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CULTIVAR DIFFERENCES OF WHEAT (*TRITICUM AESTIVUM* L.) IN NITROGEN USE EFFICIENCY

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Nigtrogen (N) use efficiency of 4 commercially cultivated wheats was studied in a pot experiment. The wheat cultivars Lu-26, Sarsabz, Sindh-81 and M-143 were grown to maturity in potted soil without (-N) or with (+N) ^{15}N-labeled ammonium sulphate used as an N source. The cultivars did not differ significantly in total dry matter yield in the absence of applied N. Application on N, however, caused a significant increase in both dry matter and N yield. Although the increase in dry matter and N yield (expressed as g pot^{-1} and mg pot^{-1}, respectively) due to applied N between cultivars, the percent increase was statistically similar. Of the total plant N, 37-40% was drived from the fertilizer; highest efficiency of fertilizer N uptake being observed in Sarsabz followed by M-143. Application of fertilizer N caused a significant increase in the plant uptake of native soil N as a result of added nitrogen interaction or ANI. This effect was also most marked in Sarsabz and M-143. The uptake of total N by different cultivars differed significantly mainly through ANI.

Key words: Added nitrogen interaction, ^{15}N, N balance, N immobilization, N loss, N uptake, Priming effect, Rhizodeposition, Wheat.

Introduction

Use of commercial nitrogen (N) fertilizers in agriculture has resulted in significant increase in crop yields. However crop plants can make use of only up to 50% of the applied fertilizer N [1,2]. From 10 to 50% of the fertilizer N is lost from the soil plant system [1,2], thereby causing economic losses as well as environmental pollution. There is increasing emphasis, therefore, on the need to increase fertilizer use efficiency.

Improvement in the efficiency of N use in crop production is best achieved through manipulation of the entire soil-plant fertilizer system [2]. One way to achieve this goal is to select crop cultivars more efficient in using available N whether applied as fertilizer or that already present in the soil. The reported literature shows that the crop varieties/cultivars show significant differences in this regard [3]. However, the mechanism through which different plant species influence the fate of applied N has not been well understood.

In expriments using ^{15}N to study the fate of fertilizer N, it is commonly observed that more unlabelled N is taken up by the fertilized than that by the unfertilized plants as a results of ANI [4-14]. There is considerable controversy over the causes and interpretation of ANI [15], However, it is logical to assume that the process of stimulated soil-N availability and related processes such as biological interchange and immobilization-mineralization, will affect overall crop productivity and N economy (including use efficiency, loss and residual value of fertilizer N). Thus N fertilizers are not only a direct source of plant aavilable N but may also make the soil N more available to plants.

The objectives of this study were to compare some wheat cultivars for: (i) uptake of N from soil and fertilizer and (ii) their effect on the interaction of applied fertilizer N with the native soil N.

Materials and Methods

The soil use in this study was a loam collected from the surface (0-15 cm) of an experimental field at the Nuclear Institute for Agriculture and Biology, Faisalabad, Pakistan. Air-dried and sieved soil (<0.5 mm) contained 0.6% C, 0.06% N and had pH (saturation extract) of 7.2.

The experiment was conducted during the normal wheat growing season (November, 1989 to April, 1990) in pots with no provision of drainage. Five and a half kg portions of the soil were placed in 24 pots of 6 kg capacity. Six replicate pots were sown to each of the 4 wheat (*Triticum aestivum* L.) cultivars Lu-26, Sarsabz, Sindh-81 and M-143. Lu-26 was obtained from Ayub Agriculture Research Institute (AARI), Faisalabad, and the remaining three were provided by the Atomic Energy Agriculture Research Centre (AEARC), Tandojam. Plant height of Lu-26, Sarsabz, Sindh-81 and M-143 was 90,91,98 and 101 cm, respectively, whereas the maturity period for the four cultivars was 125, 118, 120 and 129 days, respectively.

Six seeds were planted in each pot and after germination the stand was thinned to 3 seedlings. Triplicate pots for each

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variety were given 165 mg N each as $(^{15}NH_4)_2SO_4$ (1.0 atom percent ^{15}N excess) at the time of sowing (+N treatment). Another dose of N (165 mg pot^{-1}) was applied at tillering. Triplicate pots were left unfertilized in case of each variety (–N treatment). All the pots were given P and K as KH_2PO_4 at the rate of 165 and 208 mg pot^{-1}. Irrigation with deionized water was given as necessary and the plants were harvested at maturity in April 1990. Above-ground parts were separately collected and the roots were carefully removed from the soil for maximum recovery and washed free of soil particles.The grain was separated and all the plant components (root, straw and grain) were dried at 70° to a constant weight. Finely ground material of each component was analysed in triplicate for Kjeldahl-N [16]. Acidified and concentrated distillates were subjected to isotope-ratio analysis on a modified double inlet mass spectrometer (varian MAT GD 150) which was accurate to 0.002 atom % ^{15}N or better.

Data reported on different parameters were calculated as follows:

(i) Harvest index (HI) = grain yield/(grain + straw yield)
(ii) Nitrogen harvest index (NHI) = grain N/(N in grain + straw)
(iii) Percent N derived from fertilizer (% N dff) = At. % ^{15}N excess in sample x 100/At.% ^{15}N excess in fertilizer.
(iv) mgNdff=fraction Ndff x mg N in given sample
(v) Fertilizer N uptake (FNU) (mg pot^{-1}) by:
  (a) Difference method (DM) = Total plant N in fertilized soil minus that in unfertilized soil.
  (b) Isotopic method (IM) = fertilizer N in plant.
(vi) Added nitrogen interaction (ANI) = (total N in fertilized plant - Ndff) - total N in unfertilized plant.
(vii) 'A' (availability) value = (100 - %Ndff) x amount of fertilizer N applied/%Ndff.

Results and Discussion

In general, the differences between cultivars in total dry mater yield were not significant in the - N treatment (Table 1) an observation in line with previously reported results [17]. The response to N application in terms of % increase in dry matter yield was also not very different in the 4 cultivars but increase in grain yield due to N application showed significant differences with Sarsabz showing the highest increase. Harvest index was similar in the 4 cultivars and lower in N than in +N treatments. An improvements in HI due to applied N is frequently reported in the literature.

More N was determined in all plant components in +N than in N- treatment (Table 2). The increase in N yield due to applied N was more in Sarsabz and M-143 than the other two cultivars; NHI being statistically smilar in all cultivars, both in +N and -N treatment. In these cultivars, however, the contribution of fertilizer N to the total N of different plant components was relatively low compared to other two cultivars (Table 3).

The range of fertilizer N contribution to the total plant N (37-40%) was well within the limits reported by others [11,17,18]. Efficiency of fertilizer N uptake (FNU) [19] was calculated by both difference method (DM) and isotopic method (IM). As generally observed [20], DM gave large differences between cultivars for FNU but the values were always higher than those determined by IM

TABLE 1. DRY MATTER YIELD (g POT^{-1}) IN DIFFERENT VARIETIES.

Variety		Root	Straw	Grain	Total	HI*
Lu-26	-N	2.8	12.6	11.4	26.7	0.47
	+N	3.0	12.4	16.9	32.2	0.58
Sarsabz	-N	4.0	12.5	11.7	28.3	0.48
	+N	2.8	13.7	17.8	34.3	0.57
Sindh-81	-N	4.3	11.0	10.8	26.1	0.50
	+N	3.4	13.5	14.0	30.8	0.51
M-143	-N	3.6	10.8	11.9	26.2	0.53
	+N	3.5	13.2	16.1	32.8	0.55
LSD (P=0.05)		0.4	1.0	1.0	2.5	0.04

* Harvest index.

TABLE 2. N YIELD (mg POT^{-1}) IN DIFFERENT VARIETIES.

Variety		Root	Straw	Grain	Total	NHI*
Lu-26	-N	12.6	33.2	184.1	229.9	0.85
	+N	18.8	54.4	335.4	408.6	0.86
Sarsabz	-N	15.8	37.9	168.8	222.5	0.82
	+N	17.4	97.4	363.1	477.9	0.79
Sindh-81	-N	20.8	37.9	207.9	266.8	0.85
	+N	24.0	59.6	355.8	439.4	0.86
M-143	-N	12.7	34.6	198.5	245.8	0.85
	+N	15.5	65.6	384.9	466.0	0.85
LSD (P=0.05)		1.2	6.5	20.4	32.2	0.07

* Nitrogen harvest index.

TABLE 3. PER CENT N DERIVED FROM APPLIED FERTILIZER IN DIFFERENT PLANT COMPONENTS.

Variety	Root	Straw	Grain	Total
Lu-26	31.95b	33.16a	41.54b	39.98b
Sarsabz	33.15bc	35.23ab	37.04a	36.53a
Sindh-81	35.42c	37.23b	39.27ab	38.78ab
M-143	22.50a	35.42ab	38.00ab	37.12ab

Figures in a column sharing similar letter are not significantly different from each other at 5% level of significance according to Duncan's Multiple Range Test (DMRT).

TABLE 4. RECOVERY OF NITROGEN IN SOIL-PLANT SYSTEM AND OTHER RELATED ESTIMATES.

Variety	FNU (mg pot^{-1})		FNU	FNUt	FNR	FNL	ANI	'A'
	DM	IM	(%)	(%)	(%)	(%)		value
Lu-26	178.7a	163.4a	49.5a	85.3b	31.1b	19.4b	15.4b	495a
Sarsabz	255.5c	174.6b	52.9a	77.0a	17.2a	29.9c	80.9d	573b
Sindh-81	172.8a	170.4b	51.6a	82.0b	37.1c	11.3a	2.4a	521a
M-143	220.2b	173.0b	52.4a	84.6b	16.4a	31.2c	47.2c	559b

FNU, fertilizer N uptake; DM, difference method; IM, isotopic method; FNUt, fertilizer N utilization; FNR, fertilizer N remaining in soil; FNL, fertilizer N lost from the soil-plant system; ANI, added nitrogen interaction; "A" value, (100-%Ndff) x the amount of fertilizer N applied / % Ndff.
Figures in a column followed by a similar letter are not significantly different from each other at 5% level of significance according to Duncan's Multiple Range Test (DMRT).

(Table 4), an observation in line with many other reports [14,21,22]].

Jenkinson *et al.* [15] have described the differences between the two methods for N recovery estimates as a result of apparent ANI occuring through pool substitution and isotopic displacement reactions. Interactions which results in higher uptake of unlabeled N (from soil due to increased mineralization of native organic matter or through enhanced biological N_2 fixation) by plants have been reported by several workers [9-14]. Studies by Azam *et al.* [13, 14] suggest that the ANI is not always apparent, and a real ANI as well as 'priming" action [7] of the added N may contribute to N nutrition of plants. Azam [11] argued that real ANI may be an important factor in increased crop yields following green manuring. In the present study, the ANI could be considered real [15] at least in Sarsabz and M-143 where extra unlabeled N taken up by the plants from fertilized soil (ANI, column 8, Table 4) was greater than fertilizer N immobilized (recovered in soil after removing inorganic N by KCl extraction; Table 4, column 6); a condition essential for the occurrence of real ANI [6]. In the other two cultivars, the estimates of fertilizer N uptake by both the methods were similar presumably because ANI was negligible. Cultivar/varietal differences in the ANIs have previously been attributed to the differences in rhizodeposition which not only affects the immobilization mineralization of N (a key factor determining pool substitution and the apparent ANI) but also the rhizospheric microbial functions, particularly N_2 fixation.

The observation that Sarsabz and M-143 showed ANI and thus higher uptake of N from sources other than fertilizer (i.e., biologically fixed N and N mineralized from native soil organic matter) was further evident from higher 'A' values (Table 4). Fried and Dean [23] introduced the 'A' value concept to express the 'availability' to plants of N from soil, fertilizer or atmosphere. In our study, we used 'A' value to express the availability to plants of soil N. An increase in 'A' value observed in this study has been reported by other workers as well [14]. In the present study, Sarsabz and M-143 were found not only as efficient users of fertilizer N but were also able to significantly mobilize sources of N other than fertilizer.

Loss of fertilizer N varied from 11 to 30% in the 4 cultivars. For wheat, the reported losses vary from 10 to 30% [1,2,17]. Greater loss of N occurred in Sarsabz and M-143. However, these losses were more than compensated by the availability to plants of extra unlabeled N. As a consequence, the loss of fertilizer N had no significant bearing on the nutrition of plants and efficiency of fertilizer N use (grain yield/amount of fertilizer N applied) was not affected negatively. However, in these cultivars, excessive loss of fertilizer N could be of concern as regards fertilizer N economy and atmospheric pollution.

Results obtained in this study suggest that cultivars differ significantly in affecting the availability of N from other sources following application of fertilizer N. However, field experiments will be needed to confirm and substantiate these findings. Selection and introduction in the agricultural system of cultivars/varieties with a higher potential to exploit N sources other than fertilizer will help reduce fertilizer inputs and minimize environmental pollution caused by excessive use of nitrogenous fertilizers.

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