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Quantitative and Qualitative Characters of Wheat Crop Under Various Sources and Methods of Nitrogenous Fertilizer Application

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Abstract: The research was conducted to evaluate the best source and schedule of nitrogenous fertilizer for qualitative and quantitative characters of wheat crop at Sindh Agriculture University Tandojam, Pakistan. Various nitrogenous fertilizers (urea, ammonium nitrate and ammonium sulphate) applied in two and three splits with basal dose of P and K to Sarsabz wheat variety. Nitrogen applied in three split doses significantly increased grain and straw yields, protein and nitrogen content of the wheat crop as compared to two split applications. Among the sources of nitrogen, the urea was ranked at first place as compared to ammonium nitrate and ammonium sulphate fertilizers for recording satisfactory quantitative (grain and straw yields), qualitative characters (nitrogen and protein content in grain and straw) and it had also soil residual effect for N content in the soil. However, the soil residual K and P both were higher in ammonium sulphate. Therefore, it is recommended that urea is the best source of nitrogen and it should be applied in three split doses during various crop growth stages for obtaining satisfactory wheat straw and grain yields protein and nitrogen content.

Key words: Wheat, urea, ammonium nitrate, ammonium sulphate, nitrogen, protein, yield

Introduction

Limited research suggest that proper timing of nitrogen applications to high yielding varieties can be successful as one of the means in attempting to achieve high yield and protein. Nitrogen (N) is often the most deficient of all the plant nutrients. Wheat is very sensitive to insufficient nitrogen and very responsive to nitrogen fertilization. The most important role of N in the plant is its presence in the structure of protein, the most important building substances from which the living material or protoplasm of every cell is made. In addition, nitrogen is also found in chlorophyll the green colouring matter of leaves. Chlorophyll enables the plant to transfer energy from sunlight by photosynthesis. Therefore, the nitrogen supply to the plant will influence the amount of protein, protoplasm and chlorophyll formed. In turn, this influences cell size and leaf area and photosynthetic activity. Plants grown with an adequate supply of nitrogen make rapid and thrifty growth and are dark green in colour. Leaf and stem development is stimulated. Insufficient nitrogen results in lighter green colour, reduced tillering and disturbance of normal cell growth division, a decrease in rate and extent of protein synthesis. Because of this crop yields may also be greatly reduced. Excessive nitrogen causes lush succulent growth, resulting in greatly increased danger of lodging, delayed maturity and greater susceptibility to diseases such as rusts, septoria and powdery mildew. Plants contain more nitrogen than any other essential elements derived from the soil. Plants take up nitrogen from the time the roots begin to function until all uptake of nutrients ceases with maturity. However, the largest amounts are taken up during early stages of growth, held for later use and translocated within the plant where needed, for example, to the kernels from the leaves and stem during maturation (McKenzie, 2002).

The commonly available nitrogen fertilizers are ammonium nitrate, urea and ammonium sulphate. The nitrogen sources always do not perform the same under field conditions, it is difficult to predict future performance when temperature and precipitation are unknown. Research comparisons between nitrogen sources seldom indicate any great differences in performance between the common nitrogen sources. However, volatilization losses can be relatively larger under certain conditions. Volatilization losses would be expected to be most severe under conditions of high evaporation, high soil pH and where large amounts of residue are on the soil surface. Under these conditions, ammonium nitrate is the preferred nitrogen source to use as a topdressing. Potentially, urea can lose large amounts of nitrogen, so nitrogen fertilizers should be incorporated into the soil when ever possible (Sander, 1996). Soil moisture is considered important factor for the efficient use of fertilizers. Among the sources of nitrogen fertilizer, urea requires generally adequate moisture for its uptake by the plants, whereas, ammonium nitrate and ammonium sulphate can be used by the plant under low moisture conditions. It was further reported that urea was the best and reliable source of nitrogen fertilizer for achieving higher wheat crop grain and straw yields as compared to other nitrogen sources available in the market (Palmer and Madge, 1982). Work in southern Alberta with irrigated wheat shows that nitrogen was more efficient in increasing protein content when applied as a urea spray at the flowering stage than when applied to the soil before seeding and about 18% protein content was obtained with 100 kg N ha^{-1} urea applied in granular form. In Manitoba, work with wheat cultivars showed that split applications of nitrogen tended to increase percent protein in the grain. The protein percent difference was 0.2% between the single and split nitrogen applications at the 120 kg N ha^{-1} rate for various cultivars. At a higher nitrogen rate of 160 kg N ha^{-1} the protein percent difference was 0.6 and 1.3% between the single and the three level split nitrogen applications in wheat crop. Although the effects of split application of nitrogen tend to be variable, the literature indicates that the later applied nitrogen tends to be more effective in increasing protein content of the grain. Information is still required regarding the optimum rates, times of application and sources of nitrogen for optimum protein and yields. The guidelines for maximum economic yield of wheat production suggests that split applications of nitrogen should be performed as, 40% pre-plant, 10% in starter, 25% at tillering and 25% at stem elongation. An additional nitrogen application of about 17-22 kg ha^{-1} at swollen boot stage can have significant effects on head fill and grain protein levels (McKenzie, 1998). Looking the economic importance of the wheat crop, the research was set to asses the suitable N fertilizer source for achieving better qualitative and quantitative character of wheat crop.

Materials and Methods

The field experiment was conducted at Latif Experimental Farm, Sindh Agriculture University Tandojam, to study the effect of source and schedule of nitrogen fertilizer on quantitative and qualitative characters of wheat. The experiment was laid out in randomized complete block design (RCBD) with four replications. The treatments were nitrogenous fertilizer source (urea, ammonium nitrate and ammonium sulphate). These fertilizer sources were applied in two methods M1= two splits (1st split 50 kg N ha^{-1} and 2nd split 50 kg N ha^{-1}) and M2= three splits (1st split 33.3 kg N ha^{-1}, 2nd split 33.3 kg N ha^{-1} and 3rd split 33.3 kg N ha^{-1}).

Fertilizers: Nitrogen was applied as sources (urea, ammonium nitrate and ammonium sulphate) in two splits (1st at sowing, second at 1st irrigation) and in three splits (1st at sowing, 2nd at 1st irrigation and third at ear heading).
The basal dose of 75kg P_2O_5 and 25 kg K_2O ha^{-1} was applied in each treatment in the form of S.S.P and murate of potash during final harrowing.

Cultural practices: First irrigation was given after 15 days of sowing and subsequent irrigations were applied on the requirement of crop (Total 5 irrigations were applied). The plots were kept free of weeds by hand weeding, throughout the growing period of crop as to avoid the uptake of applied fertilizer nutrients by weeds.

Soil sampling: Soil samples were taken from experimental field before the sowing at 0-30 cm soil profile. They were air dried, ground, sieved through 2 mm sieve and analyzed for physico-chemical properties.

Statistical analysis of the data: The data recorded were tabulated and subjected to statistical analysis of variance, to discriminate the treatment means. LSD test was applied following the procedures of Steel and Torrie (1980).

Soil analysis: The collected soil samples were analyzed for following characteristics.

Characters	Method adopted
Texture:	Bouycous Hydrometer Method as described by Moodi *et al.* (1954) in Laboratory Manual for Soil Fertility.

Following characters were determined according to the United States Salinity Laboratory Staff (1954) U.S.D.A. Hand Book – 60.

pH	Using pH Meter with glass electrodes. Method No. 21.
Electrical Conductivity	Solubridge Conductivity Meter. Method No. 4b.
Organic Matter	Walklay Black Method. Soil Chemical Analysis by M.L. Jackson. Method No. 9.65-68, P 220, 1958.
$CaCO_3$	By Acid Neutralization Method.
$CO3^{-}$,HCO_3^{-}	Titration with standard H_2SO_4. Method No. 12.
Cl^{-}	Titration with standard Silver \Nitrate Method No. 13.
$Ca^{++} + Mg^{++}$	Titration with standard Versinate Solution. Method No. 7

Soil was further analysed for the determination of total N, available P, available K and micro nutrients (Zn, Cu, Fe and Mn).

Determination	**Method**
Total N	Modified Kjedhals' Method as de scribed by Jeckson (1958). In: Soil Chemical Analysis, pp: 183.
Available P	Olsen's Method as described by Jackson (1958). In: Soil Chemical Analysis, pp: 184
Available K	By Neutral Normal Ammonium AcetateExtraction Method. In: (Soil and Plant Testing as a Basis of Fertilizer Recommendations by Cottenie, (1980), FAO Soils Bulletin No. 38/2: 84-85, Using Beckman Klina Flame Photometer.
Micro nutrients	DTPA – TEA Method using Perkin Elmer 4000 Atomic Absorption Spectro Photometer as described by Winkleman *et al.* (1986) in Manual Soil Laboratory, Methods (BARD) Islamabad pp: 185.

Results and Discussion

Physico-chemical characteristics of the area before sowing of wheat crop: The pre-research analysis showed that the soil was clay loam in texture, slightly saline, deficient in nitrogen and phosphorus, but had sufficient available potassium. The pH of soil was 7.8. It was further found that the soil contained relatively low quantities of available phosphorus and total nitrogen. However, sufficient amount of Zn, Cu, Fe and Mn was found at 0-30 cm soil profile (Table 1).

Grain and straw yields: Nitrogen applied in three split doses resulted in maximum grain and straw yields, both were also significantly better with nitrogen applied in two split doses (Table 2). The higher yields in three split doses was mainly because nitrogen is a readily available nutrient and not retained in the soil for long time. These results are in agreement with the results reported by Yousef *et al.* (1977), Khalilove and Mekhtieva (1978), Rathore and Singh (1980), Garcia and Torrie (1981), Dubetz and Freyman (1982), Farnworth and Said (1983b) Destri-nicosia and Quitadamo 1983), Tila Muhammad *et al.* (1987), Chhajro (1989) all researchers reported that nitrogen fertilizer should be incorporated in the split application for achieving target straw and grain yields.

It was further found that application of urea resulted in greater grain and straw yields, followed by ammonium nitrate. Whereas, the minimum grain and straw yields were

Table 1: Physico-chemical characters of the soil before sowing of the crop

		1:5 soil water extract			
Depth	Texture	pH	EC	OM%	$CaCO_3$
0-30	Clay Loam	7.8	0.34	0.90	10.24

		Zn	Cu	Fe	Mn
Depth	Texture	MgKg^{-1}			
0-30	Clay Loam	1.4	3.0	3.10	3.10

Depth	Terxture	N %	K ppm	P ppm
0-30	Clay Loam	0.038	240	8.0

Table 2: Wheat crop quantitative and qualitative characters as affected by method and source of nitrogen fertilizer

Method of application	Sources			
	Urea	Ammonium Nitrate	Ammonium Sulphate	Mean
Grain yield (kg ha^{-1})				
Two splits	4080.00	3990.00	3900.00	3990.00
Three splits	4450.00	4290.00	4100.00	4280.00
Mean	4265.00	4140.00	4000.00	-
	Methods (M)	Sources (S)	Mx S	
SE =	48.375	59.247	83.788	
LSD (5%) =	103.038	126.196	178.468	
LSD(1%) =	142.706	174.779	247.175	
Straw yield (kg ha^{-1})				
Two splits	7000.00	6980.00	6600.00	6860.00
Three splits	7765.00	7430.00	7270.00	7470.33
Mean	7382.50	7205.00	6935.00	
	Methods (M)	Sources (S)	Mx S	
SE =	50.310	61.617	87.139	
LSD (5%) =	107.160	131.244	185.607	
LSD(1%) =	148.415	181.177	257.060	
Protein content (%)				
Two splits	8.20	7.95	7.80	7.98
Three splits	9.50	8.90	8.00	0.80
Mean	8.85	8.43	7.90	
	Methods (M)	Sources (S)	Mx S	
SE =	0.095	0.116	0.164	
LSD (5%) =	0.202	0.247	0.350	
LSD(1%) =	0.280	0.342	0.484	
Nitrogen content (%)				
Two splits	0.47	0.45	0.43	0.45
Three splits	0.50	0.48	0.46	0.48
Mean	0.49	0.46	0.45	
	Methods (M)	Sources (S)	Mx S	
SE =	0.009	0.011	0.0158	
LSD (5%) =	0.019	0.023	0.0337	
LSD(1%) =	0.26	0.032	0.0466	

obtained in case of ammonium sulphate. The greater grain and straw yields in urea treated plots were mainly due to the granular form of the urea fertilizer which remained in the soil and plant got chance to uptake uniformly with moisture as compared to ammonium nitrate and ammonium sulphate, both leached down due to their powder form and plant could not utilize N properly.

The interaction of three splits of urea gave maximum grain yield, followed by three splits of ammonium nitrate and three splits of ammonium sulphate respectively. Whereas, the interaction between two splits of ammonium sulphate

Table 3: Residual NPK in the soil after harvest of the wheat crop as affected by source and schedule of nitrogen and their interaction

	Nitrogen (%)				Phosphorus (ppm)				Potash (ppm)			
Methods	Urea	Amn. nitrate	Amn. sul.	Mean	Urea	Amn. nitrate	Amn. sul.	Mean	Urea	Amn. nitrate	Amn. sul.	Mean
Three splits	0.043	0.039	0.036	0.39	10.0	10.20	11.00	10.40	250.00	253.00	260.00	254.33
Two splits	0.060	0.050	0.045	0.052	9.80	9.85	10.80	9.88	248.00	249.00	252.00	249.67
Mean	0.052	0.045	0.041		0.90	10.03	10.50		249.00	251.00	256.00	
	Methods(M)	Source(S)	MxS		Methods(M)	Source(S)	MxS		Methods(M)	Source(S)	MxS	
S.E ±	0.008	0.003	0.014		0.093	0.114	0.161		0.161	1.635	2.002	4.009
L.S.D(5%)	0.017	0.006	-		0.198	0.243	0.343		0.343	3.483	4.265	8.541
L.S.D(1%)	-	0.009	-		0.274	0.336	0.475		0.475	4.823	5.906	-

recorded minimum grain and straw yields. The significant interaction explains that urea when applied in three splits resulted in greater grain and straw yields, as compared with ammonium nitrate and ammonium sulphate.

Protein content (%) in grain and Nitrogen content in straw: Nitrogen applied in three split doses results in maximum protein content in grain and N content in wheat straw over two splits (Table 2). Three split doses results in maximum protein grain content and N content in wheat straw, because plants have more chance for uptake of moisture over two split doses. These results are in contrast with the results reported by Olsen (1984) Nuttlal and Madge (1985) and Chhajro (1989).

It was further noted from that nitrogen applied as urea displayed maximum protein and nitrogen content in wheat grain and straw, followed by ammonium nitrate. The ammonium sulphate recorded minimum nitrogen and protein content both in grain and straw. The maximum content of grain and straw was mainly because urea retained in the soil for more time resulted that the plants have more chance for uptake as compared to other two sources.

Residual NPK in the soil: Nitrogen applied as urea in three split doses resulted in maximum residual nitrogen the soil followed by ammonium nitrate and ammonium sulphate, however, the availability of residual phosphorus and potassium was higher in ammonium sulphate followed by ammonium nitrate (Table 3). The greater residual nitrogen in urea treated plots was mainly to its granular form and other two fertilizers were in the form of powder. These results agree with those reported by Palmer and Madge (1982), who reported that nitrogen from urea has residual effect as compared to ammonium nitrate and ammonium sulphate. The greater residual availability of phosphorus and potash in ammonium sulphate was mainly because of presence of sulphur and its availability in powder form.

Nitrogen applied in three split doses increased the grain and straw yields, protein and nitrogen content of wheat and residual N in the soil. Among the sources of nitrogen, application of urea significantly increased grain and straw yields, protein content in grain, nitrogen content in straw and residual N in the soil, whereas residual P and K were higher with the application ammonium sulphate. The urea fertilizer applied in three splits recorded maximum quantitative and qualitative characters whereas, residual P and K were significantly higher due to the two split levels of ammonium sulphate. Thus, it is recommended that for obtaining better production of wheat in terms of quantitative and qualitative characters, the crop may be fertilized with urea applied in three split doses.

References

Babowicz, R.J., G.M. Hyde and J.B. Simpson, 1985. Fertilizer effects under simulated no. tillage conditions. Field Crop Abst., 39: 194.

Chhajro, H.K., 1989. Effect of nitrogen and phosphorus fertilizer levels on growth and yield of late sown wheat. M.Sc. Thesis, Sindh Agriculture University, Tandojam, Pakistan.

Cottenie, A., 1980. Soil and plant testing as a basis of fertilizer recommendation. FAO soil Bulletin No. 38/2.

Destri-Nicosia, O.L and M. Quitadmo, 1983. The effect of slow release nitrogen fertilizer on the yield of hard wheat. Field Crop Abst., 37: 308.

Dubetz, S. and S. Freyman, 1983. The effect of nitrogen and phosphorus fertilizers on winter wheat. Field Crop Abst., 37: 97.

Farnworth, J. and S.A. Said, 1983. The effect of nitrogen on Beta wheat. Field Crop Abst., 37: 307.

Garcia, M.I. L. and B.C. Torres, 1981. Effect of N and P fertilizers on the grain yield of four wheat cultivars. Mexico. Field Crop Abst., 44: 560.

Jackson, M.L., 1958. Soil chemical Analysis, Prentice Hall. Ind., Englewood Eliffs, New Jersy.

Khalilove, G.R. and E.K. Mekhtieva, 1978. Effect of fertilizer on grain yield of winter wheat on grey chest nut soils in Kiroviland Kozakh USSER. Field Crop Abst., 31: 767.

Palmer, G.M. and W.E.R. Madge, 1982. Winter wheat assessing the value of some alternative nitrogen fertilizer. Field Crop. Abst., 39:194.

McKenzie, R., 2002. Wheat Nutrition and Fertilizer Requirements Nitrogen. http://www.agric.gov.ab.ca.crops/wheat/#effect. www.Google.com citation on 25th November, 2002.

Moodi, C.G., W.W. Smith and S.M. Creary, 1954. Laboratory manual for soil fertility.

Nuttlal, M. and W.E.R. Madge, 1995. Winter wheat, nitrogen level and timing. Field Crop Abst., 39: 194.

Rathore, S.S. and R.M. Singh, 1980. Uptake of nitrogen and phosphorus by wheat as influence by soil moisture. Rajisthan, India, Field Crop Abst., 33: 876.

Sander, D.N., 1996. File G889 under:Field Crops D-12, Small Grains. http://www.ianr.unl.edu/FieldCrops/G35.htm.

Steel. R.G.D. and J.H. Torrie, 1980. Principles and procedures of statistics McGraw Hill book Co. Inc. London.

Tila Muhammad, S., A. Shah and S. Hassan, 1987. Effect of different combinations of N and P on some Agronomic character of wheat mutants. Pak. J. Sci. Ind. Res., 30: 841-845.

United State Salinity Laboratory Staff, 1954. Diagnosis and improvement of saline and alkali soils. U.S.D.A., Hand Book No., 60: 89-90.

Yousef, M.E., K. Sagir and M.A. El-Sharkwy, 1977. Response of growth and yield of semi-dwarf wheat in phosphors and nitrogen fertilizers. Libyan J. Agric., 6: 29-33.