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Effect of Utilization of Organic and Inorganic Nitrogen Source on the Potato Shoots Dry Matter, Leaf Area Index and Plant Height, During Middle Stage of Growth

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***Abstract*—**Cattle manure and mineral fertilizers are two source of Nitrogen, which can affect the growth and quantity of potato. In this research the effects of the use of cattle manure (5, 10, 15 and 20 ton ha^{-1}), Nitrogen fertilizer (50, 100 and 150 kg N ha^{-1}) and their interaction on potato growth were evaluated during field experiments in 2008 with the help of Randomized Complete Block (RCB) with the factorial arrangement of three experimental replications in Iran. At the 75 th day after emergence, dry weight of Shoots, leaf area index (LAI) and plant height were recorded. Results showed that, dry weight of Shoots, LAI and plant height increased linearly and very significantly in response to the application of manure and Nitrogen fertilizer. While the interaction between manure and Nitrogen fertilizer just on the LAI and plant height was significant, somehow the maximum amount of plant height(73 cm) was obtained by using 150 kg Nitrogen + 15 tons of manure per hectare, and maximum LAI (5.36) was obtained by using 150 kg Nitrogen + 20 tons of manure per hectare. Also in this experiment maximum tuber yield (36.8 tons ha^{-1}) was obtained by the utilization of 150 kg Nitrogen per hectare + 20 tons manure.

Keywords*—Solanum tuberosum,* LAI, cattle manure, mineral fertilizer, integrated management.

I. Introduction

LIMITATION of Nitrogen can considerably reduce the growth of potato plant and the tuber yield. So that, for beneficial growth and maximum tuber yield, Nitrogen must be added in organic or inorganic form [16], [1], [2], [8], [30], [13]. Mineral Nitrogen fertilization can increase shoots weight, leaf area, plant height and subsequently total yield [9], [29], [20], [7], [27], [21], [28], [35], [18], [34]. While, the application of excessive Nitrogen leads to immoderate growth. This effect can encourage competition between the source and sink, delayed maturity and subsequently can reduce the tuber yield [14], [18]. Also, excess Nitrogen has a negative effect on tuber quality and the environment [4], [13], [24].

These negative effects of chemical fertilizers have led nutrients management to the use of other Nitrogen sources, including organic fertilizers [22], [1], [5]. Organic fertilizers such as cattle manure, contain large amount of nutrients and influences plant growth and production via improving chemical, physical and biological fertility [31], [6], [3], [12]. Other researches showed that, LAI, shoots weight, plant height and tuber yield can be increased by application organic fertilization [25], [1], [2], But just a small amount of cattle-manure nutrients are initially available for plants use; thus it is required to application both Nitrogen fertilizers and cattle manure for optimum growth and maximum yields [19], [17], [32].

The purpose of this investigation was to determine changes in shoots dry matter, LAI, plant height (at the75th Day after emergence) and total tuber yield (at the harvest) in Agria potato by the supply of Nitrogen fertilizer, cattle manure and the integrated management of both in Iran.

II. Materials and Methods

The field experiment was laid out in the factorial arrangement based on Randomized Complete Block Design (RCBD) with three replications in April 2008 at the Agricultural Experiment Station of Azad University, Rudehen Branch, Tehran, Iran (35° 48' N altitude, 52° 5' E longitude and altitude of 1880 m above the sea level). The experimental soil was a clay loam with 1.95% organic carbon and pH 7.9. The P_2O_5 (available), K_2O (available), total Nitrogen, Mn, Fe, Zn and Cu contents were 25.2 ppm, 490 ppm, 0.167%, 11 mg kg^{-1}, 2.6 mg kg^{-1}, 1.1 mg kg^{-1} and 0.8 mg kg^{-1}, respectively (March, 2008). Treatments consisted of Nitrogen fertilizer of urea source in three levels (50, 100 and 150 Kg ha^{-1}) and cattle manure in four levels (5, 10, 15 and 20 tons ha^{-1}). Nitrogen fertilizer was supplied during three phases: planting, emergence and earting up. Cattle manure was analyzed before application and its entire rate was applied before plantation (Table I). Tuber seeds (Potatoes of Agria variety) were planted in the furrows of four rows with the depth of 15 cm, the intra-row spacing of 25 cm, and the inter-row spacing of 75 cm, on 28st April 2008.

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TABLE I
Some Properties of the Manure Samples Used in the present Study.

Parameters	Cow manure
Organic carbon (%)	46.2
C: N (%)	22.91
Total Nitrogen (%)	2.016
Total P (%)	0.72
Total K (%)	2.8
Total Mg (%)	1.2
Total Ca (%)	3.5
Total elemental content (mg kg^{-1})	
Fe	185.3
Mn	150
Cu	17.4
Zn	144.6

Observations on growth parameters, including dry weight of Shoots, LAI and plant height were recorded from three randomly selected potato plants from each plot at 75 DAE (day after emergence). Tubers were harvested on 31st October, 2008. After harvesting, the total tuber yield was determined for each plot (2 m length of the two middle rows, excluding 0.5 m from each end of plots).

Analysis of Variance (ANOVA) was performed using the General Linear Model (GLM) procedure of SAS (SAS Institute, 1996; Version: 6.12, SAS Institute Inc. Cary, NC, USA). Regressions and graphs for cattle manure and Nitrogen fertilizer were obtained by using Prism 5 for Windows (GraphPad Software, 2007; Graph Pad Software Inc. San Diego, CA). For the determination of interaction between Nitrogen fertilizer and cattle manure, the means were compared using Duncan's Multiple Range Test ($P < 0.05$).

III. Result and Discussion

Shoots dry matter, LAI and plant height showed highly significant differences in relation to the rate of Nitrogen fertilizer (Table II) as they increased significantly and linearly with increasing the Nitrogen rate using different concentrations: 0.1656 g per plant, 0.00089, 0.00239 cm , per unit increase of Nitrogen fertilizer, respectively (Fig 1). The fact that, increased concentration of Nitrogen fertilizer can increase the Nitrogen uptake. This increase has a positive effect on the chlorophyll concentration, the photosynthetic rates, the leaf expansion, the total number of leave and the dry matter accumulation. Consequently Nitrogen fertilizer plays an important role in canopy development especially on the shoots dry matter, the LAI and the plant height . [26], [10], [28] [1], [23], [15], [33].

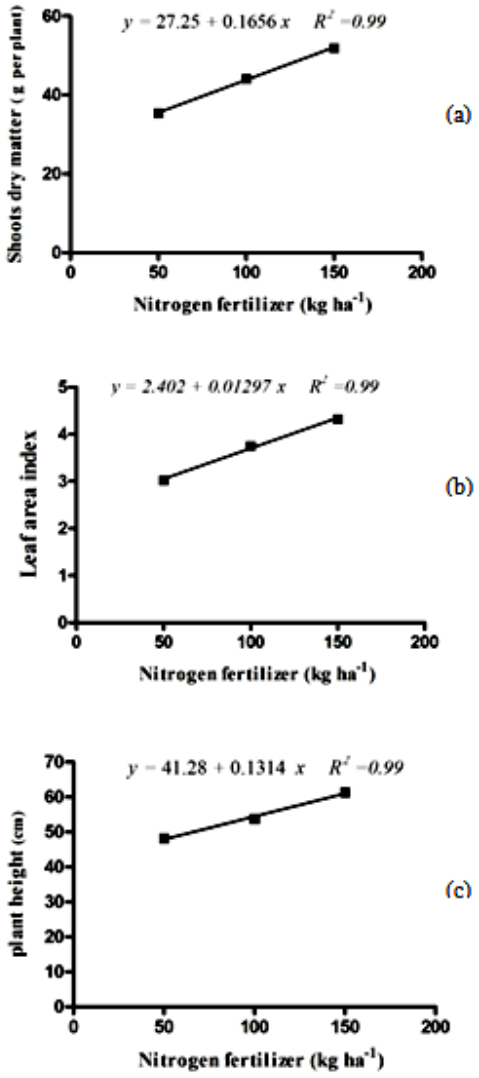

Fig. 1. Shoots dry matter (a), Leaf Area Index (b) and Plant height (c) as a function of Nitrogen fertilizer (at the 75th day after emergence).

Shoots dry matter, LAI and plant height showed highly significant differences in the presence of cattle manure rate as well (Table II). Fig 2 shows that the Shoots dry matter, LAI and plant height demonstrated an increase (1.363 g per plant, 0.01186 and 1.201 cm) per unit increase of manure, respectively. Cattle manure applied in this experiment had high Nitrogen content, thus this characteristics increased by the application of manure (Table I). In addition, take up the other nutrients is necessary for plant growth and deficient tissue mineral content, limit potential growth Therefore, manure plays a consequential role in increasing these characteristics by supplying a fraction of these nutrients and improvement the solubility of some elements [17], [11], [30].

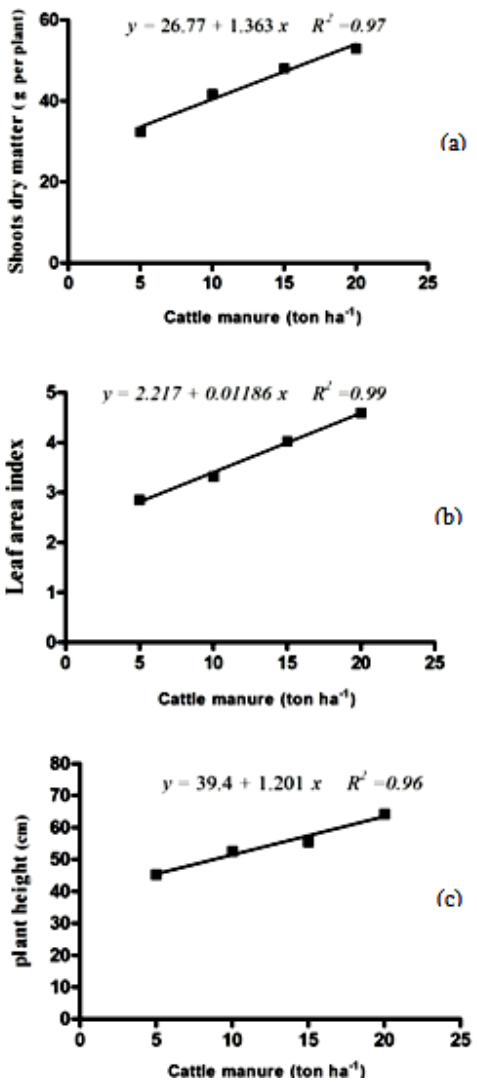

Fig. 2. Shoots dry matter (a), Leaf Area Index (b) and Plant height (c) as a function of Cattle manure (at the 75th day after emergence).

In this experiment, the combined effect of cattle manure and Nitrogen fertilizer just on the LAI and plant height was significant (Table II). Results nearly showed that they increased by increasing the integrated use of cattle manure and Nitrogen fertilizer (Table III), which can be caused by the profitable effect of Nitrogen and manure on the growth as mentioned above. In this experiment maximum amount of plant height (73 cm) was obtained by using 150 kg Nitrogen + 15 tons of manure per hectare. While, maximum LAI (5.36) was obtained by using 150 kg Nitrogen + 20 tons of manure per hectare.

During the present study, Nitrogen fertilizer, cattle manure and their interaction had a highly significant effect on tuber yield (Table II), and maximum tuber yield (36.8 tons ha^{-1}) was obtained by the utilization of 150 kg Nitrogen + 20 tons manure per hectare. These results are justified with the results of shoots. Especially with LAI, because the increase in LAI can be increased radiation absorption, And radiation absorption, (particularly at the time of tuber initiation) have a positive effect on the final tuber yield [30]. Abou-Hussein et al .(2003a) Expressed that increase of the soil nutrients can encourage the increase haulm growth which increases the photosynthetic rates and assimilation rates. So that yield components and total yield increase.

TABLE II
ANALYSIS OF VARIANCE FOR LEAF AREA INDEX, SHOOTS DRY WEIGHT, PLANT HEIGHT (AT THE 75TH AFTER EMERGENCE) AND TOTAL TUBER YIELD (AT THE HARVEST)

Source of variation	df	Leaf area index	Shoots dry weight	Plant height	Total tubers Yield
Nitrogen fertilizer (N)	2	5.0707**	823.2046**	521.0629**	235.9143**
Cattle manure (C)	3	5.2876**	712.2123**	558.2207**	204.1433**
N × C	6	0.7291*	46.8979 ns	156.4943*	85.3666**
Error Mean Square	22	0.2626	19.8074	54.5864	18.1949
C.V		13.85	10.15	13.57	13.57

**P<0.01; *P<0.05; ns = not significant

TABLE III
EFFECT OF INTERACTION BETWEEN CATTLE MANURE AND NITROGEN ON LEAF AREA INDEX AND PLANT HEIGHT ON THE 75TH DAT AFTER EMERGENCE

Cattle manure (Ton ha^{-1})	Nitrogen fertilizr (kg ha^{-1})	Leaf area index	Plant height (cm)
	50	2.825 d	45 de
5	100	2.762 d	46.7de
	150	3.015 cd	44 de
	50	2.628 d	45 de
10	100	3.182 cd	55.5 cde
	150	4.143 b	57.3 bcd
	50	2.726 d	42 e
15	100	4.598 ab	51.7de
	150	4.766 ab	73 a
	50	3.916 bc	60.6 abc
20	100	4.506 ab	61.3 abc
	150	5.360 a	70.8 ab

Values in a column with the same letter were not statistically different at $p \leq 0.05$ by Duncan test.

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REFERENCES

[1] Abou-Hussein, S.D., T. El-Shorbagy, A.F. Abou-Hadid, and U. El-Behairy. 2003 a. Effect of Cattle and Chicken Manure with or without Mineral Fertilizers on Tuber Quality and Yield of Potato Crops .*ISHS Acta Hort* 608: 95-100.

[2] Abou-Hussein, S.D., T. El-Shorbagy, A.F. Abou-Hadid, and U. El-Behairy. 2003 b. Effect of Cattle and Chicken Manure With or Without Mineral Fertilizers on Vegetative Growth, Chemical Composition and Yield of Potato Crops.*ISHS Acta Hort* 608: 73-79.

[3] Ahmad Mir, S., and S.M.K. Quadri. 2009. Decision Support Systems: Concepts, Progress and Issues - A Review. In *Climate Change, Intercropping, Pest Control and Beneficial Microorganisms, Sustainable Agriculture Reviews 2, eds*. E. Lichtfouse, 373-399. Dordrecht, Netherlands: Springer Science+Business Media B.V.

[4] Alva, A. 2004. Potato Nitrogen management. *Journal of Vegetable Crop Production* 10: 97-130.

[5] Ashwini, K.M., and K.R. Sridhar. 2006. Evaluation of pill millipede (*Arthrosphaera* magna) composit on plant growth and dry matter yield. *Electron. J. Environ. Agri. Food Chem.* 5:1323-1329.

[6] Benke, M.B., X. Hao, and C. Chang. 2009. Effects of long-term cattle manure applications on soil, water, and crops: Implications for animal and human health. In *Development and Uses of Biofortified Agricultural Products, ed*s. G.S. Bañuelos, and Z.Q. Lin, 135-153. Boca Raton, Florida: CRC Press.

[7] Biemond, H., and J. Vos. 1992. Effects of Nitrogen on the development and growth of the potato plant. 2. The partitioning of dry matter, Nitrogen and nitrate. *Annals of Botany* 70:37–45.

[8] Blumenthal, J.M., D.D. Baltensperger, K.G. Cassman, S.C. Mason, and A.D. Plavlista. 2004. Importance and effect of Nitrogen on crop quality and health. In *Nitrogen in the environment: Sources, problems, eds*. R.F. Follett, and J.L. Hatfield, 45-65. Amsterdam, Netherlands: Elsivier B.V .

[9] Bradley, G.A., and A.J. Pratt. 1955. The effect of different combinations of soil moisture and Nitrogen levels on early plant development and tuber set of the potato. *American Potato Journal* 32: 254–258.

[10] Chapman, S.C., and H.J. Barreto. 1997. Using a chlorophyll meter to estimate specific leaf Nitrogen of tropical maize during vegetative growth. *Agronomy Journal* 89: 557-562.

[11] Clemente, R., C. Paredes, and M.P. Bernal. 2007. A field experiment investigating the effects of olive husk and cow manure on heavy metal availability in a contaminated calcareous soil from Murcia (Spain). *Agriculture Ecosystems & Environment* 118: 319-326.

[12] Füleky, G., and Benedek, s. 2010. Composting to Recycle Biowaste. In sociology, organic farming, climate change and soil science, *Sustainable Agriculture Reviews 3, eds*. E. Lichtfouse, 41-76. Dordrecht, Netherlands: Springer Science+Business Media B.V.

[13] Goffart, J.P., M. Olivier , and M.Frankinet . 2008. Potato Crop Nitrogen status assessment to improve N fertilization management and efficiency: Past-Present-Future. *Potato Research* 51: 355-383.

[14] HAY, R.K.M., and A.J. Walker. 1989. Potatoes. In *An introduction to the physiology of crop yield, eds*. R.K.M. Hay, and A.J. Walker, 188-212. Harlow, England: Longman Scientific & Technical.

[15] Janat, M. 2007. Efficiency of Nitrogen fertilizer for potato under fertigation utilizing a Nitrogen tracer technique. *Communications in Soil Science and Plant Analysis* 38: 2401- 2422.

[16] Joern, B.C., and M.L. Vitosh. 1995. Influence of applied Nitrogen on potato. Part I: Yield, quality, and Nitrogen uptake. *American Potato Journal* 72: 51-63.

[17] Kolay, A.K. 2007. Manures and Fertilizers. New Delhi, India. Atlantic Publishers and Distributors.

[18] Kumar, P., S.K. Pandey, B.P. Singh, S.V. Singh, and D. Kumar. 2007. Effects of Nitrogen rate on growth, yield, economics and crisps quality of Indian potato processing cultivars. *Potato Research* 50: 143-155.

[19] Lægreid M., O.C. Bøckman ,and O. Kaarstad .1999. *Agriculture, Fertilizers and the Environment*. Wallingford, UK, CABI Publishing.

[20] Logan, B.J. 1989.Effect of irrigation and Nitrogen on yield and quality of potatoes growth in semi-ardid western N.W.S. *ISHS Acta Hort* 247:243-247.

[21] Meyer, R.D., and D.B Marcum. 1998. Potato yield, petiole Nitrogen, and soil Nitrogen response to water and Nitrogen. *Agronomy Journal* 90: 420-429.

[22] Pandey, S. 1999. Adoption of nutrient management technologies for rice production:economic and institutional constraints and opportunities. *Nutrient Cycling in Agroecosystems* 53: 103-111.

[23] Rashid, M.T., P. Voroney, and G. Parkin. 2005. Predicting Nitrogen fertilizer requirements for corn by chlorophyll meter under different N availability conditions. *Canadian Journal Of Soil Science* 85: 149-159.

[24] Sharifi, M., D.H. Lynch, B.J. Zebarth, Z. Zheng, and R.C. Martin. 2009. Evaluation of Nitrogen supply rate measured by *in situ* placement of plant root simulator™ *Probes* as a predictor of Nitrogen nupply from soil and organic amendments in potato crop. *American Journal of Potato Research* 96: 356-366.

[25] Stoner, K.A., F.J. Ferrandino, M.P.N. Gent, W.H. Elmer, and J.A. LaMondia. 1996. Effects of straw mulch, spent mushroom compost, and fumigation on the density of Colorado potato beetle (Coleoptera: Chrysomelidae) in potatoes, *Journal of Economic Entomology* **89**: 1267–1280.

[26] Tam, R. K., and O.C. Magistad.1935. Relationship between Nitrogen fertilization and chlorophyll content in pineapple leaves. *Plant Physiology* 10: 159-168.

[27] Vos, J. 1997. The Nitrogen response of potato *(Solanum tuberosum* L) in the field: Nitrogen uptake and yield, harvest index and Nitrogen concentration. *Potato Research* 40: 237-248.

[28] Vos, J., and P.E.L. Van Der Putten .1998. Effect of Nitrogen supply on leaf growth, leaf Nitrogen economy and photosynthetic capacity of potato. *Field Crops Research* 59: 63-72.

[29] Watson, D. J., and J. H. Wilson. 1956. An analysis of the effects of infection with leaf roll virus on the growth and yield of potato plants, and of its interaction with nutrient supply and shading. *Annals of Applied Biology* 44: 390.

[30] White, P.J., R.E. Wheatley, J.P. Hammond, K. Zhang. 2007. Minerals, soils and roots. In *Potato Biology and Biotechnology: advances and perspectives, eds*. D. Vreugdenhil, J. Bradshaw, C. Gebhardt, F. Govers, D.K.L. Mackerron, M.A. Taylor, and H.A. Ross, 395-409. Oxford, U.K: Elsevier.

[31] Winterhalder, B., R. Larsen, and R. B. Thomas. 1974. Dung as an essential resource in a highland Peruvian community. *Human Ecology* 2: 89-104.

[32] Wu, J., and Sardo, V. 2010. Sustainable versus organic agriculture. In sociology, organic farming, climate change and soil science, *Sustainable Agriculture Reviews 3, eds*. E. Lichtfouse, 41-76. Dordrecht, Netherlands: Springer Science+Business Media B.V.

[33] Zebarth, B.J., and C.J. Rosen. 2007. Research perspective on Nitrogen BMP development for potato. *American Journal of Potato Research* 84: 3–18.

[34] Zelalem, A., T.T. ekalign, and D. Nigussies.2009. Response of potato (*Solanum tuberosum* L.) to different rates of Nitrogen and phosphorus fertilization on vertisols at Debre Berhan, in the central highlands of Ethiopia,African Journal of plant of plant science 3:16-24

[35] Zvomuya, F., C.J. Rosen, and J.C. Miller .2002. Response of Russet Norkotah clonal selections to Nitrogen fertilization. *American Journal of Potato Research* 79:231-239.