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YIELD AND YIELD CONTRIBUTING TRAITS OF WHEAT CULTIVARS IN RELATION WITH PLANTING DATES AND NITROGEN FERTILIZATION

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ABSTRACT

A two years field study was conducted to determine the effect of different sowing dates and nitrogen fertilization on yield and yield contributing traits of wheat cultivars at New Developmental Farm of Khyber Pakhtunkhwa Agricultural University, Peshawar, Pakistan under the agro-climatic condition of Peshawar valley during 2008-09 and 2009-10. The experiment was laid out according to randomized complete block design having split plot arrangements with four repeats. Four planting dates (24th October, 13th November, 3rd December and 23rd December) with 20 days intervals allocated to main plots as factor A while eight combinations of 4 nitrogen rates (0, 100, 130 and 160 kg N ha^{-1}) and two varieties (Pirsabaq-2005 and Khyber-87) were kept in sub plots as factor B. Wheat crop responded differently to sowing dates and nitrogen fertilization for various characters. Number of spikes m^{-2}, number of grains spike^{-1} ,biological yield, grain yield and 1000-grain weight increased linearly in response to sowing dates (early and normal sowing) and nitrogen rates (130 and 160 kg ha^{-1}). Late sowing and no nitrogen application significantly decline yielding capacity of wheat cultivars. Khyber-87 performs better in term of yield as compared to Pirsabaq-2005. Some interactions of sowing dates, varieties and nitrogen levels were also responded significantly toward yield and yield components of wheat cultivars in both growing seasons.

Keywords: wheat cultivars, sowing dates, nitrogen fertilization, yield.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is cultivated world wide primarily/mainly as a food commodity. It is one of the top dominant crop in the world as well as in Pakistan. During recent years, many approaches have been made towards improvement in yield potential/capacity of wheat crop.

Planting time is one of the most critical considerations and agronomic factor involved in producing high yield of small grain cereal crops like wheat. Several studies documented the effect of plant date on wheat performance. Early or late sowing increases the risk of yield losses Ehdaie *et al*., (2001). Similarly biomass accumulation, grain yield, number of spikes m^{-2} and thousand grain weight of wheat were increased with early sowing (early November) over late sowing (December) Aftab *et al*., (2004).

Like reproductive growth, vegetative growth of wheat is also related with planting times. Sowing of wheat from 1st to 15th November produce maximum productive tillers m^{-2} Akhtar *et al*., (2006). The short growing season cultivars like Khyber-87 performed better in term of grain yield in late sowing. These cultivars produce more number of productive tillers due to better germination and good stand establishment Sattar *et al*., (2010).

Another important and economic consideration for increasing wheat productivity is the effective use of nitrogen fertilization. Nitrogen fertilization is the most important factor in front of wheat agronomist for achieving high yield targets.

Previous research reviewed that number of tellers and spikes m^{-2}, plant height, spike length, number of spikeslets and grains spike^{-1}, grain yield and straw yield of wheat increased with increased nitrogen level Sobhoel *et al*., (2000). Sufficient supply of nitrogen at optimum planting time also resulted good quality and vigorous seed. Different indicators are used for measurement of seed quality and vigor like higher net assimilation, grain filling rates and duration are mostly contributing in 1000 grain weight. Sowing dates and different nitrogen levels have also produced significant effect on 1000 grain weight. Sowing from 1st-15th November produced highest 1000 grain weight Akhtar *et al*., (2006). Similarly nitrogen application increased seed development (grain filling rate and duration) which ultimately produced highest grain weight Waraich *et al*., (2007). Biological yield is also strongly linked with sowing dates and nitrogen levels. The previous research showed that early or normal sowing dates (1st-10th November) is more effective for biological yield as compared to late sowing e.g. December Aftab *et al*., (2004). Various nitrogen rates (0, 100, 150, 200 kg ha^{-1}) had significant effect on biological yield but 200 kg N ha^{-1} produced maximum biological yield Iqtidar *et al*., (2006). The present project was therefore designed to investigate the individual as well as the interactive effect of planting dates and nitrogen rates on yield and yield contributing traits of wheat cultivars.

MATERIALS AND METHODS

An experiment was conducted at the New Developmental Farm of Agricultural University, Peshawar, during two successive seasons 2008-2009 and 2009-2010. The research farm is situated at 34.01^{0} N latitude, 71.35^{0} E longitudes and an altitude of 350 meters

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above sea level in Peshawar valley. The climate of Peshawar is continental type and is located about 1600 km north of the Indian Ocean. The irrigation source of the research area is the Warsak Canal of Kabul River. Soil has clay loam texture, low in organic matter (0.87%), extractable phosphorus (6.57 mg kg^{-1}), exchangeable potassium (121 mg kg^{-1}) and alkaline in nature (pH 8.2). Mean annual rainfall in the Peshawar varies from 300 to 500 mm $year^{-1}$ Amanullah *et al*., (2009b). The experiment layout was Randomized Complete Block Design with split pot arrangements having four replications. The experiment included two factors, factor A included four sowing dates (October 24th, November 13th, December 3rd and December 23rd) and randomly distributed in main plot and factor B included eight combination of 2 varieties (Pirsabaq-2005 and Khyber-87) and four nitrogen rates (0, 100, 130 and 160 kg ha^{-1}) were allocated randomly in the sub-plot. The area of each sub-plot was 15 m^{-2} (10 rows five meter long and 30 cm apart). The amount of nitrogen was divided in two portions, one being applied immediately at sowing and the rest was applied after 2nd irrigation. Nitrogen was added in the form of urea (46% N).

Recommended dose of TSP and MOP was also applied as a basic source of phosphorous and potassium during sowing time. All the other cultural practices were standard and kept uniform for all treatments in both years. Soil sample were collected from the soil surface of experimental area before and after the treatments (Nitrogen, P_2O_5 and K_2O) application and were analyzed for physico-chemical characteristics like pH, phosphorus (ppm) and nitrogen (%) as shown in Table-1. All observations were measured by using their standard procedures. At maturity, number of spikes m^{-2} was recorded by counting spikes in two central rows of each sub plot randomly. Five spikes from each sub plot were randomly sampled and threshed manually for the measurement of grains $spike^{-1}$. Biological yield was recorded by harvesting six central rows in each sub-plot and then converted it into biological yield kg ha^{-1}. The same bundles were threshed manually for recording grain yield kg ha^{-1}. After threshing 1000 grains were randomly picked from each sub plot and then weighted by electronic balance in grams. All the data collected during two years were subjected to statistical analyses using MSTAT-C. Least Significant Difference Test at 5% probability was used to test the significant differences among mean values of each treatment Steel and Torri, (1997).

Table-1. Soil analysis of the experimental field before and after the treatments application.

Soil chemical properties	Units	Before treatment application	After treatment application
pH		8.24	7.94
Nitrogen	%	0.018	0.034
Phosphorus	ppm	9.84	15.43

RESULTS AND DISCUSSIONS

Grain yield (kg ha^{-1})

The data (Table-2) revealed that highly significant values for grain yield kg ha^{-1} were recorded under the main effect of sowing dates, nitrogen levels and interactive effect with varieties. Highest grain yield (3681.25kg ha^{-1}) was recorded on 24th October sowing while late sowing in December decreases the grain yield (1117.17 kg ha^{-1}). Each day delay in sowing of wheat after 20th November onward decreases grain yield at the rate of 36 kg ha^{-1} day^{-1} Hussain *et al*., (1998). Increase number of unproductive tillers in delay sowing depressed grain yield Naseer El-Gizawy, (2009). Therefore sowing from end of October to mid of November may be considered as the optimum time for obtaining higher grain yield. Similarly higher number of spikes m^{-2}, number of grains $spike^{-1}$ and grain weight under early sowing have maximum contribution in grain yield. These results are in agreements with the finding of several early workers like Akhtar *et al*., (2006), Spink *et al*., (2000) and Shazad *et al*., (2002). Another possible and strong attribute cold be the high temperature ($\geq 32^0$C) during delay sowing which stretches the period of grain filling and resulted reduce development of grain and ultimately decreasing the grain yield Guilioni *et al*., (2003). Both wheat varieties performed differently in term of grain yield (kg ha^{-1}) at different sowing dates. Khyber-87 produced maximum grain yield (3753.125 kg ha^{-1}) under early sowing (24th October) as compared to delay sowing (1103.813 kg ha^{-1}). The superiority of Khyber-87 in grain yield under early and normal sowing is due to that it has more spikes m^{-2}, number of grains $spike^{-1}$ and higher HI (%). 160 kg N ha^{-1} produced maximum grain yield (2847.39kg ha^{-1}) while wheat crop without fertilization (0 kg N ha^{-1}) produce minimum yield (1347 kg ha^{-1}). The superiority of Khyber-87 in grain yield under early and normal sowing is due to that it has more spikes m^{-2}, number of grains $spike^{-1}$ and higher HI (%). Similarly nitrogen fertilization bringing significant variation in grain yield of both varieties. Khyber-87 produced higher grain yield (2994.781 kg ha^{-1}) at 130 kg N ha^{-1}, while lowest grain yield (1208.688 kg ha^{-1}) was recorded under no fertilization (0 kg N ha^{-1}). Trend line (Figure-1A) shows significant association among the interaction of sowing date x nitrogen levels for grain yield. Grain yield have no significant response across the years and other interactions.

Table-2. Grain yield (kg ha $^{-1}$) of wheat varieties as affected by sowing dates and nitrogen fertilization.

Treatments	Pirsabaq-2005	Khyber-87	Mean
24th October	3609.375 a	3753.125 a	3681.25 a
13th November	2448.438 bc	2782.813 b	2615.625 b
3rd December	2620.313 bc	2076.563 c	2348.438 b
23rd December	1130.531 d	1103.813 d	1117.172 c
LSD value = 704.4		LSD value = 1005.0	
0 kg N ha^{-1}	1490.969 b	1208.688 b	1347.829 b
100 kg N ha^{-1}	2639.406 a	2879.688 a	2759.547 a
130 kg N ha^{-1}	2620.656 a	2994.781 a	2807.719 a
160 kg N ha^{-1}	2827.25 a	2867.531 a	2847.391 a
LSD value = 704.4		LSD value = 996.2	
2008-09	2505.031	2591.828	2548.43
2009-10	2381.891	2279.688	2332.408
Mean	2486.860	2392.360	2440.419
Interaction	P-value	Interaction	P-value
Y x D	>1	Y x D x V	>1
Y x N	>1	Y x V x N	>1
D x N	0	D x V x N	>1
Y x D x N	>1	Y x D x V x N	>1

Mean of the same category followed by different letters are significantly different ($P \leq 0.05$) using LSD test.
Y = Year
D = Sowing dates
N = Nitrogen levels
V = Varieties
LSD = Least Significant Difference

Number of spikes m^{-2}

Optimum sowing time and balanced fertilizer each has an effective role in increasing the number of spikes m^{-2} as listed in Table-3. Highest significant differences are noted in the mean values of spikes m^{-2} (345.61 and 324.77) under early and normal sowing (24th October and 13th November) followed by lowest spikes m^{-2} (265.66) in case of delayed sowing (23rd December). Effective germination and better establishment could justified the increase number of spikes per unit area in early and normal sowing while poor emergence and stand establishment in late sown condition decreases the spikes m^{-2}. Not all tillers produce spikes in wheat and many tillers abort before anthesis and it may be probably due to delay sowing. These results are agreed with those of Naseer El-Gizawy, (2009) who reported significant relation among planting dates and number of spikes m^{-2}. Significant differences are found among the interaction of sowing dates and varieties. Khyber-87 contributed more in spikes production per unit area (366.75 m^{-2}) due to early sowing while minimum spikes (234.26 m^{-2}) were recorded in those plots of Pirsabak-2005 which was sown late. Genetic diversity of varieties might be attributed towards differences in number of spikes m^{-2} and number of grains spike^{-1} Haider, (2004) under various sowing dates. Similarly the variation in performance of varieties may be due to seasonal impact. Significant association was observed in the main effect of nitrogen fertilization as well as in the interaction effect with varieties. Those plots which fertilized with 160 kg N ha^{-1} produced highest spikes (335.20 m^{-2}) followed by lowest spikes (226.66 m^{-2}) in case of 0 kg N ha^{-1}. Crop having nitrogen fertilization produce more spikes Otteson *et al*., (2007). Khyber-87 responded more towards nitrogen application and resulted maximum spikes m^{-2} (371.57) but their performance reduces in control condition of nitrogen (206.29 m^{-2}). These results are not in line with those of Bakht *et al*., (2010) who stated that interactive effect of nitrogen and varieties were non significant. Both varieties perform differently for spikes m^{-2} in both years. Khyber-87 performed better under both years as compared to Pirsabak-2005. The interactions having significant trend lines (D x N and D x V x N) were shown in Figures 1B and 2A. Other interaction were found non significant for the studied parameter.

Table-3. Number of spikes m^{-2} of wheat varieties as affected by sowing dates and nitrogen fertilization.

Treatments	Pirsabaq-2005	Khyber-87	Mean
24th October	324.469 ab	366.75 a	345.61 a
13th November	337.625 ab	311.906 b	324.766 ab
3rd December	234.258 d	319.688 ab	277.047 bc
23rd December	244.531 cd	286.781 bc	265.657 c
LSD value = 51.37		LSD value = 48.02	
0 kg N ha^{-1}	206.406 e	246.906 de	226.657 b
100 kg N ha^{-1}	280.781 cd	371.565 a	326.219 a
130 kg N ha^{-1}	311.906 bc	338.094 ab	325.0005 a
160 kg N ha^{-1}	341.938 ab	328.469 abc	335.203 a
LSD value = 51.37		LSD value = 72.65	
2008-09	278.281 a	334.719v a	306.5002
2009-10	292.234 a	307.844 a	300.0391
Mean	285.258	321.281	303.269
LSD value =	72.65		
Interaction	P-value	Interaction	P-value
Y x D	>1	Y x D x V	>1
Y x N	>1	Y x V x N	>1
D x N	0	D x V x N	0
Y x D x N	>1	Y x D x V x N	>1

Mean of the same category followed by different letters are significantly different ($P \leq 0.05$) using LSD test.
Y = Year
D = Sowing dates
N = Nitrogen levels
V = Varieties
LSD = Least Significant Difference

Number of grains spikes $^{-1}$

Analysis of variance showed significant differences among planting dates for number of grains $spike^{-1}$ (Table-4). Data revealed superiority of early sowing i.e., 24th October sowing (56.71 grains $spike^{-1}$) over late planting dates 23rd December (36.89 grains $spike^{-1}$). The crop under early sowing could have (i) longer duration of the period when inflorescences (excluding grains) are growing (ii) greater crop growth rate during the period and (iii) more production of photosynthates. These results were also demonstrated by Qasim *et al*., (2008), Sattar *et al*., (2010) who concluded that early planted wheat yielded highest grains $spike^{-1}$. Probably half of the florets abort before anthesis and some are insufficiently developed which bring reduction in number of grains $spike^{-1}$. Similarly in delay sowing, the number of sterile tillers increased which also bring reduction in grains number. Sowing dates x varieties interaction were also significant. Khyber-87 has more number of grains $spike^{-1}$ (58) under normal sowing (24th October) while PS-2005 has low grains $spike^{-1}$ (35) when its planting delayed. Genetic diversity of varieties might be attributed towards differences in number of spikes m^{-2} and number of grains $spike^{-1}$ Haider, (2004) under various sowing dates. Similarly the variation in performance of varieties may be due to seasonal impact. Nitrogen levels significantly influenced number of grains $spike^{-1}$. Optimum nitrogen level (160 kg ha^{-1}) produced maximum grains (49.92 $spike^{-1}$) as compared to 0 kg N ha^{-1} (39.67 grains $spike^{-1}$). Greater partitioning of dry matter to spikes due to nitrogen fertilization causes more grains $spike^{-1}$. These results were in conformity of Subedi *et al*., (2007). The interaction

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between varieties and nitrogen showed non significant results. Significant differences among planting dates x nitrogen levels and planting dates x varieties x nitrogen interactions were recorded (Figures 1C and 2B). Other interactions were found non significant.

Table-4. Number of grains spike^{-1} of wheat varieties as affected by sowing dates and nitrogen fertilization.

Treatments	Pirsabaq-2005	Khyber-87	Mean
24th October	55.063 a	58.375 a	56.719 a
13th November	50.063 b	46.938 b	48.5 ab
3rd December	35.281 c	37.188 c	36.235 c
23rd December	36.469 c	37.313 c	36.891 bc
LSD value = 4.754		LSD value = 12.13	
0 kg N ha^{-1}	40	39.344	39.672 b
100 kg N ha^{-1}	43.25	44.125	43.688 ab
130 kg N ha^{-1}	44.969	45.156	45.063 ab
160 kg N ha^{-1}	48.656	51.188	49.922 a
LSD value = 6.723			
2008-09	43.828	44.281	44.055
2009-10	44.609	45.625	45.117
Mean	44.219	44.953	44.586
Interaction	P-value	Interaction	P-value
Y x D	>1	Y x D x V	>1
Y x N	>1	Y x V x N	>1
D x N	0	D x V x N	0.0001
Y x D x N	>1	Y x D x V x N	>1

Mean of the same category followed by different letters are significantly different ($P \leq 0.05$) using LSD test.
Y = Year
D = Sowing dates
N = Nitrogen levels
V = Varieties
LSD = Least Significant Difference

Biological yield (kg ha^{-1})

Data listed in Table-5 reflect that significant variation was found among the mean values of biological yield (kg ha^{-1}) under different sowing dates and nitrogen rates. Mid November sowing produces highest biological yield (13160.94 kg ha^{-1}) as compared to late sowing in December (5528.80 kg ha^{-1}). During normal sowing, maximum number of productive tillers m^{-2} producing highest biological yield. Similarly more number of grains spike^{-1} was closely associated with increase biological yield under normal sowing. These results are in good agreement with findings of Aftab *et al*., (2004). It can be seen from the mean values of the data that the response of biological yield towards the interaction of different sowing dates varieties was non significant. Similarly the biological yield was recorded significantly different at various rate of nitrogen. Highest biological yield (12403.12 kg ha^{-1}) was observed in highest nitrogen treatment (160 kg ha^{-1}) followed by lowest value (5996.69 kg ha^{-1}) under lowest nitrogen treatment (0 kg ha^{-1}).). Similarly the benefits from nitrogen were greater with early and normal sowing because of higher of nitrogen-uptake as a consequence of which higher biological yield resulted. These results are matched with the findings of Iqtidar *et al.*, (2006), Woolfolk *et al*., (2002). Non significant relation was observed among nitrogen rate and varieties interaction. Cultivars responses in both years were same. The interactive effect of sowing dates x nitrogen levels and sowing dates x varieties x nitrogen levels were tended to be significant as shown in Figures 1D and 2C. The other interactions were non significant.

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Table- 5. Biological yield (kg ha $^{-1}$) of wheat varieties as affected by sowing dates and nitrogen fertilization.

Treatments	Pirsabaq-2005	Khyber-87	Mean
24th October	12540.625	11993.75	12267.188 a
13th November	13109.375	13212.5	13160.938 a
3rd December	10453.125	10235.406	10344.266 b
23rd December	5497.542	5560.049	5528.796 c
LSD value = 1778			
0 kg N ha^{-1}	6126.375	5867	5996.688 b
100 kg N ha^{-1}	10940.962	11051.375	10996.169 a
130 kg N ha^{-1}	12089.924	11720.486	11905.205 a
160 kg N ha^{-1}	12443.406	11362.844	12403.125 b
LSD value = 2062			
2008-09	10842.52	10599.29	10720.91
2009-10	9957.813	9901.563	9929.688
Mean	10400.167	10250.427	10325.297
Interaction	P-value	Interaction	P-value
Y x D	>1	Y x D x V	>1
Y x N	>1	Y x V x N	>1
D x N	0	D x V x N	0
Y x D x N	>1	Y x D x V x N	>1

Mean of the same category followed by different letters are significantly different ($P \leq 0.05$) using LSD test.
Y = Year
D = Sowing dates
N = Nitrogen levels
V = Varieties
LSD = Least Significant Difference

Thousand grain weight (g)

As can be seen from Table-6, statistically significant differences were found among planting dates for 1000- grain weight. Results showed that early planted (24th October) crop in both years produced maximum 1000-grain weight (48.40 gm) over late sown crop (37.85 gm). Significant variation for 1000-grain weight was recorded among sowing dates and varieties interaction. Availability of longer period of growth in early sowing significantly increases grain filling (rate and duration) and grain filling therefore of vital importance for increased grain weight. Singh and Pal, (2003), Abdullah *et al*., (2007) working with wheat, founded that early sowing produce maximum grain weight than late planted wheat. Heavy grain weight (51.685 gm) were recorded in Khyber-87 when sown early (24th October) and the same variety produced lower seed weight (34.796 gm) under late sowing (23rd December). Effect nitrogen fertilization were significant for 1000-grain weight. 130 kg N ha^{-1} produce higher grain weight (45.13gm), while 0 kg N ha^{-1} produce lower seed weight (40.87 gm). The nitrogen application just prior to the initiation of stem extension correlates with increase sink size which in turn results in increase grain weight. Similarly nitrogen application increase the dry matter accumulation in seed as result of which heavier seed produced. Similar observation was made by Waraich *et al*., (2007). They documented that nitrogen application increases grain filling rate which produced heavy seed. Seadh *et al*., (2009) also concluded the significant response of grain weight towards nitrogen application. The varieties interaction with nitrogen were found non significant for grain weight. 1000 grain weight under sowing date x nitrogen interaction was significantly different (Figure-1E). 1000-grain weight were non significant in other factors interaction.

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Table-6. Thousand grain weight (g) of wheat varieties as affected by sowing dates and nitrogen fertilization.

Treatments	Pirsabaq-2005	Khyber-87	Mean
24th October	45.118 b	51.685 a	48.402 a
13th November	44.821 bc	43.862 bcd	44.342 ab
3rd December	44.201 bc	39.787 d	41.994 ab
23rd December	40.919 cd	34.796 e	37.857 b
LSD value = 4.198		LSD value = 6.836	
0 kg N ha^{-1}	41.88	39.86	40.87 a
100 kg N ha^{-1}	45.871	40.456	43.165 a
130 kg N ha^{-1}	47.628	42.636	45.132 a
160 kg N ha^{-1}	46.246	40.608	43.427 a
LSD value = 5.936			
2008-09	45.872	40.722	43.297
2009-10	44.941	41.06	43.0004
Mean	45.407	40.891	43.149
Interaction	P-value	Interaction	P-value
Y x D	>1	Y x D x V	>1
Y x N	>1	Y x V x N	>1
D x N	0	D x V x N	>1
Y x D x N	>1	Y x D x V x N	>1

Mean of the same category followed by different letters are significantly different ($P \leq 0.05$) using LSD test.
Y = Year
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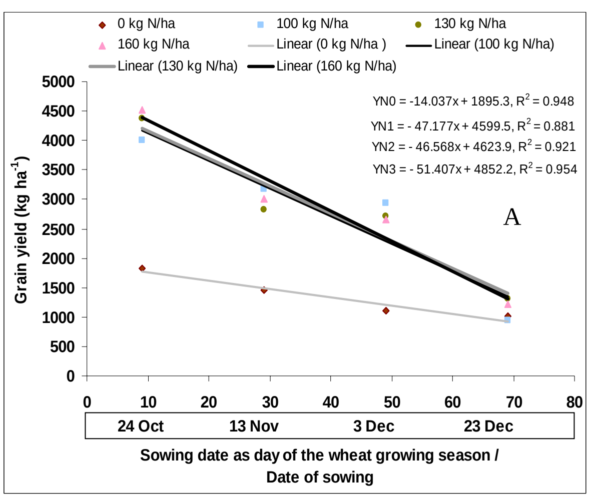

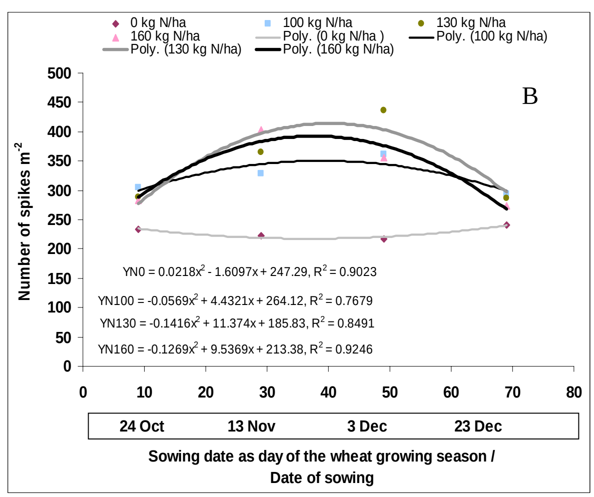

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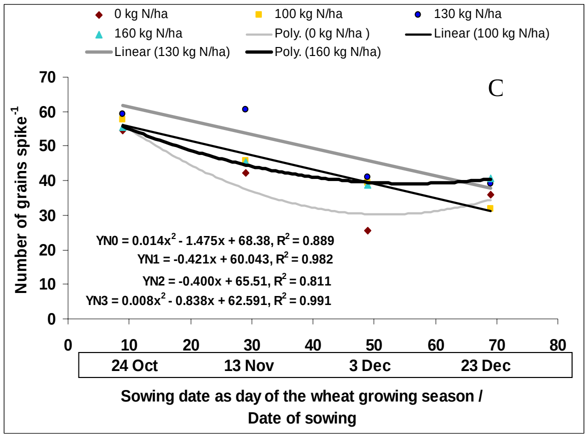

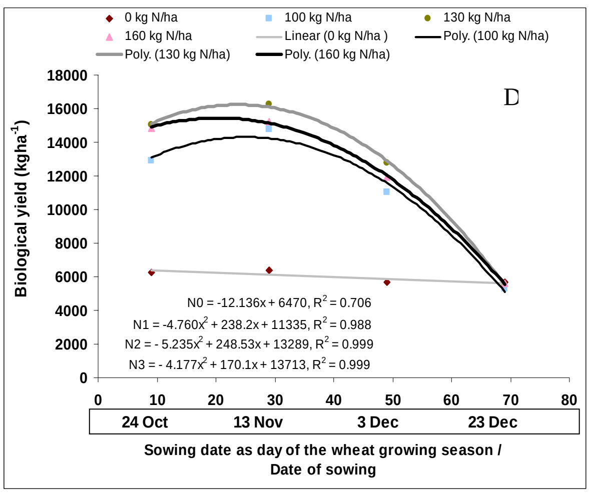

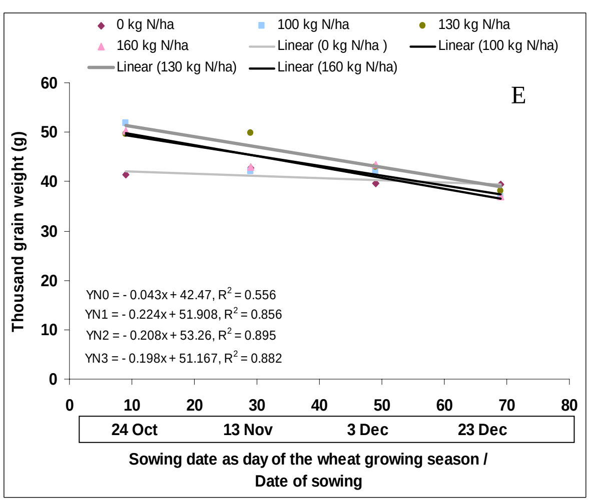

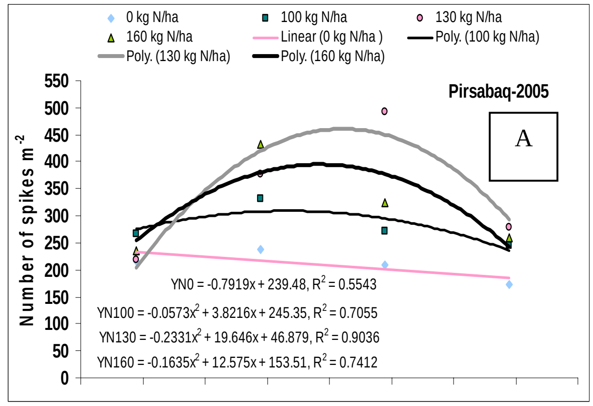

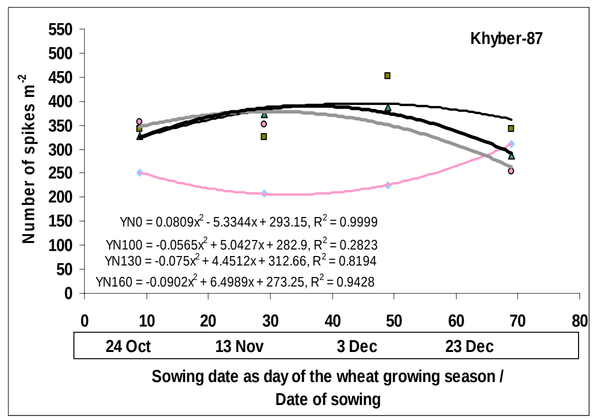

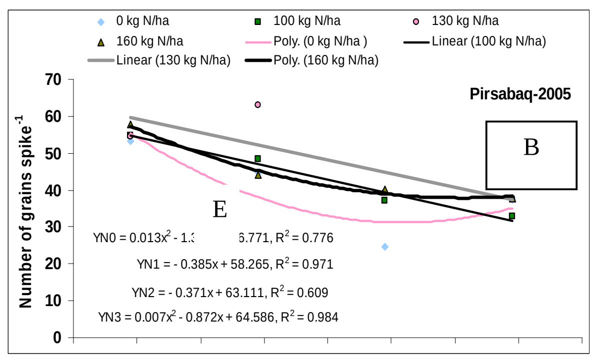

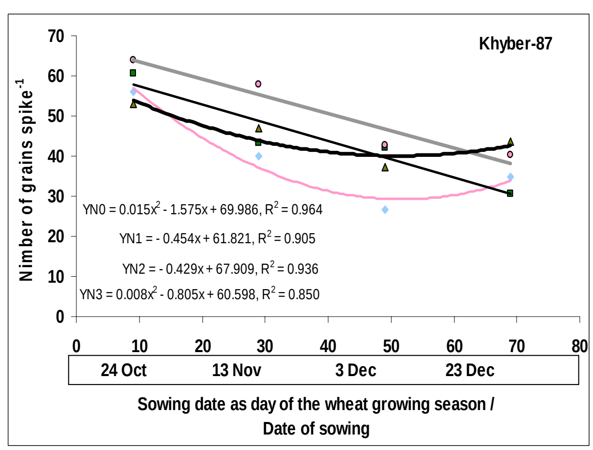

Figure-1. Grain yield (A), number of spikes m^{-2}(B), number of grains $spikes^{-1}$(C), biological yield (D) and thousand grain weight (E) of wheat as affected by interaction of nitrogen application and date of sowing, the date of sowing was coded as day of the wheat growing season starting from 15 October in Peshawar, Pakistan.

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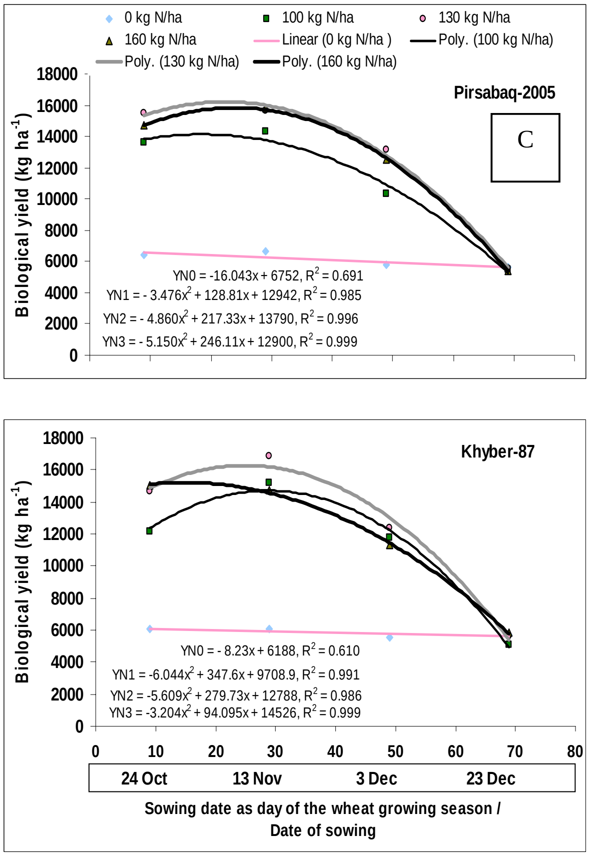

Figure-2. Number of spikes m^{-2}(A), number of grains spikes^{-1}(B) ,and biological yield (C) as affected by interaction of two wheat varieties (Pirsabaq 2005 and Khyber 87), nitrogen application and date of sowing; the date of sowing was coded as day of the wheat growing season starting from 15 October in Peshawar, Pakistan.

CONCLUSIONS AND RECOMMENDATIONS

This study confirms that planting wheat from 24th October-13th November maximizes production efficiency of wheat cultivar Khyber as compared to delay seeded condition. Similarly nitrogen fertilization at the rate of 130 kg ha^{-1} concluded best for obtaining maximum yield and yield components. Therefore, sowing of Khyber-87 in late October and early November under the effect of an optimum level of nitrogen (130 kg ha^{-1}) is recommended for the farmer community of the agro- climatic condition of Peshawar valley, Pakistan.

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