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Research Article

Effect of fertilizer dose on the performance of spring cereals

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Abstract
In country like Pakistan where population is growing at an alarming rate, food shortage is the top challenge for researchers. To contribute to this effort, field trials entitled "Effect of fertilizer dose on the performance of spring cereals" were conducted at Cereal Crops Research Institute Pirsabak Nowshehra, Khyber Pakhtunkhwa, Pakistan during 2010-2011. The experiment was laid out in RCB design with split plot arrangement replicated three times, with plot size 5X1.8m, having 6 rows 30cm apart. Fertilizer doses were allotted to main while cereal species were allotted to subplots. Fertilizer dose, cereal species and their interaction had significantly affected cereal performance. Application of 60:30:30 and 120:60:60 (N:P:K kg ha^{-1}) significantly affected plant height and phenology of cereals than no NPK. Application of 60:30:30 and 120:60:60 produced 55% and 62% more grain yield respectively than no NPK. Wheat, triticale and oat phenology was significantly delayed, oat and triticale produced taller plants than wheat and barley. Triticale yield was significantly higher than barley, wheat and oat. In case of interactions triticale with 120:60:60 NPK took more days to heading (131) and physiological maturity (168), while barley took less days to heading (109) and physiological maturity with no NPK. Significantly taller plants were produced by oat (129 cm) at 120:60:60 while barley produced dwarf plants (73cm) with no NPK. In case of grain yield, triticale produced more yield (5275 kg ha^{-1}) with 60:30:30 while oat gave lowest yield (2433 kg ha^{-1}) with no NPK. It is concluded that triticale and barley performed well on less fertile soil than wheat and oat. For optimum production, 60:30:30 and 120:60:60 (N: P: K kg ha^{-1}) are recommended for barley/triticale and wheat/oat respectively, in conditions similar to Nowshehra.

Key words: Barley; Fertilizer dose; Performance; Triticale; Yield

Introduction
Spring cereals like wheat, barley, triticale and oat are used as human food and livestock feed since ancient times. Spring Wheat (*Triticum aestivum* L.) is the major staple food crop of Pakistan. It occupies 70% of the Rabi and 37% of the total cropping area in the country. Per capita consumption of wheat in Pakistan is the highest in the world (135 kg $year^{-1}$), which contributes 72% of the total calories intake (Annual report CCRI 2010-11). In Pakistan in general and in KPK in particular, low

productivity is mainly correlated to low soil fertility.

Many researches have been conducted on crop nutrients management and optimization. These studies for example [1-3] have revealed the significant importance of fertilizer optimization for spring cereals. However there is need to work out the combine effect of NPK on combination of various spring cereals.

Keeping in view the importance of combine fertilizer optimization for spring cereals, the present study was conducted to evaluate the response of spring cereals to various levels of NPK.

Materials and methods

Field trials were conducted at Cereal Crops Research Institute Pirsabak, Nowshera during 2010-11 in randomized complete block design with split plot arrangement, having three replications. Fertilizer levels of N: P: K (0:0:0, 60:30:30 and 120:60:60 kg ha-^{1}) were allotted to main plot while cereal species (Wheat, triticale, barley and oat) were applied to sub plots. Plot size was 5 x 3.6m (18m^{2}), having 6 rows, 30 cm apart. Sowing was done on 25th of November 2010. Half of the nitrogen was applied at sowing while half of nitrogen was applied after 45 days of sowing. All of the Phosphorus and potash were applied at sowing time. Agronomic practices were conducted as per protocol for all the crop species. Data were recorded on days to heading, days to physiological maturity, plant height (cm), grain yield (kg ha^{-1}). Data recorded for various parameters were individually subjected to the ANOVA and LSD using MS Excel program.

Results and Discussion

Days to heading

Data regarding days to heading is presented in table 1. Data indicates that fertilizer levels, cereal species and their interaction significantly ($P<0.05$) affected days to heading. Significantly more days (125) were observed for 120:60:60 (N: P: K kg ha-^{1}) while less days (118) were recorded for no NPK application. Significantly more days (126) were taken by oat while least days to heading (111) were observed for barley. In case of fertilizer and cereal species interaction, more days to heading (131) were recorded when 120:60:60 (N: P: K kg ha-^{1}) was applied while least days to heading (109) were taken by barley without NPK application. Delay in days to heading with increase in fertilizer dose might be due to more nutrients availability specially nitrogen which prolongs vegetation growth period [3]. Potassium and phosphorus fertilization have significantly improved days to flowering, days to maturity, grains spike^{-1}, 1000 grain weight and grain yield as compared control Amanullah and Khan, 2010 [4]. Significant effect of cereal species might be due to difference in genetic potential [5] of different species which determines the length of vegetative and reproductive stages.

Table 1. Days to heading of spring cereals as affected by different NPK levels

NPK Levels	Cereal Species				
	Wheat	**Triticale**	**Barley**	**Oat**	**Mean**
0:0:0	121 d	119 e	109 h	122 d	118 c
60:30:30	124 c	124 c	111 g	126 b	121 b
120:60:60	127 b	126 b	114 f	131 a	125 a
Mean	124 b	123 c	111 d	126 a	

LSD for NPK Levels = 0.55
LSD for Cereal Species = 0.94
LSD for Interaction = 1.63

Days to physiological maturity

Data recorded on days to physiological maturity is given in table 2. Based on the data it is revealed that fertilizer levels, cereal species and interaction of fertilizer levels and cereal species had significantly affected days to physiological maturity. Significantly ($P<0.05$) more days (161) were observed when 120:60:60 (N: P: K kg ha-^{1}) was applied followed by 60:30:30 (N: P: K kg ha-^{1}) with 157 days. Lowest days (152) were recorded in plots without NPK application. In case of cereal species, more days to physiological maturity (163) were observed for oat while least (150 days) were recorded for barley. Regarding interaction, more days to physiological maturity (168) were recorded for oat when 120:60:60 (N: P: K kg ha-^{1}) was applied while least days (147) were taken by barley when no NPK was applied. Delay in physiological maturity with increase in fertilizer level might be the result of more nutrients availability, especially nitrogen, which enhances the vegetative growth period and hence prolongs plant life cycle **[3].** Potassium and phosphorus fertilization have significantly improved days to flowering, days to maturity, grains spike^{-1}, 1000 grain weight and grain yield as compared control Amanullah and Khan, 2010 **[4].** Significant effect of cereal species might be due to difference in genetic potential **[5]** of different species which determines the length of vegetative and reproductive stages.

Table 2. Days to physiological maturity of spring cereals as affected by different NPK levels

NPK levels	Cereal Species				
	Wheat	**Triticale**	**Barley**	**Oat**	**Mean**
0:0:0	155 d	154 de	147 g	156 d	152 c
60:30:30	159 c	155 d	150 f	165 b	157 b
120:60:60	165 b	158 c	154 de	168 a	161 a
Mean	159 b	156 c	150 d	163 a	

LSD for fertilizers = 1.57
LSD for Cereal Species = 1.10
LSD for Interaction = 1.90

Plant height (cm)

As shown table 3, fertilizer levels, cereal species and their interaction have significantly ($P<0.05$) affected plant height. Fertilizer application at 60:30:30 and 120:60:60 (N: P: K kg ha^{-1}) increased plant height by 7% and 14% as compared to no application of fertilizer. This increase may be the result of nutrients availability specially nitrogen which enhanced plant growth and hence plant height **[6]**. Oat and triticale produced significantly taller plants (119 and 112cm) than wheat and barley (100 and 76cm). Difference in plant height of different cereal species might be due to difference in genetic potential for plant height. This statement is supported by the findings of Jorgensen *et al.* **[1]** who reported that triticale and rye had a higher total dry matter yield than wheat, even at lower inputs of N fertilizer. This finding is also supported by the research work of Awasthi & Bhan (1994) **[7]** who noticed increased in leaf area and plant height with increase in fertilizer rate. In case of interaction plant height was significantly higher for oat (129 cm) at 120:60:60 (N: P: K kg ha^{-1}) while it was lowest (73 cm) for barley without fertilizer. A dose of 70 kg N significantly increased the yield of all cereal species, but yield increases at 140 kg N were not always significant when compared with 70 kg N **[8].**

Table 3. Plant height (cm) of spring cereals as affected by different NPK levels

NPK levels	Cereal Species				
	Wheat	**Triticale**	**Barley**	**Oat**	**Mean**
0:0:0	95 g	105 e	73 j	106 e	95 c
60:30:30	100 f	112 d	76 i	123 b	102 b
120:60:60	104 e	118 c	79 h	129 a	108 a
Mean	100 c	112 b	76 d	119 a	

LSD for fertilizers = 1.46
LSD for Cereal Species = 1.36
LSD for Interaction = 2.36

Grain yield (kg ha^{-1})

Fig. 1 is the graphical representation of grain yield trend. It is clear from the graph that both, fertilizer levels and cereal species as well as their interaction had significantly affected grain yield. Application of 60:30:30 and 120:60:60 (N: P: K kg ha-^{1}) produced 55% and 62% more grain yield respectively than no NPK application. This increase in grain yield at higher levels of fertilizers may be the consequence of more nutrients availability which resulted in more number of spikes m^{-2}, spike length and number of grains spike^{-1} [2]. In addition, more dry matter and N are accumulated at grain filling stage by high N demanding crops due to larger canopy than low N demanding, resulting in more grain yield and protein content at harvest. The number of grains per unit area and grain yield was closely correlated with dry matter content and N application at anthesis [9]. Wheat crop produced on average 1.59 times more grain yield and 1.77 times more straw yield with the application N fertilizer as compared to control [10]. The grain yield of wheat was improved with N fertilization due to its effect on yield components, phenology and leaf characteristics. Crop growth and senescence rate are dependent on N availability, as the number of grains set per unit area and grain size. Stronger sink (more grains per unit area and per spike) was developed with the improved availability of N [11]. Increase in grain yield with increase in fertilizer levels may be attributed to more vigorous plants which resulted in more productive plants m^{-2} , more thousand grain yield and hence more grain yield. Grain yield and crude protein concentration were increased by fertilizer N compared with the plots without N fertilizer [12]. In case of cereal species, triticale yield was significantly higher (4293 kg ha^{-1}) than barley, wheat and oat (3355, 3165 and 2794 kg ha^{-1}) respectively. It was observed that 60:30:30 (N: P: K kg ha-^{1}) was optimum dose for barley and triticale. Increase in fertilizer beyond this level was not positively correlated with grain yield. This shows that barley and triticale perform well on low fertile soil than oat and wheat. Decrease in grain yield with increase in fertilizer might be due to lodging which results in nonproductive tillers and decrease in thousand grain weight. The type and amount of N fertilizer applied at all three locations mainly influenced dry matter content and grain N status [13]. In autumn season sowing, the long vegetative duration resulted in more dry matter content and N at anthesis as compared winter sowing, which resulted in more final grain yield [9].

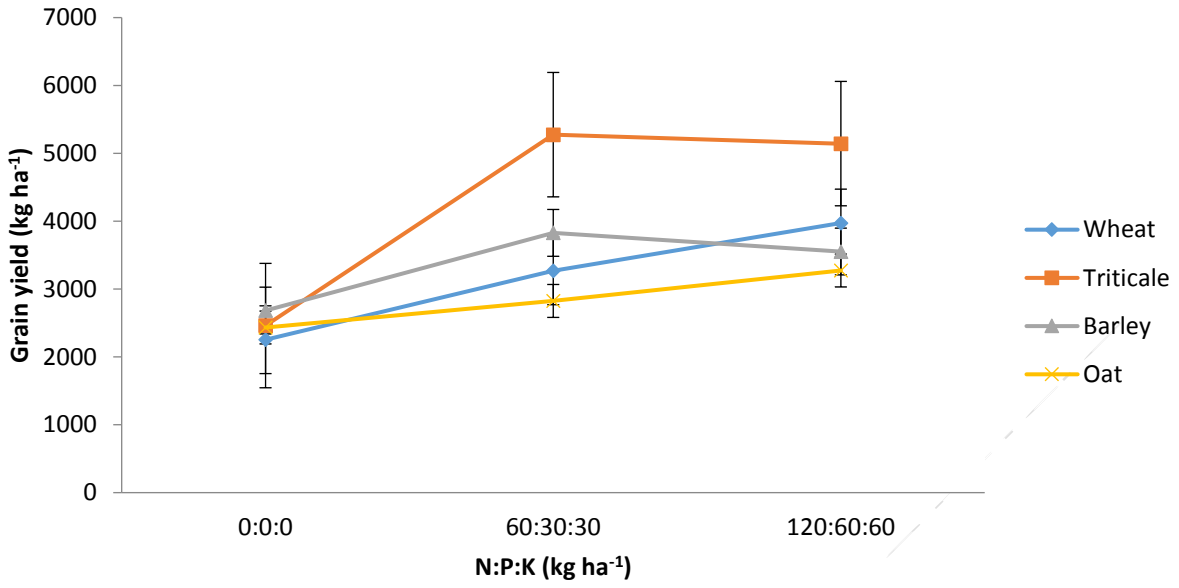

Figure 1. Grain yield (kg ha^{-1}) of spring cereals as affected by different NPK levels

Conclusions & recommendations

It is concluded that triticale and barley performed well on less fertile soil than wheat and oat. For optimum production, 60:30:30 and 120:60:60 (N: P: K kg ha^{-1}) are recommended for barley/triticale and wheat/oat respectively, in conditions similar to Nowshehra.

Authors' contributions

Conceived and designed the experiments: Z Muhammad & G Ahmad, Performed the experiments: Z Muhammad & B Iqbal, Analyzed the data: Z Muhammad & G Ahmad, Contributed reagents/ materials/ analysis tools: S Ullah, RM Khan, A Bari & S Shah, Wrote the paper: Z Muhammad & B Iqbal.

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