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GROWTH, YIELD AND NUTRIENT UPTAKE OF VARIOUS WHEAT CULTIVARS UNDER DIFFERENT FERTILIZER REGIMES

GHULAM MUSTAFA LAGHARI*, FATEH CHAND OAD*, SHAMASUDDIN TUNIO*, ALLAH WADHAYO GANDAHI*, MUZZAMMIL HUSSAIN SIDDIQUI**, ALLAH WADHAYO JAGIRANI*** and SONO MAL OAD****

* *Sindh Agriculture University, Tandojam – Pakistan.*
** *Faculty of Agriculture Rawalakot, University of AJK, Muzzafarabad – Pakistan.*
*** *Pakistan Agriculture Research Council, Islamabad – Pakistan.*
**** *Agriculture Research Station, RARC, Sakrand – Pakistan.*

ABSTRACT

Fertilizer use and management is of crucial importance in irrigated production systems of Pakistan to achieve high yield, which leads to an extensive removal of essential nutrients. Three wheat varieties (TD-1, T.J-83 and Mehran-89) were treated with nine levels of fertilizer (0-0-0, 60-60-00, 60-60-30, 120-60-00, 120-60-60, 180-60-00, 180-60-90, 240-60-00 and 240-60-120 NPK kg ha^{-1}) were set in randomized complete block design. Fertilizer application significantly enhanced growth, yield and nutrient uptake traits of wheat. Application of 120-60-60 NPK kg ha^{-1} to TD-1 recorded maximum tillers, spike length, grains spike^{-1}, biological yield, grain yield, harvest index, dry matter, leaf area index, crop growth rate and NPK uptake. Further increase in NPK rate had a non-significant response on these traits. However, application of 180-60-60 NPK kg ha^{-1} or higher fertilizer regimes produced tall plants, maximum nodes stem^{-1}, internode length, grain weight spike^{-1}, seed index, prolonged maturity days and higher lodging tendency in Mehran-89 and TJ-83.

Key Words: **Wheat, Nitrogen, Phosphorus, Potassium, Yield, Uptake, Lodging.**

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INTRODUCTION

Fertilizers constitute an integral part of improved crop production technology (Saifullah *et al*. 2002). The proper amount of fertilizer application is considered a key to the bumper crop production (Tariq *et al.* 2007). Nitrogen (N) is major factor limiting yield of wheat (Andrews *et al.* 2004). Optimum N management to wheat is important for maximum yield, optimum water utilization and minimum contamination to environment (Corbeels *et al*. 1999). There is need to reduce use of N fertilizer application and search for genotypes with greater N use efficiencies, either in a strict physiological or agronomic sense (Andrews *et al.* 2004). The efficiency of wheat cultivars to N use has become increasingly important to allow reduction in N fertilizer use without decreasing yield. Phosphorus is essential for enhancing seed maturity and seed development (Ziadi *et al*. 2008). Both P and K application favored tillering of wheat and reduced lodging in wheat (Liakas *et al.* 2001), improved photosynthetic activity and transport to the ripening grains. This resulted heavier grains (Zhang *et al.* 1999). With adequate application of phosphorus, 20% more grain yield of wheat can be obtained (Ascher *et al.* 1994). N and P uptake could be enhanced with increased P applications (Jiang *et al.* 2006). Different researchers recommended different P application rates. Chaturvedi (2006) found 28.5 kg P ha^{-1} as optimum for growth, plant height, tillers, grains spike^{-1}, 1000 grain weight, grain and straw yields. Jiang *et al*. (2006) observed 108 kg P ha^{-1} for higher leaf area index, tillers, ear bearing tillers and dry matter accumulation. Khalid *et al*. (2004) applied 45 kg P ha^{-1} in wheat and obtained maximum emergence, productive tillers, grain yield and biological yield. Potassium is a one of special significance because of its active role in bio-chemical functions of plant e.g. activating various enzymes, protein formation, carbohydrates and fat concentration, tolerance to drought and resistance to frost, lodging, pests and disease attack (Marschner, 1995). Thus K deficiency in soil may results in yield losses (Ali *et al*. 2008). Increase in cropping intensity and introduction of high yielding fertilizer responsive cultivars have resulted in a considerable drain of soil K reserves.

In the present day, intensive and high yield oriented agriculture, there is a negative K balance and soils are being mined for this essential element (Tan *et al*. 2005). Increased use of N without adding required K in soil has further aggravated K deficiency (NFDC, 2003) because K play important role in improvement of the growth indices. Increasing K amount in wheat grain increased dry matter, 1000-grain weight, tillers, K contents in plant,

plant height, protein contents and grain yield (Bahmanyar and Ranjbar, 2008). Potassium fertilizers also increased crop quality, plant nutrition, and increased protein content (Wang *et al.* 2003). Thus, deficiency of K in soils may result in decreased wheat yield (Tisdale *et al.* 2002). Potassium application also significantly helped uptake of N and P in straw as well as wheat grain (Saifullah *et al.* 2002). The interaction between N and K had positive significant effects on grain yield and quality (Wu *et al.* 2006). This study was, therefore, set to determine how fertilizer and wheat varieties can alter lodging incidence and subsequent yield expression. To understand better the effect of fertilizers and variety can provide better alternative management practices to farmers facing chronic low grain yield of wheat.

MATERIALS AND METHODS

The field investigations were conducted at Department of Agronomy, Sindh Agriculture University, Tandojam, Pakistan located at 25^{o}25'60'N 68^{o}31'60E, on clay loam soil, non-saline, low in organic matter (0.58-0.55%), available phosphorus (3.00-3.50 mg kg^{-1}) and high in exchangeable potassium (165 mg kg^{-1}). Three wheat varieties (TD-1, T.J-83 and Mehran-89) were treated with nine levels fertilizer (0-0-0, 60-60-00, 60-60-30, 120-60-00, 120-60-60, 180-60-00, 180-60- 90, 240-60-00 and 240-60-120 NPK kg ha^{-1}). The treatments were set in randomized complete block design in factorial arrangement.

Recommended land preparation operations were performed for equal distribution of irrigation and fertilizers. Sowing was done on November 15, 2008 with drill. First irrigation was applied after 20 days of sowing and subsequent irrigation were applied as per need of the crop and soil. Different levels of NPK were applied in the form of urea, di ammonium phosphate and sulphate of potash, respectively. All P, K with half N were applied during land preparation. The remaining half N was split applied with 2nd, 3rd and 4th irrigations. Weed management practices were done manually.

Plant Height

It was recorded at harvest by measuring 25 randomly selected plants from ground level to the top of the spike termination node and averaged for a single reading.

Nodes Stem^{-1}

The same sample was used for counting nodes per stem by measuring 25 randomly selected tillers.

Internode Length

Same sample was taken and internode length was measured through measuring tape and averaged for a single mean internode length in each experimental unit.

Tillers

Tiller number per unit area was counted in each row at different location of plot and values averaged for a single reading.

Spike Length

Spike length was measured from 25 randomly selected spikes at harvest from each plot through measuring tape.

Grains Spike^{-1}

It was counted from each experimental unit by manual threshing of 25 randomly selected spikes at harvest.

Grain Weight Spike^{-1}

Grain weight spike^{-1} was measured at harvest for all grains of 25 spikes, weighed on top loading digital balance and averaged for a single spike.

Maturity

Days to maturity were counted when complete loss of green color observed as difference between date of sowing till that date in each experimental unit.

Seed Index

1000 grains were weighed on an electronic balance after drying for unit seed weight.

Harvest Index

Harvest index was calculated as a ratio of grain yield to total biological yield.

Biological and Grain Yield

Biological and grain yield were recorded at two central rows harvested in each experimental unit. Subsequent sample was oven dried at 80^{o}C for maximum 36 hours to estimate dry matter yield.

Lodging

It was measured following the methods of Fischer and Stapper (1987); Rawson and Macpherson (2000) as: crop lodging from vertical (90^o) x % area lodged.

Leaf Area Index (LAI)

Leaf area index was calculated as ratio of the leaf surface area to the ground area occupied by a plant stand (Thomas and Winner, 2000). Leaf Area Index = Leaf area / ground area.

Crop Growth Rate (CGR)

Crop growth rate was calculated as plant's dry weight increase per unit of dry weight (Hunt, 1978). Crop Growth Rate = $(W_2–W_1)/(t_2–t_1)$ g m^{2}day^{-1}.

NPK Uptake

The plant N concentration was calculated by Kjeldahl Method (Jackson, 1958), P and K by Method 54a and 58a, respectively (US Salinity Lab. Staff, 1954). The obtained values of nutrient concentration were multiplied with total dry matter of plant.

Statistical Analysis

Two factors (wheat varieties and fertilizer levels) were analyzed in RCBD, factorial arrangement. Data were statistically analyzed with MSTATC software. The means were separated using LSD test ($P<0.05$) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of Varieties

In this study, wheat varieties differed significantly. Wheat variety TD-1 had significantly maximum tillers (370 m^2), spike length (12.70 cm), grains spike^{-1} (40.20), grain weight spike^{-1} (2.16 g), seed index (44.60 g), biological yield (9.70 t ha^{-1}), grain yield (4.27 t ha^{-1}), harvest index (42.90), dry matter (8.06 t ha^{-1}), leaf area index (2.80), crop growth rate (9.90 g m^2 day^{-1}) and the lowest maturity days (125). However, Mehran-89 had maximum plant height (88.60 cm), nodes stem^{-1} (5.10), internode length (13.20 cm) and higher lodging tendency (9.71%). The varietal uptake for NPK was non-significant (Table I). Previous results reported by Sharshar *et al.* (2000) and Sobh *et al*. (2000) found highest grain yield at optimum fertilizers and attributed more tillers, greatest spike length, grains per spike and heavier grain weight.

It was observed that the lodging tendency was more pronounced due to tallness and maximum internode length in Mehran-89 and TJ-83 compared to dwarf TD-1. Both varieties showed maximum lodging due to maximum internode lengths. Brancourt-Hulmel *et al*. (2003) also reported that new cultivars with shorter straw expressed higher harvest index with more consistent in yields due to relatively high tolerance for lodging, ability to produce more kernels from a given total above-ground biomass was the second factor, and thus the number of kernels per unit area had increased over time without alteration of the kernel weight. Hafner (2001) reported that most modern cereal cultivars have relatively short strong stems and transmit the aboveground forces to root, because most lodging occurs in wheat is believed to be root lodging. Berry *et al*. (2003) observed that changes in strength of the stem base and anchorage system have a large effect on lodging risk. Large differences amongst wheat varieties have been observed for lodging tendency (Berry *et al.* 2003). It is known that cultivars vary in number of leaves, nodes (Sagan *et al.* 1993), and tillers (Tràpani and Hall, 1996).

Table I *Growth, yield components and yield traits of wheat varieties under the influence of NPK levels*

Plant traits	LSD (5%)	Wheat varieties		
		TD-1	TJ-83	Mehran-89
Plant height (cm)	1.15	59.90c	71.60b	88.60a
Nodes stem^{-1}	0.09	4.20c	4.90b	5.10a
Internode length (cm)	0.16	9.16c	11.59b	13.20a
Tillers (m^{2})	5.21	370 a	333b	305c
Spike length (cm)	0.13	12.70a	10.90b	11.00b
Grains spike^{-1}	0.58	40.20a	35.30b	35.30b
Grain weight spike^{-1}	0.01	2.16a	1.80c	1.83 b
Seed index (1000 grain weight g)	0.52	44.60a	37.80c	38.30b
Days to maturity	1.15	125c	134b	142c
Biological yield (t ha^{-1})	0.15	9.70a	9.02b	9.12b
Grain yield (t ha^{-1})	0.63	4.27a	3.25b	3.33b
Harvest index	0.58	42.90a	35.20b	35.70b
Lodging (%)	0.10	2.62c	9.52b	9.71a
Dry matter (t ha^{-1})	0.15	8.06a	7.66b	7.69b
Leaf area index	0.09	2.80a	2.40b	2.50b
Crop growth rate(g m^{2} day^{-1})	0.23	9.90a	8.30b	8.20b
N-uptake (kg ha^{-1})	-	72.40	72.20	72.20
P-uptake (kg ha^{-1})	-	17.80	17.80	17.70
K-uptake (kg ha^{-1})	-	68.70	68.90	69.00

In each row, means followed by common letter are not significantly different at 5% probability level.

Effect of NPK Levels

Fertilizer rates significantly enhanced plant and nutrient uptake in wheat. Application of 120, 60 and 60 N, P and K kg ha^{-1} respectively significantly increased tillers (409 m^{2}), spike length (14.20 cm), grains spike^{-1} (47.60), grain weight spike^{-1} (2.5 g), seed index (47.6 g), biological yield (11.31 t ha^{-1}), grain yield (4.8 t ha^{-1}), harvest index (42.0), dry matter (10.2 t ha^{-1}), leaf area index (2.9), crop growth rate (10.2 g m^{2} day^{-1}), N uptake (94.2 kg ha^{-1}), P uptake (18.7 kg ha^{-1}), K uptake (95.5 kg ha^{-1}), low maturity days (132) and lodging (3.9%). Further increase in NPK showed non-significant response on these traits. However, application of 180-60-60 N-P-K kg ha^{-1} or higher fertilizer regimes recorded maximum plant height (84.2-84.7 cm), nodes stem^{-1} (5.3-5.4), internode length (12.9 cm), prolonged maturity (147-148 days) and lodging (9.0-15.0%) (Table II).

Table II *Effect of NPK levels on growth, yield components and yield traits of wheat*

Plant traits	NPK (kg ha^{-1})									
	LSD 5%	0-0-0	60-60-00	60-60-30	120-60-00	120-60-60	180-60-00	180-60-90	240-60-00	240-60-120
Plant height (cm)	1.98	47.2d	64.50c	64.70c	72.9b	73.1b	84.2a	84.5a	84.4a	84.7a
Nodes stem^{-1}	0.15	3.5d	3.92c	3.90c	4.9b	4.9b	5.3a	5.3a	5.4a	5.4a
Length of internodes (cm)	0.19	8.0e	9.86d	10.0d	10.97c	11.2b	12.9a	12.9a	12.9a	12.9a
Tillers (m^{2})	3.24	230f	268e	302d	329c	409a	408a	408a	329d	343c
Spike length (cm)	0.22	7.4g	8.70f	9.70e	12.5b	14.2a	14.2a	14.2a	11.2a	12.0a
Grains spike^{-1}	1.00	18.5g	26.70f	32.00e	41.5b	47.6a	47.6a	47.7a	33.9d	37.2c
Grain weight spike^{-1} (g)	0.04	0.79h	1.34g	1.70f	2.140e	2.5a	2.5a	2.5a	1.8d	1.9c
Seed index 1000 grain weight g	0.89	27.40f	33.60e	38.10 c	42.60b	47.6 a	48.0a	48.7a	37.5 d	38.5 c
Days to maturity	1.99	111f	118e	119e	131d	132c	148b	147b	147a	148a
Biological yield (t ha^{-1})	0.26	6.56f	7.38e	8.79 c	9.79b	11.3a	11.3a	11.4a	8.4d	8.5d
Grain yield (t ha^{-1})	0.61	1.95f	2.55e	3.23c	4.28b	4.8a	4.8a	4.9a	2.8 d	2.9d
Harvest index	1.00	29.5d	35.00c	37.0b	43.00a	42.0a	43.0a	43.4a	33.5c	34.2c
Lodging %	0.17	1.96i	3. 03g	2.77h	5.23e	3.9f	12.7b	9.0d	15.0a	11.8c
Dry matter (t ha^{-1})	0.27	5.06f	5.86e	6.41d	8.39b	10.2a	10.2a	10.3a	6.8c	6.8c
Leaf area index	0.16	1.87e	2.17e	2.46d	2.77b	2.9a	2.9a	2.8a	2.5c	2.3c
Crop growth rate (gm^{2} day^{-})	0.69	7.4e	7.8d	8.5c	9.8b	10.2ab	10.0a	8.5ac	7.8d	6.2f
N-uptake (kg ha^{-1})	1.51	19.70e	39.9d	44.60c	73.7b	94.2a	94.3a	94.6a	94.7a	94.9a
P-uptake (kg ha^{-1})	0.44	10.3b	18.6a	18.70a	18.6a	18.7a	18.7a	18.7a	18.7a	18.8a
K-uptake (kg ha^{-1})	1.94	39.6e	46.0d	65.0b	53.2c	95.5a	64.4b	95.5a	65.5b	95.6a

In each row, means followed by common letter are not significantly different at 5% probability level.

In this study, the main reason behind poor grain yield can also be attributed to lowest NPK uptake in plants, which ultimately recorded minimum values of all morphological traits. In Pakistan, nitrogen fertilizer recovery is about 30%, which is quite low (Byerlee and Siddiq, 1994) and is lower than the other developing countries (Ortiz-Monasterio *et al.* 1994). It has been reported that 7 tons ha^{-1} of wheat crop with a 40% harvest index removes approximately 207 kg N ha^{-1} in above-ground biomass (Hobbs *et al.* 1998). In other study, Rice *et al*. (1995) further reported that N requirement of wheat cultivars is influenced by yield.

Nitrogen efficiency in wheat can be improved with optimum fertilizer rate application and management techniques to optimize N application for wheat yields. This would to avoid leaching to the underground water (Gürbüz *et al.* 2005). It is commonly perceived by the farming community that high rates of N increase lodging by making plants taller. However, increasing applications of N fertilizer from 160 to 240 kg ha^{-1} increased wheat height by 2 to 3% (Crook and Ennos, 1995). The highest N supply always increases dry weight and length of the basal internodes (Berry *et al.* 2000). Contrary to that deficient plants had a lower lodging risk might be due to more reduction in weight of shoot and ear than strength of the stem base. High levels of N reduced the strength of the stem (Berry *et al.* 2000) and crop showed lodging tendency (Varga, 1980).

In this study, application of K and P to wheat significantly enhanced yield, yield components and reduced lodging. The deficiency of K resulted decrease in yield (Ali *et al.* 2005). Positive response of wheat to K application increased tillering (Tahir *et al.* 2003), plant height (Ashraf, 1986), grains $spike^{-1}$ seed index (Roy *et al.* 1990) and grain yield (Tisdale *et al.* 2002). Regarding P, previous reports shows that better yields in wheat could be achieved 20% more with adequate application of P (Ascher *et al.* 1994). P uptake and accumulation can be enhanced with increasing P applications which resulted highest leaf area index, tillers $plant^{-1}$, ear-bearing tillers, dry matter accumulation, grain yield and P uptake (Jiang *et al.* 2006). If soil is deficient in P, the response of crop to N is reduced (Senigagliesi *et al.* 1983).

This study is supported by Liakas *et al.* (2001) that increasing rates of K and P favored tillering in wheat and reduced lodging. Zhang *et al.* (1999) also reported that addition of P increased tiller numbers, improved photosynthetic activity, enhanced transport to grain ripening which resulted heavier grains, increased grain number and 1000 grain weight.

Interactive Effect

Interactive effect of varieties and N had significant effect ($P<0.05$) (Table III - V). Application of N-P-K at the rate of 120-60-60 kg ha^{-1} to TD-1 had maximum tillers (453 m^2), spikes length (15.30 cm), grains $spike^{-1}$ (50.80), grain weight spike (2.81 g), seed index (51.90 g), biological yield (11.86 t ha^{-1}), grain yield (5.72 t ha^{-1}), harvest index (48.20), dry matter (10.32 t ha^{-1}), leaf area index (3.15) and crop growth rate (10.60 g m^2 day^{-1}). Maximum plant height (100.00 cm), nodes $stem^{-1}$ (5.80), internode length (14.69 cm), were found in Mehran-89 supplied with 180-60-00 NPK kg ha^{-1}. Further increase in fertilizer rate to crop showed a non-significant increase in the values. However, application of higher fertility regimes (240-60-00 NPK kg ha^{-1}), increased lodging (20.18%) and prolonged maturity (151) in Mehran-89.

Increasing fertilizer rate increased NPK nutrient content in wheat varieties. However, differences were non-significant and NPK content ranged between 0.38-1.44%, 0.18-0.32% and 0.59-1.44%, respectively. A non-significant increase in NPK uptake was also observed in plots fertilized with different fertility levels. The uptake of N ranged between 18.60-95.30, P 10.10-19.20 and K 39.00-95.70 kg ha^{-1} (Table III). These results are in line with study of Loes (2003). Nitrogen requirement is therefore related to total N removed by the crop (Osaki *et al.* 1991). Feil (1992) indicated that cultivars producing large amounts of biomass seemed to have an efficient nutrient uptake, which could decrease total NUE of modern cultivars. In this study lowest values of crop traits were obtained as fertilizer rates decreased beyond 120-60-60 NPK kg ha^{-1}, and/ or further increase in fertilizer rate had a non-significant increase in the crop parameters. This can be ascribed that less values of yield components and nutrient uptake resulted less yield by wheat cultivars. These results agree with those obtained by Sharshar *et al.* (2000) that optimum NPK fertilizer enhanced growth and yield and nutrient uptake in wheat. Nitrogen alters plant growth more than any other mineral nutrient. In wheat suboptimal supply of N can dramatically reduce dry matter and subsequently grain yield (Nielsen and Halvorson, 1991), while oversupply of N may cause lodging, disease incidence and lower grain quality (Beuerlein *et al.* 1992).

CONCLUSION AND RECOMMENDATIONS

Application of NPK at the rate of 120-60-60 kg ha^{-1} was optimum fertilizer treatment for growth, yield and nutrient uptake. Further increase in NPK levels had a non-significant response. Among the wheat varieties, TD-1 was efficient in nutrient uptake, high yielding and tolerant to lodging under the climatic conditions of Tandojam on clay loam soil having low soil N content.

Table III *Growth, yield components and yield under the interactive effect of varieties x NPK levels*

Varieties x	NPK (kg ha-1)	Plant height (cm)	Nodes (stem-1)	Internode Length (cm)	Tillers (m2)	Spike length (cm)	Grains (spike-1)	Grain weight spike-1 (g)
TD-1	00	34.50i	3.01i	5.11i	241n	8.30j	22.50j	0.85r
	60-60-00	49.10g	3.30h	7.34h	296j	10.10h	30.40h	1.500
	60-60-30	48.00g	3.30h	7.69h	336fg	11.20f	33.90ef	1.81j
	120-60-00	59.00f	4.40de	8.72g	396c	13.90b	44.90b	2.22g
	120-60-60	59.00f	4.40de	8.92g	453a	15.30a	50.80a	2.81a
	180-60-00	72.40d	4.70d	11.07e	443a	15.30a	50.90a	2.81a
	180-60-90	72.90d	4.70d	11.11de	446a	15.30a	50.90a	2.84a
	240-60-00	72.30d	4.70d	11.21de	348ef	12.10d	37.10d	2.28f
	240-60-120	71.90d	4.70d	11.31de	367d	12.70c	40.30c	2.36d
TJ-83	00	42.70h	3.70g	8.73g	237n	6.70m	16.20k	0.76s
	60-60-00	65.90e	4.00f	10.19f	261lm	8.00jk	26.40i	1.22q
	60-60-30	66.70e	4.10f	10.34f	297j	8.90i	30.20h	1.63n
	120-60-00	74.00d	5.10c	11.57cde	303.ij	11.80de	39.40c	2.07i
	120-60-60	73.80d	5.10c	11.61cd	414b	13.70b	45.80b	2.32e
	180-60-00	80.20c	5.40b	13.02b	416b	13.70b	45.80b	2.39c
	180-60-90	80.10c	5.40b	13.01b	412b	13.70b	45.90b	2.44b
	240-60-00	79.80c	5.40b	12.92b	323gh	10.70g	32.50fg	1.67lm
	240-60-120	80.70c	5.50b	12.88b	339fg	11.60e	35.40de	1.74k
Mehran-89	00	64.30e	3.70g	10.25f	213go	7.20l	16.80k	0.77s
	60-60-00	78.60c	4.40e	12.04c	246fm	7.90k	23.40j	1.26p
	60-60-30	79.30c	4.40e	12.05c	274 okl	9.00i	31.90gh	1.64mn
	120-60-00	85.60b	5.10c	12.60b	289jk	11.70de	40.00c	2.12h
	120-60-60	86.60b	5.10c	12.94b	360de	13.60b	46.00b	2.39c
	180-60-00	100.00a	5.80a	14.69a	364de	13.70b	46.00b	2.41c
	180-60-90	100.50a	5.90a	14.70a	365de	13.70b	46.10b	2.45b
	240-60-00	101.20a	5.90a	14.76a	316hi	10.70g	32.00fg	1.70l
	240-60-120	101.40a	5.90a	14.76a	323hh	11.70de	35.70d	1.78k
SE		1.24	0.10	0.17	5.62	0.14	0.63	0.01
LSD (5%)		3.46	0.27	0.47	15.64	0.39	1.74	0.03

Means followed by common letter are not significantly different at 5% probability level.

Table IV *Growth, yield components and yield under the interactive effect of varieties x NPK levels*

Varieties x	NPK (kg ha-1)	Seed index 1000 grain weight (g)	Maturity (days)	Biological yield (t ha-1)	Grain yield (t ha-1)	Harvest index	Lodging (%)	Dry matter (t ha-1)
TD-1	00	30.10j	102m	6.54i	2.05i	30.90f	0.78p	5.12g
	60-60-00	36.90g	106l	7.45h	2.74g	36.80c	0.98p	5.99f
	60-60-30	42.60e	106kl	8.89 ef	3.78e	42.50b	1.06p	6.67e
	120-60-00	46.90b	121h	10.32c	5.03b	48.70a	3.24m	8.98b
	120-60-60	51.90a	121h	11.86a	5.72a	48.20a	2.39o	10.32a
	180-60-00	52.50a	141e	11.87a	5.68a	47.90a	4.34jk	10.32a
	180-60-90	53.10a	141e	11.88a	5.73a	48.20a	2.44o	10.34a
	240-60-00	43.30de	142d	9.25de	3.82e	41.30bc	5.43i	7.37d
	240-60-120	44.30cd	142cd	9.26de	3.88e	41.90bc	2.94n	7.40d
TJ-83	00	25.2l	111l	6.57i	1.87i	28.50g	2.54o	5.10g
	60-60-00	32.10i	120jk	7.32h	2.43h	33.20e	4.04k	5.78f
	60-60-30	35.70gh	120j	8.72f	2.91fg	33.40e	3.61l	6.28ef
	120-60-00	40.10f	130g	9.51d	3.88e	40.80bc	6.19h	8.05c
	120-60-60	45.20bc	130fg	11.03b	4.40d	39.90c	4.63j	10.16a
	180-60-00	45.60bc	147fd	11.03b	4.46cd	40.40c	16.88c	10.18a
	180-60-90	46.30b	148bcd	11.04b	4.56cd	40.40c	12.16g	10.19a
	240-60-00	34.20h	148bc	7.97g	2.35h	29.50fg	19.50b	6.56e
	240-60-120	35.30gh	148b	8.00g	2.44h	30.50f	16.07e	6.61e
Mehran-89	00	26.80 k	121i	6.58i	1.91i	29.20fg	2.57o	4.96g
	60-60-00	31.70i	129hi	7.35h	2.48h	33.70e	4.08k	5.80f
	60-60-30	35.90gh	132h	8.77ef	2.99f	34.10e	3.65l	6.30ef
	120-60-00	41.00f	144fg	9.54 d	3.94e	41.30bc	6.26h	8.29c
	120-60-60	45.60bc	144f	11.13b	4.53cd	40.70bc	4.66j	10.20a
	180-60-00	45.70bc	155b	11.15b	4.53cd	40.70bc	17.08c	10.23a
	180-60-90	46.70b	151b	11.23b	4.66c	41.50bc	12.48f	10.28a
	240-60-00	35.00h	151a	8.10g	2.42h	29.80fg	20.18a	6.62e
	240-60-120	36.00gh	154a	8.23g	2.49h	30.30fg	16.45d	6.66e
SE		0.56	0.64	0.163	0.68	0.63	0.11	0.169
LSD (5%)		1.55	3.46	0.454	0.19	1.74	0.30	0.471

Means followed by common letter are not significantly different at 5% probability level.

Table V *Growth, yield components and yield under the interactive effect of varieties x NPK levels*

Varieties x NPK (kg ha^{-1})		LAI	CGR(gm^2 day^{-1}	N (%)	P (%)	K (%)	N uptake	P uptake	K uptake
TD-1	00	2.11g	7.90fghij	0.41	0.21	0.76	20.70	10.40	39.00
	60-60-00	2.42ef	8.60efg	0.67	0.32	0.76	40.20	18.70	45.70
	60-60-30	2.68d	8.70ef	0.66	0.29	0.97	44.30	18.90	64.80
	120-60-00	2.95bc	10.30bc	0.83	0.21	0.59	74.20	18.60	52.90
	120-60-60	3.15a	10.60a	0.91	0.18	0.93	93.80	18.40	95.40
	180-60-00	3.15a	11.10a	0.91	0.18	0.63	94.20	18.60	64.80
	180-60-90	3.04a	9.20de	0.91	0.18	0.92	94.50	18.70	95.30
	240-60-00	2.85c	8.50efg	1.29	0.25	0.88	94.80	18.60	65.10
	240-60-120	2.45bc	6.00m	1.29	0.25	1.29	95.30	18.90	95.60
TJ-83	00	1.74i	7.20jkl	0.39	0.20	0.79	19.60	10.10	40.30
	60-60-00	2.05g h	7.60hijk	0.68	0.32	0.80	39.40	18.50	46.20
	60-60-30	2.33f	8.40fg	0.72	0.29	1.04	45.40	18.30	64.90
	120-60-00	2.64d	9.60cd	0.92	0.23	0.66	73.70	18.60	52.80
	120-60-60	2.88bc	10.00bc	0.93	0.19	0.94	94.00	18.90	95.50
	180-60-00	2.85bc	10.20bc	0.93	0.19	0.63	94.20	18.70	64.20
	180-60-90	2.72bc	8.20fgh	0.93	0.18	0.94	94.50	18.70	95.60
	240-60-00	2.31ef	7.80ghij	1.44	0.28	1.00	94.50	18.70	65.90
	240-60-120	2.10e	6.03m	1.43	0.29	1.44	94.60	19.20	95.40
Mehran-89	00	1.74i	7.00kl	0.38	0.22	0.80	18.60	10.20	39.60
	60-60-00	2.03h	7.40ijkl	0.69	0.32	0.79	40.10	18.70	46.00
	60-60-30	2.37ef	8.20fgh	0.70	0.30	1.03	44.20	18.80	65.20
	120-60-00	2.71d	9.70cd	0.90	0.23	0.66	73.20	18.60	53.90
	120-60-60	2.91bc	10.00bc	0.93	0.18	0.93	94.80	18.50	95.50
	180-60-00	2.88bc	10.20bc	0.92	0.18	0.63	94.70	18.80	64.10
	180-60-90	2.69b	8.10fghi	0.92	0.18	0.93	94.90	18.50	95.50
	240-60-00	2.34ef	7.30jkl	1.43	0.29	0.99	94.80	18.70	65.50
	240-60-120	2.25e	6.70lm	1.42	0.27	1.44	94.70	18.50	95.70
SE		0.10	0.25				0.94	0.34	1.26
LSD (5%)		0.28	0.70	-	-	-	-	-	-

Means followed by common letter are not significantly different at 5% probability level.

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