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Response of Durum Wheat Growth and Chlorophyll Content to Nitrogen Rates and Plant Populations

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Abstract: In order to evaluate the effect of nitrogen rates and plant populations on growth and chlorophyll content of durum wheat Seymare cultivar during the growing season, a factorial experiment based on randomized complete block design with three replications was conducted in the research center for agriculture, Islamic Azad University, Ardabil branch, Ardabil, Iran in 2008-2009 growing season. Factors included nitrogen rates: 0, 60, 120 and 180 kg ha^{-1} and plant populations: 300, 350 and 400 plant m^{-2}. Date of appearance of some growth stages, growth of the leaves and stems in terms of number and dry weight and also, leaf chlorophyll content during the growing season was recorded. Results showed that with increasing nitrogen application, some aspects such as stem dry weight, number of leaf, stem and tiller along with the leaf chlorophyll content were increased and with increasing plant population per unit area, vegetative growth period and leaf chlorophyll content were decreased, while the reproductive growth period, leaf and stem dry weight and the number of leaf, stem and tiller were increased.

Key words: Durum wheat, growth period, leaf chlorophyll content, nitrogen, plant population, Iran

INTRODUCTION

Nitrogen is one of the basic compounds in plant nutrition and its deficit directly is of important growth limiting factors in plants because the need of plants to this element is much more than the other ones (Alizadeh, 2002). Nitrogen consists of 2-4% of plant dry weight. No other element such nitrogen can stimulate plant growth. Nitrogen takes part in the construction of chlorophyll, some vitamins, Hormones, cell wall and enzymes (Kafi *et al*., 2005). Phenology is known as the date of the appearance of the important incidents in the plant life. Lieth (1974) suggests a clear definition of the phenology quoted from the phenology committee: phenology is the study of the timing of the biological incidents, tools and biological and non-biological causes of appearance of these timings and eventually, their evaluation among the different cultivars.

Wheat reaction to the plant density (population) is more than row-plants. In cereals, in the highest populations, the lowest number of seeds are produced as a result of excess competitions among the plants to reach light or water. The rate of the nitrogen application is effective in the amount and distribution of this element inside the plant (Koochaki and Mohessel, 2001). Also, soil high fertility and/or increase in nitrogen usage, causes the increase in growth and grain yield of the corn (Sarmadnia and Koocheki, 1997). Plant density has the severe impact on the length of the different phenological stages of the corn (Early *et al*., 1967). With increasing plant population, delay in flowering, earring and decreasing of the reproductive growth stage is observed (Daynard and Muldoon, 1983). Lang *et al*. (1986) reported the reduced percent of the infertile plants using the nitrogen application and decrease in plant population. Al-Rudha and Al-younis (1978) observed that increase in nitrogen application results in the delay of the flowering. Quantitative analysis of growth is a suitable method to explain and interpret the reactions of plant to the different environmental conditions during the growth period by which, distribution of the photosyntetically assimilates among the organs of the plant may be evaluated by measuring the amount of dry matter produced by the plant (Tesar, 1984). Tollenaar and Lee (2002) observed that the number of emerged leaves are reduced by decreasing available nitrogen for plant but amount of soil compaction, depth of seedingand the rate of radiation and carbon dioxide impact on the leaf growth, as well

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(Wilhelm and McMaster, 1995). Plant population can influence the growth of the leaf and stem by impacting on nutrient elements, humidity, solar radiation and plant phenological stages. Permanent cool season and small grain cereals produce one leaf each 4-6 days at the same conditions for the corn and other warm season cereals (Koochaki and Mohassel, 2001). Low temperatures may delay the length of the vegetative growth and flowering stages and restrict the available nutrients because of increase in the time at which leaves are appeared (Hill, 2007; McWilliams *et al*., 1999).

Leaf chlorophyll content is an important factor to determine the photosynthesis rate and Dry Matter (DM) production (Ghosh *et al*., 2004). In a study on the relationship between chlorophyll content and nitrogen concentration in terms of leaf unit area, it was shown that the former has a high correlation with the latter (Karimi, 2001). Ghosh *et al.* (2004) reported an increase in chlorophyll content under stress due to the application of fertilizer. Nitrogen is an important element needed by crops, since it is one of the constituents of nucleic and amino acids, proteins, peptides, chlorophyll and alkaloids (Mengel, 1992). Nitrogen application had a significant effect ($p<0.01$) on leaf chlorophyll so that there were significant differences among different levels of nitrogen. In an experiment no significant difference was observed between 0.5 and 1 Mm nitrogen application on potato by Bahavar *et al.* (2009). Salehpour *et al.* (2009) also found that nitrogen has a significant effect on the chlorophyll content of the lentil. Ghosh *et al.* (2004) reported that chemical fertilizer application increased potato chlorophyll content.

The aim of this research was investigation of the nitrogen rates and plant population's effect on growth and leaf chlorophyll content of the durum wheat during the growing season.

MATERIALS AND METHODS

The research center in which the research was carried out was located in North-Western of Iran with the elevation of 1350 m of sea level (48°,20'E, 38°,5'N). The weather of the region is very cool in winters and rather warm in summers. Soil of the location was loamy clay with a pH of 7.7 and the depth of 70 cm seeds were prepared from the agricultural organization, Germy, Iran. Surface sterilization of seeds was performed using Diniconazol fungicide before planting. Seeds were placed at the depth of 3-4 cm by spacing 15-25 cm apart on 10 rows each 4 m length. The first irrigation was done after planting and the rest, while the plant needed, based on the different plant requirements and environmental conditions. Mechanical and chemical weed controlling were executed during the season. Amount of 1/3 total applied nitrogen was applied at the planting time and the rest, was used as surface spread in the spring after the weather began to be warmer coincide with the tillering stage, 2 times. To investigate the date of appearance of several growing stages, following records were performed (Emam and Niknejhad, 2004).

The length of the vegetative growth period: from the planting date to the 50% flowering stage. The length of the reproductive growth period: from the flowering date to the physiological maturity. Date of physiological maturity; from the planting to the beginning of 50% plants turn to yellow.

In order to determine the number, dry weight and some other growing traits of the leaves and stems as a trend during the season, approximately 151 days After Planting (DAP) for one time each week, sampling was performed from each plot and was continued 7 times (193 DAP). At the end of the sampling stages, the growth rate of the plants nearly reached a constant value and hence was stopped. To do this, 5 complete plants along with the roots and tillers were taken out the soil and after removing the roots, the rest was subjected to measure. To determine the leaf chlorophyll content and the impact of the several nitrogen levels and plant populations on this trait at different growth stages, approximately 170 DAP as each week, leaf chlorophyll content was measured and recorded using the chlorophyll meter device (CC 200, USA-001495) for 7 times so that by reaching the final stages, the chlorophyll content was reduced. To measure this trait, the attached to plant leaves were placed between the two blades of the device and the content of the three sections of the leaves including the beginning, the middle and the end of the samples were read and recorded by selecting the 15 individual plants. In other words, this content was a mean of 45 reads and was done for the all plots. Data were subjected to analysis by SAS and mean companions were performed using the Duncan's multiple range test procedure. Also, graphs were drawn in Excel software.

RESULTS AND DISCUSSION

Vegetative growth period: The length of the growth period of the under study wheat was affected by the plant populations and nitrogen levels (Table 1). Results of the analysis of variance showed that there is a significant difference ($p<0.01$) between the nitrogen levels and plant populations but there was no significant difference for the interaction effect of these treatments. The longest and the shortest vegetative growth period

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

Experimental levels	Generative growth period (DAP)	Ripening growth period (DAP)	Vegetative period (DAP)
Nitrogen fertilizer (kg ha^{-1})			
0	173.66c	55.66b	227.94c
60	177.44b	56.55ab	241.05b
120	178.00b	58.33a	243.94b
180	183.77a	56.88ab	259.63a
Plant density (plant m^{-2})			
300	181.07a	53.00c	240.22a
350	177.50b	57.58b	242.97a
400	176.08b	60.00a	246.22a

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

were gained at the 300 and 400 plant m^{-2}, respectively. With increasing the nitrogen amounts, length of this period was increased so that the longest one was obtained by application of 180 kg ha^{-1} nitrogen. However, there was no significant difference between the 60 and 120 kg ha^{-1} nitrogen on this trait but with increasing the nitrogen levels and decreasing the plant populations, the length of vegetative growth period was increased (Table 1). Higher amounts of nitrogen resulted in the increase in the growth of the aerial parts and delayed the period (Jamaati-e-Somarin *et al*., 2009). Lang *et al*. (1986) observed that with increasing the plant population over the favorable point, this period is delayed one day.

Reproductive growth and ripening period: Results revealed that plant populations and nitrogen levels significantly ($p<0.05$) affected the reproductive growth period, respectively. With increasing plant population, this period was decreased so that in 300 plant m^{-2}, the shortest and in 400 plant m^{-2}, the longest one was achieved (Table 1).

Based on the some researches performed on the reduction of the mentioned period caused by the higher rates of plant population, it seems that in the lower populations, the stronger growth of the leaves and lateral stems may result and hence, the incident light radiation needed for the better photosynthesis is increased and eventually, the more suitable growth of the flowering buds is prepared (Lang *et al*., 1986). Accordingly, the beginning of the reproductive period starts with the flowering so, it is logical that with increasing plant population, the length of the reproductive growth period increases.

Also, it was found that nitrogen amount up to the 60 kg ha^{-1} decreased this period but increase in nitrogen application higher than this amount increased the period so that the longest one was achieved at the level of 120 kg ha $^{-1}$ (Table 1). Nitrogen significantly ($p<0.01$) affected the length of the ripening period and simple effect of plant population and interaction effect of plant population x nitrogen level was not significant

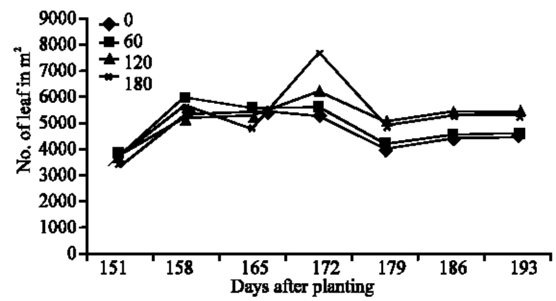

Fig. 1: Effect of nitrogen fertilizer rates on number of leaf m^{-2} during the season

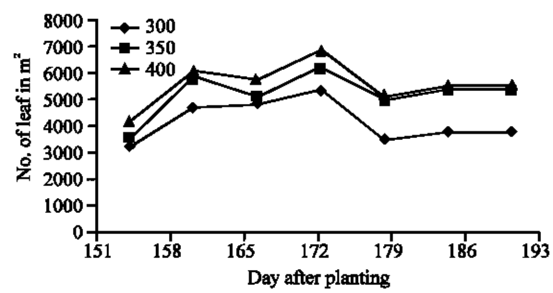

Fig. 2: Effects of plant populations on number of leaf m^{-2} during the season

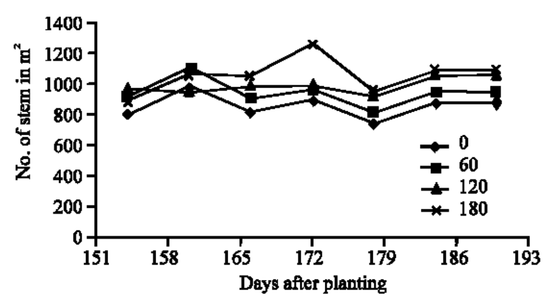

Fig. 3: Effect of nitrogen fertilizer rates on number of stem m^{-2} during the season

on this trait. Increase in the nitrogen application increased the length of this period but there was no significant difference between the 60 and 120 kg ha^{-1} usage. The longest and the shortest time to the ripening were gained at the levels of 180 kg ha^{-1} nitrogen and control, respectively (Table 1). It seems that increase in nitrogen application may improve the vegetative growth and hence, plant come to senescence later and ripening happens with delay.

Number of leaf, stem and tiller: According to the graphs for the number of leaf, stem and tiller (Fig. 1-6), it was cleared that increase in the application of the nitrogen and plant population, led to the increase in number of leaf, stem and tiller per unit area but in terms of the time, these traits were increased in the beginning of the sampling and as time passed, this value became nearly constant. Increase in the number of leaf and stem caused by the

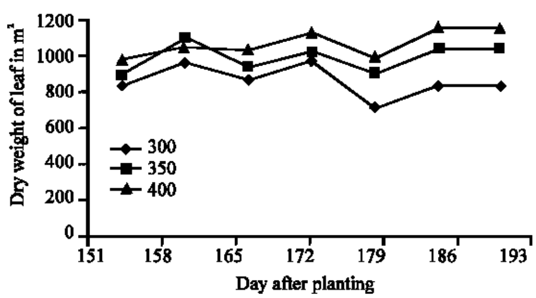

Fig. 4: Effect of plant populations on number of stem m^{-2} during the season

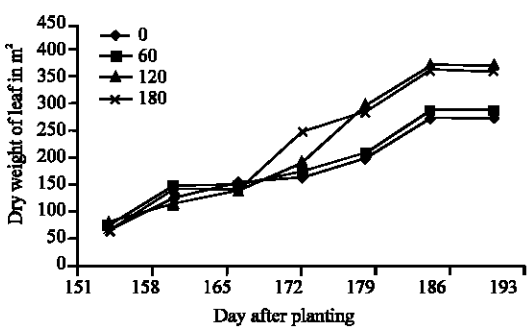

Fig. 5: Effect of nitrogen fertilizer rates on dry weight of leaf m^{-2} during the season

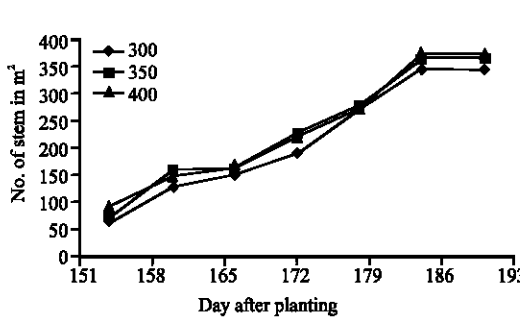

Fig. 6: Effect of plant populations on dry weight of leaf m^{-2} during the season

increase in plant population is seen in some researches (Alam *et al*., 2007). The main effect of the nitrogen is rapid extension of the leaves and stem and causes the plants more rapidly dose the canopy and benefit from the growing season; this matter has been proved by the frequent experiments (Peng *et al*., 1996; Mengel, 1992). Mengel (1992) found that the first impact of nitrogen on potato is the increase in size and number of leaves. By this means, photosynthesis/respiration ratio and production of the assimilates is increased but in the excess values, expanding of the aerial parts become more and more and as a result, the number of leaves placed in the shadow is increased So, the photosynthesis or respiration ratio is decreased. This will lead to the lower assignment of assimilates to the leaves than the tubers as the main yield (Emam and Niknejhad, 2004). The initial growth of the plant is low because of incompletion of the canopy but as the growth increases, more photo-synthetically matters are produced because of the more radiation absorption by the canopy.

Dry weight of the leaf and stem: Trend of the differences of the leaves and stems dry weight m^{-2} in different populations and nitrogen amounts has been shown in Fig. 7-10. During the time, it is clear that both of the mentioned traits have increased slowly and have become constant at the latest stages of the plant growth. Also, the

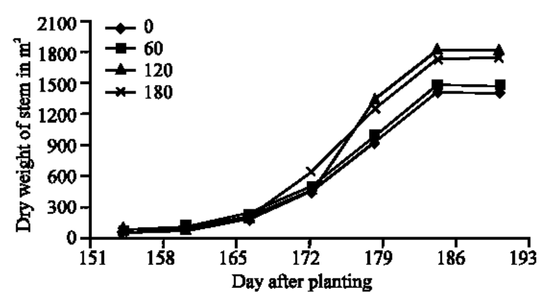

Fig. 7: Effect of nitrogen fertilizer rates on dry weight of stem m^{-2} during the season

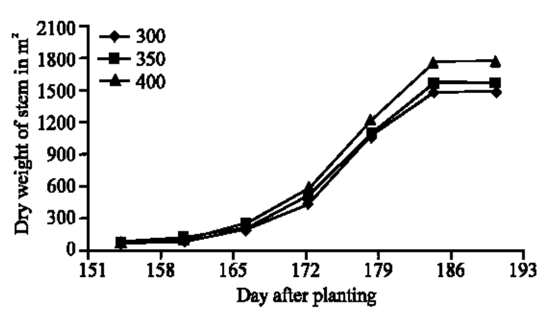

Fig. 8: Effect of plant populations on dry weight of stem m^{-2} during the season

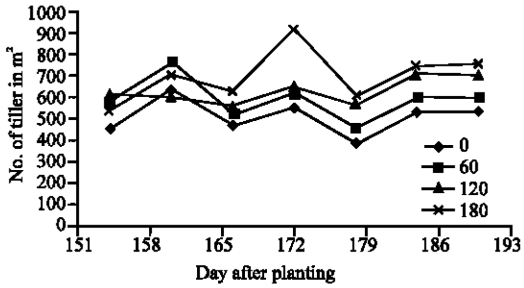

Fig. 9: Effect of nitrogen fertilizer rates on number of tiller m^{-2} during the season

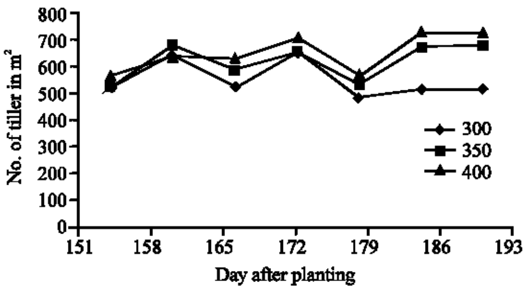

Fig. 10: Effect of plant populations on number of tiller m^{-2} during the season

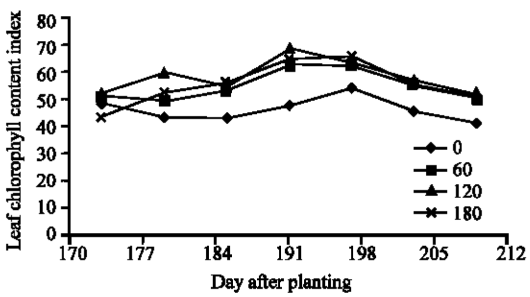

Fig. 11: Effect of nitrogen fertilizer rates on leaf chlorophyll content during the season

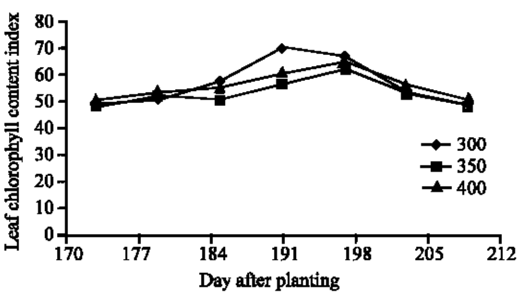

Fig. 12: Effect of plant populations on leaf chlorophyll content during the season

Fig. 7-10 show that with increasing plant population, amount of the leaf and stem dry weight has increased. Higher dry weight of the leaf and stem in higher populations may be resulted from the better growth of the plant due to the well establishment of the canopy useing the environmental resources more favorably so, the more yield can be achieved. This result is in accordance with the Cox (1996), Longnecker and Robson, (1994). With compare the results presented in the Fig. 7-10, it can be concluded that the higher nitrogen values increase the dry weight of the leaf and stem. In other words, nitrogen enhances the dry weight of the stem by expanding the aerial parts and consequently, preparing the more transportable assimilates to the stems (Costa *et al*., 2002). Due to the increase in the number of stems per unit area caused by the higher populations, it is expectable to accumulate more assimilates in the stems (Cox and Cherney, 2001).

Leaf chlorophyll content: Trend of the leaf chlorophyll content in different populations and nitrogen levels has been shown in Fig. 11 and 12. This trait was increased slowly by 198 DAP and then by reaching the end of the season, it was decreased gradually. Also, it was found that as population increased, this trait was decreased so that the most and the least one was observed in 300 and 400 plant m^{-2}, respectively. As in lower populations, the fewer plants grow so, inter plant spaces get more and ability of plants to absorb the light and nutrient elements is improved and the chlorophyll content is increased. With increasing nitrogen up to 120 kg ha^{-1}, this amount was increased and then was decreased. Bahavar *et al*. (2009) and Salehpour *et al*. (2009) reported the same results about the impact of nitrogen application on the leaf chlorophyll content as well. Ghosh *et al*. (2004) reported that chemical fertilizer application increased plant chlorophyll content.

CONCLUSION

Generally, it can be said that with increasing nitrogen levels, some traits such as the length of the vegetative, reproductive and ripening periods, number and dry weight of the leaf, stem and tillerand the leaf chlorophyll content were in creased. Also, with increasing plant population, the length of the vegetative growth period and the leaf chlorophyll content were decreased while, the number and dry weight of the leaf, stem and tiller were increased.

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