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Full Length Article

Influence of Seed Priming and Sowing Methods on Growth and Productivity of Wheat Cultivars Differing in Seed Size in Rice-Wheat Cropping system of Punjab, Pakistan

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Abstract

Poor and erratic stand establishment causes significant yield loss in wheat sown after puddled rice in rice-wheat cropping system. Such losses can be overcome by sowing of wheat with appropriate cultivar after seed priming by conservation tillage practices. Primed (hydropriming and osmopriming with $CaCl_2$) and dry seeds of three wheat cultivars AS-2002, FSD-2008, Lasani-2008 (having bold, medium and small seed size, respectively) were planted by plough tillage, happy seeder (zero tillage) and turbo seeder. Wheat planted with conservation tillage using happy seeder improved the grain yield and related parameters. Bold seeded variety 'AS-2002' had better stand establishment, yield contributing traits and grain yield than small and medium seed varieties. Crop sown with happy seeder using hydroprimed seeds completed its maturity earlier through rapid phenological developments. Hydropriming of medium seeded variety (FSD-2008) sown with happy seeder produced maximum economic return followed by osmoprimed seed of Lasani-2008 (small seeded using happy seeder. In conclusion, sowing of primed seeds (hydropriming/osmopriming) of medium seeded cultivar after seed priming with happy seeder improved the productivity of wheat sown in conventional rice-wheat system.

Keywords: Seed size; Seed priming; Conservation tillage; Rice-wheat cropping systems

Introduction

In rice-wheat cropping system of Pakistan, rice is grown in puddled fields thus formation of hardpan due to excessive use of machinery for puddling results in poor root development in succeeding wheat crop thus reduce the nutrient and water uptake from soil (Farooq *et al.,* 2011). Due to soil compaction, leaching and de-nitrification increase which ultimately leads towards the low availability of nitrogen (N) to plant (Fugelsnes and Lie, 2011). Moreover, late harvesting of rice and crop residues management is the major problem for timely preparation of seedbed of following wheat crop that delay timely wheat sowing resulting in low productivity of wheat (Farooq *et al*., 2008a, b; Nawaz *et al*., 2017). These problems may be solved by sowing wheat with zero tillage (ZT). ZT technology used for sowing of wheat crop can help to enhance the grain yield, increase input use efficiency and the net income of growers (Gupta and Seth, 2007; Erenstein *et al.*, 2008; Shahzad *et al*., 2017). ZT in wheat is helpful in timely sowing, reduces cost of production/tillage cost (Erenstein and Laxmi, 2008) and improves soil fertility status (Mohanty *et al.,* 2007). Under ZT, wheat is usually sown using different equipments like zone disk tiller machine, happy seeder, turbo seeder and tine openers (Baker *et al.,* 1996). Lampurlaneas *et al*. (2001) found that ZT facilitated water storage in soil and root growth. For sustaining agronomic production soil physical environment is important. Experimental results showed that soil physical properties are mainly affected by tillage (Rashidi and Keshavarzpour, 2008; Nawaz *et al*., 2017). ZT changed the physical properties of soil depending on the climate and adaptation factors (Martinez *et al.,* 2008). In ZT, more drainage, macro pores and higher soil water movement then conventional was recorded. The minimum disturbance of soil results better aggregate stability more infiltration rate of water include bulk density and root penetration resistance compared to conventional system of sowing of wheat with normal ploughing practices (Alvarez and Steinbach, 2009). Similarly, Cavalieri *et al*. (2009) suggested that ZT reduce damaging effects of soil erosion as compare to the conventional system of tillage. Therefore, the OM contents and pore spaces in the upper soil layers were improved using ZT system (Nawaz *et al*., 2017).

Seed selection plays major role in determining the performance and productivity of crop. Moreover, seed quality is affected by many factors *e.g*., genetic makeup of variety, seed viability and seed vigor, and moisture percentage in grains (Akbari *et al.,* 2004). Hence, seed weight substantially affects the germination, vigor and seedling establishment of crop. Seeds with higher weight may have high germination under field condition (Gorge and Ray, 2005). Size of seed may be positively linked with seed vigor as bold seed produce vigorous seedlings under field conditions.

Effectiveness of seed priming techniques in improving stand establishment and productivity of wheat and many other crops has been reported (Harris *et al.,* 2007; Farooq *et al*., 2008a; Hussain *et al.*, 2016). Seed priming is an economical technology and improves early growth of crop leading to better stand establishment and ultimately yield related benefits especially in wheat crop (Rehman *et al.,* 2011; Hussain *et al*., 2017). In hydropriming seeds are soaked in water and are dried before sowing to complete seed hydration. Aeration may or may not be provided to submerged seeds; whereas, osmopriming refers to soaking of seeds in aerated solutions with low water potential. Then the seeds are re-dried near to original weight after soaking with forced air under shade. Seeds osmoprimed with $CaCl_2$ took lesser time for seed germination compared to untreated seeds (Farooq *et al*., 2008a, b). Osmopriming with $CaCl_2$ also improved total sugars and non-reducing sugars in wheat plants (Afzal *et al.,* 2008). Osmopriming with calcium salts is an effective method for enhancing germination rate and better plant establishment in wheat (Hussain *et al.,* 2016).

The effect of seed size on the performance of wheat crop in improving yield has been reported earlier (Shahwani *et al.,* 2014; Haider *et al.,* 2016). However, there influence on the productivity of conventional and zero tillage wheat under rice-wheat cropping system are rarely investigated. So keeping this in view the present study was conducted to evaluate the impact of seed size, seed priming techniques along with planting methods on the productivity of wheat sown after puddled and aerobic rice systems.

Materials and Methods

Site, Soil and Climate

Two-year field experiment was carried out at the Adaptive Research Farm, Gujranwala, Punjab (latitude 32°N, longitude 74°E and altitude 226 m) during 2016–2017 and 2017–2018. Prior to experimentation, the soil samples (30 cm depth) were collected from the experimental site to determine the soil properties (Table 1).

Table 1: Post-experimental soil analysis of experimental site

Treatments			pH	EC ($dS\ m^{-1}$)	OM ($mg kg^{-1}$)	N ($mg\ kg^{-1}$)	P ($mg\ kg^{-1}$)	K ($mg kg^{-1}$)
			7.8	0.93	8.9	0.53	5.0	140
Conventional Method	AS-2002	C	7.1	0.81	8.3	0.40	8.0	129
		H	7.3	0.80	8.5	0.38	9.1	128
		O	8.2	0.90	7.0	0.25	8.2	120
	FSD-2008	C	7.0	0.87	6.9	0.40	8.1	139
		H	6.9	0.87	7.9	0.39	7.3	133
		O	8.1	0.70	8.1	0.49	8.4	129
	Las-2008	C	7.9	0.81	7.2	0.38	6.7	121
		H	8.0	0.91	8.0	0.50	9.7	134
		O	8.2	0.87	8.8	0.49	7.5	110
Happy Seeder	AS-2002	C	7.4	0.80	8.3	0.35	7.9	125
		H	7.0	0.67	7.7	0.43	6.9	132
		O	7.5	0.77	8.0	0.38	7.1	121
	FSD-2008	C	7.8	0.58	8.3	0.50	8.1	134
		H	7.6	7.70	7.2	0.42	7.7	140
		O	8.1	7.30	6.8	0.43	6.9	133
	Las-2008	C	7.7	0.80	7.9	0.47	7.3	125
		H	8.0	0.9	8.0	0.61	6.7	129
		O	8.1	0.87	8.1	0.49	8.0	138
Turbo Seeder	AS-2002	C	8.2	0.70	7.3	0.50	9.1	110
		H	7.8	0.69	7.8	0.38	8.1	133
		O	7.7	0.71	7.6	0.33	8.3	127
	FSD-2008	C	7.9	0.78	8.0	0.45	7.2	134
		H	8.0	7.5	8.1	0.49	7.1	140
		O	8.1	8.1	8.0	0.37	8.2	138
	Las-2008	C	7.7	0.80	8.3	0.50	8.0	133
		H	8.3	0.9	7.9	0.41	7.7	125
		O	8.0	0.87	7.8	0.38	8.0	135

Seed Material and Priming

The experimental treatments were comprised of three seed sizes, *i.e*., bold seed (AS-2002) (S_1), medium seed (FSD-2008) (S_2) and small seed (Lasani-2008) (S_3; based on 1000-seed weight), three seed priming treatments, *i.e*., control (no priming) (P_1), hydropriming (P_2) and osmopriming (P_3). Wheat was planted under different sowing methods including conventional method (plough tillage) (M_1), happy seeder (zero tillage) (M_2) and turbo seeder (zero tillage) (M_3).

Seeds of three different wheat cultivars *i.e*., AS-2002, Faisalabad-2008, Lasani-2008 were obtained from the Wheat Research Institute, AARI, Faisalabad. For hydropriming, seeds were soaked directly in the distilled water provided with aeration. For osmopriming, seeds were soaked in aerated solution of $CaCl_2$ (1.2%) for 10 h at 25 ± 2°C. The ratio of seeds to solution was 1:5 (w/v). After priming, seeds were surface washed with distilled water and re-dried under shade near to their original weight and then sealed in cloth bags and stored in a refrigerator for further use.

Experimental Design and Treatments

The experiment was laid out in randomized complete block design with split-split plot design and four replications, randomizing the sowing method in main plots, seed size in sub plots and seed priming treatments in sub-sub plots. The net plot size was 4×13 m.

Crop Husbandry

Seedbed was prepared according to treatments' requirement. For conventional tillage, the field was cultivated two times with disc harrow followed by two times cultivation along with planking. After land preparation, wheat seeds were broadcast in the field. For zero tillage, after the rice harvesting with combine harvester, wheat seeds were directly sown in field with the help of happy seeder and turbo seeder. Crop was sown on 26th and 27th of November, 2016 and 2017, respectively using125 kg ha^{-1} seed rate. Fertilizer was applied at 125-100-60 kg ha^{-1} nitrogen (N), phosphorus (P) and potassium (K). The whole P and K along with half N were applied at sowing, while remaining N was applied with first irrigation at tillering stage. Totally three irrigations were applied from sowing till maturity. First irrigation was applied 35 days after sowing (DAS), while 2nd and 3rd irrigations were applied in the 4th week of February, and 3rd week of March, respectively. Bromoxynil at 1250 mL ha^{-1} was applied five days after first irrigation with a knapsack sprayer for the control of broad leaf weeds. Fenoxaprop P-ethyl at 1000 mL ha^{-1} was applied three days after 2nd irrigation for the control of narrow leaf weeds. The crop was harvested manually at its maturity. The first year trial was harvested on 29th of April, 2017; while the second year trial was harvested on 27th April, 2018.

Observation and Measurements

Ten plants were selected at random from each sub-plot and individual plant height from soil surface to the tip of the ear head was measured with the help of a meter rod and then averaged. Total tillers and productive tillers were counted from unit area (1 m × 1 m) from each plot at harvesting time. Ten spikes were randomly selected and the spike length was recorded with the help of scale and then averaged. These spikes were threshed manually to separate the grains. The threshed grains were counted to record the number of grains per spike. Samples of 1000 grain were taken from each sub plot and then weighed on an electric balance. Total dry biomass (biological yield) of sun-dried samples was recorded for each treatment by using a weighing balance. The crop was threshed manually. Grain yield for each treatment was recorded by an electric balance and was converted into kg/ha and expressed in tons per hectare (t/ha). The values of grain yield were adjusted to 12% moisture level. Harvest index (HI) was calculated as the ratio of grain yield to the biological yield, and was expressed in percentage.

Statistical Analysis

The collected data were analyzed statistically by employing the Fisher's analysis of variance technique (Steel *et al.*, 1997) using Statistix 8.1 (Analytical software, Statistix; Tallahassee, FL, USA, 1985–2003) and honest significance difference (HSD) Tukey's test at 5% probability level was used to compare the differences among treatments means. None of the interactions were significant hence data only on main effects has been presented.

Results

Germination and Phenological Traits

Among seed size, small seeded cultivar (Lasani-2008) showed the highest germination counts in 2016–17 (Table 2). While during second year, maximum germination count was recorded in small seeded (Lasani-2008) and medium seed sized cultivar (FSD-2008). Among seed priming treatments hydroprimed wheat seed showed highest germination count that was statistically similar with osmopriming during first year; while during 2017–2018, hydropriming was best in this concern. Among wheat sowing methods, wheat planted with turbo seeder had the highest germination count during both years under study (Table 2).

Seed priming significantly affected the different reproductive phases from booting to physiological maturity during both years. Wheat sowing methods significantly affected the days to booting during first years. Among seed priming non-primed seed (control) took less time to reach booting, heading, anthesis and maturity during both years (Table 2).

Morphological, Yield and Yield Related Traits

The highest total tillers were recorded with osmopriming that was similar with hydropriming during first year; while osmopriming was the best during second year. Osmoprimed seeds produced maximum productive tillers that were statistically similar with no priming during second year of study. The maximum spike length was recorded with hydropriming that was statistically similar with no priming during both growing seasons. During first year, the maximum grains per spike were recorded with hydropriming (Table 3).

Among seed priming, the maximum biological yield was recorded with hydropriming that was statistically equal with osmopriming during 2016–2017 and 2017–2018. Osmopriming produced maximum biological yield that was statistically equal with hydropriming (Table 4). During first year; while during second year; the maximum harvest index was recorded with osmopriming that was statistically similar with hydropriming. For second year, the maximum harvest index was recorded in non-primed seed (control) that was statistically similar with hydropriming seeds (Table 4).

During first year, wheat planted with turbo seeder produced the highest number of total tillers. During second year, highest total tillers were recorded in wheat planted with turbo seeder that was statistically similar with wheat planted with happy seeder. The highest productive tillers were recorded in wheat planted with turbo seeder that was statistically similar with wheat planted with happy seeder during second year of study (Table 3).

During first year the maximum 1000-grain weight was recorded in bold seeded cultivar (AS-2002). While during

Table 2: Seed germination and phenology of wheat cultivars as affected by seed priming and sowing methods

Treatments	Germination count (%)		Days to booting		Days to heading		Days to anthesis		Days to maturity	
	2016–17	2017–18	2016–17	2017–18	2016–17	2017–18	2016–17	2017–18	2016–17	2017–18
S_1	222.5 B	221.4 B	97.1	95.5	101.8	100.1	112.5	111.8	138.2	135.5
S_2	224.3 B	226.5 A	97.1	95.5	101.8	100.1	112.5	111.8	138.2	135.5
S_3	227.4 A	225.1 A	97.1	95.5	101.8	100.1	112.5	111.8	138.2	135.5
HSD ($P < 0.05$)	1.51	1.66	NS	NS	NS	NS	NS	NS	NS	NS
P_1	222.08 B	219.1 C	95.3 C	93.7 B	101.0 C	96.4 C	111.6 B	110.8 B	137.5 B	134.7 B
P_2	228.22 A	228.1 A	97.5 B	95.8 A	102.2 B	100.7 B	112.6 A	111.9 A	138.4 A	135.6 A
P_3	226.72 A	225.7 B	98.0 A	96.3 A	102.8 A	101.1 A	112.9 A	112.1 A	138.5 A	135.8 A
HSD ($P < 0.05$)	1.52	1.72	0.38	0.57	0.39	0.42	0.33	0.43	0.41	0.34
M_1	225.2 B	223.9 B	96.8 B	95.2	101.8	97.5	112.3	111.6	138.2	135.4
M_2	224.3 B	223.1 B	97.3 A	95.6	102.1	100.4	112.4	111.6	138.1	135.3
M_3	227.4 A	225.9 A	96.7 B	95.1	101.9	100.3	112.4	111.6	138.2	135.5
HSD ($P < 0.05$)	2.72	2.08	0.46	NS	NS	NS	NS	NS	NS	NS

Means not sharing a letter in common differ at 5% probability level by Tukey's HSD test. $S_{1=}$ Bold seed (AS-2002), $S_{2=}$ Medium seed (FSD-2008), $S_{3=}$ Small seed (Lasani-2008); $P_{1=}$ Control, $P_{2=}$ Hydropriming, $P_{3=}$ Osmopriming with $CaCl_2$ (1.2%), $M_{1=}$ Conventional method (plough tillage), $M_{2=}$ Happy seeder (zero tillage), $M_{3=}$ Turbo seeder (zero tillage)

Table 3: Morphological and yield related traits of wheat cultivars as affected by seed priming and sowing methods

Treatments	Plant height (cm)		Total tillers (m^{-2})		Productive tillers (m^{-2})		Spike length (cm)		Spikelets per spike		Grains per spike	
	2016–17	2017–18	2016–17	2017–18	2016–17	2017–18	2016–17	2017–18	2016–17	2017–18	2016–17	2017–18
S_1	87.0	87.2	314.0 B	303.7 B	314.6	300.6 A	9.04 AB	9.11 A	16	15	42.1 B	42.4
S_2	89.1	88.6	319.5 AB	307.1B	320.1	303.8 B	9.14 A	9.13 A	16	16	45.1 A	45.2
S_3	85.1	86.0	331.3 A	319.6 A	328.6	316.3 A	8.82 B	8.85 B	16	16	45.0A	46.8
HSD ($P < 0.05$)	ns	Ns	15.5	12.2	Ns	12.45	0.23	0.18	ns	Ns	1.72	1.45
P_1	86.7	87.0	321.6	310.6	319.3	307.6	9.16	9.14	16	15	44.1	44.5
P_2	87.4	87.4	321.9	309.0	322.2	305.6	8.88	8.94	16	16	44.1	44.3
P_3	87.0	87.4	321.3	310.7	321.6	307.5	8.96	9.00	16	16	44.1	45.6
HSD ($P < 0.05$)	ns	Ns	Ns	ns	Ns	Ns	ns	ns	ns	Ns	ns	ns
M_1	87.2	87.4	296.1 C	283.8 B	293.9 B	280.6 B	8.98	9.06	16	16	44.6	44.3
M_2	86.9	87.3	323.6 B	314.1 A	326.6 A	310.8 A	9.09	9.05	16	15	43.5	45.6
M_3	86.9	87.1	345.1 A	332.5 A	342.7 A	329.2 A	8.93	8.98	16	16	43.3	43.7
HSD ($P < 0.05$)	NS	NS	19.8	21.8	19.87	22.13	NS	NS	NS	NS	NS	NS

Means not sharing a letter in common differ at 5% probability level by Tukey's HSD test. $S_{1=}$ Bold seed (AS-2002), $S_{2=}$ Medium seed (FSD-2008), $S_{3=}$ Small seed (Lasani-2008); $P_{1=}$ Control, $P_{2=}$ Hydropriming, $P_{3=}$ Osmopriming with $CaCl_2$ (1.2%), $M_{1=}$ Conventional method (plough tillage), $M_{2=}$ Happy seeder (zero tillage), $M_{3=}$ Turbo seeder (zero tillage)

second year, bold seeded cultivar (AS-2002) had highest 1000-grain weight that was statistically similar with medium seed sized cultivar (FSD-2008). For first year, medium seeded cultivar (FSD-2008) and small seeded cultivar (Lasani-2008) produced maximum grain yield (Table 4). While during second year, bold seeded cultivar (AS-2002) gave highest grain yield that was statistically similar with medium seeded cultivar (Lasani-2008) (Table 4). During first year, small seeded cultivar (Lasani-2008) had highest biological yield that was statistically similar with medium seeded cultivar (FSD-2008), while during second year small seeded cultivar (Lasani-2008) was best in this concern. Similarly, bold seeded cultivar (AS-2002) had maximum harvest index that was statistically similar with medium seeded cultivar (FSD-2008) during both years of study (Table 4).

Among seed priming, biological yield was maximum with hydropriming that was statistically similar with osmopriming during first year. While during second year, osmopriming produced maximum biological yield that was statistically similar with hydropriming (Table 4). The maximum harvest index was recorded with osmopriming that was statistically similar with hydropriming during first year. During second year, harvest index was maximum with no priming that was statistically similar with hydropriming (Table 4).

Among WSM, during first year, the maximum 1000-grain weight was recorded in wheat planted with happy seeder that was statistically similar with plough tillage wheat. Wheat planted with happy seeder produced maximum grain yield that was statistically similar with wheat planted with turbo seeder during second year. The maximum biological yield was recorded in wheat planted with happy seeder during first year and similar trend was observed during second year. During first year, the maximum harvest index was recorded in wheat planted with plough tillage that was statistically similar with wheat planted with turbo seeder (Table 4).

Economic Analysis

The maximum net income was obtained when medium size seed (FSD-2008) variety was hydroprimed and planted with happy seeder followed by small size seed (Lasani-2008) variety using happy seeder combined with osmopriming, medium size seed (FSD-2008) by using turbo seeder with

Table 4: Yield and related traits of wheat cultivars as affected by seed priming and sowing methods

Treatments	1000-grain weight (g)		Grain yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest index (%)	
	2016–17	2017–18	2016–17	2017–18	2016–17	2017–18	2016–17	2017–18
S_1	43.2 A	39.3 A	3.5 B	3.2 A	8.1 B	8.5 B	43.6 A	38.3 A
S_2	40.5 B	38.6 A	3.6 A	3.1 AB	8.9 A	7.9 C	42.2 AB	39.1 A
S_3	36.5 C	34.7 B	3.6 A	3.1 B	9.6 A	9.1 A	49.6 B	33.5 B
HSD ($P < 0.05$)	0.73	1.43	0.15	0.12	0.48	0.34	2.79	2.09
P_1	39.9	37.4	3.6	3.07	9.5 B	8.0 B	40.1 B	39.02 A
P_2	39.9	37.5	3.6	3.12	8.8 A	8.7 A	41.6 AB	36.6 AB
P_3	40.6	37.5	3.6	3.11	8.3 A	8.9 A	43.8 A	35.4 B
HSD ($P < 0.05$)	NS	NS	NS	NS	0.33	0.38	2.22	2.56
M_1	40.0 AB	36.7	3.6	2.8 B	8.3 B	8.1 B	44.1 A	36.1
M_2	40.2 A	38.1	3.6	3.3 A	9.4 A	9.2 A	38.9 B	36.6
M_3	39.6 B	37.7	3.6	3.1 A	8.6 B	8.3 B	42.5 A	38.3
HSD ($P < 0.05$)	0.47	NS	NS	0.22	0.42	0.21	2.93	NS

Means not sharing a letter in common differ at 5% probability level by Tukey's HSD test. $S_{1=}$ Bold seed (AS-2002), $S_{2=}$ Medium seed (FSD-2008), $S_{3=}$ Small seed (Lasani-2008); $P_{1=}$ Control, $P_{2=}$ Hydropriming, $P_{3=}$ Osmopriming with $CaCl_2$ (1.2%), $M_{1=}$ Conventional method (plough tillage), $M_{2=}$ Happy seeder (zero tillage), $M_{3=}$ Turbo seeder (zero tillage)

Table 5: Economic analysis of potential role of seed size and enhancements in improving productivity of wheat sown by different sowing methods

Treatments			Rabi 2016–2017	Rabi 2017–2018	pooled yield	Income ($ ha^{-1})	Cost of Prod. ($ha^{-1})	BCR	Net Income ($ ha^{-1})
Conventional Method	As-2002	Control (non-primed)	3.55	3.04	3.30	1027.5	612.9	1.68	414.6
		Hydro-priming	3.82	2.89	3.35	1045.4	612.9	1.71	432.6
		Osmo-priming	3.46	3.04	3.25	1013.5	612.9	1.65	400.6
	FSD-2008	Control (non-primed)	3.65	2.79	3.22	1003	612.9	1.64	390.1
		Hydro-priming	3.27	2.84	3.05	951.51	612.9	1.55	338.6
		Osmo-priming	3.38	2.76	3.07	956.96	612.9	1.56	344.1
	Lasani-2008	Control (non-primed)	3.48	2.70	3.09	962.81	612.9	1.57	349.9
		Hydro-priming	3.72	2.92	3.32	1034.9	612.9	1.69	422.0
		Osmo-priming	4.10	2.68	3.39	1056.7	612.9	1.72	443.9
Happy seeder	As-2002	Control (non-primed)	3.52	3.25	3.38	1054	505.0	2.09	549.0
		Hydro-priming	3.26	3.44	3.35	1045.4	505.0	2.07	540.4
		Osmo-priming	3.37	3.49	3.43	1068.4	505.0	2.12	563.4
	FSD-2008	Control (non-primed)	3.80	3.38	3.59	1118.3	505.0	2.21	613.3
		Hydro-priming	3.96	3.46	3.71	1155.8	505.0	2.29	650.7
		Osmo-priming	3.76	3.19	3.47	1083.3	505.0	2.15	578.2
	Lasani-2008	Control (non-primed)	3.67	3.10	3.39	1056	505.0	2.09	551.0
		Hydro-priming	3.81	3.13	3.47	1081.3	505.0	2.14	576.3
		Osmo-priming	3.77	3.50	3.63	1132.4	505.0	2.24	627.4
Turbo seeder	As-2002	Control (non-primed)	3.58	3.40	3.49	1088.3	500.3	2.18	588.1
		Hydro-priming	3.64	3.01	3.33	1037.7	500.3	2.07	537.4
		Osmo-priming	3.39	3.31	3.35	1044.7	500.3	2.09	544.4
	FSD-2008	Control (non-primed)	3.80	3.04	3.42	1065.7	500.3	2.13	565.4
		Hydro-priming	4.02	3.19	3.60	1123.8	500.3	2.25	623.5
		Osmo-priming	3.53	3.00	3.26	1017.4	500.3	2.03	517.1
	Lasani-2008	Control (non-primed)	3.59	3.09	3.34	1041.2	500.3	2.08	540.9
		Hydro-priming	3.51	3.23	3.37	1050.9	500.3	2.10	550.6
		Osmo-priming	3.54	3.01	3.27	1020.9	500.3	2.04	520.6

hydropriming method and also medium size seed (FSD-2008) by using happy seeder in conventional method (Table 5).

Discussion

Germination count and yield related traits of wheat cultivars markedly influenced by different seed priming techniques and sowing methods (Tables 2–4) *i.e.*, vigorous seeds germinate quickly and produce plants with more height and more number of tillers per unit area and results in higher grain yield and production (López-Bellido *et al.,* 2007). All three wheat varieties varied in their performance due to their difference in seed size. The numbers of tillers were maximum in FSD-2008 (medium seed size) due to its genetic character, while number of grains per spike was higher in small seeded cultivar (Lasani-2008) due to less thousand grains weight and size. Growth of seedling depends on the amount of energy stored in the seed. Test weight of bold seed was higher due to increased endosperm size and more accumulation of photo assimilates. The 1000-grain weight of all wheat cultivars (with different seed size) declined during 2018 due to abrupt increase in temperature at grain filling stage which affects the overall grain weight and yield.

Seed size has strong influence on the seedling establishment; seed with more size has more food reserve and often exhibiting rapid emergence resulting in higher grain yield and harvest efficiency (Willenborg *et al.,* 2005). Moreover, germination rate and seedling vigor improve with increase in the seed size (Meyer and Carlson, 2001). Because, in bold seed stored food reserve are the only source of food (Kaya and Day, 2008) unless the seedling start to manufacture food through photosynthesis. Thus, the more food reserve and larger embryo size in bold seeded cultivar enhance the seed germination and improve root growth in different tillage systems. Guillen-Portal *et al.* (2006) reported, large sized seed tend to develop better roots system that enable the seedling to get moisture efficiently from deeper soil layers. As seed size increases, the seed protein and starch contents increases that may lead to improved and faster plant growth (Anuradha *et al.,* 2009).

Wheat sowing methods (conventional and conservational) had no significant impact on phenological stages of wheat. However, the conservation tillage in wheat (turbo seeder and happy seeder) enhanced the seedling emergence, improved the yield related traits and grain yield of wheat (Table 2, 3 and 4). It was reported by Hao *et al*. (2001) and Hemmat and Eskandari (2004) that, under different tillage systems wheat grain yield increased by 27 to 31% over conventional tillage system. The benefits of conservation tillage were previously discussed by Farooq *et al.* (2011). Zero tillage in wheat facilitate timely sowing of wheat, improve soil structure and biological properties (soil microbial biomass carbon), increase input use efficiency that help to maximize the crop productivity (Gupta and Seth, 2007; Mohanty *et al.,* 2007; Liu *et al*., 2010).

Primed seed meets the optimum growth cycle by diminishing the emergence period (Farooq *et al.,* 2008a,b). Seed priming is a partial hydration practice that metabolizes the seed reserve, make it ready to use by germinating embryo. It speeds up the emergence process and ultimately reduces the days to booting, heading and anthesis of wheat and ultimately results in early physiological maturity (Hussain *et al.,* 2016). However, in this study, wheat crop raised from unprimed seeds showed poor germination with less grain yield as compared to osmoprimed seed sown under conservation tillage systems. Poor crop stand generated by unprimed seeds under conservation tillage may be due to poor seed-soil contact that cause delayed germination (Nawaz *et al.,* 2016). Seed priming with $CaCl_2$ was effective in improving the stand establishment under zero tillage systems that may be due to decrease in time of germination due to improved germination metabolism. Seed priming with $CaCl_2$ help achieving the uniform and early crop stand through improving the germination metabolism, quick expansion of embryo and plant tillering capacity resulting in better yield (Pandita *et al.,* 2007; Sarlach *et al.,* 2013). Furthermore, calcium (Ca^{2+}) has vital role in carbohydrate metabolism during stand establishment and initial plant developmental phases; osmopriming with $CaCl_2$ may improve the Ca^{2+} contents that are crucial for seed metabolism (Farooq *et al*., 2010).

Earlier emergence, vigorous seedlings and early flowering of osmoprimed wheat seeds than unprimed seeds might be the reason of better wheat performance under zero tillage system (Haider *et al*., 2016). Although there is poor soil-seed contact under zero tillage systems, however, primed seed exhibited early germination because of sufficient availability of internal seed moisture that stimulate the radicle protrusion (Nawaz *et al*., 2016). Maximum net income, benefit to cost ratio and net returns were obtained by planting osmoprimed medium size seeds (Faisalabad-2008) with happy seeder.

Conclusion

Wheat planted under conservation tillage such as using turbo seeder and happy seeder improved the seedling emergence, yield related traits resulting in higher grain yield compared to wheat sown by conventional system. Use of bold grain seeds cultivar produced the higher yield. Moreover, seed priming (hydropriming and osmopriming) further enhanced the performance of wheat sown under conservation tillage.

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