Research Article

Effect of Seed Priming on Production of Wheat under Different Tillage Operations

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Abstract | Wheat is a major diet component for humans in daily life. In addition to being a major source of starch and energy, wheat also provides substantial amounts of a number of components which are essential or beneficial for health. However, its production is being reduced day by day due to many issues but one of them is late sowing. Subsequently, it reduces grain filling and also production. This emerging issue can be solved by using the seed priming techniques. An experiment with randomized complete block design (RCBD) with two factors on area of four-acre land was conducted. Further, four treatments have been adopted like hydro priming, osmo-priming, on-farm priming, and control under different tillage operations just like zero tillage, conventional tillage, deep tillage, and bed sowing. Result showed that osmo-priming is the best method to increase the plant height (94.74cm), tillers (311.49 m^{-2}), spike length (10.18cm), number of grains per spike (43.24), grain yield (4244.8kg ha-1), straw yield (8330.5kg ha^{-1}) and Harvest Index (33.81%) especially in late-sown wheat. It should help to reduce the time to germinate and increases metabolic actions in plants. Healthy seedling germination will increase the yield of the crop. Moreover, it was concluded that osmo-priming is best for farmers to reduce the negative effects of zero tillage and by time of bed sowing, and then it will produce maximum results. Further, it will helpful for the farmers to enhance their income.

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Introduction

Seed priming is the procedure through which seeds are induced into a state of pre-germination metabolism by controlled rehydration to boost germination rates and germination strength (Paparella *et al*., 2015). The issue of late sowing can be solved by using seed priming techniques which enhance germination percentage and reduced the time to germinate which has elevated vigor and resulted in higher productivity of agronomic crops (Kaur *et al*., 2005; Farooq *et al*., 2006a, b, 2007a, b). This improvement in germination percentage and plant productivity both are carried out because of seed priming techniques which enhance the metabolic actions but not allowed the radical to come out (Ghasemi-Golezani *et al*., 2008; Pirasteh-Anosheh *et al*., 2011). The improvement in germination resulted in the healthy emergence of seedlings which ultimately ensured higher productivity as compared to the field where seed priming was not done (Parera and Cantliffe, 1994).

Different methods of seed priming are used to improve seed germination: Seed priming included Halo-priming, Hydro-priming, Osmo-priming, Osmo-conditioning, Osmo-hardening, Hormo-priming, Hardening, Matri-priming, and others. Halo and Hydro priming can be defined as soaking seeds in salt solutions and water respectively (Ghassemi-Golezani *et al*., 2008). All the priming methods applied to the seed had a significant effect on germination and ultimately the yield of wheat. The priming techniques like Osmo-priming in which seeds are primed in low water potential solution, hydro priming in which tap water is used for seed treatment, and On-farm techniques in which soaking the seed just before the seed sowing (Afzal *et al*., 2019, 2020). This can be practically proved by researchers that a lot of farmers from different locations confirmed that primed seed crops germinated earlier, first flowered, and then ultimately gave superior productivity (Farooq *et al*., 2008). So, it can be told that the priming techniques enhanced the germination and seedling health, a higher tillering capability that improved the production of cereal crops (Afzal *et al*., 2004; Farooq *et al*., 2008). Tillage played a significant role in the soil compaction that ultimately maintains the production of any crop. Tillage activities are done in the field to change the tilth of the soil. Tillage altered the soil's physical and mechanical properties which had an obvious effect on the root growth, development, and distribution in the soil (Russell, 1981). Soil compaction is an important factor which had a significant role in crop productivity. From research, it is evident that soil compaction on the upper layer is more than on the lower layer because of zero tillage techniques (Braim *et al*., 1992). The infiltration process of water is reduced in this compacted soil because of zero tillage which makes the soil waterlogged. Therefore, the role of zero tillage is minimized in the heavy rainy zone (Lampurlane *et al*., 2001). The furthermore important impact of tillage regarding crop productivity is about the weed. In the good tilth soils, the number of weeds is less down as compared to zero tillage and less tilth soils. The aim of the study was to test the effects of different seed priming methods on the plant growth parameters and yield of wheat. We hypothesize that "Osmo" priming is better than the other priming methods.

Materials and Methods

The study to examine the effect of different priming techniques on the growth and yield of wheat under different tillage techniques was conducted at the agronomic Research Area, University College of Agriculture, Bahauddin Zakariya University Multan, Pakistan during Rabi season 2022-23. The climate of the region is semi–arid and subtropical. The experimental area was quite uniform and the soil was silty clay loam and saline in nature. The experiment was laid out in randomized complete block design (RCBD) with split plot arrangements by keeping the tillage practices in the main plot as Factor A (T1= Zero tillage, T2= Conventional Tillage, T3= Deep Tillage, T4= Bed Sowing (90/45) and Priming techniques in a subplot as factor B (P1= Control, P2= hydro priming with distilled water, P3= Osmo priming with $CaCl_2$, P4= On farm priming.

Earlier to seedbed preparation, pre-soaking irrigation was applied. When soil reached to practicable moisture regime, the seed bed was made by cultivating the land with tractor-mounted cultivar followed by planking. The crop was sown on November 13, 2022 on a well-prepared seedbed. Sowing was done by single row manual hand drill by using a seed rate of 125 kg ha^{-1}. Nitrogen and phosphorous fertilizers were applied @ 125 and 100 kg per ha, respectively by using Urea and TSP as sources. A full dose of phosphorous and a one-third dose of nitrogen was applied at the time of sowing. Second one-third dose of nitrogen was applied at 1st irrigation and leftover nitrogen was applied at 2nd irrigation. All other agronomic practices were kept normal and uniform to keep crops free from insects and diseases. The mature crop was harvested on April 19, 2023.

Growth and yield parameters of wheat

Following growth and development parameters (Leaf area index, Crop growth rate gm^{-2} $days^{-1}$) were measured using the methodology of Amanullah *et al*.

(2020).The data of number of productive tillers, spike length (cm), number of fertile and infertile florets per spikelet's, number of grains per spike, 1000-grain weight (g), grain yield (kg ha^{-1}), biological yield (kg ha^{-1}), straw yield (kg ha^{-1}) and harvest index (%)were also recorded using the methodology of Sarlach *et al.* (2013) with little modification.

Data analysis

The data was analyzed using split plot design and means were compared by LSD Statistix 8.1v (Analytical Software, 2005).

Results and Discussion

An experiment to study the different priming techniques on the growth and yield of wheat under different tillage techniques was conducted at the agronomic Research Area, BZU, Multan. The results obtained are presented and discussed in the following lines:

Growth and development related traits

Leaf area index (LAI): Initially, the leaf Area Index improved up to 70 days after sowing (DAS) and then decreased up to 115 DAS. Different tillage practices and various priming techniques had a significant effect on LAI whereas crops sown under zero tillage had minimum LAI throughout the entire growing season (Figure 1). Similarly, among different priming techniques, the osmo-primed crop had maximum LAI whereas the control had minimum LAI. Regarding the interaction among different tillage practices and various priming techniques, the osmo-primed crop under all tillage operations performed well whereas the no-primed crop under zero tillage did not perform well in this regard (Figure 1).

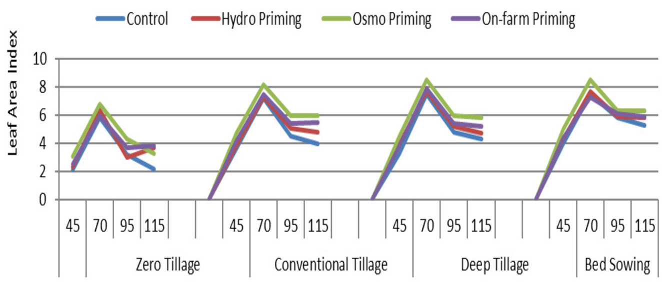

Figure 1: *Effect of different priming techniques on LAI of wheat under different tillage operations.*

Crop growth rate (CGR) (gm^{-2}day^{-1})

The data (Figure 1) show that CGR progressively increased up to 70-95 days after sowing (DAS) and then started declining. Different tillage practices and various priming techniques had a significant effect on CGR. Among different tillage practices, crop sown under bedsowing observed maximum CGR whereas crop sown under zero tillage had minimum CGR. Throughout the entire growing season. Similarly, among different priming techniques, the osmo-primed crop had maximum CGR whereas the control had minimum CGR. Regarding the interaction among different tillage practices and various priming techniques, the osmo-primed crop under all tillage practices performed well whereas the no-primed crop under zero tillage did not perform well in this regard (Figure 2). Priming significantly affects plant growth rate and resist high disease (Walter *et al.*, 2008).

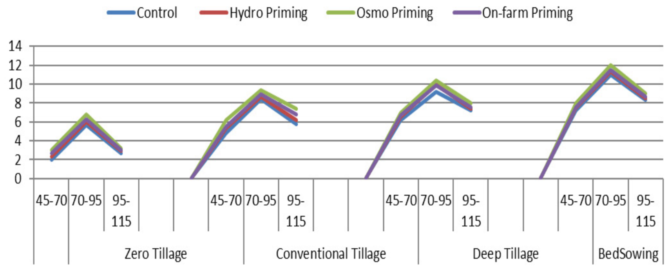

Figure 2: *Effect of different priming techniques on CGR of wheat under different tillage operations.*

Plant height at maturity (cm)

Primary techniques, tillage practices, and interaction among priming techniques and tillage practices had a significant effect on plant height. Among different priming techniques, osmo-priming and on-farm priming had maximum plant height but control had a minimum plant height Zero tillage had minimum plant height whereas bed sowing had maximum plant height. Regarding the interaction between priming techniques and tillage practices, maximum plant height was observed in on-farm priming under bed sowing which was at par with other priming techniques under bed sowing whereas minimum plant height was obtained in control under zero tillage (Table 1).

Seed treatment enhanced germination percentage which resulted in healthy seedlings that ultimately improved the plant height. These results are in line with the suggestion given by Kaur *et al.* (2005), Farooq *et al.* (2007a, b) who proposed that seed priming treatments improved the agronomic traits due to move vigorous seedlings, which were able to capture the resources in a better fashion and finally ending in healthy plants. However, the use of heavy equipment causes soil compaction (Larsen *et al.*, 1994). Reduction in the plant because of no-tillage is also previously studied by Tebrugge (1993) who studied that general reduction in plant vigor which ultimately reduced the plant height.

Number of productive tillers (m^{-2})

Priming techniques, tillage practices, and interaction among them had a significant effect on numbers of productive tillers. Among different priming techniques, osmo-priming had a maximum number of productive tillers but control had a minimum number of them. Zero tillage had a minimum number of productive tillers whereas bed sowing had a maximum number of productive tillers. Regarding the interaction among priming techniques and tillage practices, a maximum number of productive tillers was observed in Osmo-priming under bed sowing which was at par with hydro priming and Osmo-priming techniques under bed sowing whereas a minimum number of productive tillers was obtained in control under zero tillage (Table 2). Priming techniques improved the germination time and numbers of tillers. These results agreed with the findings of Ugrate *et al*. (2007) who stated that late-planted crop has lower germination, fewer tillers, smaller heads, shriveled grain, and lower biomass than the timely planted crop. Similarly, soil compaction and weed problems occurred because no tillage adversely affected the fertile tillers. Higher fertile tillers because of bed sowing were noticed which enhanced the root growth, nutrient, and water uptake (Malik *et al*., 2001).

Table 1: *Effect of different priming techniques on plant height (cm) of wheat under different tillage practices.*

Primary techniques	Tillage practices				Means
	Zero tillage	Conventional tillage	Deep tillage	Bed sowing	
Control	87.02h	94.44e	95.20c-e	95.97a-c	93.15c
Hydro priming	88.90g	95.34b-e	95.27c-e	96.39ab	93.97b
Osmo priming	91.92f	95.67b-d	95.52b-e	95.87a-c	94.74a
On-farm priming	92.62f	95.67b-d	94.77d-e	96.87a	94.98a
Means	90.11c	95.28b	95.19b	96.27a	
LSD value at 5%	T= 0.55, P= 0.55, T*P= 1.10				

Values within columns followed by the same letter do not differ significantly at the P > 0.05

Table 2: *Effect of different priming techniques on number of productive tillers(m^{-2}) of wheat under different tillage practices.*

Primary techniques	Tillage practices				Means
	Zero tillage	Conventional tillage	Deep tillage	Bed sowing	
Control	237.23k	329.53h	332.76ef	333.99c-e	308.38c
Hydro priming	239.43j	331.07g	334.27b-d	335.50ab	310.07b
Osmo priming	242.23i	332.90d-f	334.80a-c	336.03a	311.49a
On-farm priming	240.57j	332.57f	333.90c-f	335.13ac	310.54b
Means	239.87d	331.52c	333.93b	335.16a	
LSD value at 5%	T= 0.58, P= 0.73, T*P= 1.39				

Values within columns followed by the same letter do not differ significantly at the P > 0.05

Table 3: *Effect of different priming techniques on spike length (cm) of wheat under different tillage practices.*

Primary techniques	Tillage practices				Means
	Zero tillage	Conventional tillage	Deep tillage	Bed sowing	
Control	5.73h	9.39g	11.10d	11.60c	9.45b
Hydro Priming	5.80h	9.83f	11.72c	11.54c	9.72b
Osmo Priming	5.24i	10.35e	12.35b	12.78a	10.18a
On-farm Priming	5.52hi	10.10ef	12.38b	12.14b	10.03a
Means	5.57c	9.92b	11.89a	12.01a	
LSD value at 5%	T=0.19, P=0.16, T*P=0.34				

Values within columns followed by the same letter do not differ significantly at the P > 0.05

Links Researchers

Spike length (cm)

Priming techniques, tillage practices, and interaction among priming techniques and tillage practices had a significant effect on spike length. Among different priming techniques, osmo-priming and on-farm priming had maximum spike length but the control had minimum plant height. Zero tillage had minimum spike length whereas bed sowing and deep tillage had maximum spike length (Table 3). Regarding the interaction between priming techniques and tillage practices, maximum spike length was observed in osmo-priming under bed sowing whereas minimum spike length was obtained in osmo-priming under zero tillage (Table 3). These results are agreed with the findings of Ugarte *et al*. (2007) who stated the late-planted crop has lower germination, fewer tillers reduction in spike length, shriveled grain, and lower biomass than the timely planted crop.

Number of grains per spike

Priming techniques, tillage practices, and interaction among priming techniques and tillage practices had a significant effect on the number of grains per spike. Among different priming techniques, Osmo-priming and hydro priming had a maximum number of grains per spike which was at par with the on-farm priming technique but the control had a minimum number of grains per spike. Zero tillage had a minimum number of grains per spike whereas bed sowing had the maximum number of grains per spike. Regarding the interaction between priming techniques and tillage practices, the maximum number of grains per spike was observed in osmo-priming under bed sowing which was at par with hydro priming and on-farm priming under bed sowing and osmo-priming under deep tillage whereas a minimum number of grains per spike was obtained in control under zero tillage which was at par with all other tillage treatments under zero tillage (Table 4). Due to terminal high temperature the number of grains per spike and tillers become less (Laghari *et al*., 2012).

1000–grain weight

Priming techniques and tillage practices had a significant effect on 1000-grain weight. Among different priming techniques, osmo-priming had a maximum 1000 grain weight but on farm priming had a minimum 1000 grain weight. Zero tillage had a minimum 1000 grain weight whereas bed sowing had maximum1000 grain weight. Regarding the interaction among priming techniques and tillage practices, a maximum 1000 grain weight was observed in osmo-priming under bed sowing which was at par with hydro priming under bed sowing whereas a minimum 1000 grain weight was obtained in all priming under zero tillage (Table 5). These results are in line with the findings of Kaur *et al.* (2005), Farooq *et al.* (2007a, b) who noticed that increase in 1000-grain weight because of seed priming treatments. Similarly, an improvement of 1000-grain weight was noticed due to fertile soil compaction occurring because of bed sowing (Malik *et al*., 2001).

Table 4: *Effect of different priming techniques on number of grains per spike of wheat under different tillage practices.*

Primary techniques	Tillage practices				Means
	Zero tillage	Conventional tillage	Deep tillage	Bed sowing	
Control	30.48fg	44.46e	46.48cd	47.34bc	42.22b
Hydro Priming	31.34f	45.48de	47.38bc	48.38ab	43.18a
Osmo Priming	29.18g	46.28cd	48.14ab	49.34a	43.24a
On-farm Priming	29.48g	46.07cd	47.11bc	48.28ab	42.76ab
Means	30.12d	45.58c	47.28b	48.34a	
LSD value at 5%	T= 0.69, P= 0.80, T*P= 1.54				

Values within columns followed by the same letter do not differ significantly at the P > 0.05

Table 5: *Effect of different priming techniques on 1000 grain (g) of wheat under different tillage practices.*

Primary techniques	Tillage practices				Means
	Zero tillage	Conventional tillage	Deep tillage	Bed sowing	
Control	31.41g	35.24ef	36.76d	37.79bc	35.30bc
Hydro priming	32.08g	35.91de	36.31d	38.73ab	35.76b
Osmo priming	32.07g	36.51d	37.74c	39.63a	36.49a
On-farm priming	31.74g	34.84f	36.81d	36.53d	34.99c
Means	31.82d	35.63c	36.90b	38.17a	
LSD value at 5%	T=0.49, P=0.46, T*P=0.94				

Values within columns followed by the same letter do not differ significantly at the P > 0.05

Table 6: *Effect of different priming techniques on grain yield (kg ha^{-1}) of wheat under different tillage practices.*

Primary techniques	Tillage practices				Means
	Zero tillage	Conventional tillage	Deep tillage	Bed sowing	
Control	2699.30i	3970ef	3874.30f	4521bc	3766.2bc
Hydro priming	30.82g	4158.30b	4386c	4725.70a	4088b
Osmo priming	2944.70g	4530b	4509.3bc	4841a	4244.8a
On-farm priming	2944.70h	4096.70d	4078.2de	4197.7d	3829.3c
Means	2956.2c	4188.8b	4212b	4571.3a	

Values within columns followed by the same letter do not differ significantly at the P > 0.05

Table 7: *Effect of different priming techniques on grain yield (kg ha^{-1}) of wheat under different tillage practices.*

Primary techniques	Tillage practices				Means
	Zero tillage	Conventional tillage	Deep Tillage	Bed Sowing	
Control	9530g	12268ce	11780f	12689c	11567 c
Hydro priming	9636g	12396cd	12480c	14441a	12238 b
Osmo priming	9615g	11891ef	14275a	14520a	12575 a
On-farm priming	9562g	12020df	13277b	13503b	12090 b
Means	9586 d	12144 c	12953 b	13788 a	
LSD value at 5%	T=194.48, P=239.15, T*P=456.72				

Values within columns followed by the same letter do not differ significantly at the P > 0.05

Grain yield (kg ha^{-1})

Priming techniques, tillage practices, and interaction among priming techniques and tillage practices had a significant effect on grain yield. Among different priming techniques, Osmo-priming had maximum grain yield but controlled had minimum grain yield. Zero tillage had minimum grain yield whereas bed sowing had maximum grain yield (Table 6). Regarding the interaction between priming techniques and tillage practices, maximum grain yield was observed in osmo-priming and hydro priming techniques under bed sowing whereas minimum grain yield was obtained in control under zero tillage (Table 6). Seed priming techniques increased grain yield if priming is done with inorganic salts or plant growth regulators (Ruan *et al*., 2002).

Biological yield (kg ha^{-1})

Priming techniques, tillage practices, and interaction among priming techniques and tillage practices had a significant effect on biological yield. Among different priming techniques, Osmo-priming had maximum biological yield but control had minimum biological yield. Zero tillage had minimum biological yield whereas bed sowing had maximum biological yield. Regarding the interaction between priming techniques and tillage practices, maximum biological yield was observed in osmo-priming and hydro priming techniques under bed sowing whereas minimum biological yield was obtained in all priming techniques under zero tillage (Table 7). The priming treatments which enhance seed germination and seedling growth as also biological yield include hydro priming, priming with plant growth promoters, halo priming, asnd osmo-priming (Afzal *et al*., 2006).

Straw yield (kg ha^{-1})

Priming techniques, tillage practices, and interaction among priming techniques and tillage practices had a significant effect on straw yield. Among different priming techniques, all priming techniques except control had maximum straw yield but control had minimum straw yield. Zero tillage had minimum straw yield whereas bed sowing had maximum straw yield (Table 8). Regarding the interaction between priming techniques and tillage practices, maximum straw yield was observed in osmo-priming and hydro priming techniques under bed sowing whereas minimum straw yield was obtained in all priming techniques. The practices include crop rotation integrated pest management and fine tillage operation increased straw yields (Koepke, 2003; Derpsch, 2008). Regarding the interaction between priming techniques and tillage practices, maximum grain yield was observed in osmo-priming and hydro priming techniques under bed sowing whereas minimum grain yield was obtained in control under zero tillage (Table 8). Seed priming techniques increased straw yield as well if priming is done with inorganic salts or plant growth regulators (Ruan *et al*., 2002).

Table 8: *Effect of different priming techniques on straw yield (kg ha^{-1}) of wheat under different tillage practices.*

Primary techniques	Tillage practices				Means
	Zero tillage	**Conventional tillage**	**Deep tillage**	**Bed sowing**	
Control	6831e	8298.30c	7905.70c	8168.4c	7800.8b
Hydro Priming	6553.7e	8237.70c	8093.70c	9715.2a	815.1a
Osmo Priming	6516e	7361.3d	9765.50a	9679a	8330.5a
On-farm Priming	6617e	7923.3c	9198.4b	9305.6ab	8261.1a
Means	6629.4d	7955.2c	8740.80b	9217.00a	
LSD value at 5%	T=200.55, P=248.99, T*P=474.71				

Values within columns followed by the same letter do not differ significantly at the P > 0.05

Table 9: *Effect of different priming techniques on harvest index (%) of wheat under different tillage practices.*

Primary techniques	Tillage practices				Means
	Zero tillage	**Conventional tillage**	**Deep tillage**	**Bed sowing**	
Control	28.33i	32.36eh	32.90df	35.66b	32.31b
Hydro priming	31.98eh	33.60ce	35.17bc	32.73dg	33.37a
Osmo priming	32.23eh	38.10a	31.59fh	33.34de	33.81a
On-farm priming	30.80h	34.11bd	30.72h	31.09gh	31.68b
Means	30.83c	34.54a	32.59b	33.21b	
LSD value at 5%	T=0.89, P=0.84, T*P=1.70				

Values within columns followed by the same letter do not differ significantly at the P > 0.05

Harvest index (%)

Priming techniques, tillage practices, and interaction among priming techniques and tillage practices had a significant effect on the harvest index. Among different priming techniques, hydro and Osmo-priming techniques had maximum harvest index but control and on-farm priming had minimum harvest index. Zero tillage had a minimum harvest index whereas bed sowing had a maximum harvest index (Table 9). Regarding the interaction between priming techniques and tillage practices, the maximum harvest index was observed in osmo-priming techniques under conventional tillage whereas the minimum harvest index was obtained in control under zero tillage (Table 9). Soil conservation because of zero tillage is laborious practice and lower harvest index noticed that higher harvest index because of seed priming treatments.

Conclusions and Recommendations

After our whole research, we concluded that different tillage practices had a significant effect on the growth and yield of wheat. Bed sowing enhanced the productivity of wheat which may be due to more aerated and pulverized soil that eventually increased the availability of nutrients to the crop. Zero tillage negatively impacted the productivity of wheat due to more compaction of soil and weed density as compared to others. Priming techniques also considerably affect wheat productivity. Osmo-primed crop performed well under all tillage practices but maximum in bed sowing. The negative impacts that came due to the zero tillage can be hailed by the osmo-priming technique.

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Novelty Statement

Due to increased soil compaction and weed density relative to other practices, zero tillage has a detrimental effect on wheat productivity. Therefore, this technique is recommended for better production of yield and sustainability of agriculture.

Author's Contribution

Muhammad Uzair Khalid and Muhammad Hasnain: Principal author did research and wrote the 1st draft of the manuscript.
Muhammad Tauseef and Muhammad Usman: Helped in manuscript write-up.
Muhammad Akram and Ali Raza: Helped in data analysis.
Abrar Ahmad and Muhammad Shahid: Conceived the idea and supervised the project.
Muhammad Shoaib Ismail and Rabia Afzal: Helped in relevant literature.
Atta-Ulla and Muhammad Hussain Babar: Proofreading and format setting.

Conflict of interest
The authors have declared no conflict of interest.

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