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STUDIES ON RELATIONSHIP BETWEEN COLEOPTILE LENGTH AND GROWTH ATTRIBUTES OF DIVERSE WHEAT GENOTYPES TO MOISTURE

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Abstract

Selection of adoptable germplasm along with adequate soil moisture availability is key factor for maximizing plant growth and yield, particularly in rainfed environment. Keeping the impact of huge rainfed belt of Khyber Pakhtunkhwa, forty genotypes of wheat which include four local landraces having varied genetic makeup were collected from different agro-ecological zones of Pakistan and tested in the laboratory for coleoptile, shoot, and root length. It was observed that coleoptile length had positive correlation with root length ($R^2 = 0.1874$ $p<0.05$) and shoot length ($R^2 = 0.4455$ $p<0.05$). A positive and significant correlation ($R^2 = 0.5285$ $p<0.05$) was noted between root and shoot length as well. The coleoptile length was maximum in wheat NIFA-Insaf while minimum in Faislabad-2008. Thereafter five different moisture levels (100%, 80%, 60%, 40% 20% of total field capacity [TFC]) on two wheat genotypes ("NIFA-Insaf" and "Faisalabad-2008" bearing long and short coleoptile, respectively observed from laboratory experiment) were tested in field to examine the effectiveness of multiple moisture levels. These moisture levels at various capacities (%) were maintained in pots by applying measured quantity of water when it reached below their respective pre-determined lower limits of specific moisture range during complete growth time. Various growth and yield parameters were significantly affected, both by wheat genotypes and moisture levels. At availability of 100% soil moisture boosted plant growth and development, which ultimately caused different traits to perform at their maximum capacities. Study showed the maximum grain yield of 5554.4, 5378.2 kg ha^{-1} for respectively by interactive combination of NIFA-Insaf at 100% TFC. Likewise, the use of 80% TFC also gave better results for NIFA-Insaf, which might be due to better utilization of moisture and other resources made available because of longer coleoptile. As regards genotypes, 'Faisalabad-2008' (having shorter coleoptile) with 100% moisture but a remarkable yield reduction was observed with a decrease in irrigation. However, under moisture reduced-environments, NIFA-Insaf performed better than Faisalabad-2008.

Key words: Germplasm, Yield, Rainfed environment, Local landraces.

Introduction

Most of the cultivated area in Pakistan falls under arid and semi-arid conditions where wheat is an imperative crop grown successfully. A remarkable yield loss has been noticed when wheat crop is grown on arid lands. Among different yield limiting factors, moisture stress is key issue in arid as well as semi-arid regions (Ranjana *et al*, 2006). According to an estimate, 30% losses occur in production due to unavailability of water for irrigation (Uddin *et al.*, 2016; Islam *et al.* 2016; Sarker *et al.*, 2018). It is also a presumption that food crops' requirements will approximately be doubled the globe 2050 (Tilman *et al.*, 2011). So, enhanced productivity is needed to meet estimated demand for food, but availability of freshwater agriculture is reducing (Cai & Rosegrant, 2003). The lack of adequate water sources also leads to extensive use of groundwater for irrigation in most parts of the world, which has caused water level to fall and created multiple additional environmental hazards (Li *et al.*, 2008). Earlier, findings revealed that water-use-efficiency (WUE) is a crucial functional character responds the crops to preserve moisture, in water-limited areas, because this facilitates drought resistance followed by potential yield (Fang *et al.*, 2010). So far, there is an imperative need to develop irrigation water management over-exploitation of groundwater and maintain sustainable crop production (Zhang *et al.*, 2003). To overcome water scarcity for irrigation, it is important to adopt such practices to improve water consumption with limited available moisture. Such techniques comprise micro rainwater harvesting and storage of water, both techniques can boost the WUE of wheat (Ren *et al.*, 2008). WUE (water use efficiency) is considered a component of drought stress in wheat, therefore, the evolution of wheat that use available water more efficiently and ability to tolerate drought is a leading goal for increasing yield in drought prone environments (Fotovat *et al.*, 2007). WUE includes identification of water stress tolerant wheat genotypes. This activity would cause innovative utilization of irrigation water by preserving moisture at growth-tolerant phases, while maximizing yield capacity and identification of tolerant wheat genotypes to water stress (Evans & Sadler, 2008). Soil moisture content is essential for germination of seed and seedling growth but, under semi-arid Mediterranean environments, moisture in the top layer of soil is limited and seeds may be exposed to frequent dehydration. Under such conditions, deep sowing could ensure adequate seed-zone moisture before germination and thereby enhance seedling establishment (Richards *et al*., 2010; Mohan *et al*., 2013; Rebetzke *et al*., 2014). It is requisite to introduce high yielding of wheat which have resistant to drought and harsh climatic conditions. Since germination is the primary stage of growth and known to be a sensitive to water deficit, seed vigor and coleoptile length play a fundamental role in the establishment of crop plants (Khakwani *et al*., 2012). In rain-fed areas, the selection of wheat having longer coleoptile is an important element for obtaining maximum emergence as well as vigorous plant growth. This is an important practice for handling climate irregularity that helps farming community to grow crops at optimum time when wattar (moisture) condition is not in the layer. During early growth stage of a plant, coleoptile is a protecting sheath that protects emerging sprout as it arises from soil and supports to reaching the soil surface (Trethowan *et al*., 2012). It is a prime character for genotypes grown in arid regions where seeds are sown deeper than usual to reach moist soil. Soil conditions are so specific that only genotypes possessing very long coleoptiles can be grown even though these are outdated. Most of the landraces grown in such areas possess a coleoptile length of about 10 cm (Schillinger *et al*., 1998; Bai *et al*., 2004).

Currently, semi-dwarf is cultivated in the world due to the intensive use of dwarfing genes Rht-D1 and Rht-B1 which shorten both plant height and coleoptile length (Knopf *et al*., 2008; Miedaner & Voss, 2008). Less widespread gene Rht8 also conditions wheat dwarfing but has no negative impact on coleoptile length. Possessing longer coleoptiles generally have faster emergence and improved early vigor (Rebetzke *et al*., 2005). Longer coleoptiles provide greater seedling vigor, better competition with weeds, early crop establishment, more efficient soil water use, and better penetration through soil crust (Condon *et al*., 2004; Rebetzke *et al*., 2007). Since the exploration of genetic variation among the genotypes is useful in arid and semiarid regions.

The selection of wheat genotypes that could resist drought stress followed by increased yield a major challenge for breeders last 50 years (Lopez, 2003). During the current studies, considering low moisture/ water scarcity status in rain fed areas, about 40 diversified wheat genotypes were collected from different research institutes all over the country and tested for their coleoptile length under laboratory conditions, thereafter among those genotypes, two (with highest and lowest coleoptile) were selected and their performance at variable moisture under field conditions.

Material and Methods

In the two experiments were arranged to screen out diverse genotypes of wheat their coleoptile length and to examine the growth and development of wheat genotypes having variable coleoptile length under different moisture levels. The first experiment 40 genotypes including local landraces from different agro-environmental regions of the country were collected and tested in the laboratory for their germination and growth traits. Seeds of was soaked in petri dishes containing (Whatman paper) and tap water was used as a moisture source. Fungicide Topsim-M was applied @ 2 g kg^{-1} seed to protect against diseases. The parameters studied were coleoptile length, root length and shoot length. The data were recorded using the standard procedure and were subjected to analysis of variance techniques using a completely randomized design (Steel *et al*., 1997). The treatment means were using Tukey's HSD test (Black, 2011). Relationship was established using correlation and linear regression.

The second experiment two genotypes of wheat viz. Faisalabad-2008 NIFA-Insaf with shortest and longest coleoptile respectively lab experiment-1 were different moisture levels field conditions a randomized block design (RBD) with split-plot layout and three replications. Genotypes were in the main plot, whereas different irrigation levels (100%, 80%, 60%, 40% & 20% of total field capacity [TFC]) were considered in sub-plots to examine the effectiveness of multiple moisture frequencies. Experiment, plastic pots (with 4300 cm^2 area/pot) were arranged and each pot was filled with 14 kg clay loam soil having homogenous characters. Certified seed of tested genotypes was sown using the dibbling method (3 seeds/hill and 4 hills/pot). After germination, one healthy seedling was allowed in each hill to grow, whereas others were carefully uprooted. Gravimetric method (weight bases) was used to maintain water level (%) and pot weight (soil and water). Moisture levels at various capacities (%) were maintained in pots by applying the measured quantity of water, when it reached below their respective pre-determined lower limits of specific moisture range throughout the experiment. Data on various growth and yield parameters including the number of fertile tillers per pot^{-1}, grains spike^{-1}, 1000-grains weight (g), and grain yield (kg ha^{-1}) were noted. Details of experimental treatments were as under.

Detail of treatments

Main plots (cultivars)		Sub-plot (Moisture levels)		
			Pot weight (soil + water)	**Total field capacity (TFC)**
V_1	NIFA-Insaf	L_1	16.00 kg (14 kg soil + 2.00 kg water)	100 %
		L_2	15.60 kg (14 kg soil + 1.60 kg water)	80 %
		L_3	15.20 kg (14 kg soil + 1.20 kg water)	60 %
V_2	Faisalabad-2008	L_4	14.80 kg (14 kg soil + 0.80 kg water)	40 %
		L_5	14.40 kg (14 kg soil + 0.40 kg water)	20 %

Table 1. Root, shoot and Coleoptile length (cm) of wheat genotypes under laboratory conditions.

Wheat genotypes	Root length	Shoot length	Coleoptile length
Faisalabad-2008	17.31 e-h	21.45 e-i	2.25 p
AARI-2011	16.73 e-j	23.83 cde	3.11 c-g
TD-1	20.27 b-e	17.26 jkl	2.80 e-n
Ujala-2016	15.69 f-k	21.74 e-i	2.77 e-n
Gandum-1	20.21 b-e	21.24 e-i	3.24 cd
Takbeer	13.04 i-n	23.89 cde	2.88 d-l
AAS-2011	23.61 ab	25.88 bcd	2.81 e-n
Bakhtawar-92	17.13 e-i	21.19 e-i	2.87 d-l
Chakwal-50	8.20 op	20.44 e-k	2.61 i-p
Pirsabak-2013	18.03 d-g	17.10 jkl	2.29 op
Local Damani	12.79 j-n	18.17 i-l	2.71 g-n
Zam-04	16.99 e-i	19.30 g-l	2.69 h-o
Gomal-8	7.39 p	19.60 g-l	2.84 d-m
Bhakkar-2002	17.14 e-i	18.84 h-l	2.44 m-p
Tijaban-10	17.77 d-g	22.73 d-g	2.56 j-p
Chakwal-97	10.42 l-p	22.26 e-h	2.68 i-o
Bathoor-2008	20.30 b-e	23.31 def	3.00 d-i
Fakhr-e-Sarhad	19.41 c-f	22.17 e-h	2.53 l-p
Pakhtunkhwa-2015	26.41 a	22.07 e-h	2.55 k-p
Pirsabak-2015	9.12 nop	16.94 jkl	2.60 i-p
Local Marwatwal	16.85 e-j	27.19 bc	2.76 f-n
Shalkot	14.41 g-l	20.35 e-k	3.09 c-h
Millat-2011	10.16 m-p	16.41 l	2.44 m-p
Pirsabak-2004	13.39 h-m	19.60 g-l	2.47 l-p
Shahkar-2013	20.02 b-e	23.40 de	3.14 c-f
Hashim-8	15.31 f-k	19.20 g-l	2.56 j-p
Local Mexi	10.90 l-p	16.86 kl	2.42 nop
NIFA-Insaf	17.69 d-g	27.57 ab	5.59 a
NIFA-Lalma	17.41 e-h	20.88 e-i	2.72 g-n
Pakistan-13	12.02 k-o	19.77 f-l	3.25 cd
Pirsabak-2005	10.30 l-p	17.02 jkl	2.44 m-p
NARC-09	21.56 bcd	20.55 e-j	3.79 b
Local Bhakkar	20.38 b-e	30.96 a	3.50 bc
Tatara	13.13 i-n	26.13 bcd	3.19 cde
NIFA-Aman	10.03 m-p	19.66 g-l	2.63 i-p
Pirsabak-2008	23.54 abc	21.72 e-i	2.41 nop
Fareed-06	27.12 a	28.43 ab	2.85 d-m
Lasani-2008	19.42 c-f	23.82 cde	2.97 d-k
TJ-83	16.36 e-j	21.87 e-h	2.97 d-j
Galaxy-2013	18.25 d-g	23.57 de	2.48 l-p
LSD$_{0.05}$	**4.149**	**3.610**	**0.414**

Means are significant at 5% probability level

Results and Discussion

Coleoptile length (cm): Data recorded for coleoptile length are presented in (Table 1). It was observed that wheat genotype NIFA-Insaf showed largest coleoptile of which was tailed by 3.79 cm and 3.50 cm NARC-09 and Local Bhakkar respectively. Similarly, Pakistan-13, Gandam-1, Tatara, Shahkar-2013, Shalkot, Lasani-2008 and Bakhtawar-92 recorded with 3.25, 3.24, 3.19, 3.14, 3.09, 2.97 and 2.87 cm respectively and showed the similarity in their coleoptile length. Amongst evaluated NIFA-Lalma, Chakwal-50, and Pakhtunkhwa-2015 medium coleoptile length (2.72 cm, 2.61 cm, and 2.55 cm, respectively). The shorter coleoptiles of 2.29 cm noted Pirsabak-2013 which was at par with Faisalabad-2008 (2.25cm). It was further observed that coleoptile length was positively correlated with root length ($R^2 = 0.1874$ $p<0.05$) and shoot length ($R^2 = 0.4455$ $p<0.05$). Relationship between the coleoptile length with root length and shoot length shown in (Figs. 1 & 2). Earlier research findings of Trethowan, (2001) revealed that the coleoptile was highly allied with seed mass ($r^2 = 0.53$, $P<0.01$). grain affected the coleoptile and coleoptile comparing the dissimilarity (Botwright *et al.*, 2001). Rebetzke *et al.* (2007) found that wholly wheat which were semi-dwarf emerged unwell when sown deeper because such have gibberellins inside, which reduces cell enlargement and ultimately results in reduced early leaf expanse as well as reduced coleoptiles because of Rht-B1b dwarfing genes. Two contender genes viz. gibberellin C_{20} oxidase 1 and α-Expansion, which play substantial expansion of cell wall in newly growing tissues coleoptile (Singh *et al.*, 2015). Earlier findings revealed that choice of genotypes having longer coleoptile is a major factor for enlightening emergence, suppressing weeds and wheat yield (Murphy *et al.*, 2008). Rosyara *et al.* (2009) reported that high seedling vigor and larger coleoptile are necessary for early formation and afterward sophisticated grain yield of wheat in different dry regions. Subsequently elongated coleoptile essential causal factor for better-quality vigor decreases evaporative moisture loss by establishing early canopy expansion (Serban, 2012). Hence, Singh *et al.* (2010) underscored on the choosing longer coleoptile's wheat for sanitizing development and protects against various climatic variations. Narayanan *et al.* (2014) that choice of those which have deeper and prolific system of roots is more effective because over-all root and coleoptile length expresses a encouraging linear affiliations.

Root length (cm): Wheat Fareed-06 had longest roots (27.12 cm), showed non-significant difference from Pakhtunkhwa-2015 (26.41 cm) (Table 1). In the same way, root length 23.61cm, 23.54cm, 21.56cm, 20.38cm, 20.24cm AAS-2011 in Pirsabak-2008, NARC-09, Bhakkar (landrace), respectively tailed these selections with least difference. Likewise, intermediate length of roots 17.41cm, 17.31cm, 16.99cm, 15.31cm, 14.41cm, 13.04cm 12.02cm were recorded by NIFA-Lalma, Faisalabad-2008, Zam-04, Hashim-2008, Shalkot, Takbeer akistan-13 respectively. Shorter roots (17.39 & 8.20cm) were measured for Gomal-8 and Chakwal-50 respectively. Maximum root extension in different genotypes could be credited to their heritable character and holding enough food material which, upon development, utilize it for improved root and shoot development. These fallouts supported to Sanguineti *et al.* (2007) who informed length of roots and weightiness are primarily controlled with unalike group of genes. Similarly linear positive relationship was found between the coleoptile and root length. Tomar *et al.* (2016) while evaluating root images through WinRhizo Tron root scanner testified that drought tolerant species have dense root system and have lengthier depth whereas drought sensitive cultivars have higher horizontal root spread and not as much of depth.

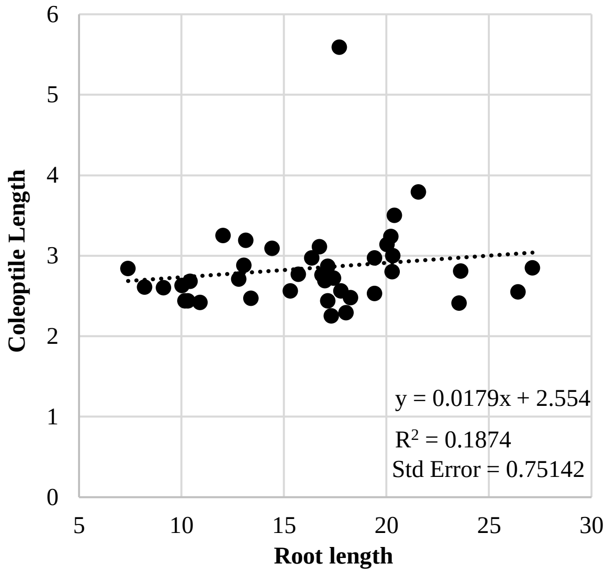

Fig. 1. Correlation of root length with coleoptile length.

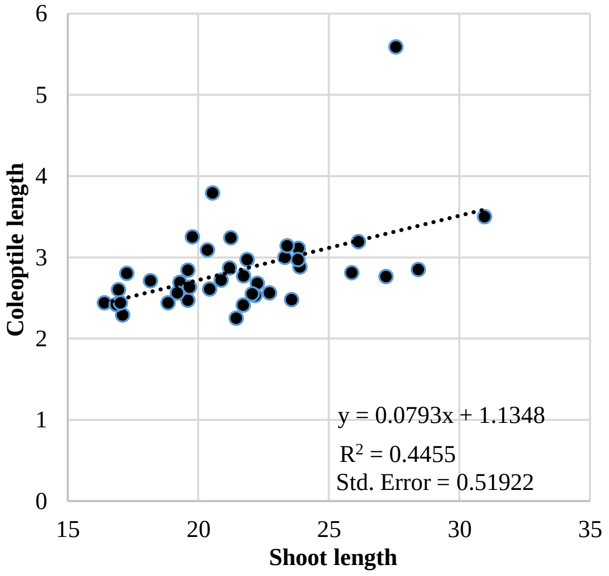

Fig. 2. Relationship between shoot length and coleoptile length.

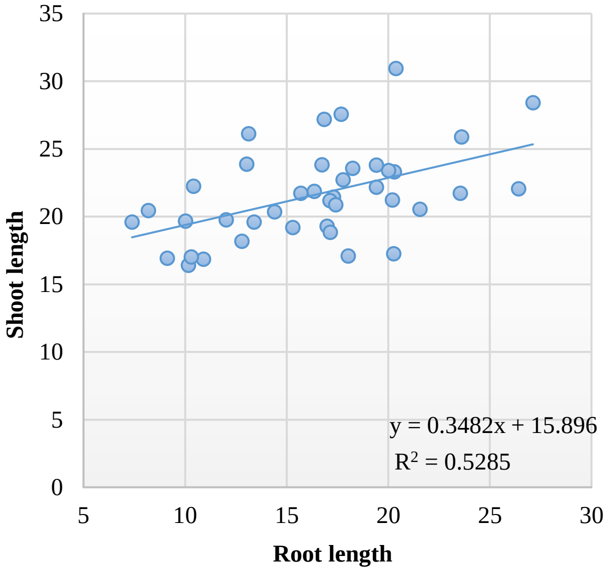

Fig. 3. Relationship between root length and shoot length.

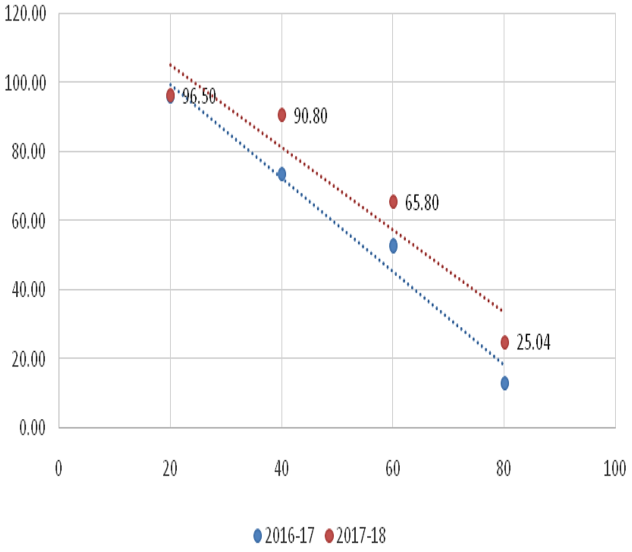

Fig. 4. Reduced yield (%) in comparison to 100% total field capacity, during two years.

Shoot length (cm): Genotype Local Bhakkar recorded shoots (30.96 cm), however, it was same in performance with wheat genotypes Fareed-06 & NIFA-Insaf having shoot length of 28.43cm and 27.57cm and found significantly larger shoots than all other cultivars (Table 1). Similarly, most of the genotypes viz. Tatara, AAS-2011, Takbeer, AARI-2011, Lasani-2008, Galaxy-2013, Shahkar-2013, Bathoor-2008, Tijaban-10 have shoot length 26.13 cm, 25.88 cm, 23.89 cm, 23.83 cm, 23.82 cm, 23.57 cm, 23.40 cm, 23.31 cm & 22.73 cm respectively found statistically similar. Other genotypes i.e. Ujala-2016, Ganum-1, NARC-09, Pakistan-2013, Bhakkar-2002, TD-1, Pirsabak-2005 had medium shoot length 21.74 cm, 21.24 cm, 20.55 cm, 19.77 cm, 18.84 cm, 17.26 cm and 17.02 cm respectively. Shortest shoots 16.41 cm were calculated in (Millat-2011). Tallest shoots in different genotypes may be due to their genetic configuration which perform vital role in the development of root and shoot. Ahmad *et al.* (2013) found that shoot & coleoptile length presenting positive relationship with root length. Length of shoot has also positive connection with coleoptile length and seedling vigor. During the current study correlation between shoot length and root length was found positive ($R^2 = 0.5285$ $p<0.05$). The relationship is shown in (Fig. 3).

Fertile tillers (pot^{-1}): Highest number of fertile tillers (13.90 & 13.10) was produced by NIFA-Insaf, while Faisalabad-2008 produced the lowest tillers (12.55 & 11.75), respectively during both cropping seasons (Table 2). In case of different moisture levels, significantly maximum tillers' quantity (20.00 & 19.62) was recorded when sowing was done at 100% field capacity, respectively for two consecutive years, respectively. Moreover, a reducing trend in tillers' appearance was observed when moisture level decreased, during both the experimental years. The lowest quantity of fertile tillers (5.75 & 5.37) was noted in minimum moisture level (20% TFC), respectively for two successive years. While assessing the interaction of and moisture regimes, cultivar NIFA-Insaf had maximum fertile tillers (21.00 & 20.75 during year-1 and year-2, respectively) at 100% field capacity. Minimum fertile off-shoots (5.50) were given by Faisalabad-2008 at 20% FC during the first year, whereas NIFA-Insaf produced lowest tillers (5.25) when sown at 20% FC in the second experimental year. Ram *et al.* (2013) depicted that water application at critical stages (tillering, jointing, heading, flowering) of plant growth boosted yield by improving number of spikes bearing heavier grains. Similarly, Islam *et al.* (2018) also observed effective tillers' appearance with high water availability. Both of these studies assure the maximum productivity of fertile off-shoots in current research project.

Grains spike^{-1}: Highest number of grains (34.60 & 32.55 for first and second year respectively) were NIFA-Insaf, while cultivar Faisalabad-2008 produced the lowest grains spike^{-1} (31.45 & 29.30 respectively) during both years (Table 3). Similarly, multiple irrigation levels also had significant impact on grains' count. Maximum number of grains (49.00 & 46.87) were produced at 100% field capacity, respectively during two years of experimentation. Significantly lower number of grains (13.62 & 12.75) was noted for plants grown at reduced moisture level (20% TFC), respectively during the two growing seasons. As far as the interaction between two factors is concerned, significantly maximum grains' count (50.75 & 49.25) was received when NIFA-Insaf cultivar was sown at 100% field capacity, respectively in two successive years. A reducing trend in grains' count was shown by both as moisture level decreased, during two consecutive years. It is obvious that adequate irrigation water availability is responsible for translocation of nitrogen from soil into plant tissues, which produces higher number of grains per unit area, thereby increasing grain yield as compared to water stress situations. It was noted that increase in grains' count might be due to change in both, spikes' count and kernels spike^{-1} with increasing irrigation levels. Albrizio *et al.* (2010) confirmed that grain yield of durum wheat is dependent on number of grains per unit area, which is influenced by nitrogen content and availability of irrigation water. Likewise, Islam *et al.* (2018) obtained maximum grains in a spike by giving high irrigation. The same trend was also observed during the current project when high water levels were maintained.

1000 grain weight (g): The two genotypes (Nifa-Insaf and Faisalabad-2008) of wheat showed non-significant differences during the first year, however, NIFA-Insaf produced significantly maximum 1000-grain weight (39.68 g) during the growing season (Table 4). On the other hand, variable irrigation frequencies had significant impact on 1000 grain weight. Highest grain weight (52.50 & 51.19 g) was recorded at 100% TFC, respectively during both the cropping seasons. Application of lowest moisture level (20% TFC) showed minimum 1000 grain weight (25.58 & 24.13 g), respectively for two consecutive years. Similarly, the collaborative effect of genotypes and moisture levels showed significant influence on grain weight. The study revealed that at each moisture level, the two-wheat showed statistically at par grain weight, during the first growing year. However, maximum 1000 grain weight (53.00) was given by NIFA-Insaf at 100% TFC, which was statistically similar to 80% TFC (51.34) of the same genotype, 100% TFC (52.00) and 80% TFC (50.00) of Faisalabad-2008, during previous experimental year. During the next year, similar but statistically significant trend was observed. Highest 1000 grain weight (52.56) was produced by NIFA-Insaf at 100% TFC, followed by 50.04 g (NIFA-Insaf at 80% FC) and 49.82 g (Faisalabad-2008 at 100% FC). The latter two treatment combinations were statistically alike with each other However, genotype Faisalabad-2008 at 20% TFC showed the lowest 1000 seed weight (25.05 & 23.58 g), respectively during both the experimental years. Bandyopadhyay *et al.* (2010) found carbon remobilization to the grains when reduced irrigation was applied. Adequate irrigation water availability is responsible for translocation of nitrogen from soil into plant tissues, which resulted in higher and heavier gains that boosted grain yield as compared to water stressed situations. Availability of reduced water level also decreased the weight of grains at similar rates. Generally, wheat plants suffer a mid-season moisture stress that reduces grains' quantity. Moral *et al.* (2003) reported that raised temperature at season's end caused incurable stress in grain. Royo *et al.* (2000) reported that water deficit during grain-filling period reduces grain weight.

Grain yield (kg ha^{-1}): As regards of different genotypes Faisalabad-2008 yield of 2333.7 and 1798.8 kg ha^{-1}, and yield was found sensitive to moisture scarcity as NIFA-Insaf that produced 2709.9 & 2415.2 kg) during both the study years (Table 5). Likewise, multiple irrigation frequencies showed significant behavior for wheat grain yield. Highest yield (5202.2 & 4748.5 kg) was obtained at 100% field capacity, respectively for two consecutive years. A drastic decrease in yield was observed in both years' experimentation. Similarly, enormous reduction in yield (200.1 & 166.4 kg) was noted at 20% irrigation level, respectively during two successive years. The study further depicted significant effects among different interactive combinations during both the years. Among various treatments, maximum yield (5554.4 & 5378.2 kg) was produced by NIFA-Insaf when grown at 100% field capacity, respectively for two years' trials. Sowing of Faisalabad-2008 at lowest field capacity (20%) gave minimum grain yield (177.0 &159.3 kg), respectively for two consecutive years. (Fig. 4) at the end of this discussion showed clear picture of percent yield reduction due to decreased moisture regimes. Behera & Panda (2009) expressed that high frequency irrigation with low volume gives high magnitudes of grain and straw yields in comparison with low frequency and high-volume application. Ali *et al.* (2007) had similar findings that high water holding capacity of soil improves yield and yield related traits. The present study also showed that wheat gave improved production when ample moisture stored into the soil during two experimental years. Royo *et al.* (2000) reported that shortage of water at anthesis reduced spikes and spikelets quantity along with fertility, while reduction in grain weight was observed at grain-filling phase.

Table 2. Effect of irrigation levels on fertile tillers (pot^{-1}) of selected wheat genotypes during the year 2016-17 & 2017-18.

Cultivars	**Irrigation levels (Total field capacity)**					**Means**
	L_1 100% TFC	**L_2 80% TFC**	**L_3 60% TFC**	**L_4 40% TFC**	**L_5 20% TFC**	
2016-17						
V_1 (NIFA-Insaf)	21.00 a	19.50 ab	14.00 c	9.00 d	6.00 e	13.90 a
V_2 (Faisalabad-2008)	19.00 ab	18.00 b	12.25 c	8.00 de	5.50 e	12.55 b
Means	**20.00 a**	**18.75 a**	**13.12 b**	**8.50 c**	**5.75 d**	
LSD$_{0.05}$	**Cultivars = 0.76**		**Irrig. Levels = 1.72**		**Interaction = 2.87**	
2017-18						
V_1 (NIFA-Insaf)	20.75 a	18.25 b	13.00 d	8.25 f	5.25 g	13.10 a
V_2 (Faisalabad-2008)	18.50 b	16.25 c	10.75 e	7.75 f	5.50 g	11.75 b
Means	**19.62 a**	**17.25 b**	**11.87 c**	**8.00 d**	**5.37 e**	
LSD$_{0.05}$	**Cultivars = 0.36**		**Irrig. Levels = 0.86**		**Interaction = 1.43**	

Table 3. Effect of irrigation levels on grains spike^{-1} of selected wheat genotypes during the year 2016-17 and 2017-18.

Cultivars	**Irrigation levels (Total field capacity)**					**Means**
	L_1 100% TFC	**L_2 80% TFC**	**L_3 60% TFC**	**L_4 40% TFC**	**L_5 20% TFC**	
2016-17						
V_1 (NIFA-Insaf)	50.75 a	47.25 a	40.25 bc	20.50 d	14.25 ef	34.60 a
V_2 (Faisalabad-2008)	47.25 a	42.25 b	36.00 c	18.75 de	13.00 f	31.45 b
Means	**49.00 a**	**44.75 b**	**38.12 c**	**19.62 d**	**13.62 e**	
LSD$_{0.05}$	**Cultivars = 1.23**		**Irrig. Levels = 2.78**		**Interaction = 4.63**	
2017-18						
V_1 (NIFA-Insaf)	49.25 a	45.50 ab	36.50 cd	18.25 e	13.25 fg	32.55 a
V_2 (Faisalabad-2008)	44.50 b	39.25 c	33.25 d	17.25 ef	12.25 g	29.30 b
Means	**46.87 a**	**42.37 b**	**34.87 c**	**17.75 d**	**12.75 e**	
LSD$_{0.05}$	**Cultivars = 1.08**		**Irrig. Levels = 2.44**		**Interaction = 4.06**	

Table 4. Effect of irrigation levels on 1000 grain weight (g) of selected wheat genotypes during the year 2016-17 and 2017-18.

Cultivars	**Irrigation levels (Total field capacity)**					**Means**
	L_1 100% TFC	**L_2 80% TFC**	**L_3 60% TFC**	**L_4 40% TFC**	**L_5 20% TFC**	
2016-17						
V_1 (NIFA-Insaf)	53.00 a	51.34 a	42.00 b	33.00 c	26.11 d	41.09 ^{NS}
V_2 (Faisalabad-2008)	52.00 a	50.00 a	40.44 b	32.29 c	25.05 d	39.96
Means	**52.50 a**	**50.67 a**	**41.22 b**	**32.65 c**	**25.58 d**	
LSD$_{0.05}$	**Cultivars = Non-sig.**		**Irrig. Levels = 2.61**		**Interaction = 4.36**	
2017-18						
V_1 (NIFA-Insaf)	52.56 a	50.04 b	39.63 d	31.50 e	24.69 f	39.68 a
V_2 (Faisalabad-2008)	49.82 b	46.28 c	37.87 d	29.94 e	23.58 f	37.50 b
Means	**51.19 a**	**48.16 b**	**38.75 c**	**30.72 d**	**24.13 e**	
LSD$_{0.05}$	**Cultivars = 0.65**		**Irrig. Levels = 1.47**		**Interaction = 2.45**	

Table 5. Effect of irrigation levels on grain yield (kg ha^{-1}) of selected wheat genotypes during the year 2016-17 and 2017-18.

Cultivars	**Irrigation levels (Total field capacity)**					**Means**
	L_1 100% TFC	**L_2 80% TFC**	**L_3 60% TFC**	**L_4 40% TFC**	**L_5 20% TFC**	
2016-17						
V_1 (NIFA-Insaf)	5554.4 a	4801.4 b	2365.8 d	604.7 e	223.1 e	2709.9 a
V_2 (Faisalabad-2008)	4850.1 b	4234.1 c	1892.1 d	515.4 e	177.0 e	2333.7 b
Means	**5202.2 a**	**4517.7 b**	**2129.0 c**	**560.1 d**	**200.1 e**	
LSD$_{0.05}$	**Cultivars = 140.19**		**Irrig. Levels = 316.14**		**Interaction = 526.48**	
2017-18						
V_1 (NIFA-Insaf)	5378.2 a	4159.5 b	1890.6 d	474.2 e	173.5 e	2415.2 a
V_2 (Faisalabad-2008)	4118.8 b	2959.1 c	1357.3 d	399.7 e	159.3 e	1798.8 b
Means	**4748.5 a**	**3559.3 b**	**1624.0 c**	**437.0 d**	**166.4 d**	
LSD$_{0.05}$	**Cultivars = 142.30**		**Irrig. Levels = 320.90**		**Interaction = 534.41**	

Conclusion

Based on results obtained after two years study it is concluded that that coleoptile length had positive correlation with root length ($R^2 = 0.1874$ $p<0.05$) and shoot length ($R^2 = 0.4455$ $p<0.05$). A positive and significant correlation ($R^2 = 0.5285$ $p<0.05$) was observed between root and shoot length as well. The coleoptile length was maximum in wheat cultivar NIFA-Insaf while minimum in cultivar Faislabad-2008. The genotype NIFA-Insaf was found more drought tolerant than Faisalabad-2008, showing higher growth and yield attributes at 100% or 80% TFC. Hence, it is recommended that wheat cultivar NIFA-Insaf should be planted in arid other alike regions for better growth and grain yield.

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