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Effect of Nitrogen on Source-Sink Relationship in Wheat

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ABSTRACT

A field experiment was conducted to evaluate the effect of four different levels of nitrogen on physiological aspects of growth and yield in wheat. Leaf area index, relative growth rate and net assimilation rate significantly increased with increasing levels of nitrogen, but the increase in leaf area duration was non-significant. Grain filling rate, grain filling duration, grain weight and grain yield also increased with the increasing levels of nitrogen. Harvest index, however, did not increase with increasing levels of nitrogen.

Key Words: Nitrogen; Source-sink; Wheat

INTRODUCTION

In cereals, dry matter production depends upon source-sink relationship, where the source being the potential capacity for photosynthesis and the sink is the potential capacity to utilize the photosynthetic products. Balanced mineral nutrition is the most important for best source-sink regulation. An adequate supply of nitrogen to the crop plants during their early growth period is very important for the initiation of leaves and florets primordia (Tisdale & Nelson, 1984).

Grain yield of wheat per unit area depends upon number of kernels per unit area and kernel weight. Grain weight is a genetically controlled trait, which is greatly influenced by environment during the process of grain filling (Kausar *et al*., 1993). Nitrogen application also increases the rate of grain filling (Langer & Liew, 1973; Whingwiri & Stern, 1982; Eichenaur *et al*., 1986). Differences in final grain weight were primarily determined by the differences in grain filling rate (Nass & Reiser, 1975) and grain filling duration (Gebe *et al*., 1982; Wong & Baker, 1986). The grain filling rate and grain filling duration depends both genetic (Wiigand & Cuellar, 1981; Mashiringwani *et al*., 1994; Mou & Kronstad, 1994) and environmental factors (Sofield *et al*., 1977; Wiegand & Cuellar, 1981; Bauer *et al*., 1985; Wheeler *et al*., 1996). Grain filling rate is dependent upon the average temperature during grain filling (Zhaq, 1986). High temperature accelerate assimilation rate and enhance movement of photosynthates from flag leaf to spike but shorter the grain filling duration (Sofield *et al*., 1977; Bruckner & Frohberg, 1987). Nitrogen plays a very vital role in the process of grain filling (Green, 1984), increases leaf area of the crop and may result in increased dry matter production by intercepting more sun light (Wilhelm, 1998). A good supply of it also results in higher net assimilation rate (Sage & Pearcy, 1987), more productive tillers (Wilhelm, 1998), more number of spikes per unit area, number of grains per spike, biological yield and grains yield (Al-Abdulsalam, 1997).

MATERIALS AND METHODS

The research work was carried out at the Students Farm, Department of Agronomy, University of Agriculture, Faisalabad. The experiment was laid out in randomized complete block design with three replications and the net plot size was 1.5 x 6 m. wheat variety, Auqab, 2000, at a seed rate of 100 kg $ha^{-1}$was sown in 6 rows spaced at 30 cm in each plot. Fertilizer treatments comprised of nitrogen, at the rate of 0, 60, 120 and 180 kg ha^{-1}in the form of urea. Phosphorus was also applied at recommended rate in the form of Tripple Super Phosphate. All phosphorus and 1/3 nitrogen was applied at sowing time, while the remaining 1/3 dose of nitrogen was applied with first irrigation and 1/3 with 3rd irrigation. The data as source parameter were recorded at booting stage. Leaf area index was measured with the help of Linear PAR Ceptometer (AccuPAR, Decagon Devices, Inc., Pullman, Washington, USA). The relative growth rate (RGR) and net assimilation rate (NAR) were calculated according to the formulae described by Radford (1967) and for this purpose 5 plants were harvested twice at 7 days interval and fresh and dry weights were recorded. Tillers were counted a week before harvesting from a unit area (1 m^2). Grain filling rate (GFR), grain filling duration (GFD) and grain weight were calculated according to the methods described by Bokhari (1989). Grain yield and total biomass were recorded after harvesting the central four rows from each plot and the harvest index (HI) was calculated as ratio between the economic yield and biological yield. The data so collected were subjected to statistical analysis according to the methods described by Steel and Torrie (1984).

RESULTS AND DISCUSSION

Nitrogen application significantly increased all the source parameters. Leaf area index at tillering and booting stages increased significantly with increase in N level. Increase in leaf area index with increase in N application may be the effect of increased rate of leaf expansion (Radin

Table I. Effect of nitrogen on different source parameters

Treatments	Number of tillers	Relative growth rate (mg g^{-1} day^{-1})	Net assimilation rate (g cm^{-2} day^{-1})	Leaf area index
T_1 = 0 kg N ha^{-1}	396.00 d	41.07 c	0.91 d	2.76 d
T_2 = 60 kg N ha^{-1}	468.00 c	56.06 b	1.37 c	4.63 c
T_3 = 120 kg N ha^{-1}	575.00 b	80.38 a	2.14 b	6.14 b
T_4 = 180 kg N ha^{-1}	618.00 a	81.62 a	2.93 a	7.45 a

Table II. Effect of nitrogen on different sink parameters

Treatments	Grain filling rate (mg day^{-1})	Grain filling duration (days)	1000-grain weight (g)	Grain yield (kg ha^{-1})
T_1 = 0 kg N ha^{-1}	44.14 d	37.00 b	37.06 c	2000.00 c
T_2 = 60 kg N ha^{-1}	49.74 c	36.00 b	43.33 b	3800.00 b
T_3 = 120 kg N ha^{-1}	55.26 b	39.00 ab	46.66 ab	4283.33 ab
T_4 = 180 kg N ha^{-1}	57.29 a	41.00 a	49.50 a	5133.33 a

& Boyer, 1987), increased leaf number (Dale & Wilson, 1977) and stimulated tiller formation (Coaldrake, 1985).

The number of tillers increased significantly with the increasing levels of nitrogen. The increase in number of fertile tillers with the increase in nitrogen levels can be attributed to the reduction in mortality of tillers and enabling the production of more tillers from the main stem (Anwar, 1988). Net assimilation rate (NAR) and relative growth rate (RGR) increased with the increasing levels of N. Increase in net assimilation rate may be attributed to increased photosynthetic capacity of the leaves with improved nutrition of the plants (Ahmad *et al*., 1990).

Grain filling rate and grain filling duration progressively increased with increase in nitrogen levels. Pearman *et al*. (1979) reported that the increase in dry matter is due to the increased light intercepting area, resulting in more assimilation of photosynthates and increase in filling rate. Grain weight increased with increase in N levels. Maximum grain weight was recorded at nitrogen level of 180 kg ha^{-1}. The grain weight is a genetically controlled trait, which is greatly influenced by environment during the process of grain filling. It appears that the application of nitrogen increased the protein percentage which in turn increased the grain weight (Kausar *et al*., 1993).

Grain yield increased with increase in nitrogen levels. The maximum grain yield was recorded at nitrogen level of 180 kg ha^{-1}. Individual comparison of means shows that grain yield increased with the increase in nitrogen level. The highest value of grain yield (5133.33 kg ha^{-1}) recorded by N application at the rate of 180 kg ha^{-1}. The unfertilized crop yielded the lowest grain yield (2000 kg ha^{-1}). The current data are supported by the earlier researchers (Ahmad *et al*., 1990; Islam *et al*., 1993; Frederick & Camberato, 1995; Al-Abdulsalam, 1997; Turk, 1998; Fixen & Leikam, 1989; Hussain, 1994; Bellido *et al*., 2000).

CONCLUSIONS

It is concluded that nitrogen improved the yield of wheat by improving both source and sink efficiency and nitrogen application @180 kg ha^{-1} proved the best for the present experimental material and the ago ecological conditions of Faisalabad.

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