strategies on yield, N-use efficiency and rhizoctonia diseases of Irish potato. M.Sc. Thesis, Faculty of North Carolina State University. A thesis submitted to the Graduate Faculty of North Carolina State University in partial fulfillment of the requirements for the Degree of Master of Science.

Osaki, M., H. Ueda, T. Shinano, H. Matsui and T. Tadano, 1995. Accumulation of carbon and nitrogen compounds in sweet potato plants grown under deficiency of N, P, or K nutrients. Soil Sci. Plant Nutr., 41: 557-566.

Samuel, Y.C., D. Essah, G. Holm and J.A. Delgado, 2004. Yield and quality of two US red potatoes: Influence of nitrogen rate and plant population. Proceedings of the 4th International Crop Science Congress Brisbane, Australia, 26 Sep-1 Oct. http://www.cropscience.org.au/icsc2004/copyright.htm.

Stephen, D.J., 1999. Multiple signaling pathways control tuber induction in potato. Plant Physiol., 119: 1-8.

Wadas, W., R. Jab³oñska-Ceglarek and E. Kosterna, 2005. The nitrates content in early potato tubers depending on growing conditions. Elect. J. Polish Agric. Univ., 8: 26-26.