INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 16, No. 5, p. 77-91, 2020

RESEARCH PAPER OPEN ACCESS

Determination of balanced nutrition in dry land wheat

Shahid Iqbal Khattak[1*], Mohammad Safdar Baloch[1], Khalid Naveed[2], Muhammad Ijaz Khan[3], Ishfaq Ahmad[3], Muhammad Amjad Nadim[1], Asghar Ali Khan[1]

[1]*Department of Agronomy, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan*

[2]*Department of Agricultural Sciences, University of Haripur, Haripur, Pakistan*

[3]*Agricultural Research Station, Ahmad Wala, Karak, Pakistan*

Key words: Wheat, Fertilizers, Growth, Economic yield, Dry land.

http://dx.doi.org/10.12692/ijb/16.5.77-91 Article published on May 15, 2020

Abstract

Wheat growers in Pakistan mostly apply Di-Ammonium Phosphate (DAP) at sowing time whereas the application of balanced NPK nutrition increases wheat yield manifolds. In this study, efforts were made to determine the effect and economics of balanced nutrition by applying all three macronutrients in their potential combinations for two successive cropping seasons of wheat under dry land conditions. The trial was laid out at the Agricultural Research Institute, Dera Ismail Khan, Pakistan in a randomized complete block design (RCBD) with three factors (Factor-A consisted of nitrogen doses, Factor-B phosphorous doses and Factor-C potassium doses). The results obtained in this study showed that nitrogen, phosphorus and potassium when applied @ 120:90:60 kg ha^{-1} produced higher economic yield and yield contributing parameters than all other combinations applied. This resulted in higher crop growth rate (3.76, 3.17, 2.33, 5.48 and 3.83, 3.24, 2.39, 5.66), net assimilation rate (0.64, 0.60, 0.41, 0.75 and 0.63, 0.58, 0.40, 0.75) net photosynthesis rate (13.3, 13.0, 10.3, 17.2 and 13.3, 13.2, 10.4, 17.4) at 63 days after sowing-DAS, (3.5, 3.6, 3.2, 5.6 and 3.5, 3.5, 3.2, 5.5) at 126 DAS, total number of tillers (269, 255, 234, 299 and 269, 257, 235 m^{-2}), spike length (8.0, 7.7, 7.7 and 8.5, 7.8, 7.5 cm), number of grains (46, 43, 44, 43 and 47, 44, 45, 54 $spike^{-1}$), 1000-grain weight (37.6, 36.3, 34.1, 42.1 and 37.9, 36.5, 34.3 and 42.7 g), economic yield (3970, 3020, 2653, 4697 and 4024, 3045, 2680 and 4750 kg ha^{-1}) and net returns per rupee invested. Based on the results obtained, it is concluded that application of NPK fertilizers @ 120 kg N, 90 kg P_2O_5 and 60 kg K_2O ha^{-1} is most suitable for successful dry-land wheat production.

* **Corresponding Author:** Shahid Iqbal Khattak ✉ shahidktk_agronomy@yahoo.com

Introduction

Wheat is the most important cereal crop consumed as bread, cakes, biscuits, bakery and confectionery products (Niamatullah *et al.*, 2011). Its straw is also used as animal feed as well as for the manufacturing of paper.

Fertilizers contribute an important part in successful crop cultivation (Saifullah *et al.*, 2002). A balanced fertilizer is intended for good yield (Tariq *et al.*, 2007). The judicious use of NPK fertilizers can improve yield from 30-40% (Maqssod *et al.*, 1999). The nitrogen, phosphorus and potassium are the main food nutrients. The soil of Pakistan is lacking these macro elements. So, it is the time to improve the soil fertility status in the country. Fertility can be improved through manures however inorganic source has the major share in crop nutrients.

Nitrogen is necessary for various growth processes of plant because it is a basic component of many chemical substances (Jabbar *et al.*, 2009). Similarly, for successful crop production application of phosphorus is considered indispensible (Malghani *et al.*, 2010). It regulates flowering and seed sitting. Shortage of its supply directly affects thousand grain weight and economic yield (Iqbal and Chuhan, 2003). Potassium has a key role in enzyme activation; it improves the concentration of chemical substances such as protein and fats and controls functions of stomata. It also improves resistance against frost, lodging, pests and diseases (Malghani *et al.*, 2010).

Keeping in view that NPK fertilizer application is the most important production factor, the current research was conducted to investigate the balance and best economical dose of NPK fertilizer application for dry land wheat production.

Materials and methods

This study was to determine the balance nutrition in dry land wheat by using 00:60:120 kg N ha^{-1}, 00:45:90 kg P ha^{-1} and 00:30:60 kg K ha^{-1} in cv. Hashim-8. The layout of the experiment was done using RCB design with three factors (Factor-A consists of nitrogen doses, Factor-B phosphorous doses and Factor-C potassium doses) replicated 3 times in 5m × 1.8m sub-plot.

The soil status is specified in Table 1. Metrological data is given in Table 2-3. To reduce the experimental errors, standard agronomic practices were followed in all treatments. Data on the following parameters were noted as per standard procedures and subjected to ANOVA techniques as recommended by Steel *et al.* (1997). Turkey's HSD Test (Gomez and Gomez, 1984) was used for means comparison when analysis of variance showed significant differences. Analysis was performed by using "Statistix 8.1" computer software.

Crop growth rate (g m^{-2} day^{-1})

Crop growth rate from boot to maturity stage (before and after anthesis) was calculated by the following formula:

$$CGR\ (g\ day^{-1}\ m^{-2}) = \frac{W_2 - W_1}{T_2 - T_1} - \frac{1}{GA}$$

Where

W_2 = final weight

W_1 = initial weight

GA = ground area

T_1 and T_2 are the time interval in days

Net assimilation rate (g m^{-2} day^{-1})

Net assimilation rate is the net gain in dry weight (dry matter) of a plant per unit leaf area per unit time. It was determined by the following formula:

$$NAR = \frac{(W_2 - W_1)\,(Ln\,(LA_2) - Ln\,(LA_1))}{(T_2 - T_1)\,(LA_2 - LA_1)}$$

Net photosynthesis rate (µ mol m^{-2} sec^{-1})

Photosynthesis rate was estimated by measuring the rate of photosynthesis per unit area with the help of digital meter photosynthesis system in 10 randomly selected wheat plants at 63 and 126 days after sowing by using CID_Model CI-340 Portable Photosynthesis System (CID BioScience Inc. USA).

Number of tillers (m^{-2})

Total number of tillers was counted randomly in each sub-plot at harvest using 1m^{-2} quadrate.

Spike length (cm)

Ten spikes from each sub-plot were randomly selected; their length was calculated, averaged and recorded.

Number of grains (spike^{-1})

Ten ear heads were randomly selected from each sub-plot. These ears were threshed and cleaned to record number of grains per spike.

1000-grain weight (g)

One thousand grains were counted from a seed lot in each sub-plot and their weight was recorded.

Economic yield (kg ha^{-1})

From each sub-plot, crop was harvested and threshed. The grains harvested were sun dried for 2-3 days to attain 10% moisture and then their weight was recorded and converted into kg ha^{-1} by using the following formula:

Grain yield (kg ha^{-1}) = grain yield m^{-2} (kg) x 10000.

Economic analysis

The following formulae were employed to find out the economic parameters.

Net return (NR) = Value of increased yield obtained-cost of N, P and K fertilizers

Value cost ratio (VCR) = Value of increased yield obtained - cost of N, P and K fertilizers

Relative increase in income (RII) (%) = (Net income/ income in control) x 100.

Results and discussion

Crop growth rate (g m^{-2} day^{-1})

Response of wheat crop to different levels of NPK displayed significant ($p \leq 0.05$) variations during 2013-14 and 2014-15 by using different variables of NP, NK, PK and N, P, and K on CGR (Table 4 and 5).

Table 1. Physico-chemical properties of the experimental site during 2013-2014 and 2014-15.

Parameters	Units	Values	
		2013-14	2014-15
EC	dsm^{-1}	1.55	1.75
pH	--	7.68	8.17
Organic matter	%	0.73	0.63
Phosphorus	mg kg^{-1}	5.27	8.87
Potassium	mg kg^{-1}	219	239
Texture class	--	Clay loam	Clay loam

In 2013-14 cropping season, NP applied plots produced maximum CGR (3.76) with 120:90 kg NP ha^{-1}. Similarly, the NK applied doses produced maximum CGR of 3.17 with 120:60 kg NK ha^{-1}; while PK doses also had 2.33 CGR at higher level (90:60 kg PK ha^{-1}) of its application. Minimum CGR was recorded in control plots. Similarly, higher crop growth rate was obtained at higher doses of NP, NK and PK during the second year cropping season.

Table 2. Average monthly temperature, humidity and rain fall of the experimental area during 2013-2014.

Month	Temperature (°C)		Humidity (%)	Rainfall (mm)
	Minimum	Maximum		
November 2013	10	26	37	02
December 2013	6	22	51	01
January 2014	6	23	53	11
February 2014	7	21	45	38
March 2014	12	24	49	50
April 2014	18	31	44	69
May 2014	22	36	30	8

The data further showed maximum CGR (5.48) during 2013-14 cropping season at 120 kg N, 90 kg P and 60 kg K ha^{-1}. Minimum value (0.24) was recorded in check plots. The results remained the same in subsequent cropping season. Our findings are in complete analogy to Rehman *et al.* (2008) who observed higher CGR and other growth parameters with the upper doses of NPK. The use of inorganic fertilizer has been reported to have a favorable effect on wheat crop growth rate and yield contributing parameters under rain fed as well as irrigated conditions (Hossain *et al.*, 2002).

Table 3. Average monthly temperature, humidity and rain fall of the experimental area during 2014-2015.

Month	Temperature (°C)		Humidity (%)	Rainfall (mm)
	Minimum	Maximum		
November 2014	9	27	38	16
December 2014	5	20	51	0
January 2015	5	19	62	28
February 2015	8	22	45	27
March 2015	12	26	58	85
April 2015	13	41	23	38
May 2015	19	42	20	0

Net assimilation rate (mg m^{-2} day^{-1})

Net assimilation rate (NAR) indicates how much a plant gains dry matter per unit leaf area in a unit time (Reddy, 2004). The interaction effect of NP, NK, PK and N, P and K was significant ($p \leq 0.05$) on NAR of wheat (Table 6 and 7). In 2013-14 cropping season, maximum NAR (0.64) was found by applying 120:90 kg NP ha^{-1}, the NK applied doses produced maximum and statistically equal NAR of 0.60 and 0.57 with 120:60 and 120:30 kg ha^{-1}, while PK applied doses also had maximum NAR of 0.43 at 90:30 kg ha^{-1}.

Table 4. Relationship between crop growth rate (g m^{-2} day^{-1}) and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Nitrogen × Phosphorus								
N doses (kg ha^{-1})	2013-2014				2014-15			
	P doses (kg ha^{-1})			Means	P doses (kg ha^{-1})			
	(0)	(45)	(90)		(0)	(45)	(90)	Means
(0)	0.30 f	0.32 ef	0.38 ef	0.33 c	0.28 f	0.33 f	0.39 ef	0.33 c
(60)	0.48 de	0.57 d	0.83 c	0.63 b	0.49 de	0.58 d	0.83 c	0.63 b
(120)	0.91 c	1.92 b	3.76 a	2.20 a	0.92 c	1.94 b	3.83 a	2.23 a
Means	0.56 c	0.94 b	1.66 a		0.56 c	0.95 b	0.68 a	
$LSD_{0.05}$	N Doses (0.07), P doses (0.07) Interaction (0.17)				N Doses (0.07), P doses (0.07) Interaction (0.16)			
Nitrogen × Potassium								
N doses (kg ha^{-1})	2013-2014				2014-15			
	K doses (kg ha^{-1})			Means	K doses (kg ha^{-1})			
	(0)	(30)	(60)		(0)	(30)	(60)	Means
(0)	0.28 g	0.33 fg	0.38 fg	0.33 c	0.28 g	0.34 g	0.38 fg	0.33 c
(60)	0.49 ef	0.64 de	0.75 d	0.63 b	0.50 ef	0.65 de	0.76 d	0.63 b
(120)	0.93 c	2.49 b	3.17 a	2.20 a	0.94 c	2.50 b	3.24 a	2.23 a
Means	0.57 c	1.15 b	1.43 a		0.57 c	1.16 b	1.46 a	
$LSD_{0.05}$	N Doses (0.07), K doses (0.07) Interaction (0.17)				N Doses (0.07), K doses (0.07) Interaction (0.16)			
Phosphorus × Potassium								
P doses (kg ha^{-1})	2013-2014				2014-15			
	K doses (kg ha^{-1})			Means	K doses (kg ha^{-1})			
	(0)	(30)	(60)		(0)	(30)	(60)	Means
(0)	0.44 g	0.53 fg	0.70 ef	0.56 c	0.44 f	0.54 f	0.71 e	0.56 c
(45)	0.53 g	1.02 d	1.27 c	0.94 b	0.53 f	1.03 d	1.28 c	0.95 b
(90)	0.73 e	1.91 b	2.33 a	1.66 a	0.74 e	1.92 b	2.39 a	1.68 a
Means	0.57 c	1.15 b	1.43 a		0.57 c	1.16 b	1.46 a	
$LSD_{0.05}$	P Doses (0.07), K doses (0.07) Interaction (0.17)				P Doses (0.07), K doses (0.07) Interaction (0.16)			

In untreated plots, lowest NAR value was observed. Similarly, more NAR was obtained at higher doses of NP, NK and PK during the second cropping season. The data further exhibited that maximum NAR (0.82) was recorded during 2013-14 cropping season at 120 kg N, 90 kg P and 30 kg ha^{-1} K and minimum NAR (0.32) in check plots. The results remained the same in the following cropping season.

Table 5. Relationship between crop growth rate (g m^{-2} day^{-1}) and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Treatments		2013-2014			2014-2015		
		0 kg K ha^{-1}	30 kg K ha^{-1}	60 kg K ha^{-1}	0 kg K ha^{-1}	30 kg K ha^{-1}	60 kg K ha^{-1}
0 kg N ha^{-1}	0 kg P ha^{-1}	0.24 k	0.29 ijk	0.32 h-k	0.23 k	0.29 jk	0.33 ijk
	45 kg P ha^{-1}	0.27 jk	0.32 h-k	0.37 h-k	0.28 jk	0.33 ijk	0.37 h-k
	90 kg P ha^{-1}	0.32 h-k	0.38 h-k	0.44 h-k	0.3 ijk	0.39 h-k	0.44 h-k
60 kg N ha^{-1}	0 kg P ha^{-1}	0.41 h-k	0.49 g-k	0.55 g-k	0.42 h-k	0.49 h-k	0.55 g-k
	45 kg P ha^{-1}	0.49 g-k	0.59 g-j	0.63 ghi	0.49 h-k	0.60 g-j	0.64 g-j
	90 kg P ha^{-1}	0.58 g-k	0.84 fg	1.07 ef	0.58 h-j	0.84 fg	1.08 ef
120 kg N ha^{-1}	0 kg P ha^{-1}	0.66 gh	0.83 fg	1.23 e	0.67 gh	0.83 fg	1.24 e
	45 kg P ha^{-1}	0.83 fg	2.14 d	2.80 c	0.83 fg	2.16 d	2.82 c
	90 kg P ha^{-1}	1.29 e	4.5 b	5.48 a	1.32 e	4.51 b	5.66 a
$LSD_{0.05}$		0.36			0.33		

The maximum NAR noted with the higher doses of macronutrients appeared to be due to improved leaf area of the crop and prolonged crop growth period. Khan *et al.* (2010) found that higher phosphorus doses increased the NAR correspondingly. Maqsood *et al.* (1999) reported higher LAI due to elevated doses of NPK which subsequently increased NAR due to more number of leaves.

Table 6. Relationship between net assimilation rate (mg m^{-2} day^{-1}) and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Nitrogen × Phosphorus								
N doses (kg ha^{-1})	2013-2014				2014-15			
	P doses (kg ha^{-1})			Means	P doses (kg ha^{-1})			
	(0)	(45)	(90)		(0)	(45)	(90)	Means
(0)	0.29 cd	0.24 de	0.20 e	0.24 b	0.27 cd	0.23 de	0.19 e	2.23 b
(60)	0.27 cd	0.25 de	0.26 cd	0.26 b	0.26 cd	0.24 de	0.26 cd	0.25 b
(120)	0.31 c	0.53 b	0.64 a	0.49 a	0.29 c	0.51 b	0.63 a	0.48 a
Means	0.29 c	0.34 b	0.37 a		0.27 c	0.32 b	0.36 a	
$LSD_{0.05}$	N Doses (0.02), P doses (0.02) Interaction (0.05)				N Doses (0.02), P doses (0.02) Interaction (0.05)			
Nitrogen × Potassium								
N doses (kg ha^{-1})	2013-2014				2014-15			
	K doses (kg ha^{-1})			Means	K doses (kg ha^{-1})			
	(0)	(30)	(60)		(0)	(30)	(60)	Means
(0)	0.25 cd	0.24 cd	0.23 d	0.24 b	0.24 c	0.24 c	0.22 c	2.23 b
(60)	0.28 bc	0.26 cd	0.24 cd	0.26 b	0.26 bc	0.25 c	0.24 c	0.25 b
(120)	0.32 b	0.57 a	0.60 a	0.49 a	0.30 b	0.54 a	0.58 a	0.48 a
Means	0.028 b	0.36 a	0.36 a		0.27 b	0.34 a	0.35 a	
$LSD_{0.05}$	N Doses (0.02), K doses (0.02) Interaction (0.05)				N Doses (0.02), K doses (0.02) Interaction (0.05)			
Phosphorus × Potassium								
P doses (kg ha^{-1})	2013-2014				2014-15			
	K doses (kg ha^{-1})			Means	K doses (kg ha^{-1})			
	(0)	(30)	(60)		(0)	(30)	(60)	Means
(0)	0.31 cd	0.28 d	0.28 d	0.29 c	0.29 d	0.27 d	0.27 d	0.27 c
(45)	0.27 d	0.36 bc	0.38 ab	0.34 b	0.25 d	0.35 c	0.36 bc	0.32 b
(90)	0.27 d	0.43 a	0.41 ab	0.37 a	0.26 d	0.41 a	0.40 ab	0.36 a
Means	0.028 b	0.36 a	0.36 a		0.27 b	0.34 a	0.35 a	
$LSD_{0.05}$	P Doses (0.02), K doses (0.02) Interaction (0.05)				P Doses (0.02), K doses (0.02) Interaction (0.05)			

Net photosynthesis rate (μ mol m^{-2} sec^{-1})

The cumulative effect of various fertilizers combination had significant ($p \leq 0.05$) effect on net photosynthesis rate (Pn) in 2013-14 and 2014-15 (Table 8 and 9). In first cropping season, highest value (13.3) of Pn was observed with the highest dose of nitrogen (120 kg) and phosphorus (90 kg ha^{-1}). Similarly, 13.0 Pn was noted in plots which received 120 kg N and 60 kg K ha^{-1}, while 10.3 Pn was recorded @ 90:60 kg PK ha^{-1}. Minimum Pn was in check plots. Similar pattern of exhibiting net photosynthesis rate was noted in 2014-15.

Table 7. Relationship between net assimilation rate (mg m^{-2} day^{-1}) and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Treatments		2013-2014			2014-2015		
		0 kg K ha^{-1}	30 kg K ha^{-1}	60 kg K ha^{-1}	0 kg K ha^{-1}	30 kg K ha^{-1}	60 kg K ha^{-1}
0 kg N ha^{-1}	0 kg P ha^{-1}	0.32 de	0.30 d-g	0.24 efg	0.29 def	0.29 def	0.23 f
	45 kg P ha^{-1}	0.24 efg	0.23 efg	0.24 efg	0.23 f	0.23 f	0.22 f
	90 kg P ha^{-1}	0.19 g	0.20 fg	0.21 fg	0.19 f	0.19 f	0.20 f
60 kg N ha^{-1}	0 kg P ha^{-1}	0.32 de	0.27 d-g	0.23 efg	0.29 def	0.26 def	0.23 f
	45 kg P ha^{-1}	0.27 d-g	0.25 efg	0.22 efg	0.26 def	0.24 f	0.21 f
	90 kg P ha^{-1}	0.25 d-g	0.26 d-g	0.28 d-g	0.24 f	0.26 def	0.28 def
120 kg N ha^{-1}	0 kg P ha^{-1}	0.31 def	0.27 d-g	0.36 d	0.29 def	0.25 ef	0.34 de
	45 kg P ha^{-1}	0.28 d-g	0.62 c	0.69 bc	0.27 def	0.59 c	0.66 bc
	90 kg P ha^{-1}	0.36 d	0.82 a	0.75 ab	0.35 d	0.79 a	0.75 ab
$LSD_{0.05}$		0.11			0.10		

Table 8. Relationship between net photosynthesis rate (63 days after sowing) and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Nitrogen × Phosphorus								
N doses (kg ha^{-1})	2013-2014				2014-15			
	P doses (kg ha^{-1})			Means	P doses (kg ha^{-1})			
	(0)	(45)	(90)		(0)	(45)	(90)	Means
(0)	3.3 i	3.8 h	4.4 g	3.9 c	3.3 i	3.7 h	4.5 g	3.8 c
(60)	4.6 f	5.6 e	6.8 d	5.6 b	4.7 f	5.5 e	6.9 d	5.7 b
(120)	8.2 c	10.0 b	13.3 a	10.4a	8.3 c	9.9 b	13.3 a	10.5 a
Means	5.4 c	6.4 b	8.2 a		5.4 c	6.4 b	8.2 a	
$LSD_{0.05}$	N Doses (0.01), P doses (0.01) Interaction (0.02)				N Doses (0.01), P doses (0.01) Interaction (0.02)			
Nitrogen × Potassium								
N doses (kg ha^{-1})	2013-2014				2014-15			
	K doses (kg ha^{-1})			Means	K doses (kg ha^{-1})			
	(0)	(30)	(60)		(0)	(30)	(60)	Means
(0)	3.2 h	3.9 g	4.6 f	3.9 c	3.1 i	3.8 h	4.5 g	3.8 c
(60)	4.6 f	5.6 e	6.8 d	5.6 b	4.6 f	5.6 e	6.9 d	5.7 b
(120)	7.5 c	10.8 b	13.0 a	10.4a	7.5 c	10.8 b	13.2 a	10.5 a
Means	5.1 c	6.8 b	8.1 a		5.1 c	6.8 b	8.2 a	
$LSD_{0.05}$	N Doses (0.01), K doses (0.01) Interaction (0.02)				N Doses (0.01), K doses (0.01) Interaction (0.02)			
Phosphorus × Potassium								
P doses (kg ha^{-1})	2013-2014				2014-15			
	K doses (kg ha^{-1})			Means	K doses (kg ha^{-1})			
	(0)	(30)	(60)		(0)	(30)	(60)	Means
(0)	4.4 h	5.3 f	6.3 d	5.4 c	4.4 i	5.3 g	6.5 d	5.4 c
(45)	5.1 g	6.4 d	7.8 c	6.4 b	5.1 h	6.4 e	7.7 c	6.4 b
(90)	5.7 e	8.5 b	10.3 a	8.2 a	5.6 f	8.5 b	10.4 a	8.2 a
Means	5.1 c	6.8 b	8.1 a		5.1 c	6.8 b	8.2 a	
$LSD_{0.05}$	P Doses (0.01), K doses (0.01) Interaction (0.02)				P Doses (0.01), K doses (0.01) Interaction (0.02)			

The interaction elucidated maximum Pn (17.2) at 63 days after sowing-DAS with N @ 120 kg, P @ 90 kg and K @ 60 kg ha^{-1} during 2013-14 cropping season. Minimum Pn of 2.8 was obtained in untreated control. At 126 DAS, all the fertilizer combinations significantly affected photosynthesis rate in both the cropping seasons (Table 10 and 11). In 2013-14, maximum Pn of 3.5 was noted as a result of nutrients application @ 120 kg nitrogen and 90 kg ha^{-1} phosphorus while PK doses produced 3.2 Pn at 90:60 kg ha^{-1}. The value of Pn was lowest in control. The trend of recording Pn remained the same in subsequent cropping season. The data further indicated that maximum Pn (5.6) was recorded at 126 DAS with the same fertilizer level as noted at 63 DAS during both the cropping seasons.

Table 9. Relationship between net photosynthesis rate (63 days after sowing) and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Treatments		2013-2014			2014-2015		
		0 kg K ha^{-1}	30 kg K ha^{-1}	60 kg K ha^{-1}	0 kg K ha^{-1}	30 kg K ha^{-1}	60 kg K ha^{-1}
0 kg N ha^{-1}	0 kg P ha^{-1}	2.8 t	3.3 r	3.8 p	2.7 s	3.1 r	4.0 o
	45 kg P ha^{-1}	3.2 s	3.8 p	4.6 mn	3.2 r	3.8 p	4.2 n
	90 kg P ha^{-1}	3.6 q	4.4 no	5.7 l	3.6 q	4.5 m	5.3 l
60 kg N ha^{-1}	0 kg P ha^{-1}	3.7 p	4.3 o	5.6 k	3.7 p	4.5 m	5.8 j
	45 kg P ha^{-1}	4.6 m	5.6 k	6.4 j	4.6 m	5.6 k	6.4 i
	90 kg P ha^{-1}	5.3 l	6.7 i	8.3 f	5.3 l	6.7 h	8.6 e
120 kg N ha^{-1}	0 kg P ha^{-1}	6.7 i	8.3 fg	9.5 e	6.8 h	8.3 f	9.8 d
	45 kg P ha^{-1}	7.5 h	9.7 d	12.3 c	7.5 g	9.7 d	12.4 c
	90 kg P ha^{-1}	8.2 g	14.5 b	17.2 a	8.2 f	14.4 b	17.4 a
$LSD_{0.05}$		0.03			0.04		

Table 10. Relationship between net photosynthesis rate (126 days after sowing) and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Nitrogen × Phosphorus								
N doses (kg ha^{-1})	2013-2014				2014-15			
	P doses (kg ha^{-1})			Means	P doses (kg ha^{-1})			Means
	(0)	(45)	(90)		(0)	(45)	(90)	
(0)	0.04 g	0.6 f	1.1 e	0.7 c	0.4 g	0.7 f	1.2 e	0.7 c
(60)	0.7 f	1.3 d	1.8 c	1.3 b	0.7 f	1.4 d	1.8 c	1.3 b
(120)	1.3 d	2.2 b	3.5 a	2.3 a	1.3 d	2.2 b	3.5 a	2.3 a
Means	0.8 c	1.4 b	2.1 a		0.8 c	1.4 b	2.1 a	
$LSD_{0.05}$	N Doses (0.00), P doses (0.00) Interaction (0.02)				N Doses (0.01), P doses (0.01) Interaction(0.02)			
Nitrogen × Potassium								
N doses (kg ha^{-1})	2013-2014				2014-15			
	K doses (kg ha^{-1})			Means	K doses (kg ha^{-1})			Means
	(0)	(30)	(60)		(0)	(30)	(60)	
(0)	0.3 i	0.8 g	1.1 e	0.7 c	0.3 i	0.8 g	1.1 e	0.7 c
(60)	0.5 h	1.4 d	1.8 c	1.3 b	0.5 h	1.4 d	1.9 c	1.3 b
(120)	0.9 f	2.5 b	3.6 a	2.3 a	0.9 f	2.6 b	3.5 a	2.3 a
Means	0.6 c	1.6 b	2.2 a		0.6 c	1.6 b	2.2 a	
$LSD_{0.05}$	N Doses (0.00), K doses (0.00) Interaction (0.02)				N Doses (0.01), K doses (0.01) Interaction(0.02)			
Phosphorus × Potassium								
P doses (kg ha^{-1})	2013-2014				2014-15			
	K doses (kg ha^{-1})			Means	K doses (kg ha^{-1})			Means
	(0)	(30)	(60)		(0)	(30)	(60)	
(0)	0.3 h	0.8 f	1.3 e	0.8 c	0.3 h	0.8 f	1.3 e	0.8 c
(45)	0.6 g	1.6 d	2.0 c	1.4 b	0.6 g	1.6 d	2.1 c	1.4 b
(90)	0.8 f	2.3 b	3.2 a	2.1 a	0.9 f	2.3 b	3.2 a	2.1 a
Means	0.6 c	1.6 b	2.2 a		0.6 c	1.6 b	2.2 a	
$LSD_{0.05}$	P Doses (0.00), K doses (0.00) Interaction (0.02)				P Doses (0.01), K doses (0.01) Interaction(0.02)			

However, minimum Pn of 0.1 was obtained in control. Similar response of net photosynthesis rate was noted in the confirmation study on subsequent year.

Higher fertilizer doses of NPK accelerated the early growth stages of plant and hence Pn of the crop (Hossain *etal*. (2010).

Number of tillers (m^{-2})

The interactive effect of NP, NK and PK was significant ($p \leq 0.05$) on tillers production, whereas the cumulative response of N, P and K was non-significant (Table 12 and 13). During the first cropping season, maximum (269) tillers were noted with 120:90 kg NP ha^{-1}, 255 tillers were produced in

NK doses @ 120:60 kg ha^{-1}, while PK fertilizer produced 234 tillers at higher level of its application (90:60 kg PK ha^{-1}) than the minimum recorded in check plots. In 2014-15, same trend of tillers production was noted as in case of first year experimentation.

Table 11. Relationship between net photosynthesis rate (126 days after sowing) and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Treatments		2013-2014			2014-2015		
		0 kg K ha^{-1}	30 kg K ha^{-1}	60 kg K ha^{-1}	0 kg K ha^{-1}	30 kg K ha^{-1}	60 kg K ha^{-1}
0 kg N ha^{-1}	0 kg P ha^{-1}	0.1 r	0.4 p	0.7 n	0.1 n	0.4 m	0.6 lm
	45 kg P ha^{-1}	0.3 q	0.6 no	1.0 lm	0.2 n	0.7 l	1.1 jk
	90 kg P ha^{-1}	0.5 op	1.2 jk	1.6 h	0.6 l	1.2 ij	1.6 g
60 kg N ha^{-1}	0 kg P ha^{-1}	0.2 qr	0.6 no	1.1 kl	0.2 n	0.7 l	1.1 jk
	45 kg P ha^{-1}	0.6 no	1.4 i	1.9 g	0.6 l	1.4 h	2.0 f
	90 kg P ha^{-1}	0.7 n	2.1 f	2.4 e	0.7 l	2.1 f	2.4 e
120 kg N ha^{-1}	0 kg P ha^{-1}	0.5 op	1.3 ij	2.1 f	0.6 lm	1.4 hi	2.1 f
	45 kg P ha^{-1}	0.9 m	2.6 d	3.1 c	1.0 k	2.7 d	3.1 c
	90 kg P ha^{-1}	1.2 jk	3.6 b	5.6 a	1.3 hij	3.6 b	5.5 a
$LSD_{0.05}$		0.03			0.04		

Table 12. Relationship between number of tillers (m^{-2}) and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Nitrogen × Phosphorus								
N doses (kg ha^{-1})	2013-2014				2014-15			
	P doses (kg ha^{-1})			Means	P doses (kg ha^{-1})			Means
	(0)	(45)	(90)		(0)	(45)	(90)	
(0)	140 h	148 g	161 f	150 c	139 h	148 g	161 f	149 c
(60)	172 e	186 d	198 c	185 b	173 e	187 d	201 c	187 b
(120)	200 c	228 b	269 a	232 a	202 c	230 b	269 a	234 a
Means	171 c	187 b	209 a		171 c	188 b	210 a	
$LSD_{0.05}$	N Doses (2.22), P doses (2.22) Interaction (5.17)				N Doses (2.43), P doses (2.43) Interaction (5.65)			
Nitrogen × Potassium								
N doses (kg ha^{-1})	2013-2014				2014-15			
	K doses (kg ha^{-1})			Means	K doses (kg ha^{-1})			Means
	(0)	(30)	(60)		(0)	(30)	(60)	
(0)	140 h	150 g	160 f	150 c	139 h	149 g	159 f	149 c
(60)	166 e	185 d	205 c	185 b	167 e	186 d	208 c	187 b
(120)	208 c	233 b	255 a	232 a	211 c	234 b	257 a	234 a
Means	171 c	189 b	207 a		172 c	190 b	208 a	
$LSD_{0.05}$	N Doses (2.22), K doses (2.22) Interaction (5.17)				N Doses (2.43), K doses (2.43) Interaction (5.65)			
Phosphorus × Potassium								
P doses (kg ha^{-1})	2013-2014				2014-15			
	K doses (kg ha^{-1})			Means	K doses (kg ha^{-1})			Means
	(0)	(30)	(60)		(0)	(30)	(60)	
(0)	161 g	169 f	182 f	171 c	162 g	169 f	183 e	171 c
(45)	169 f	189 d	204 c	187 b	170 f	189 d	205 c	188 b
(90)	184 de	210 c	234 a	209 a	185 de	211 b	235 a	210 a
Means	171 c	189 b	207 a		172 c	190 b	208 a	
$LSD_{0.05}$	P Doses (2.22), K doses (2.22) Interaction (5.17)				P Doses (2.43), K doses (2.43) Interaction (5.65)			

Such an elevated number of tillers with highest doses of all three macronutrient (NPK) might be attributed to sufficient availability of solutes to crop plants, which enhanced the root as well as vegetative growth and as a result increased the tillers production. Hussain *et al.* (2006) also recorded maximum tillers at higher NPK applied doses.

Table 13. Relationship between number of tillers (m^{-2}) and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Treatments		2013-2014			2014-2015		
		0 kg K ha^{-1}	30 kg K ha^{-1}	60 kg K ha^{-1}	0 kg K ha^{-1}	30 kg K ha^{-1}	60 kg K ha^{-1}
0 kg N ha^{-1}	0 kg P ha^{-1}	136 NS	139	145	135	138	145
	45 kg P ha^{-1}	138	149	157	138	149	157
	90 kg P ha^{-1}	147	161	176	145	161	176
60 kg N ha^{-1}	0 kg P ha^{-1}	161	171	184	162	171	185
	45 kg P ha^{-1}	165	186	207	166	187	208
	90 kg P ha^{-1}	171	197	226	172	200	231
120 kg N ha^{-1}	0 kg P ha^{-1}	186	196	218	189	197	221
	45 kg P ha^{-1}	203	232	249	207	232	251
	90 kg P ha^{-1}	236	272	299	237	273	298
$LSD_{0.05}$		-----			-----		

NS= Non-significant

Table 14. Relationship between spike length (cm) and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Nitrogen × Phosphorus								
N doses ($kg\ ha^{-1}$)	2013-2014				2014-15			
	P doses ($kg\ ha^{-1}$)			Means	P doses ($kg\ ha^{-1}$)			Means
	(0)	(45)	(90)		(0)	(45)	(90)	
(0)	4.8 g	5.4 f	5.8 e	5.4 c	4.8 h	5.5 g	5.8 f	5.4 c
(60)	5.5 f	6.1 e	6.7 c	6.1 b	5.5 g	6.1 e	6.7 c	6.1 b
(120)	6.4 d	7.0 b	8.0 a	7.3 a	6.4 d	7.1 b	8.5 a	7.3 a
Means	5.6 c	6.2 b	7.0 a		5.6 c	6.2 b	7.0 a	
$LSD_{0.05}$	N Doses (0.10), P doses (0.10) Interaction (0.234)				N Doses (1.10), P doses (1.10) Interaction (0.24)			
Nitrogen × Potassium								
N doses ($kg\ ha^{-1}$)	2013-2014				2014-15			
	K doses ($kg\ ha^{-1}$)			Means	K doses ($kg\ ha^{-1}$)			Means
	(0)	(30)	(60)		(0)	(30)	(60)	
(0)	5.1 g	5.4 f	5.6 e	5.4 c	5.1 g	5.4 f	5.7 e	5.4 c
(60)	5.6 ef	6.1 d	6.6 c	6.1 b	5.6 ef	6.2 d	6.6 c	6.1 b
(120)	6.4 c	7.4 b	7.7 a	7.3 a	6.7 c	7.5 b	7.8 a	7.3 a
Means	5.8 c	6.3 b	6.6 a		5.8 c	6.3 b	6.7 a	
$LSD_{0.05}$	N Doses (0.10), K doses (0.10) Interaction (0.234)				N Doses (1.10), K doses (1.10) Interaction (0.24)			
Phosphorus × Potassium								
P doses ($kg\ ha^{-1}$)	2013-2014				2014-15			
	K doses ($kg\ ha^{-1}$)			Means	K doses ($kg\ ha^{-1}$)			Means
	(0)	(30)	(60)		(0)	(30)	(60)	
(0)	5.2 g	5.6 f	5.9 e	5.6 c	5.2 g	5.6 f	5.9 e	5.6 c
(45)	5.8 ef	6.2 d	6.5 c	6.2 b	5.8 ef	6.2 d	6.6 c	6.2 b
(90)	6.3 d	7.1 b	7.7 a	7.0 a	6.4 d	7.1 b	7.5 a	7.0 a
Means	5.8 c	6.3 b	6.6 a		5.8 c	6.3 b	6.7 a	
$LSD_{0.05}$	P Doses (0.10), K doses (0.10) Interaction (0.234)				P Doses (1.10), K doses (1.10) Interaction (0.24)			

Spike length (cm)

Longer and healthier spikes produce more grains and yield. All the studied variables had significant ($p \leq 0.05$) effect on wheat spikes when used in NP, NK, and PK combinations, while it was non-significant as far as the interaction of N, P and K is concerned (Table 14 and 15). During the first cropping season, longer spikes (8.0 cm) were observed with NP fertilizer @ 120:90 kg ha^{-1}. Similarly, the NK applied doses produced 7.7 cm spike length @ 120:60 kg ha^{-1}, while PK fertilizer applied doses (90:60 kg ha^{-1}) had 7.7 cm spike length of wheat. Untreated control plots produced shorter spike length. A similar trend of longer spikes with higher doses of NP, NK and PK was noted in 2014-15 cropping season. The use of higher NPK doses prolonged and ensured maximum availability of NPK to crop, which increased the spike length accordingly.

Table 15. Relationship between spike length (cm) and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Treatments		2013-2014			2014-2015		
		0 kg K ha^{-1}	30 kg K ha^{-1}	60 kg K ha^{-1}	0 kg K ha^{-1}	30 kg K ha^{-1}	60 kg K ha^{-1}
0 kg N ha^{-1}	0 kg P ha^{-1}	4.7 NS	4.8	4.9	4.7	4.8	5.0
	45 kg P ha^{-1}	5.2	5.4	5.6	5.2	5.5	5.7
	90 kg P ha^{-1}	5.3	5.9	6.3	5.3	5.9	6.3
60 kg N ha^{-1}	0 kg P ha^{-1}	5.10	5.5	5.8	5.1	5.6	5.9
	45 kg P ha^{-1}	5.6	6.0	5.6	5.6	6.1	6.7
	90 kg P ha^{-1}	6.0	6.8	7.4	6.1	6.8	7.3
120 kg N ha^{-1}	0 kg P ha^{-1}	5.9	6.4	6.8	5.9	6.5	6.9
	45 kg P ha^{-1}	6.5	7.0	7.4	6.6	7.2	7.5
	90 kg P ha^{-1}	7.5	8.7	8.9	7.6	8.7	9.0
$LSD_{0.05}$			-----			-----	
NS= Non-significant							

Table 16. Relationship between number of grains (spike^{-1}) and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Nitrogen × Phosphorus								
N doses (kg ha^{-1})	2013-2014				2014-15			
	P doses (kg ha^{-1})			Means	P doses (kg ha^{-1})			Means
	(0)	(45)	(90)		(0)	(45)	(90)	
(0)	25 g	28 f	32 e	28 c	24 f	29 e	33 d	29 c
(60)	28 f	35 d	40 b	34 b	28 e	36 c	41 b	35 b
(120)	33 e	36 c	46 a	38 a	33 d	38 c	47 a	39 a
Means	28 c	33 b	39 a		29 c	34 b	40 a	
$LSD_{0.05}$	N Doses (0.65), P doses (0.65) Interaction (1.50)				N Doses (0.78), P doses (0.78) Interaction (1.80)			
Nitrogen × Potassium								
N doses (kg ha^{-1})	2013-2014				2014-15			
	K doses (kg ha^{-1})			Means	K doses (kg ha^{-1})			Means
	(0)	(30)	(60)		(0)	(30)	(60)	
(0)	25 g	29 f	31 f	28 c	25 g	29 f	32 e	29 c
(60)	32 e	34 d	37 c	34 b	33 e	35 d	37 c	35 b
(120)	34 d	38 b	43 a	38 a	35 d	39 b	44 a	39 a
Means	30 c	34 b	37 a		31 c	35 b	38 a	
$LSD_{0.05}$	N Doses (0.65), K doses (0.65) Interaction (1.50)				N Doses (0.78), K doses (0.78) Interaction (1.80)			
Phosphorus × Potassium								
P doses (kg ha^{-1})	2013-2014				2014-15			
	K doses (kg ha^{-1})			Means	K doses (kg ha^{-1})			Means
	(0)	(30)	(60)		(0)	(30)	(60)	
(0)	26 g	28 f	31 e	28 c	27 g	29 f	31 e	29 c
(45)	30 e	34 d	36 c	33 b	31 e	35 d	37 c	34 b
(90)	35 c	39 b	44 a	39 a	36 cd	40 b	45 a	40 a
Means	30 c	34 b	37 a		31 c	35 b	38 a	
$LSD_{0.05}$	P Doses (0.65), K doses (0.65) Interaction (1.50)				P Doses (0.78), K doses (0.78) Interaction (1.80)			

Number of grains (spike^{-1})

As far as the response of wheat for production of grains per spike is concerned, the use of highest nitrogen and phosphorus doses i.e. 120:90 kg ha^{-1} produced significantly highest number of 46 grains per spike in 2013-14 cropping season (Table 16 and 17). Similarly, N&K applied doses produced 43 number of grains @ 120:60 kg ha^{-1}, while PK applied doses produced 44 number of grains at higher level of its application (90:60 kg PK ha^{-1}). Minimum (25) grains were noted in untreated plots. The trend of producing grains per spike was almost the same during next cropping season. The mean values also showed the maximum 43 grains spike^{-1} in 2013-14 at highest NPK levels. However, minimum 23 grains were recorded in control. Similarly, the trend of producing number of grains remained the same in 2014-15.

Table 17. Relationship between number of grains (spike^{-1}) and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Treatments		2013-2014			2014-2015		
		0 kg K ha^{-1}	30 kg K ha^{-1}	60 kg K ha^{-1}	0 kg Kha^{-1}	30 kg K ha^{-1}	60 kg K ha^{-1}
0 kg N ha^{-1}	0 kg P ha^{-1}	23 p	24 op	26 no	23 r	24 qr	26 pqr
	45 kg P ha^{-1}	25 op	29 lmn	32 jkl	25 qr	30 m-p	32 j-m
	90 kg P ha^{-1}	27 mno	33 g-k	36 fg	28 n-q	34 g-l	37 fgh
60 kg N ha^{-1}	0 kg P ha^{-1}	26 nop	27 mno	30 jkl	27 opq	27 n-q	31 k-n
	45 kg P ha^{-1}	32 h-k	35 fgh	37 ef	34 h-l	36 f-i	38 efg
	90 kg P ha^{-1}	38 def	40 cde	43 bc	39 def	41 cde	44 bc
120 kg N ha^{-1}	0 kg P ha^{-1}	30 klm	33 g-j	35 f-i	30 l-o	34 g-k	35 f-j
	45 kg P ha^{-1}	32 ijk	37 ef	41 cd	33 i-m	38 efg	42 cd
	90 kg P ha^{-1}	40 cd	45 b	43 a	41 cde	46 b	54 a
$LSD_{0.05}$		3.13				3.76	

Table 18. Relationship between grain weight (g) and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Nitrogen × Phosphorus								
N doses (kg ha^{-1})	2013-2014				2014-15			
	P doses (kg ha^{-1})			Means	P doses (kg ha^{-1})			
	(0)	(45)	(90)		(0)	(45)	(90)	Means
(0)	23.3 g	24.4 f	24.6 ef	24.1 c	23.3 g	24.4 f	24.7 ef	24.1 c
(60)	25.3 e	26.8 d	29.8 c	27.3 b	25.4 e	26.9 d	29.8 c	27.3 b
(120)	29.1 c	32.9 c	37.6 a	33.2 a	29.1 c	33.0 b	37.9 a	33.4 a
Means	26.0 c	28.0 b	30.6 a		26.0 c	28.1 b	30.8 a	
$LSD_{0.05}$	N Doses (0.33), P doses (0.33) Interaction (0.76)				N Doses (0.33), P doses (0.33) Interaction (0.77)			
Nitrogen × Potassium								
N doses (kg ha^{-1})	2013-2014				2014-15			
	K doses (kg ha^{-1})			Means	K doses (kg ha^{-1})			
	(0)	(30)	(60)		(0)	(30)	(60)	Means
(0)	23.0 g	24.2 f	25.1 e	24.1 c	23.0 g	24.2 f	25.2 e	24.1 c
(60)	25.5 e	26.9 d	29.5 c	27.3 b	25.6 e	26.9 d	29.5 c	27.3 b
(120)	29.9 c	33.5 b	36.3 a	33.2 a	30.0 c	33.6 b	36.5 a	33.4 a
Means	26.0 c	28.0 b	30.6 a		26.2 c	28.2 b	30.4 a	
$LSD_{0.05}$	N Doses (0.33), K doses (0.33) Interaction (0.76)				N Doses (0.33), K doses (0.33) Interaction (0.77)			
Phosphorus × Potassium								
P doses (kg ha^{-1})	2013-2014				2014-15			
	K doses (kg ha^{-1})			Means	K doses (kg ha^{-1})			
	(0)	(30)	(60)		(0)	(30)	(60)	Means
(0)	25.0 f	26.0 e	26.6 de	26.0 c	25.1 f	26.1 e	26.7 de	26.0 c
(45)	26.0 e	28.0 c	30.1 b	28.0 b	26.1 e	28.1 c	30.2 b	28.1 b
(90)	27.3 cd	30.5 b	34.1 a	30.6 a	27.4 cd	30.6 b	34.3 a	30.8 a
Means	26.0 c	28.0 b	30.6 a		26.2 c	28.2 b	30.4 a	
$LSD_{0.05}$	P Doses (0.33), K doses (0.33) Interaction (0.76)				P Doses (0.33), K doses (0.33) Interaction (0.77)			

The application of balanced nutrition through higher levels of NPK for crop growth and development eventually increased the photosynthesis rate and number of grains per spike. Maqssod *et al.* (1999) also noted increased number of grains with higher doses of NPK application. Khan *et al.* (2010) also noted increased number of grains at higher level of phosphorus.

1000-grain weight (g)

As shown in Table 18 and 19, significantly heavier grains (37.6 g) were noted with 120:90 kg NP ha^{-1} in first cropping season. The NK applied doses produced grain weight of 36.3 g with 120:60 kg ha^{-1}, while PK fertilizer doses produced 34.1 g grain weight at higher level of its application (90:60 kg PK ha^{-1}). Minimum 23 g weight of 1000-grains was noted in check plots where no fertilizer was applied. Similarly, the data trend was the same in 2014-15 year of experimentation. The interaction effect showed highest value of grain weight (42.1 g) during first cropping season at 120:90:60 kg NPK ha^{-1} than the

lowest (22.8 g) in untreated control. Similar results were obtained during next cropping season. The maximum value of grain weight at elevated NPK levels was due to ample supply of nutrients during crop growing period, which enhanced the root as well as vegetative growth of crop as a result more assimilates accumulation in the grains (Mumtaz *et al.*, 2014).

Table 19. Relationship between grain weight (g) and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Treatments		2013-2014			2014-2015		
		0 kg K ha^{-1}	30 kg K ha^{-1}	60 kg K ha^{-1}	0 kg K ha^{-1}	30 kg K ha^{-1}	60 kg K ha^{-1}
0 kg N ha^{-1}	0 kg P ha^{-1}	22.8 m	23.2 lm	23.8 lm	22.8 m	23.3 lm	23.9 lm
	45 kg P ha^{-1}	22.8 m	24.7 kl	25.6 jk	22.9 m	24.7 kl	25.7 jk
	90 kg P ha^{-1}	23.3 lm	24.5 kl	26.0 jk	23.4 lm	24.6 kl	26.0 jk
60 kg N ha^{-1}	0 kg P ha^{-1}	24.5 kl	25.5 jk	25.9 jk	24.6 kl	25.5 jk	26.0 jk
	45 kg P ha^{-1}	25.5 jk	26.6 ij	28.2 gh	25.6 jk	26.7 ij	28.3 gh
	90 kg P ha^{-1}	26.4 ij	28.5 gh	34.3 d	26.5 ij	28.6 gh	34.3 d
120 kg N ha^{-1}	0 kg P ha^{-1}	27.7 hi	29.3 fgh	30.3 f	27.9 hi	29.4 fgh	30.3 f
	45 kg P ha^{-1}	29.6 fg	32.8 de	36.4 c	29.7 fg	32.9 de	36.5 c
	90 kg P ha^{-1}	32.2 e	38.4 b	42.1 a	32.4 e	38.5 b	42.7 a
$LSD_{0.05}$		1.58			1.61		

Table 20. Relationship between economic yield (kg ha^{-1}) and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Nitrogen × Phosphorus								
N doses (kg ha^{-1})	2013-2014				2014-15			
	P doses (kg ha^{-1})			Means	P doses (kg ha^{-1})			
	(0)	(45)	(90)		(0)	(45)	(90)	Means
(0)	1096 f	1226 ef	1338 cde	1220 c	1097 d	1233 cd	1349 cd	1226 c
(60)	1272 def	1451 cd	1544 c	1423 b	1484 c	1462 c	1552 c	1499 b
(120)	1464 cd	2080 b	3970 a	2505 a	1474 c	2093 b	4024 a	2530 a
Means	1277 c	1586 b	2285 a		1352 c	1596 b	2309 a	
$LSD_{0.05}$	N Doses (89.35), P doses (89.35), Interaction (207.48)				N Doses (149.7), P doses (149.7), Interaction (347.75)			
Nitrogen × Potassium								
N doses (kg ha^{-1})	2013-2014				2014-15			
	K doses (kg ha^{-1})			Means	K doses (kg ha^{-1})			
	(0)	(30)	(60)		(0)	(30)	(60)	Means
(0)	1064 f	1210 ef	1387 e	1220 c	1066 d	1217 d	1395 cd	1226 c
(60)	1253 ef	1403 e	1611 d	1423 b	1259 d	1614 c	1625 c	1499 b
(120)	2106 c	2387 b	3020 a	2505 a	2116 b	2430 b	3045 a	2530 a
Means	1474 c	1667 b	2006 a		1480 c	1754 b	2022 a	
$LSD_{0.05}$	N Doses (89.35), K doses (89.35), Interaction (207.48)				N Doses (149.7), K doses (149.7), Interaction (347.75)			
Phosphorus × Potassium								
P doses (kg ha^{-1})	2013-2014				2014-15			
	K doses (kg ha^{-1})			Means	K doses (kg ha^{-1})			
	(0)	(30)	(60)		(0)	(30)	(60)	Means
(0)	1136 f	1263 ef	1434 de	1277 c	1138 d	1472 cd	1445 cd	1352 c
(45)	1338 def	1488 d	1931 c	1586 b	1347 cd	1499 c	1942 b	1596 b
(90)	1950 c	2249 b	2653 a	2284 a	1957 b	2289 b	2680 a	2309 a
Means	1474 c	1667 b	2006 a		1480 c	1754 b	2022 a	
$LSD_{0.05}$	P Doses (89.35), K doses (89.35), Interaction (207.48)				P Doses (149.7), K doses (149.7), Interaction (347.75)			

Economic yield (kg ha^{-1})

As per data shown in Table 20 and 21, the highest economic yield of 3970 kg ha^{-1} was recorded using 120 kg nitrogen and 90 kg ha^{-1} phosphorus during 2013-14. Similarly, 3020 kg ha^{-1} wheat yield was noted with 120 kg N and 60 kg K ha^{-1}, while PK applied doses produced 2653 kg ha^{-1} @ 90:60 kg PK ha^{-1}.

Table 21. Relationship between economic yield (kg ha^{-1}) and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Treatments		2013-2014			2014-2015		
		0 kg K ha^{-1}	30 kg K ha^{-1}	60 kg K ha^{-1}	0 kg K ha^{-1}	30 kg K ha^{-1}	60 kg K ha^{-1}
0 kg N ha^{-1}	0 kg P ha^{-1}	950 l	1070 kl	1267 g-l	940 g	1075 fg	1275 d-g
	45 kg P ha^{-1}	1081 kl	1222 h-l	1377 f-l	1089 fg	1227 d-g	1383 d-g
	90 kg P ha^{-1}	1160 i-l	1337 f-l	1517 e-j	1170 efg	1349 d-g	1528 d-g
60 kg N ha^{-1}	0 kg P ha^{-1}	1107 jkl	1280 g-l	1431 e-k	1111 fg	1898 d	1443 d-g
	45 kg P ha^{-1}	1317 f-l	1380 -l	1657 efg	1326 d-g	1388 d-g	1672 def
	90 kg P ha^{-1}	1337 f-l	1550 e-i	1747 ef	1340 d-g	1555 d-g	1761 def
120 kg N ha^{-1}	0 kg P ha^{-1}	1350 f-l	1439 e-k	1603 e-h	1363 d-g	1444 d-g	1616 d-g
	45 kg P ha^{-1}	1615 e-h	1863 e	2760 d	1625 d-g	1883 de	2770 c
	90 kg P ha^{-1}	3353 c	3860 b	4697 a	3360 bc	3963 b	4750 a
$LSD_{0.05}$		433.18			726.03		

The economic yield (1064 kg ha^{-1}) was lowest in control. The pattern of producing grain yield remained the same at NP, NK and PK applied doses in 2014-15. Maximum economic yield of 4697 kg ha^{-1} was produced @ 120 kg, 90 kg and 60 kg NPK ha^{-1} during 2013-14, while lowest value (950 kg ha^{-1}) in control. The result remained the same in next year study. The maximum economic yield at higher NPK applied doses appeared to be consistent supply of nutrients, which accelerated crop growth and photosynthesis rate and translocated more assimilates towards higher wheat yield. Malghani *et al.* (2010) obtained higher economic yield with higher NPK levels.

Table 22. Relationship between economic analysis and NPK fertilizer doses in dry land wheat production in 2013-14 and 2014-15.

Treatments (kg ha^{-1})		Net return (Rs)		Value cost ratio (Rs)		Relative increase in income (Rs)	
		2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
N1P1K1	0:0:0 NPK	0	0	0	0	0	0
N1P1K2	0:0:30 NPK	-1200	-1125	0.76	0.78	92.60	0.96
N1P1K3	0:0:60 NPK	64	-365	1.01	0.96	117.38	121.10
N1P2K1	0:45:0 NPK	-3341	-3212	0.56	0.57	68.74	56.66
N1P2K2	0:45:30 NPK	-3869	-4250	0.69	0.66	70.11	57.43
N1P2K3	0:45:60 NPK^{-1}	-3949	-4766	0.78	0.73	77.34	51.05
N1P3K1	0:90:0 NPK	-8345	-8395	0.45	0.44	15.76	-31.65
N1P3K2	0:90:30 NPK	-7721	-8244	0.62	0.59	32.17	-14.18
N1P3K3	0:90:60 NPK	-7001	-8093	0.72	0.68	49.85	3.32
N2P1K1	60:0:0 NPK	195	130	1.04	1.03	110.47	116.45
N2P1K2	60:0:30 NPK	691	17913	1.07	2.82	125.22	500.50
N2P1K3	60:0:60 NPK	483	-322	1.03	0.98	130.78	135.74
N2P2K1	60:45:0 NPK	95	-455	1.01	0.96	120.36	123.70
N2P2K2	60:45:30 NPK	-2929	-3697	0.82	0.78	89.14	70.64
N2P2K3	60:45:60 NPK	895	-501	1.04	0.98	147.35	151.43
N2P3K1	60:90:0 NPK	-6085	-6869	0.67	0.63	50.85	9.76
N2P3K2	60:90:30 NPK	-4309	-5674	0.82	0.76	87.32	48.95
N2P3K3	60:90:60 NPK	-3045	-4740	0.89	0.83	107.09	82.72
N1P1K1	120:0:0 NPK	3142	2609	1.33	1.27	156.88	181.73
N3P1K2	120:0:30 NPK	950	-82	1.06	0.99	136.52	140.12
N3P1K3	120:0:60 NPK	1158	-134	1.06	0.99	147.52	153.40
N3P2K1	120:45:0 NPK	5515	4100	1.35	1.26	197.89	230.11
N3P2K2	120:45:30 NPK	8411	6542	1.40	1.31	243.98	295.23
N3P2K3	120:45:60 NPK	32075	27225	2.24	2.05	561.25	739.57
N3P3K1	120:90:0 NPK	55023	48307	3.52	3.21	854.39	1166.55
N3P3K2	120:90:30 NPK	66207	60754	3.46	3.26	1008.70	1439.67
N3P3K3	120:90:60 NPK	87951	78534	3.75	3.46	1300.90	1823.72

Economic analysis

The economic analysis (Table 22) illustrated that during the year 2013-14 maximum net return (Rs.87951) was obtained with NPK application @ 120:90:60 kg ha^{-1}. Minimum net return (-8345) was noted with 0:90:0 kg ha^{-1}. Overall the return value was more in 120 kg N ha^{-1} alongside the variable doses of P and K. Similarly, maximum value cost ratio-VCR (3.75) was recorded with the same dose of fertilizer application which steeply decreased with the decreasing fertilizer levels. Maximum relative increase in income-RII (1300.90) was also recorded at the same fertilizer dose. RII shifted in the same fashion as of the net return. The maximum net return value and cost benefit ratio in addition to relative increase in income at higher fertilizer doses seemed to be due to sufficient availability of NPK throughout crop growth stages. Earlier, Naimatullah *et al.* (2011) applied increased NPK doses and recorded higher net return as well cost benefit ratio. Shah *et al.* (2011) reported maximum net return at increased doses of nitrogen in addition to phosphorus and potassium application. The tendency of economic determinants was almost similar as noted in the first year experimentation.

Conclusion

On the claim of observations recorded in the study, it is accomplished that the application of NPK @ 120:90:60 kg ha^{-1} produced higher grain yield and yield contributing parameters than all other combinations applied.

Acknowledgement

The authors are thankful to Mohammad Safdar Baloch for his valuable suggestions and guidance during the research.

References

Gomez KA, Gomez AA. 1984. Statistical Procedure for Agricultural Research. John Willey and Sons Inc., New York.

Hossain MI, Shah SH, Hussain S, Iqbal K. 2002. Growth, yield and quality response of three wheat (*Triticum aestivum* L.) varieties to different levels of NPK. International Journal of Agriculture and Biology **4(3),** 362-364.

Hossain MD, Musa MH, Talib J, Jol H. 2010. Effects of nitrogen, phosphorus and potassium levels on kenaf (*Hibiscus cannabinus* L.) growth and photosynthesis under nutrient solution. Journal of Agriculture Sciences **2(2)**, 49-57. http://dx.doi.org/10.5539/jas.v2n2

Hussain I, Ayyaz KM, Ahmad KE. 2006. Bread wheat varieties as influenced by different nitrogen levels. Journal of Zhejiang University of Sciences **2,** 304-306. http://dx.doi.org/10.1631/jzus.2006.130070.

Iqbal M, Chauhan HQI. 2003. Relationship between different growth and yield parameters in Maize under varying levels of phosphorus. Journal of Biological Sciences **3(10),** 921-925. http://dx.doi.org/10.3923/jbs.2003.921.925

Jabbar A, Aziz T, Bhatti IH, Virk ZA, Khan MM, Wasal-U-Din. 2009. Effect of potassium application on yield and protein contents of late sown wheat (*Triticum aestivum* L.) Under field conditions. Soil and Environment **28(2),** 193-196.

Khan MB, Lone MI, Ullah R, Kaleem S, Ahmad M. 2010. Effect of different phosphatic fertilizers on growth attributes of wheat (*Triticum aestivum* L.). Journal of American Sciences **6(12),** 1256-1262.

Laghari GM, Oad FC, Tunio S, Gandahi AW, Siddiqui MH, Jagirani AW, Siddiqui H. 2010. Growth, yield and nutrient uptake of various wheat cultivars under different fertilizer regimes. Sarhad Journal of Agriculture **26(4),** 489-497.

Malghani Al, Malik AU, Sattar A, Hussain F, Abbas G, Hussain J. 2010. Response of growth and yield of wheat to NPK fertilizer. Science International **24(2),** 185-189.

Maqsood M, Akbar M, Yousaf N, Mehmood MT, Ahmad S. 1999. Effect of different rate of N, P and K combination on yield and components of yield wheat. International Journal of Agriculture and Biology **1(4),** 359-361.

Mumtaz MZ, Aslam M, Jamil M, Ahmad M. 2014. Effect of different phosphorus levels on growth and yield of wheat under water stress conditions. Journal of Environment and Earth Science **4(19),** 23-30.

Naimatullah M, Khan M, Khan MQ, Sadiq M, Zaman KU, Hayat CS, Rehman S. 2011. Impact of NPK application on the number of productive tillers and cost benefit analysis of wheat in hill-torrent irrigated areas of Dera Ismail Khan Division, Khyber Pakhtunkhwa. Journal of Animal and Plant Sciences **21(2),** 211-214.

Reddy SR. 2004. Principles of crop production - growth regulators and growth analysis. 2nd edition, Kalyani Publishers, Ludhiana, India.

Rehman S, Khalil SK, Rehman A, Saljoqi AUR. 2008. Organic and inorganic fertilizers increase wheat yield components and biomass under rain fed conditions. Sarhad Journal of Agriculture **24(1),** 11-20.

Saifullah A, Ranjha M, Yaseen M, Akhtar MF. 2002. Response of wheat to potassium fertilizer under field conditions. Pakistan Journal of Agriculture Sciences **39(4),** 269- 272.

Shah WA, Khan HU, Anwar S, Nawab K. 2011. Yield and yield components of wheat as affected by different seed rates and nitrogen levels. Sarhad Journal of Agriculture **27(1),** 17-25.

Steel RGD, Torrie JA, Deekey DA. 1997. Principles and Procedure of Statistics: A Biometrical approach, **3rd Eds**. McGraw Hill Book Co. Inc. New York. P 400-408.

Tariq JM, Arif M, Akbar H, Ali S. 2007. Response of wheat to source, type and time of nitrogen application. Sarhad Journal of Agriculture **23(4)**, 471-879.