Research Article

Yield and Yield Contributing Traits of Wheat Varieties as Affected by Nitrogen Rates

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Abstract | Wheat (*Triticum aestivum* L.) is a major staple food crop of Pakistan. It is grown on the maximum cropped area every year. The suitable variety identification for agro-climate and its optimum N-fertilizer demand with application are need of the day to overcome on N-leaching from the soil and to ensure future food security. Present study was, therefore, conducted in two seasons (2011-12 and 2012-13) at the Agronomy Research Farm, the University of Agriculture Peshawar, Pakistan. Treatments were laid-out in a randomized complete block design; split plot arrangements using four replications. The experiments were comprising of seven N-rates i.e. 0, 30, 60, 90, 120, 150, and 180 kg ha^{-1} as main plots treatment and the five wheat varieties i.e. Saleem-2000, Uqab, Pirsabak-2005, Tatara-96 and Pirsabak-2004 as subplot treatment. Results revealed higher spikes m^{-2} (286), grains spike^{-1} (38.55) and thousand grains weight (44.67 g) which resulted maximum grain yield (3308 kg ha^{-1}) from N-rate 150 kg ha^{-1} as compared to the control. Among the varieties for yield and yield traits, Pirsabak-2005 produced the highest grain yield (3043 kg ha^{-1}) and the minimum (2494 kg ha^{-1}) grain yield was observed by wheat variety Saleem-2000. The highest grain yield of the variety corresponds to higher thousand grains weight (46.98 g), spikes per meter square (263) and grains spike^{-1} (37.24). Variety Saleem-2000 showed the minimum number of spikes m^{-2} (242) and grains spike^{-1} (34.13). It can be concluded from results that application of 150 kg N ha^{-1} is optimum rate of N-fertilizer for irrigated spring wheat production in the area. Among the available spring wheat varieties, Pirsabak-2005 is relatively the best variety for grain yield in agro-ecological condition of Peshawar that may effectively contribute in food security of the growing population in the region.

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Introduction

Wheat (*Triticum aestivum L.)* belongs to the family Poaceae and occupies the largest cultivated area of greater than 9039 thousand hectares in Pakistan with a total production of 25,286 thousand tones to yield 2797 kg ha^{-1} (MNFSR, 2014). Wheat is largely consumed as a staple food providing the maximum protein as compared to other cereals. Its straw is mainly utilized as high value animal feed and partly as raw material of paper industry (Chondie, 2015). Average yield of wheat in Khyber Pakhtunkhwa (KP) is around 1550 kg ha^{-1}, which is half of the national average (MNFSR, 2014). One reason of low production is the imbalance nutrients application and unknown variety in cultivation in addition to the low organic matter in soil (Shah, 2014). Pakistan is endowed with a fertile soil and favourable climate for crop production. Wheat yield is very low in general due to diverse fertility, improper rotations, availability of the quality

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seed, appropriate wheat variety, lodging, rust and smut and use of traditional production techniques (Akmal et al., 2011). Growing population pressure compelled growers to increase yield per unit area. Farmer prefers to grow cereals that exhaust soil nutrition (Saha et al., 2010). It is need of the day to improve cropping system based on scientific outcomes so that agricultural production, specifically wheat crop, can be increased.

Nitrogen is an integral part of plants and is of primary importance for healthy growth of plants as compared to other nutrients. It is a vital constituent of proteins, which increase leaf area, and as a result speeds up the synthesis of carbohydrates. Nitrogen also increased yield of crops. Providing adequate amount of N at proper time can result in healthy and economic performance (Chondie, 2015). Optimum N-application to plants speeds up life processes, promotes conversion of sugar into protein, which results in more protoplasm (Brady and Weil, 2002). Nitrogen is almost 7% of the total dry matter of plants and in a higher concentration is essential for the cell components e.g. nucleic acids, amino acids, enzymes, and photosynthetic pigments (Bungard et al., 1999; Maighany and Ebrahimzadeh, 2004). They have confirmed that split N-applications results in better yield, with higher spikes per unit area and limited lodging with improved grain weight. Research has confirmed that N-rate 120 kg ha^{-1} is sufficient for wheat (Abedi et al., 2011).

To get optimum production of wheat under the changing climate expected with higher rainfall at post-anthesis stage of the crop, it is essential to have sufficient N-content in soil for quality grains resulting in good baking quality. The present study, therefore, aims to determine optimum N-rate for the most suitable variety of wheat to be planted under the climatic conditions of Peshawar, Khyber Pakhtunkhwa.

Materials and Methods

Experimental Site

Comparison of most suitable wheat variety and N-rate as spring wheat in Peshawar region was conducted in crop growth seasons 2011-12 and 2012-13, at Agronomy Research Farm, The University of Agriculture, Peshawar. The location of the experimental site was at 34° 1'13.50 "N and 71° 28'53.02 "E with an altitude of about 350 m above the sea level. The environmental conditions of the research farm were relatively warm to hot (semi-arid subtropical) with the continental climate (Shah, 2014) receives a mean annual rainfall less than 500-700 mm. The soil of the experimental field was silt-clay-loam having 1.15 % organic matter and deficient in total soil nitrogen (0.089 % soil). The nature of the soil was alkaline, has a pH of 7.85 (Akmal and Ali, 2015). Soil series of the location is classified as tarnab series (Soil survey of Pakistan). Weather data of the crops growth seasons of the experiment duration are shown in Figure 1.

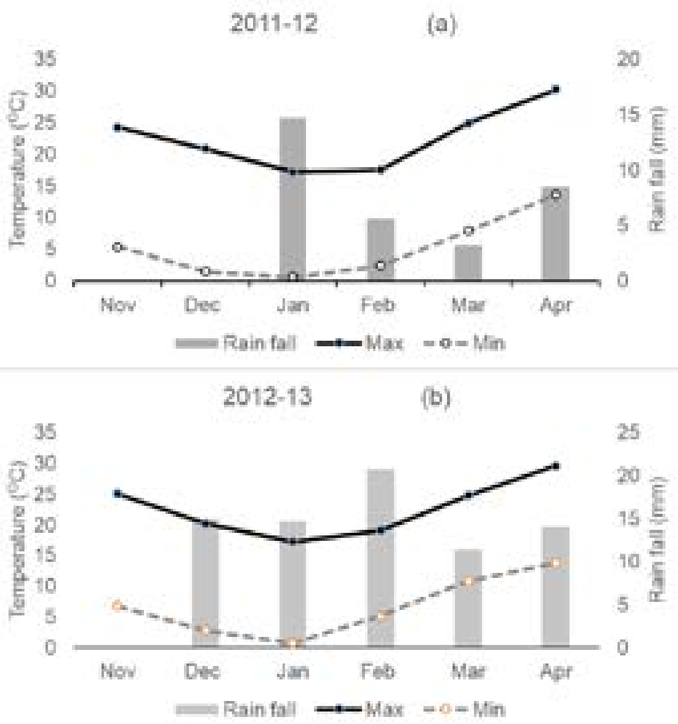

Figure 1: *Mean monthly precipitation and temperature recorded during the crop growth seasons at the Experimental site*

Experiment Detail

The experiments were conducted in randomized complete block (RCB) design; split plot arrangements having four replications. Treatments N-rates (N) i.e. 0, 30, 60, 90, 120, 150 and 180 (kg ha^{-1}) were used as main plots and the wheat varieties (i.e. Saleem-2000, Uqab, Pirsabak-2005, Tatara-96, Pirsabak-2004) as sub plots treatment. A subplot was measuring 1.8 m x 7 m accommodating 6 rows in North- South directions; spaced equally 30 cm. Seeds of the wheat varieties were collected from Cereal Crop Research Institute (CCRI), Pirsabak Nowshera for sowing in each season. Seeds were planted in second week of Nov. in 2011 and 2012, respectively. Nitrogen was applied from urea source in three splits during the crop growth. First application of N-fertilizer was completed at seedbed preparation, second after 30 days of sowing (DAS) and last i.e. the 3rd application about 60 DAS. Information on N application rates during the crop growth seasons is shown in Figure 2.

Yield Traits Observation

Data regarding spikes m^{-2} i.e. spikes bearing tillers were counted in a meter-long row at two locations in a sub plot, randomly selected, close to the physiological maturity stage of the crop (first week of May each year). Number of spikes m^{-2} was manually counted between the marked locations in an experimental unit and spikes density was converted to standard unit. Ten spikes were randomly selected from each experimental unit; grains were removed, counted and averaged for a single mean reading per spike. A total of 1000 grains weight (g) was taken at random from threshed samples of grain yield, the grains were counted independently using electronic grain counter and weighed.

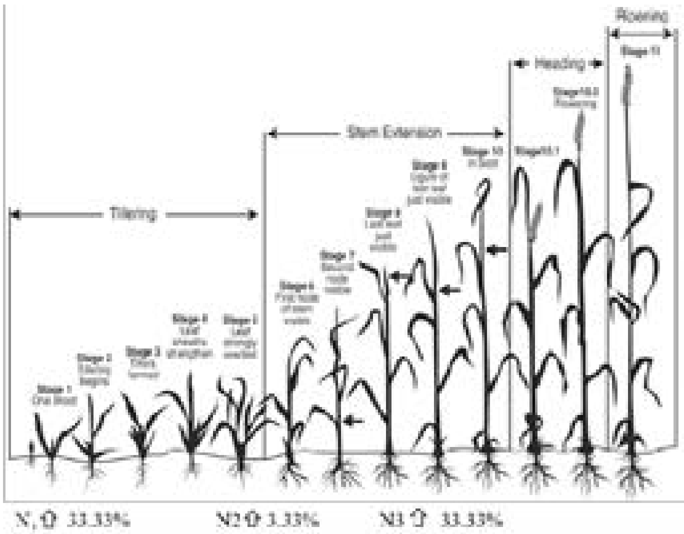

Figure 2: *Schedule of the split N-application (kg ha^{-1}), as per growth stage*

Yield (kg ha^{-1})

On approaching the crop to maturity, two central rows were harvested manually, bundled and allowed to dry in the field for about 15 days. The bundles were turned over periodically, after complete drying weighed for total biomass and subsequently threshed, using a mini lab wheat thresher. Grains after collection were weighed to record grain yield for an

Table 1: *Spikes m^{-2} (SPM) and grains $spike^{-1}$ (GPS) of wheat varieties as influenced by various N-rates*

	(SPM)			(GPS)		
Treatments	Years (Y)		Mean	Years (Y)		Mean
	2011-12	2012-13		2011-12	2012-13	
N-rate (kg ha^{-1})						
0	223.30 e	218.29 f	221 f	30.76 f	30.52 f	30.64 g
30	230.10 e	225.37 ef	228 ef	32.20 e	31.64 e	31.92 f
60	236.45 de	235.20 e	236 e	33.35 e	33.45 d	33.40 e
90	246.40 cd	247.03 d	247 d	35.30 d	35.07 c	35.18 d
120	256.95 bc	263.15 c	260 c	37.55 c	37.20 b	37.38 c
150	267.10 ab	279.23 b	273 b	39.30 b	37.79 b	38.55 b
180	276.35 a	295.30 a	286 a	40.70 a	39.10 a	40.00 a
LSD (p<0.05)	14.43	11.36	8.86	1.23	1.01	0.77
Varieties (V)						
Saleem-2000	236.96 d	246.75 b	242 d	34.43 c	33.84 c	34.13 c
Uqab	245.79 c	250.42ab	248 c	35.54 b	34.59 bc	35.06 b
Pirsabak-2005	266.86 a	258.83 a	263 a	37.13 a	37.36 a	37.24 a
Tatara-96	237.89 d	247.03 b	242 cd	34.91 bc	33.40 c	34.16 c
Pirsabak-2004	252.96 b	256.68 a	255 b	35.96 b	35.64 b	35.80 b
LSD (p<0.05)	6.74	9.48	5.77	1.07	1.25	0.82
Mean	208.1	211.8		29.87	29.57	
Interactions			**Probability (p<0.05)**			
N x V			0.98			0.17
Y x N			0.01			0.31
Y x V			0.04			0.29
Y x N x V			0.99			0.76

Means followed by different letter(s) within a category and/or column are different statistically using LSD (p≤0.05) test experimental unit and converted into grains weight in kg ha^{-1}.

Two years' data were collectively analyzed appropriate for the field layout on using a computer based software (Genstat version) and means, where found significant were separated using LSD (p<0.05) test. Interactions of the treatments are shown in graphics based on two years' averages.

Results and Discussion

Spikes (m^{-2}) and grains per spike of wheat varieties affected by N-rate revealed the maximum number for N- rate 180 kg ha^{-1} for a year or two years' average, which did not differ than N 150 kg ha^{-1} in the second year (Table 1). Spike number and/or grain per spike decreased by limiting N-rate to non-significant response for the spike per unit area only at N-rate 30 kg ha^{-1} from control. However, spikes m^{-2} and grains per spike did vary for wheat varieties with the highest for Pirsabak-2005 followed by Pirsabak-2004 for a year or two years' averages. Saleem-2000 and Tatara-96 showed the lowest spikes m^{-2} on two years' averages. Grains $spike^{-1}$ was observed similar for Uqab and Pirsabak-2004 while the lowest for the variety Saleem-2000. Interactive effect of treatments (N-rate x variety) did not vary statistically for any of the parameters i. e., spike per unit or grain per spike. Thousand grains weight was the highest for N-rate 180 kg ha^{-1}, which did not varied statistically from N-rates 150, 120 and 90 kg ha^{-1} in first year (Table 2) or N-rates 120, 150 and 180 kg ha^{-1} in second year and/or two year's average. But thereafter every reduction in N-rate decreased thousand grains weight significantly for a year. On two years' averages, grains weight was same (p<0.05) for N-rate 150 and 180 kg ha^{-1}, N 120 and 90, and 90 and 60 kg ha^{-1}. The minimum thousand grains weight was observed for control. Among varieties, a significant variation was found in thousand grains

Table 2: *Thousand grains weight (TGW in g) and grain yield (GY in kg ha^{-1}) of wheat varieties as influenced by various N-rate*

Treatments	(TGW)			(GY)		
	Years (Y)		Mean	Years (Y)		Mean
	2011-12	2012-13		2011-12	2012-13	
N-rate (kg ha^{-1})						
0	40.44 c	41.38 c	40.91 d	1923 e	1875 d	1899 f
30	40.70 bc	41.89 c	41.29 d	2026 e	2310 c	2168 e
60	41.97 ab	42.76 bc	42.36 c	2460 d	2550 c	2505 d
90	42.41 a	43.72 b	43.06 bc	2807 c	2906 b	2857 c
120	42.51 a	45.55 a	44.03ab	3183 b	3056 ab	3119 b
150	43.27 a	46.07 a	44.67 a	3329 ab	3286 a	3308 a
180	42.94 a	45.72 a	44.33 a	3389 a	3329 a	3359 a
LSD	1.41	1.56	1.02	186.52	317.62	177.78
Varieties(V)						
Saleem-2000	40.65 c	41.41 d	41.03 d	2576 c	2412 c	2494 c
Uqab	40.96 c	43.01 c	41.99 c	2741 b	2676 b	2708 b
Pirsabak-2005	45.41 a	48.54 a	46.98 a	2962 a	3125 a	3043 a
Tatara-96	40.51 c	41.41 d	40.96 d	2492 c	2558 bc	2525 c
Pirsabak-2004	42.63 b	44.97 b	43.80 b	2883 a	3025 a	2954 a
LSD	1.34	1.34	0.94	96.45	167.32	95.86
Mean	35.29	36.93		2294.78	2332.12	
Interactions			**Probability values (p<0.05)**			
N x V			0.70			0.88
Y x N			0.00			0.09
Y x V			0.23			0.01
Y x N x V			0.98			0.27

Means followed by different letter(s) within a category and/or column are different statistically using LSD (p≤0.05) test weight. Pirsabak-2005 showed the highest grains weight, followed by Pirsabak-2004. Lowest grains weight was observed for variety Saleem-2000 and Tatara-96.

Interactive effect of treatments on grains weight was non-significant. Grain yield (kg ha^{-1}) was recorded maximum at N-rates 150 that did not vary from N 180 kg ha^{-1}. Thereafter, every reduction in N-rate decreased ($p<0.05$) grain yield. For varieties, a significant variation observed in grain yield. Variety Pirsabak-2005 exhibited the highest grain yield that did not differ for Pirsabak-2004. The lowest grain yield was observed for variety Saleem-2000 that did not differed from Tatara-96. Interactive effect of varieties and N-rate was non-significant on grain yield.

Nitrogen has significantly increased spikes per meter over the control (Bundy and Andraski, 2004). Khan et al. (2008) reported increase in spikes with N-fertilization to wheat. It might be due to the fact that N had improved crop stand, enhanced tillers, which improved spikes m^{-2}. A reduction of soil-N has limited yield components (Li et al., 2001). Sufficient N to soil at early vegetative growth stage has accelerated the crop growth rate that has resulted in higher spike number per meter (Rozas et al., 1999). Varieties also differ in tillers of the genetic variability (Shah and Ahmad, 2006; Khaliq et al., 2004). It is reported that optimum N-rate increased grain per spike as the transition of carbohydrates in phloem increased the cell division (Tabatabaii et al., 2011). Tillers production is believed to be an inherited genotypic trait. However, Bhorghi (2000) reported that if N-content increased to optimum that increased in biomass; attributed to plant larger leaves, which stay green for longer time also attributes to tall stems with relatively denser tillers. Grains $spike^{-1}$ also interesting trait was found significant for N-rate and variety. Higher grain at N-rate 180 kg ha^{-1} as compared to other level of nitrogen could be attributed to better plant growth (Marschner, 1995). Pirsabak-2005 produced more grains $spike^{-1}$ could be due to its potential expression in the environment (Gozubenli et al., 2001) and the differences among varieties are not unusual (Abdel-Ati and Zaki, 2006). Varieties have genetic potential to express as grains $spike^{-1}$ (Saha et al., 2010). The 1000 grains weight (g), a meaningful trait contributing in yield, is also affected by N-rate and variety (Table 2) with highest for N 120 kg ha^{-1}. However, further increase in N-rate to 180 kg ha^{-1} showed a non-significant effect on thousand grains weight. Increase thousand grains with optimum N-rate may be due to higher grain protein (Guenis et al., 2003). Likewise, Abdel-Ati and Zaki (2006) have observed variations in grain weight of different varieties of the same species. Nitrogen supplied at the rate of 150 kg ha^{-1} resulted significantly ($p<0.05$) higher grain yield with no further increase in yield by increasing N to 180 kg ha^{-1}. This increase in grain yield is consequent of increase in grains $spike^{-1}$ and grain index (Purcino et al., 2000; Foyer et al., 2002). According to Purcino et al. (2000) and Foyer et al. (2002), N plays a key role in photosynthesis of plants, thus increased grain yield. Differences in yield by varieties are quite natural and can be attributed with canopy architectures of the crop in the canopy and its assimilated distribution from vegetative to reproductive parts during growth and development (Bakht et al., 2010; Akmal et al., 2011; Akmal and Ali, 2015). Yield of plant is consequent of healthier spike per unit area, higher grains per spike, and the grain weight, resulted the yield accordingly.

Conclusions

The study suggested that under the recent climatic change, N-fertilizer to wheat is preferably splits to ensure higher soil N-content at post anthesis stage of wheat for high yield. The existing 120 can be 150 kg ha^{-1} for well-irrigated or high rainfall conditions and variety Pirsabak-2005 can be the best option to plant in the area.

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Authors' Contribution

Gul Naz conducted research, measured observation and prepared draft. Mr. Akmal designed the experiment and helped in structuring the manuscript with editing.

References

Abdel-Ati, A.A., and K.I. Zakii. 2006. Productivity of some wheat cultivars in calcareous soils under organic farming and rainfed conditions with special references to plant diseases. J. Agri. Sci. Mansoura Univ. 31(4):1875-1889.

Abedi, T., A. Alemzadeh and S.A. Kazemeini. 2011. Wheat yield and grain protein response to nitrogen amount and timing. Aust. J. Crop Sci. 5 (3):330-336.

Akmal, M., and N. Ali. 2015. Response of wheat varieties to sowing intervals as rainfed crop in Khyber Pakhtunkhwa (KP) Pakistan. Project report submitted to Inter-Cooperation (IC). Pp. 112.

Akmal, M., S.M. Shah, M. Asim and M. Arif. 2011. Causes of yield reduction by delayed planting of hexaploid wheat in Pakistan. Pak. J. Bot. 43:2561-2568.

Bakht, J., M. Shafi, M. Zubair, M.A. Khan and Z. Shah. 2010. Effect of foliar vs. soil application of nitrogen on yield and yield components of wheat varieties. Pak. J. Bot. 42(4):2737-2745.

Bhorghi, B. 2000. Nitrogen as determinant of wheat growth and yield in wheat ecology and physiology of yield determination. Viva Books Private Limited, India. Pp. 71-74.

Brady, N.C. and R.R. Weil. 2002. The nature and properties of soils (13th ed.). Pearson Education Ltd., USA. Pp. 960.

Bundy, L.G. and T.W. Andraski. 2004. Diagnostic tests for site-specific nitrogen recommendation for winter wheat. Agron. J. 96:608-614. http://dx.doi.org/10.2134/agronj2004.0608

Bungard, R.A., A. Wingler, J.D. Morton and M. Andrews. 1999. Ammonium can stimulate nitrate and nitrite reductase in the absence of nitrate in clematis vitalba. Plant Cell Environ. 22:859-866. http://dx.doi.org/10.1046/j.1365-3040.1999.00456.x

Chondie, Y.G. 2015. Effect of integrated nutrient management on wheat: A Review. J. Biol. Agri. Healthcare. 5(13):68-76.

Foyer, C.H., H. Vanacker, L.D. Gomez and J. Harbinson. 2002. Regulation of photosynthesis and antioxidant metabolism in maize leaves at optimal and chilling temperatures: Review. Plant Physiol. Biochem. 40:659-668. http://dx.doi.org/10.1016/S0981-9428(02)01425-0

Gozubenli, H., A.C. Ulger and O. Sener. 2001. The effect of different nitrogen doses on grain yield and yield related characters of some maize genotypes grown as second crop. J. Agri. 16:39-48.

Guenis, A., M. Alpaslan and A. Unal. 2003. Effects of boron fertilization on the yield and some yield components of bread and durum wheat. Tur. J. Agri. 27:329-335.

Khaliq, I., N. Parveen, and M.A. Chowdhry. 2004. Correlation and path coefficient analyses in bread wheat. Int. J. Agric. Biol. 6(4): 633-635.

Khan, A., M.T. Jan, M. Arif, K.B. Marwat, and A. Jan. 2008. Phenology and crop stand of wheat as affected by nitrogen sources and tillage systems. Pak. J. Bot. 40(3):1103-1112.

Li, C., W. Cao, and T. Dai. 2001. Dynamic characteristics of floret primordium development in wheat. Field Crops Res. 71:71–76. http://dx.doi.org/10.1016/S0378-4290(01)00144-7

Maighany, F. and H. Ebrahimzadeh. 2004. Intervarietal differences in nitrogen content and nitrate assimilation in wheat (*Triticum aestivum L.*) under salt stress. Pak. J. Bot. 36(1):31-39.

Marschner, H. 1995. Mineral nutrition of higher plants. Academic Press, Sandiego, Ca. Pp. 379-396.

MNFSR. 2014. Ministry of National Food Security and Research, Government of Pakistan-Islamabad. Pp. 1-3.

Purcino, A.A.C., M.R.E. Silva, S.R.M. Andrade, C.L. Belele, S.N. Parentoni and M.X. Santos. 2000. Grain filling in maize: The effect of nitrogen nutrition on the activities of nitrogen assimilating enzymes in the pedicel placento chalaza region. Maydica. 45(2):95-103.

Rozas, S., H.E. Echeverria, and G.A. Studdert. 1999. No-tillage maize nitrogen uptake and yield: Effect of urease inhibitor and application time. Agron. J. 91:950-955. http://dx.doi.org/10.2134/agronj1999.916950x

Saha, P.K., A.T.M.S. Hossain and M.A.M. Miah. 2010. Effect of potassium application on wheat (*Triticum aestivum L.*) in old Himalayan piedmont plain. Bangladesh J. Agri. Res. 35(2):207-216. http://dx.doi.org/10.3329/bjar.v35i2.5883

Shah, A. 2014. Optimizing N- fertilizer through managing crop residues and tillage for wheat production. PhD Theses. University of Agriculture, Peshawar, Pakistan. Pp. 176.

Shah, Z., and M.I. Ahmad. 2006. Effect of integrated use of farm yard manure and urea on yield and nitrogen uptake of wheat. J. Agri. Boil. Sci. 1(1):60-65.

Tabatabaii, S., E.M. Yarnia, M.B. Khorshidi-Benam and E.F.M. Tabrizi. 2011. Effect of potassium fertilizer on corn yield (Jet acv.) under drought stress condition. American- Eur. J. Agri. Environ. Sci. 10(2):257-263.