Pak. J. Agri. Sci., Vol. 51(1), 25-31; 2014
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
http://www.pakjas.com.pk

EXPLORING THE ROLE OF ROW SPACING IN YIELD IMPROVEMENT OF WHEAT CULTIVARS

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Growth and development of individual plant is generally modified with space available to it. The performance of divergent wheat cultivars sown under different row spacing was evaluated in a field experiment performed at the Agronomic Research Area, Faculty of Agricultural Sciences and Technology, Bahauddin Zakariya University Multan, Pakistan during rabi season 2011-2012. The experimental setup was randomized complete block design (RCBD) with split plot arrangement replicated thrice. The main plots comprised of broadcast along with row spacings 10, 20 and 30 cm while five wheat cultivars i.e., Bhakar 2002, Seher 2006, Shafaq 2006, Faisalabad 2008 and Lasani 2008 were allocated in sub plots. The row spacing exhibited substantial effects on growth, yield and yield related attributes of wheat cultivars under study. The significant increase in LAI, LAD, CGR, number of fertile tillers per m^2, spikelets per spike and number of grains per spike led to the highest grain yield in the cultivar Lasani 2008 at 20 cm row spacing. Nevertheless, the largest plant height and 1000-grain weight was obtained in Bhakar 2002 under 30 cm row spacing but it could not reimburse the severe decline in fertile tillers per m^2 resulting in reduced grain yield. The minimum grain yield was recorded for broadcast method in all cultivars, as unevenly distributed plants were unable to utilize land, light and other inputs efficiently. Thus, it may be concluded that wheat could be sown at 20 cm row spacing irrespective of cultivar to exploit its maximum growth and yield potential.
Keywords: Wheat, row spacing, plant population, productivity, tillering capacity

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a staple food in Pakistan and one of the chief sources of calories for human (Godfray *et al*., 2010; Kilick, 2010). It contributes 10.1% to value added in agriculture and 2.2 % to GDP of Pakistan (GOP, 2013). The European Union, China, India and the United States are the four largest wheat producers, with 25500, 24300, 29690 and 19826 thousand hectares of cultivated area and average yields of 5.17, 4.86, 3.16 and 3.11 t ha^{-1}, respectively (USDA, 2012). While, in Pakistan wheat is cultivated in an area of 8.693 million hectares with an average yield of 2.79t ha^{-1} (GOP, 2013). The unit area yield is critically much lower than the yields grasped in other developed countries of the world. In addition to inputs like cultivars, fertilizers and seed rate etc. responsible for its low yield, proper row spacing also have constructive role in maximizing the yield of crops (Chaudhary *et al*., 2000; Bakht *et al*., 2007; Hussain *et al*., 2011). In Pakistan yield potential of newly developed high yielding varieties can be exploited fully by adopting proper array of site-specific technology (Masood *et al*., 2004).

The space available to plants is one of important primary determinants for growth, development and yield of the crop plants (Hassan and Arif, 2012). Row spacing changes the microclimate inside canopy for better light and CO_2 utilization in an attempt to enhance crop productivity (Duncan and Schapough, 2000). Proper spacing can help to optimize tillering capacity and improve the yield components of wheat crop (Thorsted *et al*., 2006). The plant population per unit area beyond an optimum limit enhance competition among the plants for natural resources, resulting in weaker plant and severe lodging (Sangoi, 2000; Chen and Neill, 2006; Mukhtar *et al*., 2012). In this view, it was imperative to evaluate the role of different row spacings on the growth and productivity of newly developed wheat cultivars under the agro ecological conditions of Multan.

MATERIAL AND METHODS

***Site description*:** The present study to explore the role of row spacing for resources use efficiency of divergent wheat cultivars was conducted at Agronomic Research Area, Faculty of Agricultural Sciences and Technology, Bahauddin Zakariya University Multan (Latitude 71.43^o E and Longitude 30.2^o N), during the Rabi season 2011-2012.

***Experimental details*:** The experiment was laid out in randomize complete block design with split plot arrangement replicated thrice. The net sub plot size was 5 m × 1.8 m. The spacings and wheat cultivars were randomized in the main plot and sub plots, respectively. Main plot comprised of broadcast and 10, 20 and 30 cm row spacing. The five wheat cultivars Bhakar 2002, Seher 2006, Shafaq

2006, Faisalabad 2008 and Lasani 2008 were owed in sub plots.

***Crop husbandry*:** The sowing was done by hand drill in well prepared seed bed on 15th November 2011using the seed rate 125 kg ha^{-1}. Nitrogen and phosphorus were applied @ 200 and 150 kg ha^{-1}, respectively by using urea and triple super-phosphate. Whole phosphorus and half of nitrogen were applied at sowing time and remaining nitrogen was applied with first irrigation. All other agronomic practices were kept constant to keep the crop insect and disease free. At maturity, crop was harvested on 18th April, 2012.

***Observations*:** At physiological maturity of wheat crop 1 m^2 was selected randomly from two different sites of each plot to record the data on plant height, number of fertile tillers, spike length, number of spikelets per spike, number of grains per spike, 1000-grain weight, biological and grain yield by using standard procedures. Leaf area was measured fortnightly using a leaf area meter (Area Meter AM-200 ADC Bio-scientific limited).Thereafter, leaf area index (LAI) was calculated followed by the formula of Watson (1947). Leaf area duration (LAD) and crop growth rate (CGR) were estimated following the procedures described by Hunt (1978).

***Statistical analysis*:** All the data collected were analyzed statistically using the Fisher's analysis of variance technique. Duncan's multiple range test (DMR) was used to compare significance of treatment means at 5% probability level (Steel *et al*., 1997).

RESULTS

Row spacing describes interplant competition for nutrients, sunlight interception and water thereby; resource use efficiency of cultivars may increase or decreased. In present study, different row spacing significantly influenced all the growth and yield parameters of wheat cultivars. LAI, LAD and CGR were substantially affected by row spacing and cultivars. Maximum LAI, LAD and CGR were attained by Lasani-2008 under row spacing of 20 cm at 90 DAS (days after sowing) and then start declining (Fig. 1-3 a & b).

The plant height reflects the growth behavior of a crop. In addition to genetic characteristics, soil nutrients status and environmental condition under which it developed influenced plant height. The experimental results showed the negative correlation between row spacing and plant height (Fig. 4). The cultivar Faisalabad 2008 produced maximum plant height (103.0 cm) followed by Bhakar 2002 (101.3cm) and Lasani 2008 (101 cm) under narrow row spacing (10 cm). However, all the cultivars showed reduced plant height under broadcast method of sowing with the least plant height (71.0 cm) in case of Faisalabad 2008 (Fig. 4). Tillering capacity is one of the main yield contributing parameters in cereals. Statistical analysis of data showed that wheat cultivars and row spacing had a significant effect on number of fertile tillers per m^2 (Fig. 5).

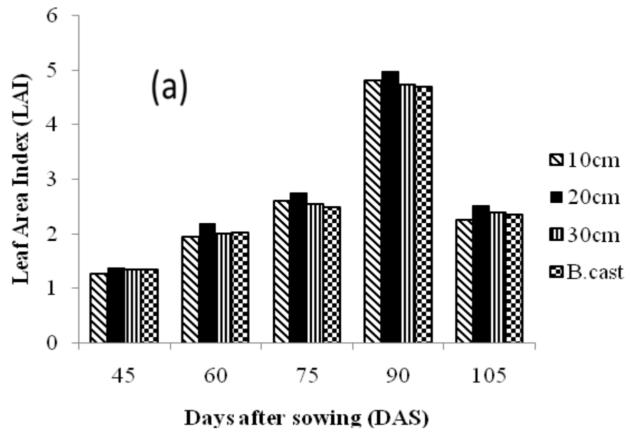

Figure 1a. Leaf area index as influenced by row spacings

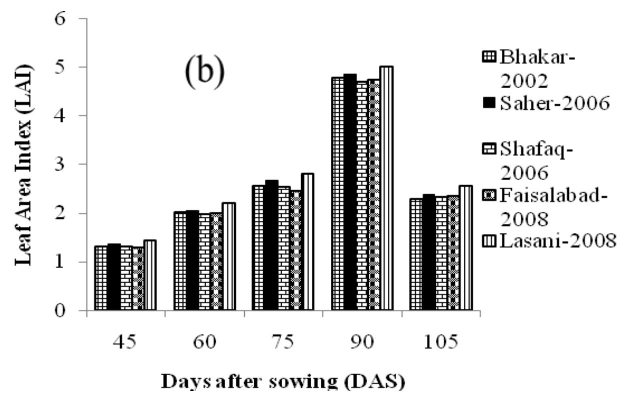

Figure 1b. Leaf area index as influenced by wheat cultivars

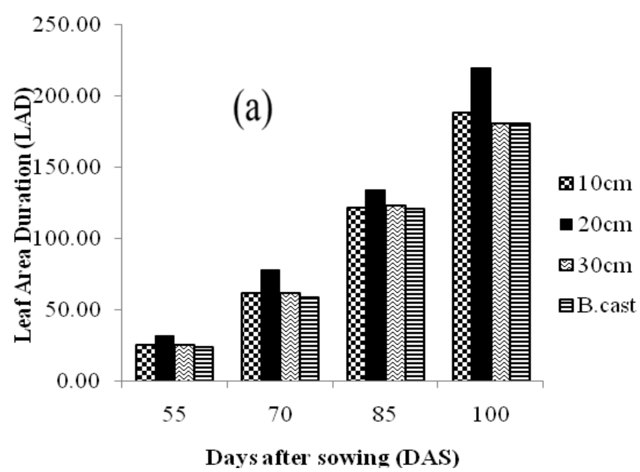

Figure 2a. Leaf area duration as influenced by row spacings

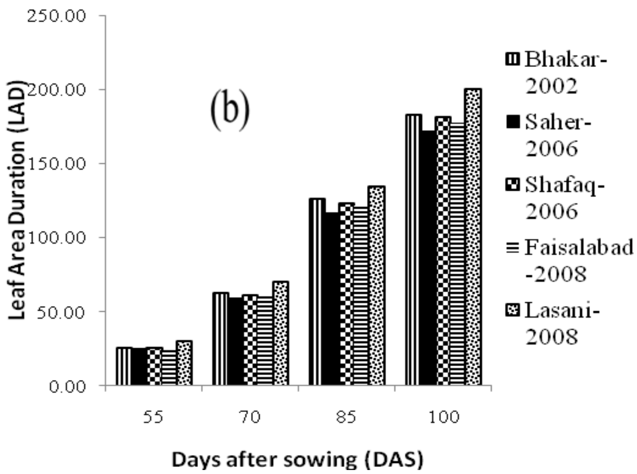

Figure 2b. Leaf area duration as influenced by wheat cultivars

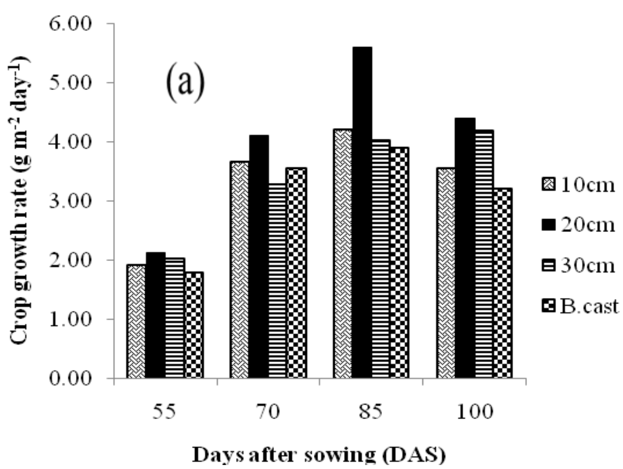

Figure 3a. Crop growth rate (g m^{-2} day^{-1}) as influenced by row spacings

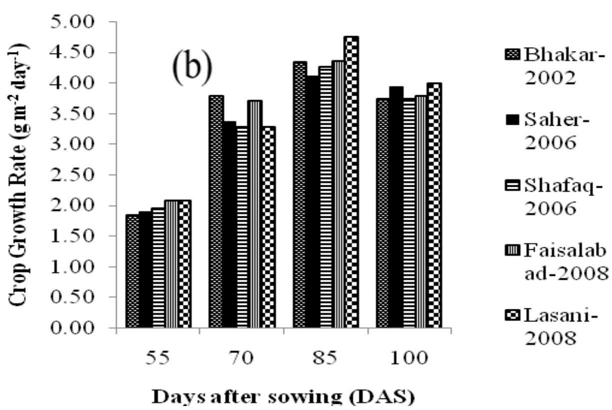

Figure 3b. Crop growth rate (g m^{-2} day^{-1}) as influenced by wheat cultivars

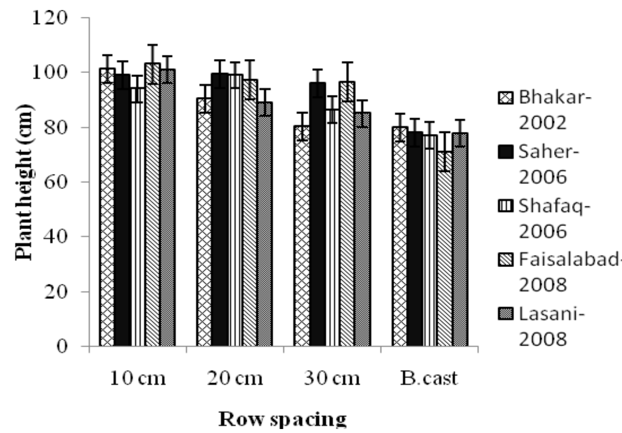

Figure 4. Effect of row spacings on plant height (cm) of wheat cultivars

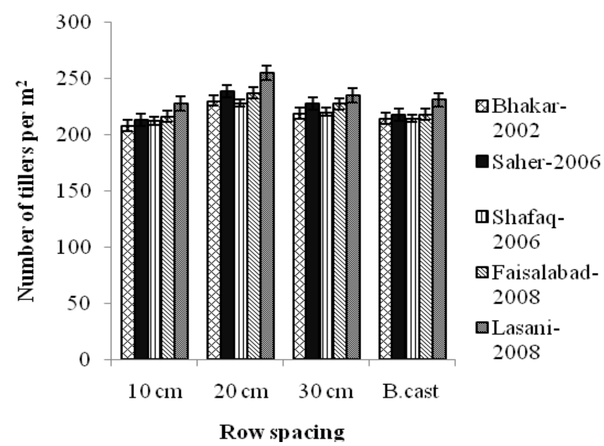

Figure 5. Effect of row spacings on number of tillers per m^2 of wheat cultivars

Wheat cultivar Lasani-2008 produced maximum number of tillers per m^2 (255.30) under 20 cm row spacing. While, Bhakar 2002 produced the minimum (208.30) fertile tillers per unit area under 10 cm row spacing (Fig. 5). In case of broad cast method of sowing, all the cultivars showed number of fertile tillers lesser than 30 cm but higher than 10 cm row spacing. Variance analysis showed significant differences in spike length under different row spacing and cultivars (Fig. 6). Spike length was increased with the increasing row spacing. Results showed that wheat cultivar Lasani 2008 exhibited highest spike length (15.17 cm) under 30 cm of row spacing, which was statistically similar with 20 cm. Faisalabad-2008 produced the minimum spike length (11.30 cm) under row spacing of 20 cm, which was similar with Bhakar 2002 (11.37 cm) under 10 cm rows apart. Data showed that wheat cultivar Lasani 2008 produced maximum number of spikelets per spike under row spacing of 20 cm.

However, Shafaq-2006 produced minimum number of spikelets per spike under broadcast (Fig.7). The number of grains per spike differed significantly among different treatments (Fig. 8).

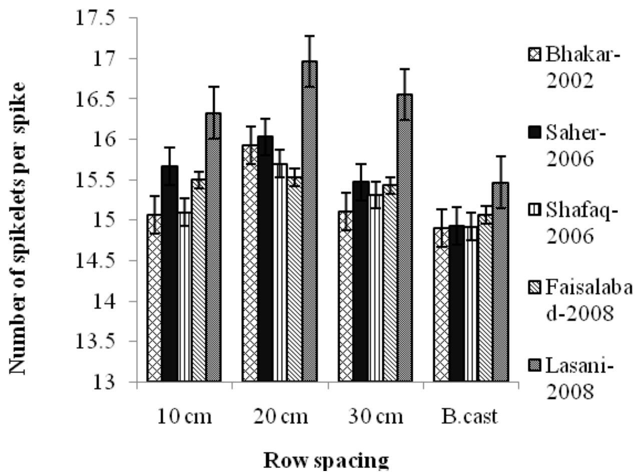

Figure 7. Effect of row spacings on number of spikelets per spike of wheat cultivars

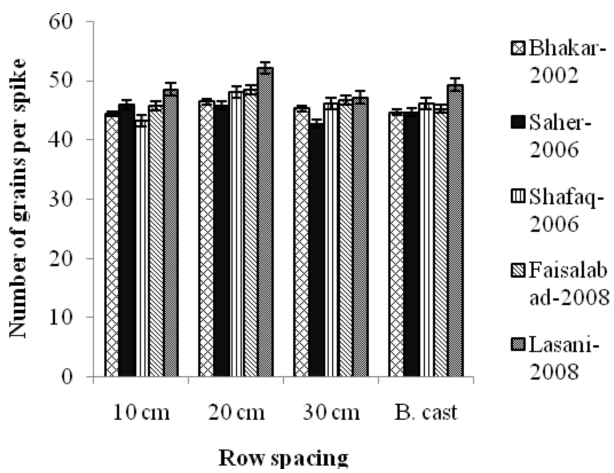

Figure 8. Effects of row spacingon number of grains per spike of wheat cultivars

Wheat cultivar Lasani-2008 under row spacing of 20 cm produced maximum (52.10) number of grains per spike (Fig. 8). The least number of grains per spike were found in Saher-2006 when planted at 30cm row spacing. The interactive effects of row spacing and wheat cultivars significantly influenced the 1000 grain weight (Fig. 9). Bhakar 2002 produced maximum 1000 grain weight (50. 63 g) under row spacing of 30 cm. In all the cultivars 1000-grain weight was increased under broader row spacing (30 cm) as compared to narrow row spacings (10 & 20 cm) The minimum (42.57 g) 1000-grain weight was recorded in Faisalabad-2008 under broadcast methods of sowing.

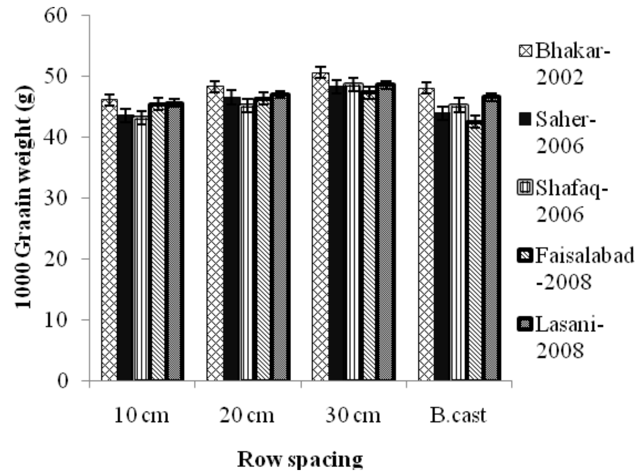

Figure 9. Effects of row spacingon 1000 grain weight (g) of wheat cultivars

Biological yield, grain yield and harvest index was significantly influenced by different row spacing and cultivars. Wheat cultivar Lasani-2008 and Bhakar-2002 produced maximum (10510 kg ha^{-1}) and minimum (8463 kg ha^{-1}) biological yield under row spacing of 20 cm and 10cm, respectively (Fig. 10). Lasani 2008 in 20 cm row spacing produced maximum grain yield (4560 kg ha^{-1}) against the minimum (2793 kg ha^{-1}) which was recorded for Faisalab-2008 under broadcast methods of sowing (Fig.11). Maximum harvest index (45.89) was recorded for Lasani-2008 in 10 cm row spacing. While minimum (29.75) was recorded for Bhakar 2002 in wider rows (30 cm) (Fig. 12).

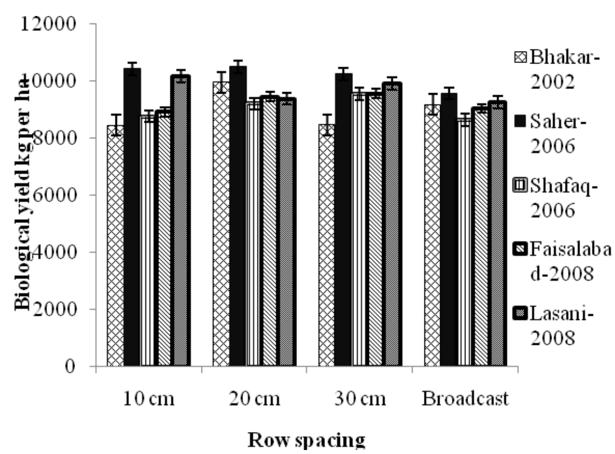

Figure 10. Effects of row spacingon biological yield (kg ha^{-1}) of wheat cultivars

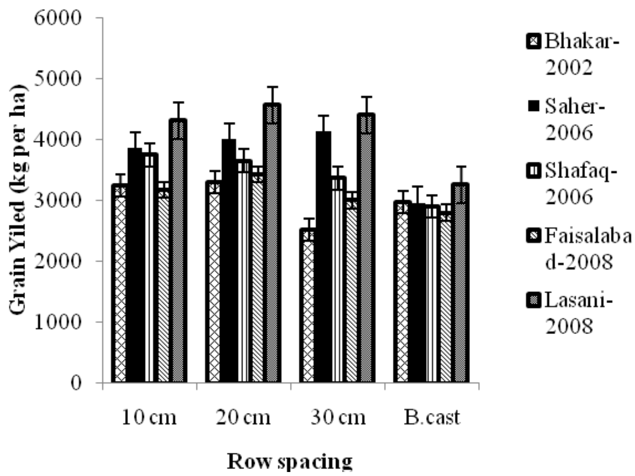

Figure 11. Effects of row spacingon grain yield (kg ha^{-1}) of wheat cultivars

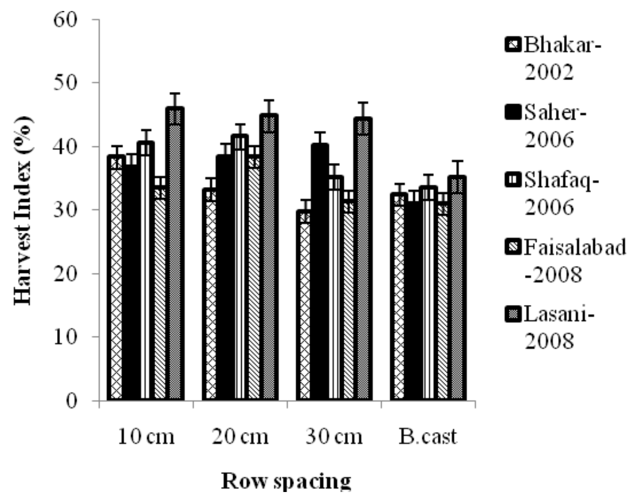

Figure 12. Effects of row spacing on harvest index (%) of wheat cultivars

DISCUSSION

The experimental results revealed that growth and yield attributes of all wheat cultivars differed substantially in numerous row spacings. Lasani 2008 performed better under optimum row spacing of 20 cm as compared with others. Moreover, considerably higher LAI, LAD and CGR were recorded in Lasani 2008 under optimum row spacing of 20 cm. Row spacing might altered the architecture, photosynthetic ability of leaves and dry matter portioning of crops (Samani *et al*., 1999). So, the genetic variability of cultivar and efficient utilization of available resources ultimately enhanced photosynthesis (Zhou *et al*., 2010). Improved photosynthetic efficiency represents higher assimilate partitioning of the crop contributing towards higher LAI, LAD and CGR which ultimately increased the yields (Hussain *et al*., 2012).

Faisalabad 2008 attained higher plant height at 10 cm row spacing. These results are in line with those of Mohamadzadeh *et al*. (2011) who elucidated that plant height increased with the decrease in row spacing. The cultivar Lasani 2008 produced maximum number of fertile tillers per m^2under row spacing of 20 cm as compared with narrow and wider row spacing due to consistent allotment of plants for better circulation of solar energy in to a plant canopy. Optimum row spacing can be a valuable approach to optimize tillering capacity of wheat (Kakar *et al*., 2001).

There was positive correlation between spike length and row spacing. It might be due to efficient consumption of water, nutrients and light due to negligible inter-rows competition and lower plant population (Sial *et al*., 2001). Better spike length in Lasani 2008 was also credited to higher allometric parameters throughout the growth period which allocated prominently higher assimilates for spike development (Shearman *et al*., 2005).The difference in number of spikelets per spike of cultivars was attributed to variation in spike length and genetic makeup which is an inherent character of wheat cultivars (Eskandari and Kazemi, 2010).

Wheat grain contributes materially towards the final grain yield and is entirely inherent character (Jan *et al*., 2000). Higher number of grains per spike was recorded under medium row spacing of 20 cm in Lasani 2008. This character is mainly dependent on genetic variability and supplied required nutrients; it seems that under narrow spacing the number of grains per spike reduced due to limited availability of nutrients, light and space (Abbas *et al*., 2009; Naseri *et al*., 2012). Row spacing positively influenced the 1000 grain weight. The weight of individual grain expresses the magnitude of grain development which is an important yield determinant and plays a crucial role in exploiting the yield potential of a crop. It seems that under wider row spacing higher amount of assimilate stored at the initiation of grain filling. While sever competition under narrow spacing, diminished the availability of photosynthates during the same period which ultimately reduced the grain weight (Ali *et al*., 2010).

Yield of a crop is the expression of combined effects of various yield components and dependent upon crop management, type of variety and various other factors. Supreme biological and grain yield was recorded for Lasani 2008 under row spacing of 20 cm (Fig. 10 & Fig. 11) may be owing to more LAI, LAD, CGR, fertile tillers per m^2, spikelets per spike and no. of grains per spike with efficient utilization of nutrients, sunlight interception and water, which ultimately produced more biomass and grains (Ranjbar *et al*., 2010). These results are similar with the findings of Johnson and Hanson (2003) and Bakht *et al*. (2007) who observed that higher yield under optimum row spacing was the consequence of consistent allocation of plants that results in better sharing of solar radiation to plant canopy which reduced inter plant competition. Individual genotypes responded differently due to their different genetic makeup under same or varying growing conditions (Otteson *et al.*, 2007; Alignan *et al*., 2009). Delay in planting decreases wheat yields (Hussain *et al*., 2012). Better genetic makeup of cultivars along with wider row spacing observed superior harvest index as increased dry matter portioning is a fundamental response of wider row spacing in the crops (Shearman *et al.*, 2005). Harvest index is an indicator of dry matter partitioning towards the reproductive organs. Row spacing, cultivars and their interaction had significant effect on harvest index (Fig. 12).Wheat cultivar Lasani-2008 showed higher harvest index indicated its superior ability of better dry matter partitioning towards grains. These findings are in agreement with the work of Ali *et al*. (2010).

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