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IMPROVEMENT IN WHEAT (TRITICUM AESTIVUM L.) YIELD BY MANIPULATING SEED RATE AND ROW SPACING IN VEHARI ZONE

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ABSTRACT

Seed rate and row spacing in a given area have marked effects on wheat yield components. Field experiments were conducted at Adaptive Research Farm, Vehari for a period of three years from 2005-06 to 2007-08 to investigate the impact of various seed rates and row spacings on the yield of wheat cv. Uqaab-2000. Four levels of seed rate (125, 150, 175 and 200 kg ha $^{-1}$) and three row spacing (11.25, 15.00 and 22.50 cm) were tested in split plot design with seed rate in main plots and row spacing in sub plots. The results indicated that main effects of seed rate and row spacing affected number of tillers m^{-2}, no. of grain $spike^{-1}$, 1000 grain weight, grain yield and harvest index significantly ($p<0.05$) and different seed rates did not affect straw yield significantly in 2007-08. Three years average results indicated that maximum grain yield (4.13 t ha^{-1}) was obtained where moderate seed rate of 150 kg ha^{-1} was used by planting wheat during second fortnight of November and 22.50 cm apart rows gave higher grain yield than 15.00 cm and 11.25 cm. Straw yield increased with the increase in seed rate and showed superiority of 11.25 cm over 15.00 cm and 22.50 cm row spacing. Maximum harvest index values of 48.14% were recorded at seed rate of 150 kg ha^{-1} with 22.50 cm row spacing. Interaction between seed rate and row spacing was significant for no. of grain $spike^{-1}$, 1000 grain weight, grain yield, straw yield and harvest index in 2005-06. There was significant relationship (R^2=0.88, 0.99) between grain yield and harvest index at various seed rates and row spacing.

Key Words: *Triticum aestivum*; seed rate; row spacing; yield; Pakistan

INTRODUCTION

Wheat (*Triticum aestivum* L.) ranks first among the cereal crops in Pakistan and occupies about 66% of the annual food crop area. Out of many factors responsible for its low yield, improper seed rate and row spacing are considered limiting factors for wheat production. Proper row spacing and seed rate are most important management factor affecting the agronomic characteristics of wheat (Ansari *et al*., 2006, Marwat *et al*., 2002, Chaudhary *et al*., 2000). Under the present practice of sowing wheat after rice and cotton, wheat often gets delayed reducing the yield to a considerable extent. Late seeding dates normally result in higher seeding rates because a delay in sowing normally reduces individual plant growth and tiller production (Gooding and Davies, 1997; Satorre, 1999). Suitable combination of seed rate and row spacing could increase grain yield of wheat (Marshall and Ohm, 1987.) whereas seeding rates alone did not influence the grain yield (Rafique, *et al.,* 1997) much. According to Ali *et al* , (1996), seed rate of 100-125 kg ha^{-1} with row spacing of 12.5 - 25 cm guaranteed maximum grain yield of wheat in Multan district. They found that tillers were more in wider row spacings (37.5 cm) followed by 25 cm and 12.5 cm row spacings. Chaudhary *et al*., (2000) reported that seed rate of 150 kg ha^{-1} increased the number of grains $spike^{-1}$ and depressed the number of fertile tillers m^{-2}.

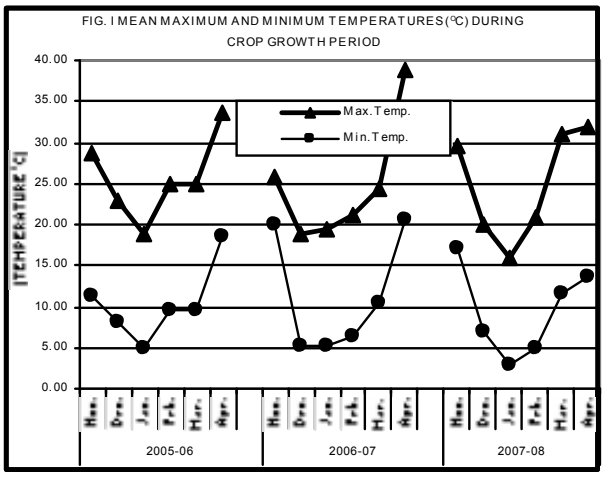
Khan *et al.* (2001) reported higher wheat yield at seed rate of 100-150 kg ha^{-1} in 27 cm- 13.5 cm apart rows, respectively. Assenheimer *et al.* (1999) reported that row spacing of 20 cm resulted in significantly higher wheat grain yield in comparison with 30 cm row spacing; however, seed rate did not have effect on wheat yield. After conducting field trials on two wheat cultivars, Malik *et al*. (1996) concluded that grain and straw yields were high with 15 cm row spacing and decreased with increased row spacing while harvest index was not affected significantly by row spacing. Arif *et al.* (2003) suggested 150 kg ha^{-1} seed rate with 22.5 cm row spacing for maximum wheat yield. They also found that plant height, grains $spike^{-1}$, and 1000-grain weight decreased with increase in seed rate, however, tillering increased with increasing seed rate. Research results reported by Anderson and Garlinge (2000) have shown that yields of wheat and barley increased as the spacing between rows is decreased similarly narrow row spacing consistently produced higher grain yield than wide row spacing (Chen and Neill., 2006. Johnson and Hargrove., 1988) whereas Ahmad *et al.* (2003) concluded that maximum grain yield and harvest index of wheat can be obtained with row spacing of 20 cm. Increasing seed rate of wheat from 100 to 200 kg ha^{-1} increased the grain and straw yields (Kumpawt, 1998). Keeping in view the above findings the study was conducted at Adaptive Research Farm Vehari with the objectives to determine seed rate and row spacing effects on wheat grain yield.

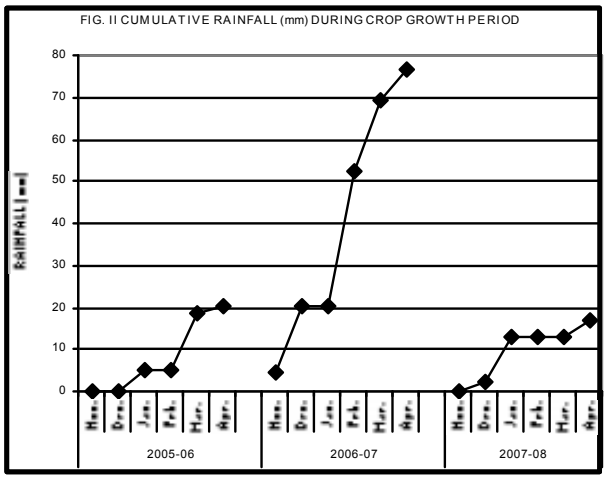
MATERIALS AND METHODS

The study was conducted at Adaptive Research Farm, Vehari during 2005-06, 2006-07 and 2007-08. The soil was loam in texture and seed bed preparation was carried out with two rotavator and two cultivator with two plankings. Experimental field was kept fallow before conducting trials. The experiment was laid out in split plot design with three replications. Four seed rates of 125, 150, 175 and 200 kg ha^{-1} were in main plot whereas three row spacings of 11.25 cm, 15.00 cm and 22.50 cm were in sub plots with plot size of 4.50 x 10.50 m. At sowing, 64 kg N/ha, 114 kg P/ha and 62 kg K/ha was used in the form of urea, diamonium phosphate and sulphate of potash, respectively. Remaining 64 kg N/ha was applied at first irrigation. Wheat variety Uqaab-2000 was planted on November 22, 2005, November 28, 2006 and November 21, 2007. Four irrigations were applied during crop growth period. All other agronomic, cultural and plant protection practices were kept normal and uniform. Mean maximum and minimum temperatures (^{O}C) and rainfall (mm) data were recorded during crop growth period in all the experimental years and are shown in Fig. I and Fig. II, respectively. A quadrate of one m^2 made of iron rod was placed randomly at three places in each sub plot and fertile tillers near maturity were counted and then mean was calculated as per m^{-2}. The number of grains $spike^{-1}$ was counted by threshing the ten randomly selected spikes from each treatment. For 1000- grain weight five samples of thousands grains were taken at random from a total lot of each sub plot and weighed on an electric balance in the laboratory. Wheat bundles of each sub plot were threshed with thresher and average grain yield and straw yield was recorded in kg $plot^{-1}$ and then converted into t ha^{-1}. Harvest index was calculated by using the following formula:

$$H.I = \frac{\text{Grain yield (t. ha}^{-1})}{\text{Biological yield (t. ha}^{-1})} \times 100$$

Data were analyzed with analysis of variances (ANOVA) procedures (Steel *et al.,* 1997)., and the means differences were compared at 5 percent level of probability by Duncan's Multiple Range Test (Duncan, 1955).





RESULTS AND DISCUSSION

Number of Tillers (m^{-2}): Main effect of seed rate and row spacing affected tillers m^{-2} significantly ($p<0.01$) during the three years. At seed rate of 200 kg ha^{-1}, maximum (315, 318 and 316) number of tillers m^{-2} were observed in the years 2005-06, 2006-07 and 2007-08, respectively (Table 1) as against the minimum(270, 267 and 277) observed at seed rate of 150 kg ha^{-1} in three years. Highest number of tillers m^{-2} (308, 298 and 318) were recorded at row spacing of 11.25 cm in experimental years (Table 1) as against minimum (283, 276 and 288) observed at row spacing of 22.5 cm in 2005-06, 2006-07 and 2007-08, respectively (Table 1). Interaction was found non-significant for the three years. The findings were in line with Chaudhary *et al*., (2000) and Arif *et al.,* (2003), who reported increased tillering with increase in seed rate. The results are also in line with Rafique *et al*., (1997), who observed linear increase in the number of tillers as the seed rate was increased. Whereas, the findings are not in accordance with Bellatore *et al*., (1985) who found decreased tillering as the seed rate was increased.

Number of Grains $Spike^{-1}$: Main effect of seed rate and row spacing affected number of grains $spike^{-1}$ significantly ($p<0.01$) during the three years. At seed rate of 150 kg ha^{-1}, maximum number of grains $spike^{-1}$ was received in the years 2005-06, 2006-07 and 2007-08 (Table 2) as against the minimum observed at seed rate of 125 kg ha^{-1} (Table 2). Highest number of grains $spike^{-1}$ (41, 39 and 42) were recorded at row spacing of 22.5 cm in experimental years (Table 2) as against minimum (36, 38 and 38) observed at

row spacing of 11.25 cm in 2005-06, 2006-07 and 2007-08 respectively (Table 2). Hence interaction between seed rate and row spacing significantly influenced the number of grains in 2005-06 where maximum number of grains spike^{-1} was recorded in the plot treated with seed rate of 150 kg ha^{-1} at 22.5 cm apart rows.

The results are in line with Ali *et al*., (1996), Chaudhary *et al.,* (2000) and Rafique *et al*., (1997), who explained that lower seeding rates significantly increased the number of grains and vice versa. By increasing seed rate the number of grains spike^{-1} is reduced (Khan *et al*., (2002, and Mehrvar and Asadi, 2006).

1000- Grain Weight (g): Main effect of seed rate and row spacing affected 1000- grain weight (g) significantly ($p<0.01$) during the three years. At seed rate of 150 kg ha^{-1}, maximum 1000- grain weight was received in the years 2005-06, 2006-07 and 2007-08 (Table 3) as against the minimum observed at seed rate of 200 kg ha^{-1} . Highest 1000- grain weight was recorded at row spacing of 22.5 cm in experimental years (Table 3) as against minimum observed at row spacing of 11.25 cm in 2005-06, 2006-07 and 2007-08. Hence interaction between seed rate and row spacing significantly influenced the 1000- grain weight in 2005-06 where maximum number of grains spike^{-1} was recorded in the plot treated with seed rate of 150 kg ha^{-1} at 22.5 cm apart rows. The results are in line with Ali *et al*., (1996), Chaudhary *et al.,* (2000) and Rafique *et al*., (1997), who explained that low seed rates significantly increased the 1000- grain weight. The results also confirm the findings of Rafique *et al*., (1997) who concluded increased grain weight at wider row spaces. Khan *et al*., (2002) and Mehrvar and Asadi, 2006 concluded that by increasing seed rate the 1000-grains weight is reduced.

Grain yield: The effect of seed rate and row spacing on grain yield (t ha^{-1}) of wheat was highly significant ($p<0.01$) during all the years of study (Table-4). The yield in 2007-08 was significantly higher ($p<0.05$) than the other years mainly because of favorable weather conditions due to less rainfall received during crop growth period. (Fig. I & Fig. II). Optimum rainfall received caused increase in grain yield. The three years average data showed that grain yield was maximum (4.13 t ha^{-1}) at seed rate of 150 kg ha^{-1} followed by 3.87 and 3.74 t ha^{-1} with seed rates of 175 and 200 kg ha^{-1}, respectively as against the minimum grain yield of 3.61 t ha^{-1} with seed rate of 125 kg ha^{-1}. The data recorded during 2005-06 depicted that seed rates of 150 and 175 kg ha^{-1} gave higher grain yields of 4.05 and 3.88 t ha^{-1}, respectively than seed rates of 125 and 200 kg ha^{-1}. The 2006-07 experiment showed that seed rate of 150 kg ha^{-1} gave maximum grain yield of 4.12 t ha^{-1} followed by 3.90 and 3.78 t ha^{-1} with seed rate of 175 and 200 kg ha^{-1}, respectively as against the minimum grain yield of 3.67 t ha^{-1} with seed rate of 125 kg ha^{-1}. The results of the study conducted during 2007-08 revealed that seed rate of 150 kg ha^{-1} gave maximum grain yield than 175 and 200 kg ha^{-1} and minimum grain yield was produced from the plots where seed rate of 125 kg ha^{-1} was applied. These results are in analogy with the findings of earlier workers (Arif ***et al***., (2003, Khan *et al*., (2001) who reported higher yield with seed rate of 150 kg ha^{-1}, however disagree with those of Rafique *et al*. (1997) who concluded that seeding rates did not influence the grain yield of wheat. The data presented in Table-4 showed that row spacing of 22.50 cm produced maximum wheat grain yield followed by 15.00 cm as against the minimum with 11.25 cm row spacing. The trend of results during all the experimental years was almost the same which confirmed the superiority of wider row spacing of 22.50 cm over narrow row spacings of 15.00 and 11.25 cm. The interaction between seed rate and row spacing was found to be non-significant during all the years of study except in 2005-06 where maximum return was obtained by planting wheat with seed rate of 150 kg ha^{-1} at 22.50 cm apart rows. The results of the study showed that the present practice of planting wheat with seed rate of 150 kg ha^{-1} in 22.50 cm apart row is satisfactory for mid sowing. However little advantage could be gained by increasing/decreasing seed rate or row spacings if wheat is planted too early or too late in the season. Similar results have been reported by Assenheimer *et al.* (1999), Ahmad *et al.* (2003) and Arif *et al.* (2003), who suggested 150 kg ha^{-1} seed rate with 22.50 cm apart rows to get maximum yield. But are in contradiction with the findings of Khan *et al.* (2001), Malik *et al*. (1996) and Anderson and Garlinge (2000) who reported that yields of cereals increases as the spacing between rows is decreased. Based on these data, increasing seed rates above current recommendations is not necessary for mid sowing wheat crop in the season.

Table-1 Effect of various seed rates and row spacings on number of tillers (m^{-2}) of wheat.

Treatment	2005-06	2006-07	2007-08	Mean
Seed Rate (kg ha^{-1})	---------- Tillers (m^{-2})----------			
125	270.02^{b}	267.73^{d}	277.12^{b}	271.62^{b}
150	306.18^{a}	303.12c	308.28^{a}	305.86^{a}
175	310.36^{a}	313.92 ^{b}	311.51^{a}	311.93^{a}
200	315.04^{a}	318.18^{a}	316.61^{a}	316.61^{a}
Mean	300.4	300.73	303.38	
LSD $_{(0.05)}$ Seed rate	9.31	3.82	11.75	10.46
Row Spacing (cm)				
11.25	308.07^{a}	298.85^{a}	318.5^{a}	306.64^{a}
15.00	294.64^{b}	293.37^{b}	305.42^{b}	299.63^{b}
22.50	283.18^{c}	276.82^{c}	288.41^{c}	282.80^{c}
Mean	295.29	289.68	304.11	
LSD $_{(0.05)}$ Row Spacing	6.19	4.01	4.54	3.14
Seed rate x Row spacing	NS	NS	NS	NS

Any two means not sharing a letter in common differ significantly ($p\leq0.05$).
NS= Non significant

Straw yield: Economic yield is the ultimate goal of all crop production pursuits. The straw yield for various seed rates was significant for the year 2005-06 and 2006-07 and non-

Table-2 Effect of various seed rates and row spacings on No. of grains spike $^{-1}$ of wheat.

Treatment	2005-06	2006-07	2007-08	Mean
Seed Rate (kg ha^{-1})	---------- **No. of grains spike** -----			
125	33.83 c	36.61 d	38.88 d	36.44 d
150	40.07 a	40.31 a	42.11 a	40.83 a
175	39.57 a	39.48 b	40.57 b	39.87 b
200	38.57 b	37.53 c	39.40 c	38.5 c
Mean	38.01	38.48	40.24	
LSD $_{(0.05)}$ Seed rate	0.70	0.145	0.622	0.361
Row Spacing (cm)				
11.25	36.83 b	38.19 c	38.90 b	37.97 c
15.00	37.92 ab	38.47 b	40.66 a	39.02 b
22.50	41.23 a	39.85 a	42.25 a	41.11 a
Mean	38.66	38.83	40.60	
LSD $_{(0.05)}$ Row Spacing	1.51	0.106	0.929	0.611
Seed rate x Row spacing	3.03	NS	NS	1.22

Any two means not sharing a letter in common differ significantly (p≤0.05).
NS= Non significant

Table-3 Effect of various seed rates and row spacings on 1000- grain weight (g) of wheat.

Treatment	2005-06	2006-07	2007-08	Mean
Seed Rate (kg ha^{-1})	---------- **1000- grain weight (g**			
125	34.20 b	39.64 b	34.18 b	36.01 b
150	36.28 a	40.74 a	36.26 a	36.42 a
175	33.33 c	38.81 c	33.56 b	35.23 c
200	32.77 d	37.83 d	33.44 b	34.68 d
Mean	33.14	39.25	34.36	
LSD $_{(0.05)}$ Seed rate	0.05	0.257	0.708	0.252
Row Spacing (cm)				
11.25	31.73 c	38.80 b	33.22 c	34.59 c
15.00	33.50 b	38.81 b	34.13 b	35.48 b
22.50	35.2 a	41.15 a	36.72 a	37.69 a
Mean	33.47	39.58	34.69	
LSD $_{(0.05)}$ Row Spacing)	0.02	0.183	0.692	0.219
Seed rate x Row spacing	0.054	NS	NS	NS

Any two means not sharing a letter in common differ significantly (p≤0.05).
NS= Non significant

significant results were recorded during 2007-08 whereas it was significant for row spacing during all the study years (Table-5). The higher straw yield was observed in 2007-08 than the other years of study that might be due to favorable weather conditions for plant growth in this year. The data showed that minimum straw yield was found in the plots where seed rate of 125 kg ha^{-1} was used and there was a linear increase in straw yield as the seed rate was increased and highest straw yield was recorded from the plots where seed rate of 200 kg ha^{-1} was applied. This might be due to the fact that higher seed rates might resulted in more plant population and greater plant height which resulted in higher straw yield. The trend of result was almost the same during all the experimental years and pooled data also reflected the same results. The increase in straw yield with increase in seed rate was also reported by earlier researchers (Bellatore, *et al.,* 1985 and Kumpawt, 1998).

Table-4 Effect of various seed rates and row spacings on grain yield (t ha^{-1}) of wheat.

Treatment	2005-06	2006-07	2007-08	Mean
Seed Rate (kg ha^{-1})	---------- Grain yield (t ha^{-1}) ----------			
125	3.65d	3.67d	3.53d	3.61 d
150	4.05a	4.12a	4.22a	4.13 a
175	3.88b	3.90b	3.83b	3.87b
200	3.74c	3.78c	3.71c	3.74 c
Mean	3.83	3.86	3.82	
LSD $_{(0.05)}$ Seed rate	0.04	0.02	0.14	0.05
Row Spacing (cm)				
11.25	3.80b	3.82c	3.70c	3.78c
15.00	3.81b	3.86b	3.91b	3.86b
22.50	3.84a	3.92a	4.08a	3.95a
Mean	3.81	3.86	3.89	
LSD $_{(0.05)}$ Row Spacing)	0.01	0.02	0.09	0.03
Seed rate x Row spacing	0.01	NS	NS	0.06

Any two means not sharing a letter in common differ significantly (p≤0.05).
NS= Non significant

Table-5 Effect of various seed rates and row spacings on straw yield (t ha^{-1}) of wheat.

Treatment	2005-06	2006-07	2007-08	Mean
Seed Rate (kg ha^{-1})	---------- Straw yield (t ha^{-1}) ----------			
125	4.11c	4.17c	4.36	4.22c
150	4.23b	4.31bc	4.42	4.32b
175	4.26b	4.44ab	4.52	4.41ab
200	4.35a	4.52a	4.58	4.48a
Mean	4.23	4.36	4.47	
LSD $_{(0.05)}$ Seed rate	0.04	0.15	NS	0.10
Row Spacing (cm)				
11.25	4.27a	4.43a	4.56a	4.43a
15.00	4.23b	4.37a	4.45ab	4.35b
22.50	4.21c	4.27b	4.39b	4.29c
Mean	4.23	4.35	4.46	
LSD $_{(0.05)}$ Row Spacing)	0.02	0.08	0.13	0.04
Seed rate x Row spacing	0.03	NS	NS	NS

Any two means not sharing a letter in common differ significantly (p≤0.05).
NS= Non significant

The row spacing data showed superiority of closer row spacing over wider row spacing for straw yield during all the years of study (Table-5). The data depicted that higher straw yield was found in 11.25 cm row spacing followed by 15.00 cm, while minimum were recorded in

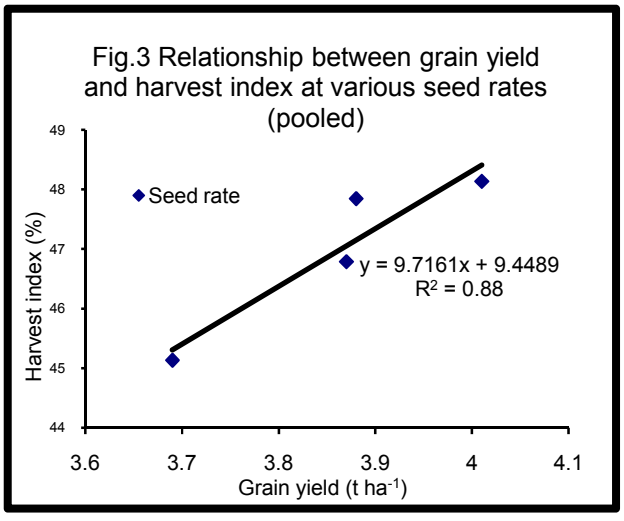
22.50 cm row spacing. The trend of result was almost the same during all the study years. The results are in agreement with the findings of Malik *et al.* (1996). The interaction between seed rate and row spacing was found to be significant during 2005-06 only where maximum straw yield was recorded with seed rate of 200 kg ha^{-1} in 11.25 cm row spacing. Non-significant differences were recorded during the year 2006-07 and 2007-08. These results agree with earlier findings of Bellatore, *et al.* (1985) and Kumpawt, (1998).

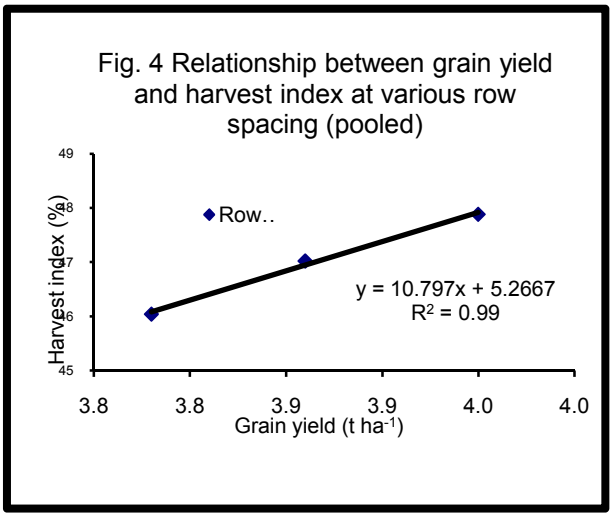
Harvest index: The effect of seed rate and row spacing on harvest index was significant and the values given in Table-6 indicated that during 2005-06 highest harvest index values of 47.94%, 47.70% and 47.67% were recorded with seed rate of 150 kg ha^{-1} followed by of 175 and 125 kg ha^{-1}, respectively however the results were non-significant with each other whereas the lowest harvest index was recorded with seed rate of 200 kg ha^{-1}. Almost similar results were observed during 2006-07 and from the results of the study conducted during 2007-08 it was concluded that maximum harvest index values were obtained in the plots where seed rate of 125 kg ha^{-1} was used. The data further indicated that there was a progressive decrease in the harvest index values as the seed rate was increased and minimum harvest index was recorded with seed rate of 200 kg ha^{-1} during the year under discussion. Among row spacing the highest harvest index was recorded in 22.50 cm row spacing followed by 15.00 cm row spacing and lowest harvest index was observed in 11.25 cm row spacing (Table-6). The trend of result was the same during all the experimental years. The average data of the study also reflected the same trend for harvest index values. The interaction between seed rate and row spacing was significant in 2005-06 only where highest harvest index was observed with 150 kg ha^{-1} seed rate x 22.50 cm row spacing while lowest harvest index was computed for seed rate of 200 kg with 11.25 cm row spacing. These findings are in agreement with the work of Ahmad *et al.* (2003) who concluded that maximum harvest index can be obtained with row spacing of 20 cm but are in contradiction with the findings of Malik *et al.* (1996) who reported that harvest index were not affected significantly by row spacing. Significant relationships (R^2=0.88, n=4 and R^2=0.99, n=3) between grain yield (t ha^{-1}) and harvest index (%) were also observed with respect to seed rate (Fig. 3) and row spacing (Fig. 4). By increasing grain yield for one unit causes enhancement in harvest index at the same rate and vice versa.

Table-6 Effect of various seed rates and row spacings on harvest index (%).

Treatment	2005-06	2006-07	2007-08	Mean
Seed Rate (kg ha^{-1})	---------- Harvest index (%) ----------			
125	47.67a	46.76b	49.13a	47.85a
150	47.94a	48.88a	47.59b	48.14a
175	47.70a	46.77b	45.90c	46.79b
200	46.23b	45.58c	43.60d	45.13c
Mean	47.38	46.99	46.55	
$LSD_{(0.05)}$ Seed rate	0.33	0.78	0.99	0.39
Row Spacing (cm)				
11.25	47.08c	46.25c	44.78c	46.04c
15.00	47.36b	46.92b	46.77b	47.02b
22.50	47.72a	47.83a	48.11a	47.88a
Mean	47.38	47.00	46.55	
$LSD_{(0.05)}$ Row Spacing)	0.13	0.46	1.04	0.35
Seed rate x Row spacing	0.25	NS	NS	NS

Any two means not sharing a letter in common differ significantly ($p \leq 0.05$).
NS= Non significant





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