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Impact of different rates of NP fertilizers and irrigation on yield components of maize (*Zea mays* L.), NH_4-N and NO_3-N losses at various soil depths

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Abstract

The present experiment was carried out at New Developmental farm, of the University of Agriculture, Peshawar to study the effect of different rates of nitrogen, phosphorus fertilizers and irrigation on total N, NH_4-N and NO_3-N at various soil depths in maize crop (*Zea mays* L). The experimental design was randomize complete block design with split plot arrangement.Irrigation with two levels (Irrigation at the same day, Irrigation after 5 days) was kept in main plot whereas different fertilization treatments N (50, 100, 150 kg ha^{-1}) and P (0, 60, 90 kg ha^{-1}) were arranged in subplot.The results showed that the treatments combinations (N @ 150 kg ha^{-1} and P @ 90 kg ha^{-1}) N_3P_3, (irrigation at the same day and N @ 150 kg ha^{-1}) I_1N_3, and (irrigation at the same day and P @ 90 kg ha^{-1}) I_1P_3 yielded maximum grain yield and biological yield. It was observed that among soil chemical properties total mineral nitrogen N, NH_4-N and NO_3-N concentration at upper soil surface, sub soil surface and at the depth (0-15cm) maximum values were recorded highest at treatments combinations N_3P_3(N @ 150 kg ha^{-1} and P @ 90 kg ha^{-1}), I_1N_3(irrigation at the same day and N @ 150 kg ha^{-1}) and I_1P_3(irrigation at the same day and P @ 90 kg ha^{-1}) while the maximum losses were also recorded in the same treatment combinations. It was apparent from the present study that distribution of urea in the rooting zone has the potential to enhance N use efficiency and minimize N losses via ammonia volatilization. Moreover irrigation after application of Urea and Single superphosphate (SSP) is recommended which can cause these fertilizers to diffuse from upper surface to sub surface and can be easily uptake by plants consequently maximum yield components can be obtained.

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Introduction

Maize (*Zea mays* L.) belongs to family Gramineae, and is an important summer cereal crop which ranks the third after wheat and rice in the world. It is extensively grown in temperate, tropical and subtropical regions. Maize is grown widely in many countries of the world. It is good source of nutrition and generates many by products such as starch, glucose and also produce corn oil. Bio fuel such as ethanol is producing by maize starch in the world(Ahmad *et al.*, 2007).

The principle reasons for decreased maize production in Pakistan are low soil fertility and deficient utilization of fertilizers consequently elements in the soil depleted(Buresh*et al.*, 1997). Maize requires adequate supply of nutrients particularly nitrogen (N) and phosphorus (P) for good growth and high yield.

In essential plant elements which are required for plant development, N function as predominantly for plant development and growth because N is a basic component of chlorophyll (Schrader, 1984; Marschner, 1986).N is also constituent of low molecular weight plant compounds including nucleotides, amides and amines. Consequently, sufficient N is a prerequisite for achieving good crop yields (Abid*et al.*, 2005).

Phosphorus is second essential nutrient after nitrogen which enhance maize yield (Chen *et al.*,1994) and commands primarily reproductive functions in plant (Wojnowska*et al.*, 1995). Generally, P is the second most crop-limiting nutrient in most soils. Plant growth behaviour is influenced by the application of phosphorus (Hajabbasi and Schumacher, 1994; Gill *et al.*,1995; Kaya *et al.*,2001). P also plays significant role in plant growth, chemical conversion of sugar and starch, energy for photosynthesis, constitution of nucleus, fat and albumen also provide energy for photosynthesis and stoke energy in compounds of phosphate by breaking down of carbohydrates (Ayub*et al.*, 2002).It is promptly transfer in plants, move to younger tissuesfrom older ones resulting in formation of cells and leaves, stem and roots growth (Ali *et al.*, 2002). Adequate P results in rapid growth and earlier maturity and improves the quality of vegetative growth. It is widely deficient throughout Pakistani soils about 90 % are found to be deficient so phosphatic fertilizers are indispensable for high yielding of crops (Rashid and Memeon, 2001).

Maize responds well to the management practices like irrigation and N and P fertilizers. Proper time and supplemental irrigation should be realized in irrigation scheduling for the most effective use of available water in optimizing maize production. Soil moisture and nutrients accessibility have a close interconnectedness.It is consider that under irrigated circumstances fertilizers can be used efficiently.With enough nutrients and in a good moisture conditions limitation of plant growth can be minimize by enhancing nutrients uptake as compared to those plants that grow under less moisture stress (Michael, 1981). Moisture stress has no significant effect on emergence timing, number of leaves plant^{-1}but hold up initiation of tasseling and silking emergence, also decreased plant height and vegetative reproduction in maize. Maize hybrids have a pivotal role while deciding about the type and amount of fertilizer in order to meet the requirements for growth and development throughout life span of crop (Chandrashekra*et al.*, 2000, Khaliq*et al.*, 2008).Keeping in mind the above scenario the aim of the present findings was to evaluate the effect of different rate of fertilizers i.e. Nitrogen and Phosphorous and Irrigation on yield components of maize, NH_4-N and NO_3-N losses at various soil depths.

Materials and methods

Experimental location

A field experiment was established at the New Developmental Farm (NDF) of the University of Agriculture Peshawar, during May, 2013. The experiment was laid out in Split plot design having three replications. In the main plots two levels of irrigations was applied i.e. irrigation at the same of sowing FC 50-60 % (I_1) and irrigation after five days of sowing FC 20-30 % (I_2), while three levels of Nitrogen using urea i.e. @ (50, 100 and 150 kg ha^{-1}) and three levels of Phosphorus(P_2O_5)using single super phosphate i.e. @ (0, 60 and 90 kg ha^{-1}) with one control was applied in the sub plots. The plot size was 10.5m^2 and Azam variety of maize was sown. A basal dose 60 kg ha^{-1} of K_2O was applied to all plots. All other cultural practices including hoeing, weeding, and irrigation was carried out to all plots uniformly.

Soil sampling

Soil samples were collected after treatment application at upper surface, sub surface andpost harvestfrom (0-15 cm) depths for NH_4-N, and NO_3-N concentrations in soil.

Soil analysis

Before sowing four composite soil samples, comprising 10 randomly collected soil cores (0–10 cm) each, will collected and pass through a 2 mm sieve to remove visible plant litter and roots. Sieved soil samples were analyzed for soil physical and chemical properties such as, soil texture, Electrical conductivity (EC), pH, total nitrogen (N), organic matter (OM), cation exchange capacity (CEC), and AB-DTPA extractable Phosphorus (P).Soil moisture and temperature at 0-10 cm soil depth wasmonitor.

Soil Texture

A 50 g soil sample was added to 10 mL of Na_2CO_3 and water, then shaken for 5 min through dispersing machine. Hydrometer reading was noted after 40 sec and 2 hours along with temperature. 40 sec reading was assumed to represent silt and clay and 2 hours to represent only clay in the suspension. The amount of sand was calculated from subtracting the present sand and silt from the total.

Soil EC (1:5) and pH

The electrical conductivity was determined in 1:5 soil suspensions by using EC meter (Jenway Model 4510) after calibration with standard KCl solution. For pH Five grams of soil was added to 50 mL of distilled water and shaken for 20-30 minutes to make a 1:5 suspension. The pH was determined in the suspension using pH meter (Inolab WTW Series pH 720) after calibrating the instrument with standard buffers of 4.0 and 10.0.

Organic Matter

One gram of air dried soil was taken in a conical flask and 10 mL of 0.5 N $K_2Cr_2O_7$ and 20 mL of conc. H_2SO_4 added to it. It was then allowed to stand for 30 min to complete the reaction. Later 200 mL of ditilled water was added and the suspension was filtered. Orthophenolpthalein Indicator, 2-3 drops was added to the filtrate and then titrated against 0.5 N $Fe_2SO_4.7H_2O$ until the color changed to dark brown, indicating the end point. The percent organic matter was calculated using the following formula.

% OM =

$$\frac{[(\text{mL of } K_2Cr_2O_7 \text{ x N})-(\text{mL of } FeSO_4.7H_2O \text{ x N})]}{\text{Weight of soil}} \times 0.69$$

AB-DTPA Extractable P

P concentration in soil sample was determined by extracting soil solution with AB-DTPA. 10g of soil was taken in conical flask then 20ml of AB-DTPA solution was added and placed on shaking machine for 15 mints. There after samples will be filtered with watt man No. 42. One ml sample was taken from each sample then 5ml of ascorbic acid was added and made the volume up to 25ml. Samples were placed for 15 mints for colour development. Then P was determined by spectrophotometer (Lambda-35), at 880nm after proper colure development.

Determination of mineral N in soil

Total mineral N in soil was determined by the steam distillation method. In this method,a 20 g sample of moist soil wasshaked with 100 ml of 1 M KCl for one hour and filtered. Twenty ml of the filtrate was distillated with either MgO to recover NH_4-N or withMgO + devarday's alloy to recover total mineral N. The distillate was collected in 5 ml boric acid mixed indicator solution and then titrated against 0.005 *M* HCl. The NO_3-N was determined by subtracting the NH_4-N from the total mineral N.

Yield parameters

Biological yield (kg ha^{-1})

Two central rows were harvested at the maturity from each plot, tied into bundles separately. The bundles were sun dried and weighed by spring balance for calculating biological yield and the data was converted to kg ha^{-1}. The yield obtained from the two central rows of each plot was weighed with a spring balance and the data was converted into kg ha^{-1}.

Biological yield (kg ha^{-1}) =

$$\frac{\text{Biological yield plot}^{-1}}{\text{R-R distance (m) x Row length (m) x No. of Rows}} \times 10{,}000$$

Grain yield (kg ha^{-1})

For recording grain yield data, two central rows were harvested in each plot with the help of a sickle. Ears were removed from the harvested plants, dried and threshed with the help of small sheller. The grains obtained from the ears of each plot were weighed with an electronic balance and the data was converted into kg ha^{-1}. Grain yield (kg ha^{-1}) =

$$\frac{\text{Grain yield plot}^{-1}}{\text{R-R distance (m) x Row length (m) x No. of Rows}} \times 10{,}000$$

Statistical Analysis

The data recorded was analyzed using formulas in MS excel sheet suitable for Split plot design. Comparisons of means were done by utilizing LSD test at 5 % level of probability.

Result and discussion

Soil physico-chemical characteristics

Various soilphysico-chemical characteristics are shown in Table 1. These physico-chemical characteristics were detected and sampled from field at 0-10 cm depth before conducting the experiment.

Table 1. Physico-chemical characteristics of soil under investigations.

Soil properties	Unit	Values
Sand	%	41.4
Clay	%	51.4
Silt	%	7.2
Soil texture	-	Silt loam
$pH_{(1:5)}$	-	7.95
$EC_{(1:5)}$	d Sm^{-1}	1.12
Lime	%	15.3
Organic matter	%	0. 9
Total nitrogen content	%	0.1
Bulk density	gm cm^3	1.35
AB-DTPA extractable P	mg kg^{-1}	2.14

Effect of nitrogen and phosphorous on grain yield (kg ha^{-1})

The results regarding effect of nitrogen and phosphorous on grain yield (kg ha^{-1}) are presented in Table 2. Maximum grain yield was observed in interaction N_3P_3 (5927.23 kg ha^{-1}). Grains yield means among different combination of nitrogen and phosphorus were found to be highly significant at $P < 0.05$ probability level. Minimum grain yield was obtained in control (3979.36 kg ha^{-1}) followed by N_1P_1 (4694.61 kg ha^{-1}). It indicated that grains yield was significantly affected by interaction of nitrogen and phosphorus. These consequences are resemblance with the findings of Magboul*et al.* (1999) who reported that increased levels of nitrogen and phosphorus fertilizers enhanced yield and yield component of maize. The maximum grains yield (5927.23 kg ha^{-1}) was obtained with the interaction of N_3P_3. Regarding this, similar results were found by Nour and Lazin (2000) who reported that the combination of nitrogen and phosphorus affected grain yield in a significant manner. These results are also confirmed by Abdel Malik *et al.* (1976) who accounted that grain yield increased significantly with the interaction of nitrogen and phosphorus. Singh and Dubey (1991) also reported that the combination of nitrogen and phosphorus fertilizers maximize weight of grains ear^{-1}.

Effect of nitrogen and phosphorous on biological yield (kg ha^{-1})

The data concerning the effect of nitrogen and phosphorous on biological yield ((kg ha^{-1}) are shown in Table 3. Biological yield was found to be highly significantly different among different combination of nitrogen and phosphorus, again N_3P_3 (18251.17 kg ha^{-1}) was found to contain highest biological yield followed by N3P2 (17288.33 kg ha^{-1}), N3P1 (16265.67 kg ha^{-1}), N2P3 (14914.67 kg ha^{-1}) and N2P2(14491.67 kg ha^{-1}) while minimum biological yield was measured in control (9124.00 kg ha^{-1}) where zero amount of nitrogen and phosphorus was applied. The results further showed that maximum biological yield (18251.17 kg ha^{-1}) was obtained by the interaction of N_3P_3 whereas lowest biological yield was obtained from control (9124.00 kg ha^{-1}). This may be due to the fact that by supplement of appropriate amount of nitrogen and phosphorus nutrients during the period of plant growth. These results are in proximity with the results of Hanif (1990) who documented that connectedness of nitrogen and phosphorus increased biological yield of maize crop.

Table 2. Effect of different levels of irrigation, nitrogen and phosphorus on grain yield (kg ha^{-1}) of maize.

		Irrigations		
Nitrogen (N)	Phosphorus (P)	I 1	I 2	N X P
1	1	4414.28 g	4974.95 f	4694.61 e
1	2	5620.88 c	5175.09 de	5397.99 c
1	3	6057.14 b	5619.04 c	5838.09 a
2	1	5192.06 de	5152.38 ef	5172.22 d
2	2	5747.61 c	5261.90 de	5504.76 bc
2	3	6006.35 b	5625.69 c	5816.02 a
3	1	5401.58 cd	5180.95 de	5291.27 cd
3	2	5746.03 c	5396.82 cde	5571.43 b
3	3	6322.73 a	5531.74 cd	5927.23 a
	1	5002.64 e	5102.76 e	5052.70 c
	2	5704.84 b	5277.94 d	5491.39 b
	3	6128.74 a	5592.16 c	5860.45 a
1		5364.10 c	5256.36 e	5310.23 c
2		5648.67 b	5346.66 d	5497.67 b
3		5823.45 a	5369.84 c	5596.64 a
		5612.07 a	5324.28 b	
		Planned Mean comparison		
	Control	3979.36		
	Rest	5468.18		

Means followed by different letters are significantly different from one another at 5% level of probability.

Effect of irrigation and nitrogen on grain and biological yield (kg ha^{-1})

Table 2 and 3 shows the effect of irrigation and nitrogen on grain and biological yield Maximum grains yield were recorded from the interaction I_1N_3 (5823.45 kg ha^{-1}) followed by I_1N_2 (5648.67 kg ha^{-1}), I_2N_3 (5369.84 kg ha^{-1}), I_1N_1 (5364.10 kg ha^{-1}), and I_2N_2 (5346.66 kg ha^{-1}) while minimum from I_2N_1 (5256.36 kg ha^{-1}). Biological yield affected by interaction of irrigation and nitrogen levels indicates that the maximum biological yield (17909.00 kg ha^{-1}) were obtained from interaction effect of I_1N_3 followed by I_2N_3 (16627.78 kg ha^{-1}), I_1N_2 (15285.11 kg ha^{-1}), I_2N_2 (13359.11 kg ha^{-1}), and I_1N_1 (12146.67 kg ha^{-1}) while minimum from I_2N_1 (10511.78 kg ha^{-1}). These findings are similar with Hammad*et al.* (2012) who reported that irrigation and nitrogen treatments significantly affected vegetative growth parameters. This may be due to fact that when irrigation was applied at the same day after sowing it dissolved nitrogen fertilizer and becomes available to maize crop. These results are similar with Khatun*et al.* (2012). These results are also in accordance with Gheysari*et al.* (2009) who reported that irrigation and nitrogen in maximum amount facilitate to uptake of nitrogen which increase grain yield, biological yield and growth all parameters in maize. These results support the idea that urea use efficiency may be improved through reduced gaseous losses of NH_3 if urea is moved into the soil with small amounts of irrigation. Irrigation facilitates the transport of added urea into the root-zone of sub-surface soil layers, dilutes surface NH_4^+ concentration, reduces NH_3 partial pressure and thereby minimizes NH_3 losses possibly due to low soil pH in sub-surface soil. The distribution and movement of applied N during an irrigation event will depend on N form (urea versus NH_4^+). The source of $NH_3$is mainly the exchangeable NH_4^+ present in the soil. We suggest that, although soil colloids adsorb NH_4^+ ions, applying irrigation after urea application could reduce the higher concentration of NH_4^+-N in the surface soil layer, thereby resulting in its even distribution down the soil profile and laterally away from the application point.

Table 3. Effect of different levels of irrigation, nitrogen and phosphorus on biological yield (kg ha^{-1}) of maize.

		Irrigations		
Nitrogen (N)	Phosphorus (P)	I 1	I 2	N X P
1	1	10584.67 k	9282.00 l	9933.33 i
1	2	12308.00 i	10682.67 k	11495.33 h
1	3	13547.33 h	11570.67 j	12559.00 g
2	1	14816.00 f	12304.00 i	13560.00 f
2	2	15460.67 e	13522.67 h	14491.67 e
2	3	15578.67 e	14250.67 g	14914.67 d
3	1	17170.00 c	15361.33 e	16265.67 c
3	2	17784.00 b	16792.67 d	17288.33 b
3	3	18773.00 a	17729.33 b	18251.17 a
	1	14190.22 d	12315.78 f	13253.00 c
	2	15184.22 b	13666.00 e	14425.11 b
	3	15966.33 a	14516.89 c	15241.61 a
1		12146.67 e	10511.78 f	11329.22 c
2		15285.11 c	13359.11 d	14322.11 b
3		17909.00 a	16627.78 b	17268.39 a
		15113.59 a	13499.56 b	
		Planned Mean comparison		
	Control	9124.00		
	Rest	14306.57		

Means followed by different letters are significantly different from one another at 5% level of probability.

Table 4. Effect of different levels of irrigation, nitrogen and phosphorus on Total mineral N (mg kg^{-1}) concentration at upper soil surface.

		Irrigations		
Nitrogen (N)	Phosphorus (P)	I 1	I 2	N X P
1	1	41.48 c	32.73 d	37.10 e
1	2	48.48 ab	44.39 bc	46.43 bc
1	3	48.12 ab	47.64 b	47 .88 b
2	1	49.93 ab	33.31 d	41.62 d
2	2	52.56 a	40.66 c	46.61 bc
2	3	51.17 a	49.93 ab	50.55 a
3	1	41.77 c	46.73 bc	44.25 c
3	2	48.48 ab	46.84 bc	47.66 b
3	3	53.31 a	53.11 a	53.21 a
	1	44.39 b	37.59 c	40.99 c
	2	49.84 a	43.96 b	46.90 b
	3	50.86 a	50.23 a	50.55 a
1		46.02 ab	41.59 c	43.80 b
2		51.22 a	41.30 c	46.26 ab
3		47.85 ab	48.89 ab	48.37 a
		48.36 a	43.93 a	
		Planned Mean comparison		
	control	25.43		
	Rest	46.14		

Means followed by different letters are significantly different from one another at 5% level of probabili.

Effect of irrigation and phosphorus on grain and biological yield (kg ha⁻¹)

Grain yield at different treatment combinations of irrigation and phosphorus was highly significantly different at $P < 0.05$ (Table 2 and 3). Maximum grains yield were achieved from the combination I_1P_3 (6128.74 kg ha^{-1}) followed by I_1P_2 (5704.84 kg ha^{-1}), I_2P_3 (5592.16 kg ha^{-1}), I_2P_2 (5277.94 kg ha^{-1}), I_2P_1 (5102.76 kg ha^{-1}) and I_1P_1 (5002.64 kg ha^{-1}). Minimum grain yield was measured in I_1P_1 (5002.64 kg ha^{-1}). Mean values for biological yield indicates that at interaction I_1P_3 maximum biological yield was achieved with the value of (15966.33 kg ha^{-1}) followed by I_1P_2 (15184.22 kg ha^{-1}), I_2P_3 (14516.89 kg ha^{-1}), I_1P_1 (14190.22 kg ha^{-1}) and I_2P_2 (13666.00 kg ha^{-1}) whereas minimum biological yield was achieved from the combination I_2P_1 (12315.78 kg ha^{-1}).

Table 5. Effect of different levels of irrigation, nitrogen and phosphorus on NH_4-N (mg kg^{-1}) concentration at upper soil surface.

		Irrigations		
Nitrogen (N)	Phosphorus (P)	I 1	I 2	N X P
1	1	25.08 d	25.52 d	25.30 d
1	2	41.07 ab	29.23 cd	35.15 bc
1	3	35.93 bc	37.74 ab	36.84 bc
2	1	40.60 ab	24.86 d	32.73 c
2	2	42.99 a	34.94 bc	38.97 ab
2	3	44.06 a	40.02 ab	42.04 a
3	1	36.15 a	30.39 cd	33.27 c
3	2	38.97 bc	29.87 cd	34.42 bc
3	3	37.45 ab	38.21 ab	37.83 abc
	1	33.94 b	26.92 c	30.43 b
	2	41.01 a	31.34 b	36.18 a
	3	39.15 a	38.66 a	38.90 a
1		34.03 bc	30.83 c	32.43 b
2		42.55 a	33.27 c	37.91 a
3		37.52 b	32.82 c	35.17 a
		38.03 a	32.31 b	
		Planned Mean comparison		
	control	11.06		
	Rest	35.17		

Means followed by different letters are significantly different from one another at 5% level of probability.

Table 6. Effect of different levels of irrigation, nitrogen and phosphorus on NO_3-N (mg kg^{-1}) concentration at upper soil surface.

		Irrigations		
Nitrogen (N)	Phosphorus(P)	I 1	I 2	N X P
1	1	16.39 ab	7.21 c	11.80 ab
1	2	7.41 c	15.17 ab	11.29 ab
1	3	14.18 ab	9.90 bc	12.04 ab
2	1	9.33 bc	8.45 c	8.89 b
2	2	9.57 bc	5.72 cd	7.64 b
2	3	7.11 c	9.92 ab	8.51 b
3	1	5.62 cd	16.33 ab	10.98 ab
3	2	9.51 bc	16.98 a	13.24 a
3	3	15.86 ab	14.90 ab	15.38 a
	1	10.45 ab	10.66 ab	10.56 ab
	2	8.83 b	12.62 a	10.72 ab
	3	12.38 b	11.57 a	11.98 a
1		12.66 ab	10.76 b	11.71 a
2		8.67 b	8.03 b	8.35 b
3		10.33 b	16.07 a	13.20 a
		10.55 a	11.62 a	
		Planned Mean comparison		
	control	14.38		
	Rest	11.09		

Means followed by different letters are significantly different from one another at 5% level of probability

The maximum grains and biological yield (6128.74 kg ha^{-1}) and (15966.33 kg ha^{-1}) respectively was produced from plants which carried combination I_1P_3. These results are in accordance with Amanullah*et al.* (2010b) who noticed that increased in grain and biological yield might be due to increase in yield and yield components of maize by increased level of P. The lowest grain yield (5002.64 kg ha^{-1}) and biological yield (12315.78 kg ha^{-1}) produced by those plants which received treatments I_1P_1 and I_2P_2 respectively. Ibrikci*et al.* (2005) observed that the deficiency of P is a common factor for limiting growth and yield, particularly in high calcium carbonate soils, which cut back solubility of P. These findings were also confirmed by Singaram and Kothandaraman (1994) who observed that P applied @ (90 kg ha^{-1}) increased yield of maize crop.

Table 7. Effect of different levels of irrigation, nitrogen and phosphorus on Total mineral N (mg kg^{-1}) concentration at sub soil surface.

		Irrigations		
Nitrogen (N)	Phosphorus (P)	I 1	I 2	N X P
1	1	27.30 de	10.73 f	19.02 e
1	2	30.80 cd	25.84 e	28.32 c
1	3	32.43 bc	33.13 bc	32.78 bc
2	1	24.15 e	21.18 e	22.66 d
2	2	36.23 ab	27.94 de	32.08 bc
2	3	31.44 c	35.23 b	33.34 ab
3	1	43.34 a	33.43bc	38.38 a
3	2	29.63 cd	30.28 cd	29.95 bc
3	3	34.13 bc	32.32 bc	33.22 ab
	1	31.60 ab	21.78 c	26.69 b
	2	32.22 ab	28.02 b	30.12 a
	3	32.67 ab	33.56 a	33.11 a
1		30.18 ab	23.24 c	26.71 b
2		30.61 ab	28.12 b	29.36 b
3		35.70 ab	32.01 ab	33.85 a
		32.16 a	27.79 a	
		Planned Mean comparison		
	control	14.76		
	Rest	29.97		

Means followed by different letters are significantly different from one another at 5% level of probability.

Total Mineral N, NH_4-N and NO_3-N concentration in soil

The results regarding interaction of nitrogen phosphorus, irrigation nitrogen and irrigation phosphorus for Total mineral N, NH_4-N and NO_3-N concentration in upper soil surface, sub soil surface and at the depth (0-15 cm) are presented in Table 4 to 12. Moreover the interaction betweenirrigation, nitrogen and phosphorus were found to be significantlyaffecting Total mineral N and NO_3-Nat $P < 0.05$ level of probability. The amount ofTotal mineral N, NH_4-N and NO_3-Nwere increased with the rate of nitrogen increases and maximum amount were obtained at treatments combinations N_3P_3 and N_2P_3(Table 4 to 12).Highest amount of Total mineral N was recorded in the combination N_3P_3 (53.21 mg kg^{-1}) whereas slightly lowest was recorded in the combination N_1P_1 (37.10 mg kg^{-1}) as compared to control, where the amount was 25.43 mg kg^{-1}. The highest rate of NH_4-N at upper soil surface was obtained when irrigation was applied at the same day of sowing (FC 50-60 %). Similarly NO3-N was obtained at the sub soil surface and at the depth (0-15 cm) is shown in Tables. This might be due to the hydrolysis of urea which can occur soon after its application (Daward*et al,* 2011). This fact was also supported by the researchers, Rawluk*et al.* (2001), Sanz-Cobena*et al.,* (2008), Watson *et al.* (1998) and Zaman*et al.* (2008) who observed that hydrolysis of urea take place 1-2 days after its application. The losses of N also occurred when plant leaves contain redundant amount of NH_4-N (Witte *et al.* (2002).

Table 8. Effect of different levels of irrigation, nitrogen and phosphorus on NH_4-N (mg kg^{-1})concentration at sub soil surface.

		Irrigations		
Nitrogen (N)	Phosphorus (P)	I 1	I 2	N X P
1	1	12.08 bcd	3.97 e	8.02 b
1	2	14.18 abc	10.56 bcd	12.37 a
1	3	14.47 abc	13.59 abc	14.03 a
2	1	9.57 cd	8.11 d	8.84 b
2	2	14.47 abc	11.43 bcd	12.95 a
2	3	12.66 bcd	15.63 ab	14.15 a
3	1	17.33 a	13.13 abc	15.23 a
3	2	12.43 bcd	12.60 bcd	12.51 a
3	3	15.28 ab	13.48 abc	14.38 a
	1	12.99 ab	8.40 c	10.69 c
	2	13.69 ab	11.53 b	12.61 b
	3	14.14 a	14.23 a	14.18 a
1		13.57 ab	9.37 c	11.47 b
2		12.23 b	11.73 bc	11.98 b
3		15.01 a	13.07 ab	14.04 a
		13.60 a	11.39 a	
		Planned Mean comparison		
	control	5.54		
	Rest	12.50		

Means followed by different letters are significantly different from one another at 5% level of probability.

Table 9. Effect of different levels of irrigation, nitrogen and phosphorus on NO_3-N (mg kg^{-1}) concentration at sub soil surface.

		Irrigations		
Nitrogen (N)	Phosphorus (P)	I 1	I 2	N X P
1	1	14.88 d	6.77 e	10.82 d
1	2	21.03 abc	15.28 d	18.15 c
1	3	22.30 ab	19.54 abcd	20.92 abc
2	1	13.13 d	13.07 d	13.10 d
2	2	21.76 ab	16.51 d	19.13 bc
2	3	18.78 cd	19.60 abcd	19.19 bc
3	1	26.02 a	20.30 abcd	23.16 a
3	2	17.21 bcd	17.68 bcd	17.44 c
3	3	18.84 bcd	18.84 bcd	18.84 c
	1	18.01 ab	13.38 c	15.69 b
	2	20.00 a	16.49 bc	18.24 a
	3	19.98 a	19.33 ab	19.65 a
1		19.40 a	13.86 c	16.63 b
2		17.89 ab	16.39 bc	17.14 b
3		20.69 a	18.94 ab	19.81 a
		19.33a	16.40a	
		Planned Mean comparison		
	Control	9.22		
	Rest	17.86		

Means followed by different letters are significantly different from one another at 5% level of probability.

The results of the present experiment (Table 6, 9 and 12) showed that the concentration of NO_3-N was minimum at the upper soil surface as compared to sub soil surface and at the depth (0-15 cm). These results are in accordance with Nunnipieri*et al.* (1990) and Zaman*et al.* (2008) who reported that the variation in the concentration of NO_3-N after urea application was due to N transformation as well as might be because of high rate of N application (150 kg N ha^{-1}) in our experiment. In our case more amount of N loss in the form of NH_4-N form occurred, these findings are in agreement with the results of Gioacchini*et al.* (2002) and Rochette*et al.*(2009). Many researchers Mulvaney and Bremner (1981), Zamaan*et al.* (2008) and Hojito*et al.* (2010) found that high amount of urea losses occurred due to high pH "hotspot" that was formed by urea granules after its application. These findings further reveals that N losses in our study were also due to high pH of soil in the experimental plot. Further studies by Dawar*et al.* (2011) confirmed that majority of ammonia losses starts with 2-3 days after the application of urea that might be due to the reason that hydrolysis of urea takes place rapidly as a result greater number of NH_4^+ and OH^- ions formed.

Table 10. Effect of different levels of irrigation, nitrogen and phosphorus on Total mineral N (mg kg^{-1}) concentration at (0-15 cm) soil depth.

		Irrigations		
Nitrogen (N)	Phosphorus (P)	I 1	I 2	N X P
1	1	16.42 h	13.50 h	14.96 f
1	2	23.25 g	17.21 h	20.23 e
1	3	27.71 fg	32.08 ef	29.90 d
2	1	30.81 f	24.91 g	27.86 d
2	2	42.33 c	39.67 cd	41.00 c
2	3	36.25 de	41.35 cd	38.80 c
3	1	43.67 c	31.15 ef	37.41 c
3	2	50.00 b	43.98 c	46.99 b
3	3	57.96 a	44.98 c	51.47 a
	1	30.30 b	23.19 c	26.74 c
	2	38.53 a	33.62 b	36.07 b
	3	40.64 a	39.47 a	40.05 a
1		22.46	20.93 d	21.70 c
2		36.46	35.31 c	35.89 b
3		50.54	40.04 b	45.29 a
		36.49 a	32.09 a	
		Planned Mean comparison		
	control	11.73		
	Rest	34.29		

Means followed by different letters are significantly different from one another at 5% level of probability.

At the end of our experiment when post harvest soil samples at the depth (0-15 cm) were analyzed for NO_3-N we found maximum at (0-15 cm) depth as compared to upper soil surface and sub soil surface (Table 6,9 and 12).The reason might be nitrification process which increases with the time and depth due to moisture level by irrigation. These findings are in consistent with the results of Dawar*et al.* (2011) who observed maximum nitrification after irrigation.

In the present findings, maximum concentration of NH_4-N at the initial days of soil sampling were recorded at upper soil surface and sub soil surface (Table 5 and 8) after its application, this fact was supported by findings of Zaman*et al.* (2013) who reported that hydrolysis of urea by urease enzymes occurred immediately after application of urea. To avoiding urea hydrolysis which enhance amount of NH_3 during the first few days after its application is a vital stage for securing soil N losses.These findings were also reported bySanz- Cobena*et al.*(2008). In order to protect from NH_3 volatilization more rainfall or irrigation is required which took urea from upper soil surface into sub surface layers, where urea will contact with plants roots and will facilitate N uptake. The application of urea (150 kg N ha^{-1}) produced significantly maximum amount of NH_4-N than that of urea applied (50 kg N ha^{-1}) this might be due to abundance of substrate urea @ (150 kg N ha^{-1}). These findings are related to results of Zaman*et al.* (2013) who found higher concentration of NH_4-N when urea was applied at greater amount. With the time and depth the concentration of NH_4-N was decreased (Table8 and 11) which revealed that the NH_4-N moved downward to sub soil surface irrigation water. The mentioned researcher also observed that the amount of NH_4-N was gradually decreased from upper soil surface with the time reason might be due to reduction in NH_4-Namount at soil surface due to nitrification, uptake by plants and movement towards sub soil surface layer by irrigation or rainfall water. This fact was also reported by other researchers, Sanz-Cobena*et al.* (2008) who found that concentration of NH_4-N decreased due to NH_3 volatilization and microbial immobilization.

Table 11. Effect of different levels of irrigation, nitrogen and phosphorus on NH_4-N (mg kg^{-1}) concentration at (0-15 cm) soil depth.

		Irrigations		
Nitrogen (N)	Phosphorus (P)	I 1	I 2	N X P
1	1	10.43 e	9.92 e	10.18 d
1	2	14.29 cde	12.25 de	13.27 cd
1	3	18.04 bc	15.58 bcde	16.81 b
2	1	15.46 cde	12.25 d	13.85 cd
2	2	17.62 bc	8.69 e	13.15 cd
2	3	24.71 a	16.68 bcd	20.70 a
3	1	12.22 de	11.38 e	11.80 d
3	2	20.08 b	13.65 de	16.86 b
3	3	15.75 bcde	14.99 cde	15.37 bc
	1	12.70 c	11.18 c	11.94 c
	2	17.33 ab	11.53 c	14.43 b
	3	19.50 a	15.75 b	17.63 a
1		14.26 bc	12.58 c	13.42 b
2		19.26 a	12.54 c	15.90 a
3		16.01 b	13.34 c	14.68 ab
		16.51 a	12.82 a	
		Planned Mean comparison		
	control	7.02		
	Rest	14.67		

Means followed by different letters are significantly different from one another at 5% level of probability

Table 12. Effect of different levels of irrigation, nitrogen and phosphorus on NO_3-N (mg kg^{-1}) concentration at (0-15 cm) soil depth.

		Irrigations		
Nitrogen (N)	Phosphorus (P)	I 1	I 2	N X P
1	1	5.99 g	3.58 g	4.79 e
1	2	8.96 fg	4.96 g	6.96 e
1	3	9.67 fg	16.51 de	13.09 d
2	1	15.35 def	12.66 ef	14.00 cd
2	2	24.72 cd	30.98 bc	27.85 b
2	3	11.54 ef	24.67 cd	18.10 c
3	1	31.45 b	19.78 d	25.61 b
3	2	29.93 bc	30.33 bc	30.13 b
3	3	42.21 a	29.98 bc	36.10 a
	1	17.60 b	12.01 c	14.80 b
	2	21.20 ab	22.09 a	21.64 a
	3	21.14 ab	23.72 a	22.43 a
1		8.21 e	8.35 e	8.28 c
2		17.20 d	22.77 c	19.98 b
3		34.53 a	26.70 b	30.61 a
		19.98 a	19.27 a	
		Planned Mean comparison		
	control	4.71		
	Rest	19.62		

Means followed by different letters are significantly different from one another at 5% level of probability.

Nitrification converts NH_4-N into NO_3-N which later emitted as N_2O and N_2 through a process called denitrification, more production of NO_3-N means more emission via N_2O and N_2 and more NO_3 leaching occur, these processes might be minimize by irrigation water through drawing NH_4 into deeper soil layer as stated by Dobbies and Smith (2003). In our findings at the upper soil surface minimum concentration of NO_3-N was obtained (Table 6). These findings are in accordance with Silver *et al.* (2001) who noted that concentration of NO_3-N was gradually cut back from upper soil surface layer where urea was applied the reason might be due to availability of NH_4-N in upper soil surface layer and downward movement of NO_3-N to sub soil layer, either uptake by plant, denitrification process and possibly by assimilation reduce the amount of NO_3-N. Zaman and Nguyen (2012) stated that due to urea hydrolysis great amount of NH_4-N can be formed in upper soil surface which results in increase of soil pH, consequently volatilization of ammonia. Further researchers,indicate that, if not incorporated urea into the soil 30 % of N losses might be happened from soil surface. For the increase of urea efficiency, mobility of urea downward into the soil is necessary which could be possible by increasing moisture level. MoreoverDawar*et al.* (2011) reported that downward movement of urea dilutes its concentration as a result more accumulation of NH_4-N minimizes. In the present findings the concentration of NO_3-N was found to reduce at upper soil surface which means nitrification process was slowed down.

Conclusions

It is apparent from the results that biological yield (kg ha^{-1}) and grain yield(kg ha^{-1}) were significantly affected by treatment combinations and irrigation. Forthe present investigation, it can be concluded that the distribution of urea in the rooting zone has the potential to enhance N use efficiency and minimize N losses via ammonia volatilization. Moreover, irrigation after application ofUrea and SSP, cause these fertilizers to move from upper surface to sub surface and can be easily uptake by plants. Further irrigation at the same day after fertilizer application minimizes the conversion of $NH_4 - N$ to $NO_3 - N$. Highest total mineral nitrogen, NH4, and NO_3 were recorded at the rate of 150 kgN ha^{-1} and 90kg P ha^{-1} and therefore these doses are recommended for the cultivation of maize crop.

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References

Abdel Malik, Negm SH, Bachata MA. 1976. Corn yield as affected by NPK fertilization calcareous soil. Agriculture research revision **52,** 57-61.

Abid H, Ghulam A, Ashfaq A, Sayed AW. 2005. Water use efficiency of maize of affected by irrigation schedules and nitrogen rates. Journal of Agriculture, Sciences **4,** 339-342.

Amanullah Zakirullah M, Khalil SK. 2010b. Timing and rate of P application influence maize phenology, yield and profitability in Northwest Pakistan. International Journal of Plant production **4,** 281-292.

Ahmad I. 1989. The effect of phosphorus application in different proportions with nitrogen on the growth and yield of maize. M.Sc(Hons), Agriculture thesis, department of agronomy university of agriculture faisablabad, Pakistan.

Ayub M, Nadeem MA, ShararMS, Mahmood N. 2002. Response of maize (Zea mays L.) fodder to different levels of nitrogen and phosphorus. Asian

Journal of Plant Sciences **1,** 352-354.

Buresh RJ, Sanchez PA, Calhoun F. 1997. Replenishing soil fertility in Africa. SSSA Spec. Publ. 51. SSSA and ASA, Madison, WI.

Chandrashekra CR, Harlapur SI, Muralikrishna S, Girijesh GK. 2000. Response of maize to organic manures with inorganic fertilizers. Karnataka. Journal of agriculture sciences **13,** 144-146.

Chen ML, Jiang XL, ZoovBY, Zheri ZY. 1994. Mathematical models and best combination of high yield cultivation technique for rapeseed variety Zhenyouyoum. Acta Agrical Zhejiiangenesis **6,** 22-26.

Dawar K, Zaman M, Rowarth JS, Blennerhassett J, Turnbull MH. 2011. Urease inhibitor reduces N losses and improves plant-bioavailability of urea applied in fine particle and granular forms under field conditions Agriculture. Ecosystems and Environment **144,** 41-50.

Dobbie KE, Smith KA. 2003. Impact of different forms of N fertilizers on N_2O emission from intensive grassland. Nutrient cycle of agrosystem **67,** 37-46.

Gill MPS, Dhillon NS, Dev G. 1995. Phosphorous requirement of pearl millet and sorghum fodder as affected by native fertility of arid brown soil. Indian Journal of Agriculture Research **29,** 83–8.

Gheysari M, Mirlatifi SM, Bannayan M, Homaee M, Hoogenboom G. 2009. Interaction of water and nitrogen on maize grown for silage. Agriculture water management **96(5),** 809-821.

Gioacchini P, Nastri A, Marzadori C, Giovannini C, Antisari LV, Gessa C. 2002. Influence of urease and nitrification inhibitors on N losses from soils fertilized with urea. Biology fertility soil **36,** 129-135.

Hammad HM, Ahmad A, Abbas F, Wajid F. 2012. Optimizing water and nitrogen use for maize production under semiarid conditions. Turkish Journal of agriculture. **36,** 519-532.

Hanif M. 1990. Growth and yield of maize genotypes as influenced by NPK application. M.Sc. (Hons) Agronomy Thesis, Department of Agronmy, University of Agriculture Faisalabad.

Hajabbasi MA, Schumacher TE. 1994. Phosphorus effect on root growth and development in two maize genotypes. Plant and soil **158,** 39–46.

Hojito M, Hayashi K, Matsuura S. 2010. Ammonia exchange on grasslands in an intensive dairying region in central Japa. Jpn. Journal of soil science and plant nutrition **56,** 503-511.

Ibrikci H, Ryan J, Ulger AC, Buyuk G, Cakir B, Korkmaz K, Karnez E, Ozgenturk G, Konuskan O. 2005. Maintenance of P fertilizer and residual P effect on corn production. Nigerian Journal of Soil Science **2,** 279-286.

Kaya C, Higgs D, Kimak H. 2001. The effect of high salinity (NaCl) and supplementary phosphorous and potassium on physiology and nutrition development of spinach. Bulg. Journal of plant physiology **27,** 47–59.

Khaliq T, Ahmad A, Hussain A, Ranjha AM, AliM A. 2008. Impact of nitrogen rates on growth, yield, and radiation use efficiency of maize under varying environments Pak. Journal of Agriculture Sciences **45,** 1-7.

Khatun HA, Oh DH, Hasan MM, Sultana S, Khatun M, Rahman SME. 2012. Effect of irrigation and nitrogen levels on the growth and yield of maize. Biological and Biomedical Reports **2,** 87-93.

Magboul E, Nour AM, Abdelrahman AM. 1999.

Maize research program. Agricultural Research Corporation, Ministry of Agriculture and Forestry,

Marschner H. 1986. Mineral nutrition of higher plants. Academic Press Inc., San. Diego, USA 148-173 p.

Michael AM. 1981. Irrigation, theory and practice.Vikas Publishing House, New Delhi, India, 901 p.

Mulvaney RL, Bremner JM. 1981. Control of urea transformation in soils. Soil Biochem **5,** 153-196.

Nannipieri P, Ciardi C, Palazzi T, Badalucco L. 1990. Short-term nitrogen reactions following the addition of urea to a grass-legume association. Soil Biol. Biochem. **22,** 549-553.

Nour AM, Lazin ME. 2000. Annual report, maize research program agricultural research corporation ministry of agriculture and forestry, Sudan.

Rashid A, Memon KS. 2001. Soil and fertilizer phosphorus. Soil Sci. B. Elenaand R. Bantel (Eds). National Book Foundation, Islamabad, Pakistan. 300-302 p.

Rawluk CDL, Grant CA, Racz GJ. 2001. Ammonia volatilization from soils fertilized with urea and varying rates of urease inhibitor NBPT. Canadian Journal of Soil Sciences **81,** 239-246.

Rochette P, Angers DA, Chantigny MH, MacDonald JD, Bissonnette Bertrand N. 2009. Ammonia volatilization following surface application of urea to tilled and non-tilled soils: a laboratory comparision. Soil Till. Res. **103,** 310-315.

Rochette P, Angers DA, Chantigny MH, MacDonald JD, Bissonnette Bertrand N. 2009b. Ammonia volatilization following surface application of urea to tilled and non-tilled soils: a laboratory comparision. Soil Till. Res. **103,** 310-315.

Sanz-Cobena A, Misselbrook TH, Arce A, Mingot JI, Diez JA, Vallejo A. 2008. An inhibitor of urease activity effectively reduces ammonia emissions from soil treated with urea under Mediterranean conditions. Agric. Ecosyst. Environ., **126,** 243-249.

Singaram P, Kothandaraman GV. 1994. Studies on residual, direct and cumulative effect of phosphorus sources on the availability, content and uptake of phosphorus and yield of maize. Madras Agriculture research **81,** 425-429.

Singh Dubey. 1991. Response of maize to the application of nitrogen and phosphorous. Current Research. University of Agricultural Science. In Fertilizer Abst. 540-543 p.

Sanz-Cobena A, Misselbrook T, Camp V, Vallejo A. 2011. Effect of water addition and the urease inhibitor NBPT on the abatement of ammonia emission from surface applied urea. Agriculture Ecosystem and Environment **45,** 1517-1524.

Sanz-Cobena A, Misselbrook TH, Arce A, Mingot JI, DiezJA Vallejo A. 2008. An inhibitor of urease activity effectively reduces ammonia emissions from soil treated with urea under Mediterranean conditions. Agriculture Ecosystem and Enviornment **126,** 243-249.

Silver WL, Herman DJ, Firestone MK. 2001. Dissimilatory nitrate reduction to ammonium in upland tropical forest soils. Journal of Ecology **82,** 2410-2416.

Watson CJ. 2000. Urease activity and inhibition: Principles and Practice. Proceeding, The International Fertilizer Society, York, UK. No. 454 p.

Watson CJ, Poland P, Allen MBD. 1998. The efficacy of repeated applications of the urease inhibitor N-(n-butyl) thiophosphorictriamide for improving the efficiency of urea fertilizer utilization on temperate grassland. Grass forages sciences **53,** 137-145.

Whitehead DC, Raistrick N. 1993. The volatilization of ammonia from cattle urine applied to soils as influenced by soil properties. Plant Soil **148,** 43-51.

Witte CP, Tiller SA, Taylor MA, Davies HV. 2002. Leaf urea metabolism in potato. Urease activity profile and patterns of recovery and distribution of ^{15}N after foliar urea application in wild-type and urease-antisense transgenics. Plant Physiol. **128.** 1129-1136.

Wojnowska T, Panak H, Seikiewiez S. 1995. Reaction of winter oilseed rape to increasing levels of nitrogen fertilizer application under condition of KetizynChernozem. RoslingOleiste **16,** 173-180.

Zaman M, Zaman S, Adhinarayanan C, Nruyen ML, Nawaz S, Dawar KM. 2013. Effects of urease and nitrification inhibitors on the efficient use of urea pastoral systems. Soil Science and Plant Nutrition. 1-11 p.

Zaman M, Nguyen ML. 2012. How application timing of urease and nitrification inhibitors affect N losses from urine in pastoral system. Agriculture Enviornment and Ecosystem **156,** 37-48.

Zaman M, Nguyen ML, Blennerhassett JD, Quin BF. 2008. Reducing NH_3, N_2O and NO_3^--N losses from a pasture soil with urease or nitrification inhibitors and elemental S-amended nitrogenous fertilizers. Bio-fertilizer soil. **44,** 693-705.

Zhengping WO, Van Cleemput Liantie L, Baert L. 1991. Effect of urease inhibitors on urea hydrolysis and ammonia volalitilization. Bio-fertilizer soil **11,** 43-47.