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INFLUENCE OF SOWING DATES AND PLANTING METHODS ON WEED DYNAMICS IN WHEAT CROP

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Different sowing dates and planting methods of wheat has a varying impact on the associated weeds. An experiment was conducted to explore the influence of different sowing dates (raised bed planting, drill sowing and broadcasting) and planting methods (November 15, November 30, December 15) in wheat and its associated weeds during 2008-09 and 2009-10. Wheat planted on raised beds had the minimum weed infestation. Similarly among the various sowing dates, wheat planted on December 15 observed minimum weed density and biomass recorded at all the harvesting intervals i.e. 40, 60 and 80 days after sowing. *Chenopodium album* and *Phalaris minor* were the dominant weed species of the experimental field. Weed dynamics was observed maximum at November 15 because likewise wheat, environmental conditions at this time were also most suitable for the associated weeds to germinate. Maximum grain yield, productive tillers, grains per spike and thousand grain weight was recorded, where wheat was planted on raised beds on November 15 during both the years of experimentation. In conclusion, for getting maximum marginal rate of return wheat should be planted at November 15 on raised beds.

Keywords: Sowing dates; planting methods; grain yield; weed dynamics; wheat

INTRODUCTION

Wheat is a staple food of millions of people in Pakistan and elsewhere. The major reasons for the low wheat productivity are late sowing (Inamullah *et al.,* 2007; Aujla *et al.,* 2010; Hussain *et al*., 2012a) improper planting techniques (Fahong *et al.,* 2004; Khan *et al.,* 2007) and uncontrolled weeds (Abouziena *et al*., 2008) along with other problems like improper irrigation supplies and imbalance crop nutrition (Mullaa *et al.*, 1992; Kibe *et al.*, 2006). Wheat can be sown by different techniques viz., line sowing by drilling, broadcasting and raised bed planting. Each of the planting method has a varying impact on weed competition (Ashrafi *et al.,* 2009). In Pakistan, during 2009, total wheat production was 23.86 million tonnes while in Punjab province it was 17.92 million tonnes (Anonymous, 2009) which is below from many other wheat producing countries of the world. Wheat is generally sown by broadcast method and weed control is fairly difficult in broadcast (Byerlee *et al*., 1986) compared with bed planting or drill sowing. Crops sown on raised beds have less weed infestation than the flat/flood irrigation system. Weed dry biomass under raised beds was 24 and 31% lower than in basins for maize and wheat crops, respectively (Hassan *et al*., 2005). Production potential of wheat under different sowing dates was studied by Kumar *et al.* (2000) and observed maximum grain yield of mid-November planted wheat as compared to early and late planting. Recently Hussain *et al*. (2012a) reported 58% yield penalty in late planted wheat (25th Dec) than wheat planted on 10th Nov due to severe cutback in entire yield related traits. Similarly Akhtar *et al.* (2006) harvested better grain yield of wheat when sowing was done on November 15 and before November 30.

Among the factors influencing wheat productivity, the sowing date is of particular importance. This in turn is closely correlated with soil preparation, which has a critical effect on the periodicity of weed seed germination, allowing the weed species composition to be controlled (Berzsenyi, 2000). Choudhry *et al*. (1992) and Thill *et al.* (1978) found that early and mid-planting of wheat realized the potential yield better than late planting. Bhan (1987) concluded that delaying the sowing of wheat post November reduced weed population, but also reduced wheat yield. In an experiment, Subhan *et al.,* (2003) concluded that weed density and dry weed biomass were less in December 15 planting as compared to early and mid-plantings of wheat on October 15 and November 15. Timely planting (in the month of November) yields promising results in terms of enhanced productivity of wheat (Akhtar *et al*., 2006). Environmental conditions at this time also favour proper seed germination and thus lead to the healthy crop stand that reduces the chances of insect pests attack (Mushtaq and Salim, 2012). Similarly in comparison of different planting methods raised bed planting and drilling in lines suffered less weed population than the broadcast method (Ram *et al*., 2005; Aggarwal and Gosswami, 2003; Tanveer *et al*., 2003).

Interaction between the sowing dates and planting methods of wheat was remained unexplored and influence of this

interaction on the weed dynamics and yield attributes of wheat was also needed to be investigated. Therefore, a study was planned with the objectives to investigate the weed density and biomass and yield response of wheat under different sowing methods planted at varying dates and to estimate the maximum profitability under these varying conditions.

MATERIALS AND METHODS

***Experimental details*:** The field experiment was conducted during years 2008-09 and 2009-10 at the research area Department of Agronomy, University of Agriculture, Faisalabad (31.25°N, 73.09°E with 184.8 m altitude). The previous history of the field showed heavy infestation of weeds. Before sowing of the crop, soil samples were collected to a depth of 0-15 cm and 15-30 cm with soil auger and analyzed for various physico-chemical properties. Soil organic matter content of the experimental plot was 0.66-0.53% with a soil pH of 8.4-8.3. Using a seed rate of 100 kg ha^{-1} wheat cultivar Sehar-2006 was sown on raised bed, by drilling and by broadcast method on November 15, November 30 and December 15. Raised beds of 60 cm width were prepared with the help of spade with furrows of 30 cm width in between. Net plot size was 2.7 m × 5 m. There were 3 beds in one plot and 4 rows of wheat on each bed. In drill sowing, single row hand drill was used to sow the seed in 22.5 cm spaced lines and there were 12 lines in one plot. While in case of broadcasting, the same amount of seed was simply broadcasted in each plot.

***Crop husbandry*:** A basal dose of nitrogen, phosphorus and potash at 146 kg N, 85 kg P_2O_5 and 35 kg KCl ha^{-1} was applied in the respective plots in the form of urea, diammonium phosphate and sulphate of potash, respectively. The whole P, K and one third of N was broadcasted at the time of sowing, while remaining N was applied in two equal splits, i.e. $1/3^{rd}$ with first irrigation and $1/3^{rd}$ with 2^{nd} irrigation. The first irrigation was done 20 days after crop emergence, and subsequent irrigations were done at different critical crop stages especially at tillering, booting, anthesis and grain development stage. Five irrigations were applied in the whole season. To maintain the uniformity, every time all the plots were irrigated for equal time duration. The crop was manually harvested at maturity.

***Observations*:** A quadrate measuring 50 × 50 cm^2 was randomly placed at two places in respective plots to record weeds. Weeds were cut from the ground level and brought to the laboratory to record their biomass. The dry weight of weeds was determined by drying in an oven at 70°C until constant weight. After that their dry weight was measured with the help of electric balance. This was repeated at 40, 60 and 80 days after sowing. At the time of maturity, yield related traits like grains per spike, thousand grain weight and productive tillers were recorded. A quadrate measuring 50 × 50 cm^2 was randomly placed at two places in respective plots to count the number of productive tillers. This was finally converted to productive tillers per square meter. Whole the plots were harvested at maturity and manually threshed to measure the grain yield which was converted to tons per hectare by unitary method.

***Statistical analysis*:** Experiment was laid out in Randomized Complete Block Design (RCBD) having split plot arrangements with three replications. Analysis of the data was carried out by using Fisher's analysis of variance technique and least significance difference test (LSD test) at 5% was applied to compare the difference among treatment means (Steel *et al.,* 1997).

***Economic and marginal analysis*:** Economic analysis was carried out on the basis of variable costs and wheat crop to look into comparative benefits of different treatments. Marginal analysis was carried out according to procedures devised by CIMMYT (1998).

RESULTS

***Weed dynamics*:** Weed species of the experimental area were comprised of lambsquarters (*Chenopodium. album*), canary grass (*Phalaris. minor*), fumitory (*Fumaria parviflora*), wild oats (*Avena fatua*) and blue pimpernel (*Anagallis arvenses* L.). Among these *C. album* and *P. minor* were the dominant weed species found in the experimental field while others were present in less number. Little seed canary grass (*Phalaris minor* Retz.) and lambsquarters (*Chenopodium album* L.) were reported as the densely populated and frequently occurring weeds of wheat in the country among the other problematic weeds (Siddiqui and Bajwa, 2001).

Total weed density and biomass was significantly influenced by all the sowing dates and planting methods recorded at 40, 60 and 80 DAS during years 2008-09 and 2009-10 (Table 1). Interaction between sowing dates and planting methods was also significant and it was observed that minimum total weed density and biomass was noted where wheat was planted on beds at December 15 (D_3M_1) against the maximum total weed density where wheat was planted by broadcast method at November 15 (D_1M_3) at all recorded times during both years (Table 1). Among the different sowing dates minimum total weed density and biomass was observed where wheat was planted at December 15 and in comparison to November 15 planted wheat, reduction in total weed density and biomass by wheat planted at December 15 and November 30 was 52% and 32% respectively (Table 1). Similarly planting methods also differed significantly in their influence upon total weed density and minimum total weed density and biomass was recorded where wheat was planted on raised beds. In comparison to broadcasted wheat, total weed density recorded in bed planted and drilled wheat was 46% and 23% less respectively (Table 1).

Table 1. Effect of sowing dates and planting methods on the total weed density and total weed dry weight (g m^{-2})

	Total weed density						Total weed dry weight					
	40 DAS		60 DAS		80 DAS		40 DAS		60 DAS		80 DAS	
Sowing dates	**2008-09**	**2009-10**	**2008-09**	**2009-10**	**2008-09**	**2009-10**	**2008-09**	**2009-10**	**2008-09**	**2009-10**	**2008-09**	**2009-10**
D_1 = November 15	145.76 a†	112.88 a	86.24 a	180.44 a	131.32 a	129.12 a	11.44 a	5.68 a	19.64 a	24.44 a	21.64 a	60.64 a
D_2 = November 30	98.04 b (-33)	80.88 b (-28)	50.44 b (-42)	163.32 b (-9)	72.00 b (-45)	83.76 b (-35)	5.96 b (-48)	2.76 b (-51)	5.72 b (-71)	17.92 b (-27)	14.64 b (-32)	39.12 b (-35)
D_3 = December 15	78.36 c (-46)	61.32 c (-46)	35.56 c (-59)	152.44 c (-16)	21.32 c (-84)	53.76 c (-58)	1.36 c (-84)	0.84 c (-85)	4.60 b (-77)	5.84 c (-76)	10.88 c (-50)	18.92 c (-69)
LSD (p) 0.05	14.64	11.20	10.68	5.04	18.08	6.76	1.00	0.32	2.52	2.60	0.44	4.16
Sowing methods												
M_1 =Bed Sowing	82.80 c (-38)	46.24 c (-70)	44.00 c (-39)	118.68 c (-42)	56.88 c (-42)	60.24 c (-46)	4.88 c (-33)	1.12 c (-76)	6.08 b (-62)	7.28 c (-70)	12.28 c (-36)	12.92 c (-81)
M_2 = Drill Sowing	106.72 b (-20)	94.68 b (-39)	56.44 b (-21)	174.24 b (-14)	68.88 b (-30)	95.12 b (-15)	6.52 b (-11)	3.52 b (-24)	7.92 b (-50)	16.28 b (-34)	15.64 b (-19)	38.84 b (-42)
M_3 = Broadcasting	132.68 a	156.24 a	71.76 a	203.32 a	98.88 a	111.32 a	7.32 a	4.64 a	15.92 a	24.64 a	19.24 a	66.92 a
LSD (p) 0.05	6.56	5.56	5.48	4.60	5.52	7.28	0.72	0.32	2.00	1.96	0.52	3.76
Interactions												
D_1M_1	127.32 c	52.00 ef	67.32 c	134.68 d	92.00 c	78.00 de	10.80 a	1.56 e	12.88 bc	13.44 e	15.92 d	23.64 f
D_1M_2	148.68 b	132.00 b	82.00 b	176.68 c	109.32 b	140.00 b	11.44 a	7.24 b	14.44 b	25.04 c	21.08 b	53.16 c
D_1M_3	161.32 a	160.68 a	109.32 a	230.00 a	192.68 a	169.32 a	12.00 a	8.20 a	31.60 a	34.88 a	28.00 a	105.04 a
D_2M_1	66.68 ef	46.68 ef	37.32 ef	121.32 e	62.00 d	69.32 ef	2.88 d	1.24 ef	2.96 f	5.84 fg	10.80 f	12.16 g
D_2M_2	101.44 d	94.00 cd	48.68 d	173.32 c	76.68 c	84.68 d	6.68 c	2.48 d	4.76 ef	17.64 d	15.12 d	40.00 d
D_2M_3	126.00 c	102.00 c	65.32 c	193.32 b	77.32 c	97.32 c	8.32 b	4.60 c	9.44 cd	30.24 b	18.04 c	65.28 b
D_3M_1	54.40 f	40.00 f	27.32 f	100.00 f	16.68 f	33.32 g	0.92 e	0.52 g	2.40 f	2.60 g	10.16 f	3.00 h
D_3M_2	70.00 e	58.00 e	38.68 de	170.68 c	20.68 ef	60.68 f	1.44 e	0.88 fg	4.56 ef	6.24 f	10.76 f	23.36 f
D_3M_3	110.68 cd	86.00 d	40.68 de	186.68 b	26.68 e	67.32 ef	1.72 de	1.16 ef	6.80 de	8.76 f	11.68 e	30.44 e
LSD (p) 0.05	11.36	9.64	9.28	7.96	9.56	12.56	1.24	0.60	3.44	3.40	0.88	6.56

† Means not sharing a letter in common differ significantly at 0.05 p; Figures in parenthesis show percent decrease over November 15 and Broadcasting;

Table 2. Effect of sowing dates and sowing methods on the grain yield and yield contributing traits

Treatments	Grains per spike		1000 grain weight (g)		Productive tillers (m^{-2})		Grain yield (t ha^{-1})	
Sowing dates	**2008-09**	**2009-10**	**2008-09**	**2009-10**	**2008-09**	**2009-10**	**2008-09**	**2009-10**
D_1 = November 15	41.06 a†	43.17 a	39.92 a	41.10 a	290.78 a	325.33 a	2.37 a (38)	2.98 a (51)
D_2 = November 30	37.95 b	39.49 b	36.00 b	37.70 b	257.11 b	291.67 b	2.01 b (17)	2.40 b (21)
D_3 = December 15	35.79 c	34.69 c	31.73 c	34.28 c	238.11 c	232.67 c	1.72 c	1.98 c
LSD (p) 0.05	0.59	1.28	1.37	1.23	3.46	7.57	0.09	0.2
Planting methods								
M_1 = Bed Sowing	39.13 a	40.27 a	36.61 a	38.33 a	269.44 a	291.33 a	2.15 a (16)	2.57 a (15)
M_2 = Drill Sowing	39.00 a	39.87 a	36.42 a	38.21 a	266.00 a	289.56 a	2.10 a (14)	2.55 a (14)
M_3 = Broadcasting	36.67 b	37.21 b	34.62 b	36.54 b	250.56 b	268.78 b	1.85 b	2.24 b
LSD (p) 0.05	0.56	0.75	0.97	1.48	4.49	3	0.09	0.13
Interactions								
D_1M_1	42.07	44.98	40.65	41.88	301.67 a	338.00 a	2.50	3.11
D_1M_2	41.97	44.067	40.62	41.62	296.67 a	331.00 b	2.44	3.08
D_1M_3	39.13	40.467	38.48	39.80	274.00 b	307.00 c	2.17	2.76
D_2M_1	38.92	40.400	36.72	38.22	264.33 c	302.00 c	2.11	2.54
D_2M_2	38.70	40.167	36.59	38.18	261.00 c	301.67 c	2.07	2.5
D_2M_3	36.23	37.900	34.70	36.69	246.00 d	271.33 d	1.86	2.18
D_3M_1	36.40	35.433	32.47	34.88	242.33 d	235.67 e	1.85	2.07
D_3M_2	36.33	35.367	32.05	34.82	240.33 d	234.33 e	1.77	2.08
D_3M_3	34.63	33.267	30.68	33.13	231.67 e	228.00 f	1.53	1.78
LSD (p) 0.05	ns*	ns	ns	ns	7.77	5.20	ns	Ns

† Means not sharing a letter in common differ significantly at 0.05 p; Figures in parenthesis show percent increase over December 15 and Broadcasting, *ns = non-significant

Table 3. Economic Analysis (2008-09)

Treatments	$D_1 S_1$	$D_1 S_2$	$D_1 S_3$	$D_2 S_1$	D_2S_2	D_2S_3	$D_3 S_1$	$D_3 S_2$	$D_3 S_3$	Remarks
Grain yield	2.50	2.44	2.17	2.11	2.07	1.86	1.85	1.77	1.53	Mg ha^{-1}
Adjusted yield	2.25	2.20	1.95	1.90	1.86	1.67	1.67	1.59	1.38	10% less, to bring at farmer level
Income Rs. ha^{-1}	59063	57645	51266	49849	48904	43943	43706	41816	36146	Rs. 1050 /40 kg
Straw yield	9.41	9.38	8.7	8.09	8.09	7.66	7.07	7.01	6.67	Mg ha^{-1}
Adjusted yield	8.47	8.44	7.83	7.28	7.28	6.89	6.36	6.31	6.00	10% less, to bring at farmer level
Income Rs. ha^{-1}	33876	33768	31320	29124	29124	27576	25452	25236	24012	Rs. 160 /40 kg
Gross income	92939	91413	82586	78973	78028	71519	69158	67052	60158	Rs. ha^{-1}
Cost that vary	3750	2500	375	3750	2500	375	3750	2500	375	Charges (Rs. ha^{-1}) for, > Bed sowing @ 3775/- > Drill sowing @ 2500/- > Broadcasting @375/-
Net benefits	89189	88913	82211	75223	75528	71144	65408	64552	59783	Rs. ha-1

D_1 = November 15; D_2 = November 30; D_3 = December 15; S_1 = Bed Sowing; S_2 = Drill Sowing; S_3 = Broadcasting

Table 4. Economic Analysis (2009-10)

Treatments	$D_1 S_1$	$D_1 S_2$	$D_1 S_3$	$D_2 S_1$	D_2S_2	D_2S_3	$D_3 S_1$	$D_3 S_2$	$D_3 S_3$	Remarks
Grain yield	3.11	3.08	2.76	2.54	2.5	2.18	2.07	2.08	1.78	Mg ha^{-1}
Adjusted yield	2.80	2.77	2.48	2.29	2.25	1.96	1.86	1.87	1.60	10% less, to bring at farmer level
Income Rs. ha^{-1}	73474	72765	65205	60008	59063	51503	48904	49140	42053	Rs. 1050 /40 kg
Straw yield	10.57	10.60	9.60	8.57	8.50	7.57	7.30	7.33	6.80	Mg ha^{-1}
Adjusted yield	9.51	9.54	8.64	7.71	7.65	6.81	6.57	6.60	6.12	10% less, to bring at farmer level
Income Rs. ha^{-1}	38052	38160	34560	30852	30600	27252	26280	26388	24480	Rs. 160 /40 kg
Gross income	111526	110925	99765	90860	89663	78755	75184	75528	66533	Rs. ha^{-1}
Cost that vary	3750	2500	375	3750	2500	375	3750	2500	375	Charges (Rs. ha^{-1}) for, > Bed sowing @ 3775/- > Drill sowing @ 2500/- > Broadcasting @375/-
Net benefits	107776	108425	99390	87110	87163	78380	71434	73028	66158	Rs. ha^{-1}

D_1 = November 15; D_2 = November 30; D_3 = December 15; S_1 = Bed Sowing; S_2 = Drill Sowing; S_3 = Broadcasting

Table 5. Marginal Analysis (2008-09)

Treatments	Cost that vary (Rs.)	Net profit (Rs.)	Marginal cost	Marginal net benefits	*Marginal rate of returns (%)
D_1 S_3	375	82211	-	-	-
D_2 S_3	375	71144	0	D	D
D_3 S_3	375	59783	0	D	D
D_1 S_2	2500	88913	2125	29130	1371
D_2 S_2	2500	75528	0	D	D
D_3 S_2	2500	64552	0	D	D
D_1 S_1	3750	89189	1250	24637	1971
D_2 S_1	3750	75223	0	D	D
D_3 S_1	3750	65408	0	D	D

D_1 = November 15; D_2 = November 30; D_3 = December 15; S_1 = Bed Sowing; S_2 = Drill Sowing; S_3 = Broadcasting

Table 6. Marginal Analysis (2009-10)

Treatments	Cost that vary (Rs.)	Net profit (Rs.)	Marginal cost	Marginal net benefits	*Marginal rate of returns (%)
D_1 S_3	375	99390	-	-	-
D_2 S_3	375	78380	0	D	D
D_3 S_3	375	66158	0	D	D
D_1 S_2	2500	108425	2125	42267	1989
D_2 S_2	2500	87163	0	D	D
D_3 S_2	2500	73028	0	D	D
D_1 S_1	3750	107776	1250	34748	2780
D_2 S_1	3750	87110	0	D	D
D_3 S_1	3750	71434	0	D	D

D_1 = November 15; D_2 = November 30; D_3 = December 15; S_1 = Bed Sowing; S_2 = Drill Sowing; S_3 = Broadcasting

***Crop parameters*:** Wheat grain yield, productive tillers, grains per spike and thousand grain weight was significantly influenced by all the sowing dates and planting methods during both the years of experimentation (Table 2). Interaction between sowing dates and planting methods was significant only for productive tillers, while non-significant for grains per spike, thousand-grain weight and grain yield (Table 2). Maximum grains yield (2.50 and 3.11 t ha^{-1}) and yield related traits were recorded where wheat was planted on beds at November 15 and this was followed by the wheat planted in lines by drill on the same date (Table 2). Among the various sowing dates wheat planted on November 15 produced maximum grain yield and in comparison to late planted wheat on December 15. Grain yield obtained from November 15 and November 30 planted wheat was 38, 51 and 17, 21% more during both years of experimentation (Table 2). While in case of different planting methods, bed planted wheat produced maximum grain yield during both years and this was statistically similar to the drill planted wheat. In comparison to broadcasted wheat, bed and drill sown wheat produced 14-16% more grain yield (Table 2).

***Economic and marginal analysis*:** Economic and marginal analysis revealed that sowing of wheat on November 15 on raised beds and by drilling observed maximum net benefits during 2008-09 and 2009-10, respectively (Tables 3-4). A further perusal into marginal analysis revealed that sowing of wheat at November 15 on raised beds gave better marginal rate of return (MRR) during both the year of experimentation (1971 and 2780%) as compared to the other planting techniques at different dates. This was followed by the drilling of wheat at November 15 where MRR was 1371 and 1989% during 2008-09 and 2009-10, respectively (Tables 3-4). While all other planting methods and sowing dates were uneconomical due to higher cost involved.

DISCUSSION

In present study weed infestation was much higher in early sown wheat while delay in sowing not only decreased the weed density (Table 1) but also caused decline in grain yield of wheat (Table 2). It may be due to the favorable temperature during mid-November, which was suitable not only for crop but also for the weeds emergence and establishment. During the early sowing much higher weed density compared to the delayed sowing was earlier reported (Subhan *et al*., 2003). While low temperature during December inhibits the germination of wheat and its associated weeds. Previously it was concluded that delay in sowing of wheat past November reduced weed population to a significant level and also reduced wheat yield (Bhan,

1987). However, total weed density and dry biomass differed significantly between the years; possibly due to the difference in precipitation received and temperature between the two experimental years.

Different wheat planting methods significantly influenced the weed density and dry biomass during both the years of study (Table 1). Possible reason of the low weed pressure in bed sowing is, weed seeds are usually present in the upper soil layer and are buried to deeper depth during bed preparation and may not germinate well. Higher weed population in broadcasted wheat was possibly due to the poor stand establishment of wheat (Table 2), as seeds are not placed at proper depth by broadcasting. Whereas in case of drilled and bed planted wheat seeds were placed at proper depth and there was better and uniform wheat germination (Table 2), which suppressed the weed germination and growth (Table 1). In comparison of different planting methods of wheat, 30-40% less weed infestation was reported in raised beds than the traditional flat sowing in line and broadcasting (Ram *et al*., 2005; Ghani and Zahid, 2006; Mollah *et al*., 2009). Similarly, in comparison of drill sowing of wheat, more weed density was recorded in broadcasted wheat and this was probably due to the low wheat plant population achieved from broadcasting (Hassan *et al*., 2003).

Maximum grain yield, productive tillers, grains per spike and thousand grain weight were recorded at early planting of wheat at November 15 during both years of experimentation (Table 2). This was possibly due to the better crop stand in case of early planting (November 15) although at this sowing date weed density and biomass was also high but crop stand was good enough to compete with the associated weeds. In case of late planting (December 15), although weed dynamics was minimum but wheat germination was also poor, leading to reduced number of productive tillers and ultimately reduced grain yield (Table 2). Moreover number of grains per spike and thousand grain weight was also lower as compared to the timely plating of wheat and similarly in an experiment Laghari *et al*. (2012) observed decrease in number in grains per spike and grain weight due to late planting of wheat than timely plantation. That's why maximum net benefits were obtained when wheat was planted at November 15 during both the year of experimentation. In a field trial, early sowing of wheat at November 15 produced maximum productive tiller and grain yield as compared to the late sowing of wheat (Shah *et al*., 2006). Delay in sowing of wheat reduced the grain yield and this was due to reduction in yield contributing traits; number of productive tillers, grains spile^{-1} and grain yield (Ansary *et al*., 1989). Along with other factors grain yield has direct relation with duration of vegetative period; short vegetative duration reduces the grain yield. Longer the vegetative phase (planting to heading), the greater would be the grain yield (Alvaro *et al*., 2008). Shortening of vegetative growth from post emergence to pre flowering by delay in sowing can cause substantial yield losses (Akmal *et al*., 2011; Hussain *et al*., 2012b). Better performance of wheat varieties were also reported by Hameed *et al*. (2003) if sown in early November while, Shahzad *et al*., (2002) recorded minimum production in late sowing of wheat.

Planting methods has significant effect on the wheat plant population; highest number of productive tillers was observed in bed planting of wheat (Table 2). The higher grain yield under bed planting can be attributed to lower weed densities, which allowed better crop growth and resulting in higher grain yield. Aggarwal and Gosswami (2003) reported significantly lower weed population and higher grain yield of wheat under bed planting compared to flat planting method. Low grain yield in broadcasted wheat was due to lower plant population (Table 2) and high weed infestation (Table 1). Maximum productive tillers were recorded in case of bed planted wheat as compared to the drilled and broadcasted wheat (Tanveer *et al*., 2003). The grain yield obtained from drill planted wheat was more as compared to the broadcast method of planting wheat (Table 2). Drill planting gives better results as compared to the broadcast method (Fenech and Papy, 1977). Higher grain yield and yield contributing traits were observed in case of drill sowing as compared to the broadcast planting of wheat (Kipps, 1970; Shaalan *et al.,* 1977).

***Conclusion*:** Delay in sowing caused substantial yield decrease with simultaneous reduction in weed infestation. Similarly selection of appropriate planting method is also very necessary for getting maximum return of a crop. Maximum grains per spike, thousand grain weight, productive tillers and grain yield was recorded under timely planting of wheat at November 15 on raised bed. Although grain yield and yield related traits recorded in bed sowing and drill sowing are statistically similar but marginal analysis indicates higher marginal rate of return in bed sowing of wheat on 15 November. So adoption of raised bed planting on November 15 is necessary for getting maximum returns.

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