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EFFECT OF TIME AND METHOD OF N APPLICATION AND MOISTURE REGIMES ON UPTAKE OF N FROM N^{15} LABELLED AMMONIUM NITRATE, UREA AND AMMONIUM SULPHATE BY WHEAT

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Abstract. The effect of time and method of N application and of moisture regimes (two irrigations vs four irrigations) on N uptake from N^{15} labelled ammonium nitrate, urea and ammonium sulphate by wheat was studied in the field. Ammonium nitrate was most productive for grain yield, and utilization of N in grain from ammonium nitrate applied at seeding was significantly higher than from urea and ammonium sulphate. In case of ammonium nitrate band placement and broadcast and worked-in methods of application were equally good for the utilization of fertilizer N by wheat. Urea and ammonium sulphate were better utilized when applied in a side band. Moisture levels (two irrigations vs four irrigations) did not have significant effect on grain yield and utilization of fertilizer N.

With the progressive use of N fertilizers for obtaining higher yield of wheat and with the production of different N fertilizers, a need for investigating the factors that affect the efficiency of applied fertilizer has arisen. Fertilizer placement and time of application are of prime importance in this respect. Isotopically-labelled fertilizers provide a unique and valuable tool for investigating these factors.

The N sources differ in their efficiency to increase yield of wheat grain,[1-6] depending on soil conditions, such as pH, water and environmental conditions. In alkaline soil NO_3 source was more productive for grain yield than NH_4 source.[5] Under semiarid conditions NH_4 and NO_3 sources produced more grain than urea form.[6] Spratt[7] found that wheat receiving NH_4-N at sowing produced more leaves and stems than those receiving NO_3-N at sowing but grain yield was not affected. Wheat receiving NO_3-N at boot stage had significantly higher percentage of N in grain than that receiving NH_4-N. The efficiency of fertilizer for grain production can be improved if N uptake by wheat is increased by applying the proper form of N at the appropriate time.

The 'A' value concept developed by Fried and Dean[8] is used for assessing the nutrient status of soil. This concept is based on the assumption that when a plant is presented with two different sources of a nutrient, it will take up nutrient from each source in direct proportion to the amount available from the two sources. Many workers[9-11] have assessed the availability of various fertilizers by using 'A' value data. Where the experiment is laid down on one soil, the availability of soil nutrient is considered constant and any change in the availability of the fertilizer results in a change in the soil nutrient fertilizer–nutrient ratio such that lower fertilizer nutrient uptake is reflected in a higher 'A' value and vice versa.

The objectives of this experiment were to investigate: (a) the effect of stage of growth at application on utilization of applied N; (b) the effect of methods of application on utilization of applied N at different stages of growth; and (c) the effect of frequency of irrigation on N utilization from N^{15}-labelled ammonium nitrate, urea and ammonium sulphate.

Materials and Methods

A field experiment was conducted at Nuclear Institute for Agriculture and Biology, Lyallpur, during 1971–72 on sandy clay loam soil having total N 0.03%, available P (Olson) 12 p.p.m. and pH 8.4. Mexipak-65 wheat was sown at 120 kg/ha seeding rate. The wheat received 120 kg N/ha, half at seeding half at tillering stage (30 days after sowing). Three and N^{15}-labelled fertilizers used were; (a) ammonium nitrate, $^{15}NH_4{}^{15}NO_3$, with 1% N^{15}-enrichment equally distributed between NH_4 and NO_3 ions; (b) urea, $(^{15}NH_2)_2CO$, with 1% N^{15}-enrichment; and (c) ammonium sulphate, $(^{15}NH_4)_2SO_4$, with 1% N^{15}-enrichment.

Triple superphosphate was applied at 30 kg P/ha to all treatments. At seeding N fertilizers were applied either in a band 5-cm to the side and 2-cm below the seed or broadcast and worked into the soil (broadcast/worked-in). At tillering stage N fertilizers were broadcast over the area.

The experimental design used was a split plot. The two moisture regimes (optimum and dry) were the main plots and the N fertilizer treatments were the subplots. Each treatment was replicated four times. The individual subplot was 5×1 m with five rows of wheat plants 20 cm apart. For the applica-

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TABLE 1. EFFECT OF TIME and METHOD OF APPLICATION OF THREE N FERTILIZERS ON YIELD, TOTAL N UPTAKE, FERTILIZER N UPTAKE, FERTILIZER N UTILIZATION, and 'A' VALUE OF WHEAT AT TWO MOISTURE REGIMES.

N application (kg/ha)			Yield (kg/ha)		Total N uptake (kg/ha)		Fert. N uptake (kg/ha)		Utilization of fert. N (%)		'A' value (kg/ha)	
Seeding		Tillering stage										
Broadcast/ worked-in	Side band		†M_1	M_2	M_1	M_2	M_1	M_2	M_1	M_2	M_1	M_2
Grain												
NH_4NO_3												
60*		60	5658	5369	108·3	98·0	29·4	25·3	49·0	42·2	164	174
60		60*					32·8	31·6	54·7	52·6	146	135
	60*	60	5484	5238	104·1	94·4	28·7	25·8	47·9	43·1	184	159
	60	60*					36·6	33·8	61·0	56·0	123	109
Urea												
60*		60	5329	5361	95·4	93·7	17·9	17·0	29·9	28·4	275	271
60		60*					31·7	35·1	52·8	58·5	124	102
	60*	60	5331	5272	100·2	98·4	22·2	19·0	36·9	31·6	221	262
	60	60*					36·5	37·1	60·8	61·8	107	101
$(NH_4)_2SO_4$												
60*		60	5258	5198	91·4	89·4	16·2	16·4	27·2	27·3	283	270
60		60*					33·6	37·9	56·0	63·2	105	81
	60*	60	5173	5007	90·8	87·7	19·0	19·8	31·7	33·0	230	234
	60	60*					35·2	35·9	58·7	59·8	96	90
Control			1871	2061	28·6	31·4	—	—	—	—	—	—
LSD (for fertilizer treatments)												
	P=0·05		678		13·56		7·04		11·73		61	
	P=0·01		898		17·97		9·34		15·57		81	
Straw												
NH_4NO_3												
60*		60*	9538	8747	40·7	37·5	9·1	8·2	15·2	13·7	—	—
60		60*					11·5	12·6	19·1	12·1	—	—
	60*	60	9279	8928	41·1	38·2	9·7	6·1	16·1	10·1	—	—
	60	60*					15·8	14·5	26·3	24·2	—	—
Urea												
60*		60	9407	9318	40·2	39·7	7·3	6·3	12·2	10·5	—	—
60		60*					11·9	13·8	19·9	23·0	—	—
	60*	60	8856	9013	37·9	38·4	8·7	7·0	14·5	11·6	—	—
	60	60*					13·3	13·5	23·0	22·5	—	—
$(NH_4)_2SO_4$												
60*		60	9151	8697	39·1	37·2	7·9	6·0	13·1	10·0	—	—
60		60*					16·5	13·2	27·5	22·1	—	—
	60*	60	8653	8193	36·7	35·0	6·8	6·7	11·4	11·2	—	—
	60	60*					13·5	11·3	22·5	18·9	—	—
Control			3670	3986	11·7	12·1	—	—	—	—	—	—
LSD (for fertilizer treatments)												
	P=0·05		1016		6·01		—		—		—	
	P=0·01		1346		7·96		—		—		—	

* N^{15}-labelled fertilizer; †M_1, four irrigations applied at tillering stage, flag leaf stage, heading and when kernels were watery to milky ; and M_2, two irrigations applied at tillering stage and boot stage.

tion of N^{15}-labelled fertilizers each subplot was divided into two equal parts of 2.5×1 m; one part received N^{15}-labelled fertilizer at seeding and the other part at tillering stage.

The optimum moisture plots were irrigated four times—at tillering stage (30 days after sowing), flag leaf stage (90 days after sowing), at heading (110 days after sowing) and when kernels were watery to milky (124 days after sowing). The dry-treatment plots were irrigated twice only—at tillering stage and at boot stage (100 days after sowing). Irrigation for seed bed preparation was additional to both the levels. Each irrigation was 7.5 cm deep. Rainfall during the wheat season was 1.7 cm.

At maturity grain and straw yields were determined. Grain and straw samples were collected dried at 70°C ground and analysed for total N and N^{15}. Total N was determined by Kjeldahl method, and N^{15} analyses were made by the staff at the Seibersdorf Laboratory of IAEA, Vienna.

The efficiency of the different N sources was evaluated by using 'A' value data as described by Rennie.[11] The 'A' values were calculated from grain data and were based on the formula :

'A' value = rate of N application × (Soil N in plant/Fert. N in plant)

An analysis of variance was made and LSD worked out to test the significance of differences between means.

Results

The yield, total N uptake, fertilizer N uptake, per cent utilization of fertilizer N and 'A' value data are given in Table 1. The LSD given in the table is for fertilizer treatments. The LSD for moisture regimes is not given because the two moisture levels did not produce any significant effect.

The grain yield was higher under optimum moisture (four irrigations), but not at a significant level. For example, ammonium nitrate, when broadcast/worked-in, produced 5658 and 5369 kg/ha grain under optimum moisture and dry treatment (two irrigations), respectively. Ammonium nitrate was more productive for grain yield as compared to urea and ammonium sulphate, but not at a significant level. The method of applying N at seeding did not have any significant effect on grain yield.

Total N uptake in grain was highest (108.3 kg/ha) under optimum moisture when ammonium nitrate was broadcast/worked-in, and it varied with N source. Under dry treatment, the total N uptake did not differ significantly with the N source. Fertilizer N uptake in grain from ammonium nitrate was significantly higher (29.4 kg/ha, 25.3 kg/ha) than that from urea (17.9 kg/ha, 17.0 kg/ha) and ammonium sulphate (16.2 kg/ha, 16.4 kg/ha) when N was broadcast/worked-in at seeding under both moisture levels. The method of application of N had an effect on fertilizer N uptake in grain in case of urea and ammonium sulphate, band placement being superior to broadcast/worked-in, but not at a significant level. In case of ammonium nitrate both the methods of N application were equally efficient for utilization of fertilizer N in grain. Per cent utilization of fertilizer N in grain under optimum moisture from ammonium nitrate applied at seeding was 49.0 and 47.9 when N was broadcast/worked-in and placed in a band, respectively. These values were significantly higher than those for urea and ammonium sulphate. The 'A' value data showed that N applied at tillering stage was utilized better than that applied at seeding in all the N sources; ammonium sulphate being superior followed by urea and ammonium nitrate.

The source of N had an effect on straw yield but not at a significant level. Moisture levels had no significant effect, although straw yield was higher under optimum moisture.

Discussion

The efficiency of applied N for wheat production depends on time and method of applidcation[12,13] and source of N.[1,3] The results of this study showed that ammonium nitrate was most productive for grain yield indicating that ammonium nitrate was a better source of N for wheat because of its NO_3-N which the wheat plant could utilize more efficiently during early growth period, and the wheat plant had preference for NO_3-N.[5-14]

Frequent irrigation is also considered essential for obtaining higher yield of Mexican wheat grown in Pakistan.[15,16] The results of this study showed that availability of water at tillering stage and boot stage was critical, and by synchronising irrigation with these two growth stages it was possible to save two irrigations without appreciable reduction in grain yield.

In connection with water use by wheat, precipitation (rainfall and dewfall) should also be considered. Rainfall received during wheat growing period was 1.7 cm which was too low to replace two irrigations. Dewfall seems to have contributed sufficient moisture to meet the water requirement of wheat. This point was not investigated in this study. Our results suggest that a detailed and systematic investigation of the effect of precipitation and microclimate on water use by wheat is extremely important and it would help use the available irrigation water efficiently for higher wheat production.

Per cent utilization of fertilizer N and 'A' value data are useful in assessing the N fertilizer management practices.[11] These data showed that ammonium nitrate applied at seeding was utilized most efficiently because a sizeable art of the N from urea and ammonium sulphate was probably lost through volatilization under alkaline soil conditions[17] and this loss would vary with the method of placement-banded fertilizer being subject to less loss as compared to broadcast fertilizer. This is reflected in better utilization of banded urea and ammonium sulphate. The 'A' value showed that at tillering stage ammonium nitrate was utilized less efficiently then urea and ammonium sulphate because the mobile NO_3-N was leached down with irrigation at this stage leaving less N for plant use.[3] Per cent utilization of fertilizer N and 'A' value data also showed that N applied at tillering stage was utilized better than that given at seeding, indicating that availability of N at this stage would be critical[18] for wheat crop.

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References

1. S.V. Jain, C.M. Mathur and K.M. Mehta, Indian J. Agron., **3**, 213 (1959).
2. O.P. Gautam, Indian J. Agron., **6**, 67 (1961).
3. A. Wahhab, *Fertilizer Trials in Farmers Fields* (Dept. Agric. Govt. of West Pakistan, 1965), p. 156.
4. K.C. Sharma and N.K. Anant Rao, Indian J. Agron., **11**, 229 (1966).
5. A. Hamid, Pl. Soil, **37**, 389 (1972).
6. J. Alessi and J.F. Power, Agron. J., **65**, 53 (1973).
7. E.D. Spratt, Agron. J., **66**, 57 (1974).
8. M. Fried and L.A. Dean, Soil Sci., **73**, 263 (1952).
9. J. Mitchell, J. Soil Sci., **8**, 73 (1957).
10. D.A. Rennie and J. Mitchell, Can. J. Agr. Sci., **34**, 354 (1954).
11. D.A. Rennie, Tech. Rept. IAEA-120, 132 (1970).
12. N.K. Jain, D.P. Maurya and H.P. Singh, Exptl. Agr., 7, 21 (1971).
13. A. Hamid, Exptl. Agr., 9m. 59 (1973).
14. H.B. Hutchinson and N.H.J. Miller, J. Agr. Sci., **3**, 179 (1909).
15. R.A. Khan, Agr. Pakistan, **2**, 397 (1969).
16. M.D. Khan, M.J. Saleem and I.A. Khan, J. Agr. Res. (Punjab), **8**, 343 (1970).
17. S.G. Misra and B. Singh, Indian J. Agron., **14**, 214 (1969).
18. J.P. Patel and R. Sarivastava, Indian Farming, **16**, 19 (1966).