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ISOTOPIC AND NON-ISOTOPIC ESTIMATIONS OF FERTILIZER NITROGEN UPTAKE BY WHEAT

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Recoveries of fertilizer N in wheat (cv. Mexi Pak-65) grown in a field experiment were calculated by:(i) difference method; (ii) linear regression of total N in wheat plant on rates of applied N; (iii) ^{15}N method; and (iv) linear regression of fertilizer N uptake on rates of labelled fertilizer.

The difference method overestimated recoveries of applied fertilizer N (in grain) 92, 75 and 64% at three rates of application when compared to the ^{15}N method. Similarly linear regression of total N in wheat on rates of N over estimated recoveries by 25% at the three rates of application when compared to linear regression of fertilizer N in wheat on rates of ^{15}N labelled fertilizer.

The difference method of calculating the recoveries of fertilizer N in wheat could give values similar to those calculated by ^{15}N method when the minimal N treatment was used as a base instead of zero-N.

Key words: Wheat, N recovery, ^{15}N laballed fertilizer.

Introduction

Presently agriculture depends heavily on chemical nitrogen fertilizers for obtaining higher yields of crops. Because of ever increasing cost of chemical fertilizers it is imperative to develop fertilizer management practices that would ensure higher efficiency of fertilizers. The efficiency of fertilizer is judged from the recovery values in above ground parts of the crop calculated either by non-isotopic method or isotopic ^{15}N method [1,2].

The use of ^{15}N as a tracer allows precise measurements of fertilizer N in the soil - plant system, and it has been extensively used to evaluate the fate of applied N in soils [3]. However, for field experiments the use of ^{15}N tracer has been restricted by the higher cost of ^{15}N and by the difficulty of performing N isotops ratio analysis. Thus there is a need for the evaluation of experiments to learn wheather or not similar results could be obtained with non-isotopic method.

The objectives of this study were to compare recoveries of fertilizer N in wheat under field conditions as calculated by: (i) the difference method (ii) linear regression of total N in crop on rates of applied N; (iii) isotopic 15N method and (iv) linear regression of labelled fertilizer N uptake on rates of ^{15}N labelled fertilizer; and to evaluate the data to learn whether similar results could be obtained with non-isotopic method as with ^{15}N tracer method.

Materials and Methods

A field experiment was conducted on sandy loam soil having 0.03% total N; (determined by macro kjeldahl's method); 8 ppm available P (extracted with alkaline sodium bicarbonate solution, P determined colorimetrically by the phospho molybdenum blue method); and pH 8.2. (determined by glass electrode, soil/water ratio 1:2.5). Wheat crop (cv. Mexi Pak-65) was sown at 120 kg/ha seeding rate. The wheat was fertilized at 0.20, 60 and 120 kg N/ha, using ammonium nitrate labelled with ^{15}N (1% ^{15}N enrichment equally distributed between NH_4^+ and NO_3^- ions). Single superphosphate was applied at 30 kg P/ha to all treatments. At seeding the N and P fertilizers were broadcast and worked in the soil.

The treatments were given in a randomized block design with five replicates, with plots 5 x 1 m containing five rows of wheat plants 20 cm apart. The crop received normal cultivation and irrigation. At maturity the grain and straw yields were recorded. For yield data the central three rows of plants were harvested discarding 0.5 m length of rows on both ends of the plots. Grain and straw samples for chemical analyses were collected from the middle row of the plant. Grain and straw samples were analysed for total N and ^{15}N. Total N was determined by Kjeldahil's method, and ^{15}N analysis was done by mass spectrometer.

The percent recoveries of fertilizer N were calculated by: (i) difference method, (ii) linear regression of total N in plant on rates of applied N, (iii) isotopic ^{15}N method and (iv) linear regression of fertilizer N uptake on rates of laballed fertilizer [1,2].

Results and Discussion

The application of fertilizer N significantly increased the yield of grain and straw over that of the control (Table 1). The control produced 2242 kg/ha grain with an increase of 861 kg/ha from the application of 20 kg N/ha. As the rate of fertilizer was increased from 20 to 120 kg N/ha grain yields increased from 3103 kg/ha to 3858 kg/ha and that of straw from 5171 to 7199 kg/ha. The yield response to the fertilizer additions was curvilinear.

Total N uptake progressively increased in both grain and straw as the rate of fertilizer N increased from 0 to 120 kg

TABLE 1. EFFECT OF RATE OF $NH_4 No_3$ ON YIELD AND N UPTAKE IN WHEAT.

N application Kg/ha	Yield Kg/ha	Total N uptake Kg/ha	% N_{dff}*
		Grain	
0	2242	37.3	0
20	3103	47.2	8.5
60	3468	62.9	23.2
120	3858	79.0	36.1
C.V., %	12.4	8.6	5.2
S. E.(m)	95	3.4	1.5
LSD (P=0.05)	304	11.1	4.8
		Straw	
0	3618	6.2	0
20	5171	12.8	7.8
60	5779	17.6	19.2
120	7199	28.4	37.4
C.V,%	13.6	9.5	7.1
S. E.(m)	272	2.4	1.6
LSD (P=0.05	866	7.9	5.2

*N_{dff} = derived from fertilizer.

N/ha. Similarly N_{dff} in grain and straw increase with the increase of N application and it increased linearly with the increase in fertilizer addition (Fig. 1).

Recoveries calculated by difference method varied from 34.7 to 49.0% in grain and from 18.5 to 23.0% in straw (Table 2). The percent recoveries of fertilizer N in grain and straw calculated by ^{15}N method ranged from 23.9 to 25.5% and from 6.0 to 8.9%, respectively.

The recoveries calculated by linear regression of total N in plant parts on the rate of fertilizer N were 29.6% in grain and

TABLE 2. RECOVERY OF FERTILIZER N (%) IN WHEAT AS ESTIMATED BY DIFFERENT METHODS OF CALCULATIONS

N application kg/ha	Methods: Non-isotopic: Difference	Non-isotopic: Linear regression	Isotopic: ^{15}N tracer	Isotopic: linear regression
		Grain		
0	-	-	-	-
20	49.0	29.6	25.5	23.7
60	42.6 (26.3)*	29.6	24.3	23.7
120	34.7 (26.6)*	29.6	23.9	23.7
C.V.,%	14.2	-	5.3	-
S.E. (m)	3.8	-	1.7	-
		Straw		
0	-	-	-	-
20	23.0	8.5	6.0	8.8
60	19.0	8.5	6.5	8.8
120	18.5	8.5	8.9	8.8
C.V.,%	12.8	-	13.4	-
S.E.(m)	3.2	-	1.1	-

*Values calculated by keeping 20 kg N/ha as the base instead of Zero nitrogen

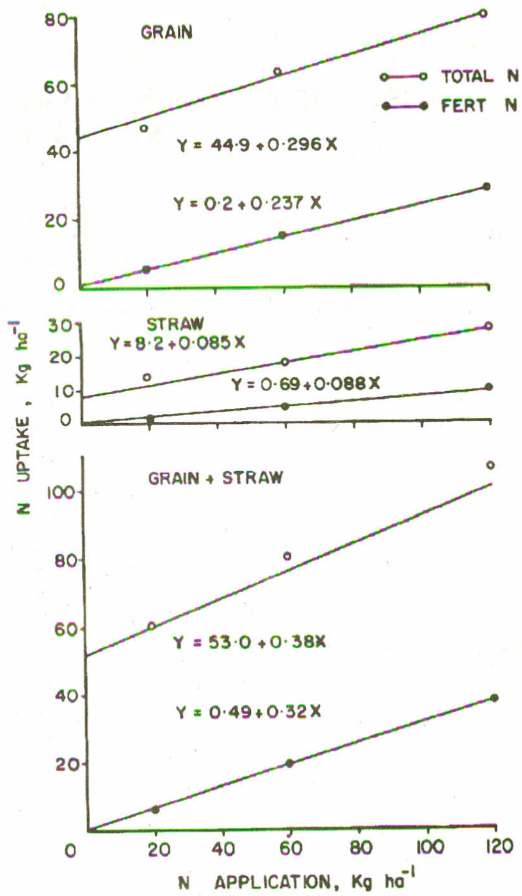

Fig. 1. Total and fertilizer N uptake diagram for wheat as influenced by fertilizer rate under field conditions.

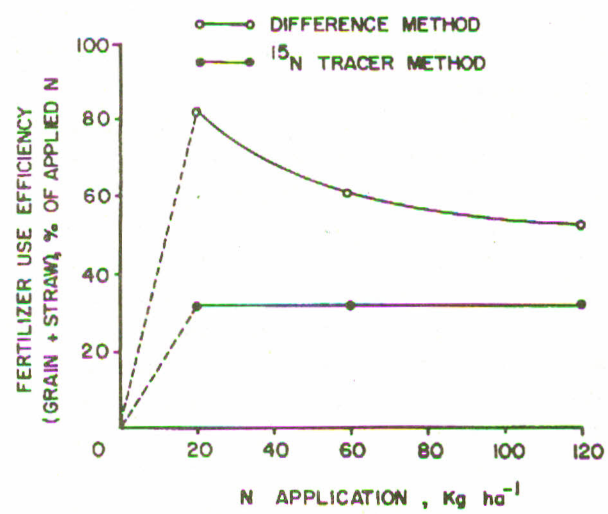

Fig. 2. Harvested fertilizer N use efficiency in wheat (grain + straw) grown in the field.

8.5% in straw (Table 2). The recoveries calculated by the linear regression of ^{15}N in plant parts on the rate of labelled fertilizer applied were 23.7% in grain and 8.8% in straw.

The difference method overestimated recoveries (in grain) 92, 75 and 64% at the three rates of N application, respectively, when compared to the ^{15}N tracer method. Similarly linear regression of total N in crop on rates of N overestimated recovery by 25% at the three rates of application when compared to linear regression of fertilizer N in wheat grain on rates of ^{15}N labelled fertilizer. The harvested fertilizer recoveries (in grain + straw) calculated by difference method were 62 to 160% higher as compared to those calculated by ^{15}N tracer method (Fig.2); the overestimation being highest at the lowest rate of fertilizer application and vice versa. Such overestimations of recoveries of fertilizer N in crops calculated by non-isotopic methods as compared to isotopic methods have commonly been observed [1,4]. On the contrary Nielsen and Jensen [5] and Recous *et. al.* [6] did not observe this phenomenon in their field experiments on spring barley and winter wheat.

The overestimation of fertilizer N in wheat calculated by nonisotopic method as compared to isotopic method can be attributed to the so called "priming effect" of added fertilizer N [7-9]. Legg and Stanford [10] have discussed explanations other than the priming effect. Different views are held regarding the use of ^{15}N tracer in fertilizer use efficiency studies. Terman and Brown [11] and Jansson [12] have stated that ^{15}N tracer techniques offer no distinct advantages over non-isotopic methods in most routine N efficiency studies if multiple rates are compared. Whereas Westerman and Kurtz [1] and Fried *et. al* [13] suggested that the use of ^{15}N tracer is almost essential in agronomic experiments. Inspite of all this neither the difference method nor the 15_N uptake method of measuring fertilizer N use efficiency can give unequivocal results (9). If there is a real added nitrogen interaction, fertilizer use efficiency calculated by difference method will be in error; if there is an apparent added nitrogen interaction, the efficiency calculated by the ^{15}N method will be in error.

In the present study recovery of fertilizer N in wheat grain was also calculated by difference method keeping 20 kg N/ha as a base instead of zero nitrogen. The recovery values of fertilizer N thus obtained (given in parentheses in Table 2) were remarkably similar to those calculated by ^{15}N method. In our opinion the ^{15}N method being expensive could be replaced by the difference method by using minimal N rate as the base instead of zero nitrogen in routine agronomic experiments studying fertilizer use efficiency. ^{15}N tracer should only be used in experiments when information on the soil N and the fate of fertilizer N in soil-plant system is desired.

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