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Vegetative Growth of Potato (*Solanum tuberosum* L.) Cultivars, Under the Effects of Different Levels of Nitrogen Fertilizer

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Abstract: To study, the growth of different shoot parts of two potato cultivars under the effects of different levels of N fertilizer, a split-plot experiment was conducted based on Completely Randomized Block Design (CRBD) with four replications in Ardabil agriculture research station in 2007. Cultivars included Agria and Satina and N fertilizer levels included control, 80, 160 and 200 kg N ha^{-1}. Results showed that Agria was significantly superior in all traits except stem length. The effect of N on all traits was significant. As N level increased, auxiliary branch number and plant height increased. The maximum stem and leaf biomass and leaf number was achieved in 160 kg N ha^{-1} treatment and the highest main stem number was achieved in 80 kg N ha^{-1} treatment. The yield difference among 80, 160 and 200 kg N ha^{-1} was insignificant. Over time auxiliary (not main) branch number, plant height, stem dry weight and tuber yield increased. Leaf number and leaf biomass declined after 94 DAP (Days After Planting). Generally, potato is a crop that strongly affected by nitrogen rates. But the effect of nitrogen on aboveground was more violent than tubers. Therefore, a range of 80-160 kg N ha^{-1} is recommended.

Key words: Leaf biomass, nitrogen, stems biomass, potato cultivars, tuber yield

INTRODUCTION

Cultivars in Ardabil Region should quickly complete their vegetative growth before the beginning of water limitation and the end of appropriate growing period so that they can well-use growth factors in production. N fertilizer application in an appropriate level improves the quality and quantity of potato tubers. Insufficient available N leads to reduced growth, reduced light interception (Carter and Bosma, 1974), limited yields (Porter and Sisson, 1991) and early crop senescence (Kleinkopf *et al*., 1981). Excessive available N can result in reduced yields (Lauer, 1986) especially, in late-maturing varieties (Porter and Sisson, 1991), delayed tuber set (Kleinkopf *et al*., 1981) and reduced tuber dry matter content (Porter and Sisson, 1991). The main role of N is in swift development of shoot and allows the plant to quickly complete its canopy and exploit the growth period as much as possible. Different experiments have proved it Honeycutt *et al*. (1996). Beraga and Caeser (1990) in an experiment reported that the first effect of applying N fertilizer in potato field was the increase in leaf number and size. N increases photosynthetic/respiration ratio through increasing mature leaf number and hence, improves yield (Jenkins and Nelson, 1992). But excess amount of N extraordinarily increases shoot development, which in turn decreases photosynthesis/respiration ratio, then less assimilate is transported to tubers (Shakh *et al*., 2001). Jamaati-e-Somarin *et al*. (2008) reported that the increase in N application up to optimum level increased leaf number per plant and tuber yield, but applying greater amounts of N stimulated foliage growth and delayed tuber formation (Honeycutt *et al*., 1996). N application increases stem dry weight, stem length and stem number (Jamaati-e-Somarin *et al*., 2009). Jamaati-e-Somarin *et al*. (2009) also reported that N fertilizer significantly increased potato plant height, led to the increase in plant green area and finally increased shoot development, so that under low fertilizer level, early-maturing cultivars have greater foliage development than late-maturing cultivars and this difference diminishes as N application level increases (Ankumah *et al*., 2003). Ankumah *et al*. (2003) also reported that higher N level is more effective on shoot dry weight in late-maturing cultivars than on that in early maturing ones. Various levels of N application affect plant height too and it has been shown that as N application

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level increases, foliage development and plant height increase (Beraga and Caeser, 1990). The effect of N application is indeed associated with cultivar potential in utilizing N fertilizer. Late-maturing cultivars usually have better ability in utilizing fertilizer than early-maturing ones (Khajehpour, 2006). Vos (1995) indicated that the increase in N level significantly increased leaf number and stem number. Auxiliary branch number is affected by both N fertilizer and cultivar as well. Under higher N level, late-maturing cultivars significantly produce more auxiliary branches than early-maturing ones (Khajehpour, 2006). The extent of potato plant branching is effective on its final yield (Beraga and Caeser, 1990). In some potato varieties, foliage grows very fast at early growing period but their growth rate slows down over time (Khajehpour, 2006). Early-maturing cultivar usually have better performance in shoot development, shoot dry weight and tuber yield than late-maturing ones and have faster growth rate, but due to their shorter vegetative and reproductive growth period, late-maturing cultivars will outreach them at late growing stage (Ankumah *et al*., 2003).

This study was designed to establish optimum N recommendations for two potato cultivars, Agria and Satina. Individual objectives included determination of optimal N fertilizer rate to maximize tuber yield, vegetative growth especially, leaf and stem biomass and relation between their in other words, if the trend of tuber and above ground growth were same or not.

MATERIALS AND METHODS

The experiment was conducted in Ardabil Agriculture Research Station in 2007. Ardabil Province (Alt. 1350 m from sea level) has very cold winters, rainy springs and dry summers with annual precipitation of 400 mm. Soil texture is clay according to composition (46.5% clay, 27.5% silt and 26% sand). The studied cultivars included late-maturing cultivar Agria and early-maturing cultivar Satina. The experiment was a split-plot one based on completely randomized block design with four replications. Different N fertilizer levels (factor N) including control, 80, 160 and 200 kg pure N ha^{-1} formed the main plot and the cultivar (factor V) including Satina and Agria formed subplot hence, forming 8 experimental plots (4.5×5 m^2) in each replication. A distance of one meter was left between main and sub plots as border effect. In each subplot, 6 rows were manually planted at the depth of 10 cm in May, 9th. The tubers with the weight of 60-70 g were used in planting (Love *et al*., 2005). The space between rows was 75 cm and between plants in each row was 25 cm. N fertilizer was used in two sessions: during planting (half of various fertilizer levels) and 6 weeks after planting (as dressing concurrent with earthing up), in which plants were at rapid growth stage. During growing season, the plots were sampled 6 times in 57, 70, 83, 94, 105 and 118 Days after Planting (DAP), each time 5 plants were destructively taken from the center rows. The plants were moved to central laboratory of agricultural college of Mohagegh Ardabili University. Their tubers weighted with weighting machine with precise of 0.01 g. Main stem were those that directly joined to seed tubers. Auxiliary branch grows on main stem. Stem heights were determined by measuring their length from soil surface to the tallest portion. Stems and leaves separately dried within a period of 48 h at 48°C to measurement of their dry weight. For the aim of determine of leaf number not dried but green leaves counted. Also, active stems were counted in order to determine of stem numbers. All data were statistically analyzed and the means were compared using Software SAS and all tables were drawn using Software Microsoft Office, Excel. The means were compared by Duncan test at the level of 5%.

RESULTS

Time of 50% flowering: In order to determine 50% flowering during rapid growth period 10 plants in different treatments randomly labeled. Then, every day plants, which made flowers were counted. The day, in which 5 plants from 10 plants flowered, estimated as 50% of flowering. Result showed that flowering affected by cultivars, nitrogen and their interaction. Increase in nitrogen levels caused to decrease in flowering. Control and 200 kg N ha^{-1} appropriated lowest and highest amount, respectively. Flowering for control, 80, 160 and 200 kg N ha^{-1} were 53.46, 55.19, 57.88 and 61.02 days after planting, respectively. Agria cultivar flowered later than Satina. The day, in which Agria and Satina flowered were 58.44 and 55.46 days after planting, respectively. Interaction effect of Nitrogen and cultivars showed that Agria cultivar produced flower later than Satina in all treatments of nitrogen (Fig. 1). But gradient of linear curve for Agria was more (2.828) than Satina (2.357).

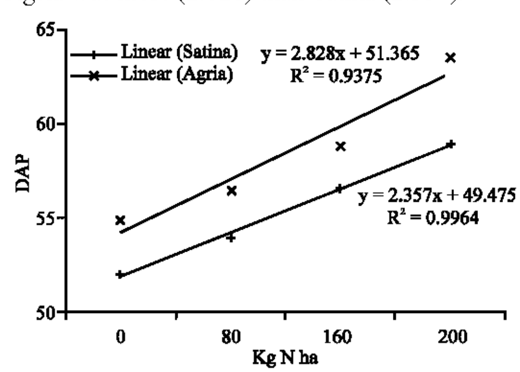

Fig. 1: Interaction effect of cultivars and nitrogen levels on flowering

Table 1: Summary of variance analysis of plant morphological traits during time

Source of variation	df	MS Stem No. per plant	Auxiliary branch no. per plant	Plant weight (cm)	Stem DW $plant^{-1}$ (g)	Leaf No. per plant	Leaf DW $plant^{-1}$ (g)	Tuber yield $plant^{-1}$ (g)
Replication	3	0.57	0.62	230.91	9.65	200.07	22.61	4052.69
Nitrogen (N)	3	64.29**	149.02**	6134.52**	2580.03**	10169.9**	3391.12**	562754.79**
Error	9	0.70	0.31	175.27	15.43	100.53	29.43	24100.83
Cultivar (V)	1	77.53**	8.56**	133.81	213.07**	1396.44**	634.75**	77966.60*
N×V	3	2.05*	0.23	435.70**	16.26*	116.99**	71.82**	77451.23**
Error	12	0.46	0.24	71.52	3.10	10.46	5.69	11795.02
Sampling (S)	5	0.61	81.19**	1028.65**	1428.04**	6871.52**	911.59**	1923618.58**
N×S	15	0.94	3.55**	8265.00	71.95**	124.08**	52.46**	36429.46**
V×S	5	0.46	0.31	13.65	4.95	15.33	6.72	18029.72
N×V×S	15	0.56	0.26	84.55	5.73	26.65	8.22	26796.38
Error	120	0.94	0.43	59.35	9.15	38.16	16.31	12830.61
CV	-	19.10	19.10	14.56	16.50	11.04	16.40	21.27

* and ** shows the significance at the probability levels of 5 and 1%, respectively

Table 2: Means comparison of main effects (CV, N and S)

Studied levels	Stem No. per plant	Auxiliary branch no. per plant	Plant height (cm)	Stem DW $plant^{-1}$ (g)	Leaf No. per plant	Leaf DW $plant^{-1}$ (g)	Tuber yield $plant^{-1}$ (g)
Cultivar							
Agria	4.448b	3.901a	53.73a	19.30a	58.63a	26.42a	552.60a
Satina	5.719a	3.479b	52.06a	17.20b	53.24b	22.78b	512.29b
N fertilizer							
Control	3.521c	1.281d	36.44c	7.71d	35.17d	13.12d	372.9b
80 kg ha^{-1}	6.302a	3.677c	55.05b	22.01b	62.89b	29.03b	587.4a
160 kg ha^{-1}	5.385b	4.365b	58.42ab	24.20a	68.34a	32.34a	609.4a
200 kg ha^{-1}	5.126b	5.438a	61.69a	19.07a	57.35c	23.91c	560.2a
Sampling (DAP)							
57	5.266a	1.422f	42.24c	9.08f	52.22d	18.50d	121.8e
70	4.938a	2.563e	51.15b	11.34e	63.03b	23.37c	360.8d
83	5.063a	3.345d	55.95a	19.03d	65.69b	30.16a	581.2c
94	5.048a	4.047c	55.87a	20.84c	69.39a	29.75a	678.0b
105	5.234a	5.000b	54.43ab	23.31b	56.44c	27.41b	683.7b
118	4.953a	5.766a	57.75a	25.89a	28.86e	18.41d	769.2a

*Numbers with same words in each column have no significant differences to each other. Figures with same coefficients did not show significant difference at probability level of 5%

Stem number per plant: Data variance analysis (Table 1) showed that N, cultivar and their interaction had significant effects on stem number per plant. Satina had the highest stem number per plant and showed a significant difference with Agria (Table 2). N level of 80 kg N ha^{-1} and control yielded the highest and lowest stem number per plant, respectively and the levels of 160 and 200 kg N ha^{-1} stood between two extremes. So, with the increase in N fertilizer level up to 80 kg N ha^{-1}, stem number per plant increased but further increase in N fertilizer level did not affect it anymore. Stem number did not have considerable variation during growing period because it is a kind of traits, which are mainly dependent on tuber size and shoot number per tuber. Means comparison of cultivar×N interaction showed that early maturing cultivar Satina had the highest stem number per plant at fertilizer level of 80 kg N ha^{-1} and Agria produced the most stem number at 160 kg N ha^{-1}. With increase in nitrogen level for both cultivars stem number decreased, any more and the lowest number produced at fertilizer level of control (Table 3).

Auxiliary branch number per plant: N, cultivar, time (of sampling) and N×sampling significantly affected auxiliary branch number per plant. Means comparison showed that CV Agria had more auxiliary branches (3.91 numbers $plant^{-1}$) than CV Satina, possibly because of more main stem in the latter than that in the former. N had significant effect on this trait, too. The increase in N level led to the increase in auxiliary branch number and control had the least auxiliary branch number. Auxiliary branch number increased over growing season so that the highest number was associated with the final sampling, i.e., 118 DAP. According to Table 4, N×time interaction indicated that at all fertilizer levels, auxiliary branch number increased over time. But control had the slowest rate of increase and 200 kg N ha^{-1} had the fastest one. In addition, in all sampling stages fertilizer levels of control, 80, 160 and 200 kg N ha^{-1} had the highest to lowest auxiliary branch number, respectively.

Plant height: Variance analysis (Table 1) showed that plant height was affected by N fertilizer, N×cultivar interaction and time on the probability level of 1%. Means comparison indicated that with the increase in fertilizer level, plant height significantly increased so that fertilizer levels of 160 and 200 kg N ha^{-1} commonly stood in the superior group and control had the lowest plant height

Table 3: Means comparison of N×CV interaction

	Means of traits						
Studied levels	Stem No. per plant	Auxiliary branch no. per plant	Plant height (cm)	Stem DW plant^{-1} (g)	Leaf No. per plant	Leaf DW plant^{-1} (g)	Tuber yield plant^{-1} (g)
Agria×control	3.13e	1.42a	35.17d	8.25e	36.89f	13.87g	344.6c
Agria×80	5.48b	3.98a	58.19ab	23.30b	66.06b	30.85b	636.9a
Agria×160	4.85c	4.56a	6211.000a	25.97a	73.02a	35.87a	665.9a
Agria×200	4.33d	5.65a	59.47ab	19.69c	58.56d	25.08e	563.0b
Satina×control	3.92d	1.15a	37.70d	7.17e	33.44g	12.36h	401.1c
Satina×80	7.13a	3.38a	51.92c	20.73c	59.71d	27.22d	537.8b
Satina×160	5.92b	4.17a	54.72bc	25.43b	63.67c	28.81c	552.8b
Satina×200	5.92b	5.23a	63.91a	18.45d	56.15e	22.75f	557.5b

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

Table 4: Means comparison of S×N

	Means of traits						
Studied levels	Stem No. per plant	Auxiliary branch no. per plant	Plant height (cm)	Stem DW plant^{-1} (g)	Leaf No. per plant	Leaf DW plant^{-1} (g)	Tuber yield plant^{-1} (g)
N level (kg ha^{-1})×sampling (days after planting)							
Control×57	3.44a	0.188m	31.09a	3.38m	34.88h	11.01jk	61.69l
Control×70	3.31a	0.563lm	39.10a	5.65lm	42.69g	14.08ij	268.3k
Control×83	3.63a	1.13kl	38.29a	7.59kl	41.81g	15.50i	398.6ij
Control×94	3.50a	1.44jk	35.76a	8.39jkl	46.38g	15.32ij	523.2fgh
Control×105	3.50a	2.25i	35.58a	9.36ijk	31.75hi	14.85ij	463.8hij
Control×118	3.75a	2.13ij	38.79a	11.90ghi	13.50j	7.94k	518.5ghi
80×57	6.00a	1.25kl	42.70a	10.19hijk	60.44ef	22.47fg	137.3l
80×70	6.19a	2.38i	51.65a	14.42g	69.44cd	25.47dfg	401.0ij
80×83	6.25a	3.19h	57.41a	21.96f	73.00bcd	34.59b	612.8efg
80×94	6.50a	4.31fg	59.03a	26.32de	75.25bc	35.61b	800.6bc
80×105	6.56a	5.19de	59.70a	29.75bc	66.06de	35.22b	807.0bc
80×118	6.31a	5.75vd	59.83a	29.43bcd	33.13hi	20.84gh	765.5bcd
16×57	6.25a	1.81ijk	45.72a	13.35gh	59.56f	22.78fg	149.6l
16×70	5.19a	3.25h	56.47a	13.92g	70.81cd	29.65cd	410.5hij
16×83	5.13a	4.31fg	64.05a	24.19ef	78.38b	40.53a	670.5de
160×94	4.94a	4.81ef	63.23a	27.08cde	85.81a	38.59ab	687.4cde
160×105	5.84a	5.81cd	60.59a	31.94ab	74.6bc	34.30b	807.0bc
160×118	4.88a	6.19bc	60.45a	34.70a	41.44g	28.20cde	931.2a
200×57	5.38a	2.44i	49.45a	9.39 ijk	54.00f	17.74hi	138.7l
200×70	5.06a	4.06g	57.40a	11.369ghij	69.19cd	24.29efg	363.3jk
200×83	5.25a	4.76efg	64.07a	22.36f	69.56cd	30.01c	642.8def
200×94	5.26a	5.63cd	65.44a	21.56f	70.13cd	29.50cd	697.8cde
200×105	4.94a	6.75b	61.83b	22.21f	53.88f	25.28defg	657.0de
200×118	4.88a	9.00a	71.94a	27.51cd	27.38i	16.64hi	861.6a

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

(Table 2). The increase in plant height was significant on 57, 70 and 83 DAP. Difference in stem height from 83-118 DAP were not significant. The greatest variation happened until 83 DAP and afterwards the variations were not considerable (Table 2). Cultivar×N interaction showed that plant heights of both cultivars increased by the increase in N fertilizer level and in both cultivars, control had the lowest plant height. At fertilizer levels of 80, 160 and 200, CV Agria unlike CV Satina did not exhibit considerable variations (Table 2). Cultivar Agria and Satina produced greater amount of stem length at 160 and 200 kg N ha^{-1}, respectively. For cultivar Agria little decrease happened at 200 kg N ha^{-1}.

Stem dry weight per plant: Variance analysis table (Table 1) shows that N, cultivar, sampling frequency, N×sampling and N×cultivar had significant effects on stem biomass. Means comparisons of main effect of cultivar (Table 2) indicates that CV Agria significantly produced more stems biomass than early-maturing CV Satina. Among N levels, the levels 160, 80, 200 kg N ha^{-1} and control had the lowest biomass, respectively. With the increase in N level up to 160 kg N ha^{-1}, stem dry weight increased, but at the level of 200 kg N ha^{-1}, it started to decrease so that it was even lower than that at N level of 80 kg N ha^{-1}. Growth trend (sampling frequency) showed that stem dry weight significantly increased from the beginning of growth period though the end and the highest amount was achieved on 118 DAP (25.89 g plant^{-1}) and the lowest amount was achieved on 57 DAP (9.08 g plant^{-1}) (Table 2). Means comparison of cultivar×N showed that CV Agria ×160 kg N ha^{-1} was superior to the other treatments with a significant statistical difference and CV Agria ×80 kg N ha^{-1} stood in the next rank. In both cultivars, stem dry weight per plant increased with the increase in N level from control to 160 kg N ha^{-1} but with the further increase in N level up to 200 kg ha^{-1}, it started to decrease. In both cultivars, at different N levels CV Agria stood in superior group compared to CV Satina (Table 3). In N×sampling interaction, the level of 160 kg N ha^{-1} showed a significant difference with other N levels from the viewpoint of this trait and the maximum stem dry weight was achieved at the level of 160 kg N ha^{-1} at last sampling (118 DAP). N fertilizer at all levels had a significant effect on stem biomass throughout the growing season. The least and the most stem biomass was related to control (no-fertilizer)×57 DAP (first sampling) (3.38 g plant^{-1}) and 160 kg N ha^{-1}×118 DAP (34.7 g plant^{-1}), respectively (Table 4).

Leaf number per plant: Means comparison of leaf number (Table 1) showed that CV Agria had significantly more leaves than CV Satina. Among N levels, the highest leaf number was related to 160 kg N ha^{-1} and the lowest one to control. From control up to 160 kg N ha^{-1}, leaf number increased but further increase up to 200 kg N ha^{-1} led to its decline. Among different samplings, the highest leaf number per plant was related to fourth sampling (94 DAP), which had significant difference with other samplings. The last sampling (118 DAP) had the lowest leaf number. Means comparison of interactions showed that CV Agria was superior in whole growing period so that Agria ×160 kg N ha^{-1} stood in first group with a significant difference. In both cultivars, leaf number increased from control to 160 kg N ha^{-1} but further increase led to its decline. N×sampling interaction indicated that fourth sampling (94 DAP)×160 kg N ha^{-1} had the highest leaf umber per plant with a significant difference. From the beginning of growing period until third sampling, N levels of 200 and 80 kg ha^{-1} produced more leaves than control and 160 kg N ha^{-1}, but then N level of 160 kg ha^{-1} significantly outreached both levels and exhibited more leaves. Control had the lowest leaf number during growing period to which had a significant difference with other levels (Table 4).

Leaf dry weight per plant: Means comparison showed a significant superiority of CV Agria to CV Satina. CV Aria had higher yield than CV Satina due to better vegetative growth. N level of 160 kg ha^{-1} had a significant difference with other levels. N levels of 80 and 200 kg ha^{-1} and control had the lower leaf biomass, respectively. Sampling frequency significantly affected this trait, too. Third and fourth samplings had the highest biomass without having significant difference and therefore, they stood in a same group. First and last samplings (118 DAP) had the lowest leaf dry weight per plant. Leaf dry weight variance trend under the effect of N×cultivar interaction showed that CV Agria was superior at all fertilizer levels and the difference between two cultivars was higher at 160, 200 and 80 kg N ha^{-1} and control, respectively. Means comparison of sampling×N showed that the level 160 kg Nha^{-1} was superior to other levels during whole growing period and exhibited a significant difference, so that this level had the highest biomass at samplings of 83 and 94 DAP. The decrease in leaf biomass at levels of 160 and 200 kg N ha^{-1} started on 83 DAP. At the level of 80 kg N ha^{-1} and control, the decrease was lower during 83-105 DAP. With the increase in N level, the variation of leaf biomass was greater in different samplings. In fact, it reached to the highest level and started to decrease sooner.

Tuber yield per plant: According to variance analysis (Table 1), cultivar, N fertilizer, cultivar × N fertilizer, time and N fertilizer×time had significant effects on tuber yield. In the main effect of cultivar, CV Agria (552.60 g plant^{-1}) had higher yield than CV Satina. In the main effect of N, the highest tuber yield per plant was gained by applying 160 kg N ha^{-1}. With the increase in N level from control to 80 kg ha^{-1}, yield significantly increased, but further increase did not significantly rose yield. The study of tuber growth trend showed that its yield significantly increased from the beginning of growth period and reached to the peak at last sampling (118 DAP). Fourth and fifth samplings (94 and 105 DAP, respectively), however, stood in same group (Table 2). Means comparison of cultivar×N interaction (Table 3) indicated that the yield of both cultivars rose with the increase in N level up to 160 kg ha^{-1}, but the yield of CV Agria decreased at N level of 200 kg ha^{-1}. In addition, at lower N levels, the rate of yield increase was higher in CV Agria than that in CV Satina (Table 3). N×time interaction showed that tuber yield per plant increased with the lengthening of growth period but its rate was low in control and the highest yield was gained at last sampling in the treatment of 160 kg N ha $^{-1}$ (Table 4).

DISCUSSION

One of the challenges of potato production, as with any crop is the rate of Nitrogen (N) fertilizer. Furthermore, various cultivars can differently response to definite amount of N fertilizer. In this experiment, we studied influence of nitrogen levels on vegetative growth characteristic and yield of two cultivars, Agria and Satina. In both cultivars increase in nitrogen amounts led to delay flowering. Flowering for Satina occurred earlier than Agria. Brown and Scott (1984) reported that lower amount of nitrogen decreased period of growth stage and accelerated beginning of flowering. Reversely with increase in nitrogen level tuberization delayed. Cole (1975) reported that interaction effect of Nitrogen×Cultivar on tuberization was significant. He noted that high amount of nitrogen more delayed flowering of late maturing cultivars. The cultivar Agria produced greater amounts than Satina in all characteristic but main stem number. Stem length of Agria was longer than Satina but not significant. When, we examine the role of N fertilizer on vegetative characteristic, it is clear that 160 kg N ha^{-1} has an important role in aboveground growth especially for aboveground biomass, leaves number and stem height. Main and secondary stem number were greater at 80 and 200 kg N ha^{-1}, respectively. But tuber yield for 80, 160 and 200 kg N ha^{-1} were not significant. When, we focus on interaction effect of cultivars×nitrogen levels (Table 3), it is found that range of 80-160 kg N ha^{-1} for Agria and 80-200 kg N ha^{-1} for Satina produced the most and the same yield. Therefore, the data suggests that low rates of N could be applied without significantly reducing potato yield. The lowest rate of N (80 kg N ha^{-1}) used in this study is significantly less than rate that farmers use for potato production in Ardabil. In this study, potato plants grown in soil amended with 80 kg N ha^{-1} produced tuber yield comparable to higher N rates. Similar result was reported by Meyer (2002). High N rates have been reported to delay tuber initiation (Marschner, 1995). Also, supply of further N can lead to allocation of assimilate for aboveground growth rather than tuber. It is mentionable that more growth intense competition among plants and within plants, which can lead to fall off leaves. Production maximum yield with low Nitrogen rate undoubtedly can reduce the contamination of environment problems and increase revenue. The average number of stem is a variable that is mostly affected by cultivar characteristic (Morena *et al*., 1994); however, disease and environmental condition play an important role too. Alam *et al*. (2007) reported the effect of various treatments on stem number and got the lowest stem number with no-fertilizer treatment. Also, Hossain *et al*. (2003) reported the increase in stem number due to applying nitrogen fertilizer. Auxiliary branch number was affected by both N fertilizer level and cultivar and at higher N level, late-maturing cultivars grew the greatest foliage (Khajehpour, 2006). The increase in plant height with the increase in N fertilizer level was reported by Meyer (2002). Hossain *et al*. (2003) reported the significant increase in plant height during growing season for all treatments. Also, in another study, Jamaati-e-Somarin *et al*. (2009) reported that N fertilizer significantly increased plant height and shoot development. Shakh *et al*. (2001) reported the increase in stem dry weight, stem length and stem number with the increase in N application (180 kg ha^{-1}). Alam *et al*. (2007) reported that shoot yield was affected by treatments and the maximum yield was gained with 100% application of chemical nitrogen fertilizer with 10 tons organic fertilizer. Beraga and Caeser (1990) reported that the first consequence of applying N fertilizer in potato fields is the increase in size and number of leaves. The increase in mature leaves due to the application of N increases photosynthesis/ respiration ratio, which in turn, increases assimilate and yield (Shakh *et al*., 2001). But, if excess N is applied, shoot development will be so increased that more leaves will be shadowed, then photosynthesis/respiration ratio will decline, which in turn, will led to the transfer of less assimilate to tubers because more assimilate will be used in vegetative organs (Jenkins and Nelson, 1992). Jamaati-e-Somarin *et al*. (2008) reported that N increased leaf number per plant, affected tuber yield and increased it up to optimum level. Meyer (2002) reported that CV Atlantic had higher yield than CV Superior in both years and showed that lower levels of N can be applied without having significant effect on yield. Thus, it can be concluded that the effect of N on vegetative organs was significant, while this development and growth of vegetative organs positively affected tuber yield just up to N level of 80 kg ha^{-1} and the further increase in N level did not affect it. At low N levels, foliage development of early-maturing cultivars was more extensive than that in late-maturing cultivars but with the increase in N level, this difference was not significant any more (Ankumah *et al*., 2003).

CONCLUSION

This study indicates that potato production in ardabil region strongly impressed by nitrogen treatments. But amount of changes between aboveground and tuber growth weren't the same. Maximum aboveground growth needs more Nitrogen level than tuber growth. Leaf and stem dry weight, leaf number per plant were maximums at 160 kg N ha^{-1} for both cultivars. Plant height and secondary branch increased with increase in Nitrogen and most amounts was obtained at 200 kg N ha^{-1} in both Agria and Satina. Although, tuber yield increased with supplement of nitrogen, yield changes were different for cultivars. Tuber yields for Agria at ranges from 80-160 kg N ha^{-1} and for Satina at ranges from 80-200 kg N ha^{-1} were insignificant. So, significant increase in aboveground growth couldn't increase tuber yield. As a whole, range of 80-160 kg N ha^{-1} is recommended. Because 200 kg N ha^{-1} is very much and causes environmental problems and 80 kg N ha^{-1} perhaps will be lower depend on year, region and environmental conditions.

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