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Effect of seed priming, bio fertilizer inoculations and nitrogen levels on yield attributes, yield and economic returns of late sown wheat

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Abstract
A field experiment was conducted at CCSHAU, Hisar to determine the effect of seed priming, biofertilizer inoculations and nitrogen levels on late sown wheat. The experiment comprised of 5 seed priming treatments i.e. no seed priming, seed priming with water, seed priming with water + *Azotobacter*, seed priming with water + AM fungi, seed priming with water + Biomix in main plot and 4 nitrogen levels *viz.* 120, 135, 150 and 165 kg ha^{-1} in sub plot was carried out in split plot design with three replications. Seed priming with water along with either of biofertilizer inoculations i.e., *Azotobacter*, AM fungi and Biomix significantly improved grain yield, straw yield and yield attributes except 1000 - grain weight as compared to non primed-uninoculated treatment. However, harvest index was not significantly influenced by seed priming as well as inoculation treatments. The net returns (Rs.44041 ha^{-1} ha) and B:C ratio (2.07) were highest under the treatment water primed seeds inoculated with biomix closely followed by water primed seeds inoculated with AM fungi with returns of Rs. 43471 ha^{-1} and B:C of 2.06. Application of 150 kg N ha^{-1} significantly improved yield attributes except 1000 grain weight; yields and economic returns over both 120 and 135 kg N ha^{-1} levels, however, it was at par to 165 kg N ha^{-1} dose. Integrated use of 135 kg N ha^{-1}and water primed seed inoculated with biomix gave yield and economic returns comparable to highest dose of 165kg N ha^{-1} alone.

Keywords: late sown wheat, seed priming, *Azotobacter*, AM fungi, biomix, yield attributes, yield

Introduction
Wheat is the most important cereal crop grown in different parts of the world. It is the staple food for over 35% of the global population and provides more calories and proteins in the diet. Its delayed sowing beyond November 20, the optimal time results in linear yield decline of 1-1.5% per day. This decrease in yield is mainly due to appreciable reduction in crop life cycle under delayed sowing. The crop under late sowing has to complete its life cycle in a short period as starch accumulation by plants terminates at the same time in both normal and late-sown conditions (Akmal *et al*., 2011; Khan *et al*., 2010) [2, 28]. The declining trend in crop productivity under late sowing could be minimized by improving the sowing practices. Seed priming has been shown to improve the performance of late-sown wheat (Farooq *et al*., 2008) as it reduces time between sowing and seedling emergence and promotes synchronized emergence, improve germination giving better crop stand and final yield (Gupta *et al*., 2008; Khan *et al.*, 2011) [9, 11]. It is the simple, cost effective and useful technique to combat drought and other abiotic stress and advance the seedlings emergence by about 10 days which is beneficial for increasing wheat yield (Jafar *et al*., 2012) [11].
Biofertilizers promote growth of plant by increasing the availability of nutrients. *Azotobacter* is a free living nitrogen fixing bacterium fixes annually 60-90 kg N ha^{-1}. The use of Arbuscular Mycorrhizal Fungi (AMF) is capable of forming symbiotic association with most crops and has potential to promote growth due to its higher binding capabilities and mineral nutrition. Biomix is a unique combination of selected sp. of microbes which can solubilise residual phosphates, iron, magnesium etc. from soil making them more easily available to plants. The wheat crop under late sown conditions attains less growth and need adequate nitrogen for promotion of growth and yield. Thus, integrated use of all the above practices, need to be evaluated on late sown wheat crop.

Material and Methods

The field investigation was carried out during *rabi* 2015-16 at Research Farm of Department of Agronomy, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana (India) situated at 29° 10' N latitude and 75° 46' E longitude at an elevation of 215.2 m above mean sea level. Soil of the experimental site was sandy loam in texture, slightly alkaline in reaction (pH 8.3), low in organic carbon (0.32%) and available nitrogen (161 kg ha^{-1}), medium in available phosphorus (13 kg ha^{-1}) and high in available potassium (356 kg ha^{-1}). During the crop growing period, the mean weekly maximum and minimum temperature ranged between 15.3 to 39.9^{0}C and 4.0 to 21.3^{0}C, respectively. The rainfall received was 30.5 mm and the total pan evaporation was 367.4 mm during the crop growing period. The experiment comprising of five seed priming treatments *i.e.* no seed priming, seed priming with water, seed priming with water + inoculation with *Azotobacter*, seed priming with water + inoculation with AM fungi, seed priming with water + inoculation with Biomix (*Azotobacter* + *Azospirillum* + PSB) in main plots and four nitrogen levels *viz.* 120, 135, 150 and 165 kg ha^{-1} in sub plots was carried out in split plot design with three replications. The seeds were primed with soaking in water for 12 hours and thereafter inoculated with respective biofertilizer as per treatments and dried under shade prior to sowing. Sowing of the wheat variety WH 1124 was done on 29th December, 2015 by drilling method at 5-6 cm depth using different types of seed as per treatment with the help of tractor drawn seed drill at 20 cm row spacing. Recommended basal dose of P (60 kg P_2O_5 ha^{-1}) and K (30 kg K_2O ha^{-1}) and half dose of N as per treatments was applied to all the plots at the time of sowing and remaining half dose of N was top dressed at 1st irrigation. Other agro-practices were as per Package of Practices, CCSHAU, Hisar.

Results and Discussion

Yield attributes and yield: The priming of seed with water alone had no significant effect on increasing yield attributes viz. effective tillers, spike length and number of grains $spike^{-1}$ (Table 1). However, inoculation of water primed seeds with biofertilizer strains significantly increased the above yield attributes compared to both non primed and uninnoculated seeds. Among priming and inoculation treatments, biomix (*Azotobacter* + *Azospirillum* + PSB) inoculation gave maximum values of yield attributes but was statistically at par with inoculations of water primed seed with *Azotobacter and* AM fungi alone. Similar findings were reported by Ali *et al.* (2013) and Ramamurthy *et al.* (2015). The improvement due to seed priming with water + biofertilizer inoculations ranged between 8.7 to 11.0% for effective tillers, 5.8 to 7.6% for spike length and 11.3 to 14.3% for number of grains $spike^{-1}$, over non primed uninoculated seed. Seed priming with water + biofertilizer inoculations failed to significantly improve the 1000 grain weight of wheat under late sown condition. This is mainly due to the fact that 1000 grain weight being a trait of more genetic in nature was less influenced by management practices.

The data (Table 1) further indicated that significantly higher grain and straw yield were recorded by inoculation of water primed seed with either AM fungi or Biomix biofertilizers, however, *Azotobacter* was statistically at par with water priming of seed but better over non primed seed treatment. There was an increase of 9.5, 8.6, 6.1 and 2.7% in grain yield with water priming of seed + Biomix, seed priming + AM fungi, seed priming + *Azotobacter* and water priming of seed over non primed-uninoculated treatment (Fig 1), respectively. This increase in grain yield is due to increased values of yield attributes under seed priming + biofertilizer inoculations. The corresponding increase was 7.4, 6.6, 6.2 and 2.8 % for straw yield (Fig 1). These findings are in conformity with the results of Behl *et al*. (2003) [6] for AM fungi; Milosevic *et al*. (2012) and Narula *et al.* (2005) [19] for *Azotobacter*; Bahrani *et al*. (2010) [4] for *Azotobacter* and Mycorrhiza and Saber *et al*. (2012) [24], Singhal *et al*. (2012) [25] for PSB in wheat. Harvest index was not significantly influenced by seed priming and biofertilizer inoculation treatments. This might be on account of almost similar pattern of increase in grain and biological yields under all the seed priming and biofertilizer inoculation treatments. Similar results were reported by Jakhar (2004) [12].

The spike length, number of grains per spike and effective tillers m^{-2} increased significantly with increasing nitrogen up to 150 kg N ha^{-1}. Further increase in nitrogen dose to 165 kg N ha^{-1} did not increased yield attributes significantly over 150 kg N ha^{-1}. However, 1000 - grain weight did not increase significantly with increasing N levels (Table 1). Similar results were reported by Jakhar (2004) [12]. Increased yield attributes due to increasing level of N were due to better growth parameters with the increasing level of N. These findings substantiate the results of Patel *et al.* (2012) [22]; Pandey *et al.* (2014) [21] and Kaur *et al.* (2016) [13]. The grain and straw yields were improved significantly with increase in N dose up to 150 kg ha^{-1} which was statistically at par with 165 kg N ha^{-1} dose (Table 1). There was an increase of 4.5, 8.2 and 11.3% in grain yield and 3.8, 8.4 and 9.7% in straw yield with 135, 150 and 165 kg N ha^{-1} respectively, over 120 kg N ha^{-1} (Fig. 2). The higher yields with increasing nitrogen levels could be ascribed to its favorable effect on growth and yield attributing characters. Corroborative findings have been reported by Beheraa and Rautaray (2010), Patel *et al.* (2012) [22]; Pandey *et al*. (2014) [21], Kaur *et al.* (2016) 13]; Narolia *et al.* (2016) [18], Nishant *et al.* (2016) [20] in wheat crop.

Relationship between yield attributes and grain yield presented in Fig 3 showed that number of effective tillers had highest determination factor (R^2 = 0.940), followed by number of grains $spike^{-1}$ (R^2 = 0.935), spike length (R^2 = 0.884) and least value for 1000 grain weight (R^2 = 0.619), indicating comparatively strong relationship of number of effective tillers and number of grains $spike^{-1}$ with grain yield than spike length and 1000 grain weight. So, in order to enhance the productivity of late sown wheat more focus should be laid on the agronomic practices enhancing these yield parameters.

Economics

The net returns and B:C ratio were not increased significantly by seed priming with water (Table 1). Biofertilizer inoculations gave higher net returns and B:C than uninoculated treatment. All the biofertilizer inoculations were statistically at par with each other in all the economic parameters. The higher economic returns in these treatments were mainly due to higher yields with only Rs. 120-220 additional cost of treatments. Similar findings were reported by Tulasa Ram (1999) [13] and Gupta (2002) [21].

Application of nitrogen @ 150 and 165 kg ha^{-1} significantly increased net returns and B:C of wheat crop as compared to 120 and 135 kg N ha^{-1} level (Table 3). However, the differences among the later two levels were not significant to each other in respect to net returns. Similar results were reported by Tulasa Ram (1999) [26]]and Gupta (2002) [21]. Similarly, nitrogen application @ 135 kg ha^{-1} with either biofertilizer produced higher net returns (Rs. 43070 ha^{-1} with Biomix and Rs. 42375 ha^{-1} with AM fungi) in comparison to higher N dose of 165 kg ha^{-1} without inoculation (Rs. 41128 ha^{-1}). Highest net returns (Fig. 4) were obtained by Biomix with 165 kg N ha^{-1} (Rs. 47611 ha^{-1}). Higher economic returns with enhanced N fertilizers and biofertilizer might be ascribed to increase in grain and straw yields. Similar results of combined application of N and biofertilizer on net returns and B:C were reported by Chand *et al.* (2014) [7], Yadav *et al.* (2014) [7], Verma *et al*. (2015) [7] and Kumar *et al*. (2016) [7].

Table 1: Effect of seed priming, biofertilizer inoculations and nitrogen levels on yield attributes, yield and economics of late sown wheat

Treatment	Effective tillers (No. m.r.l^{-1})	Spike length (cm)	Number of grains Spike^{-1}	1000-grain weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)	Cost of cultivation (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C
Seed priming and inoculation										
No seed priming	59.8	8.40	36.3	39.22	36.50	56.10	39.4	40579	37529	1.92
Seed priming with water	62.1	8.49	37.9	39.43	37.49	57.70	39.4	40791	39468	1.97
Seed priming + Inoculation with *Azotobacter*	65.0	8.89	40.4	40.07	38.73	59.57	39.4	40911	41983	2.03
Seed priming + Inoculation with AM fungi	66.3	8.98	41.4	40.29	39.64	59.82	39.9	40911	43471	2.06
Seed priming + Inoculation with Biomix	66.4	9.04	41.5	40.08	39.97	60.26	39.9	41011	44041	2.07
SEm±	0.8	0.08	0.6	0.36	0.66	0.86	0.6	-	973	-
CD at 5%	2.7	0.27	2.1	NS	2.14	2.80	NS	-	3222	-
Nitrogen level (kg ha^{-1})										
120	58.3	8.48	36.2	39.35	36.29	55.65	39.5	40548	37059	1.92
135	63.3	8.67	38.5	39.41	37.92	57.76	39.6	40743	40191	1.99
150	66.0	8.93	40.7	40.14	39.26	60.33	39.5	40939	43069	2.05
165	68.1	8.97	42.4	40.37	40.39	61.03	39.8	41135	44874	2.09
SEm±	0.9	0.07	0.7	0.31	0.42	0.61	0.4	-	704	-
CD at 5%	2.5	0.21	1.9	NS	1.21	1.76	NS	-	2043	-

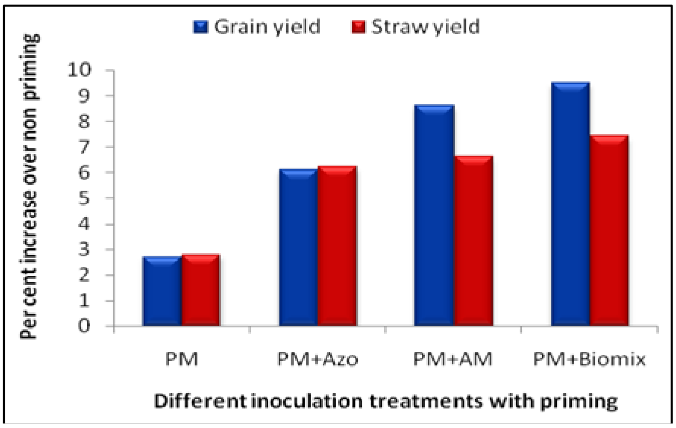


Fig 1: Effect of seed priming and bio-fertilizer inoculations on per cent increase in grain and straw yields

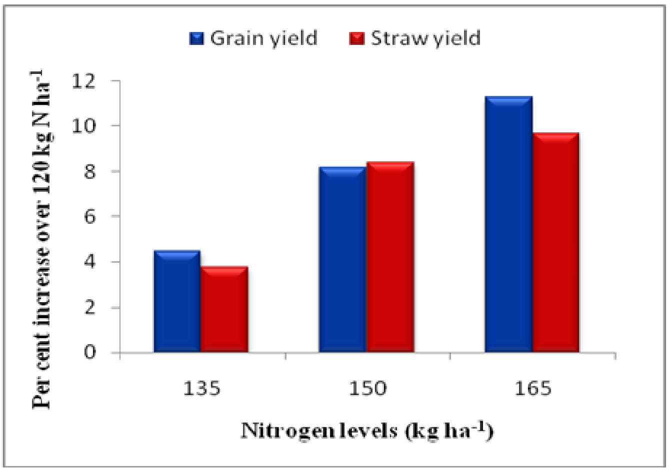
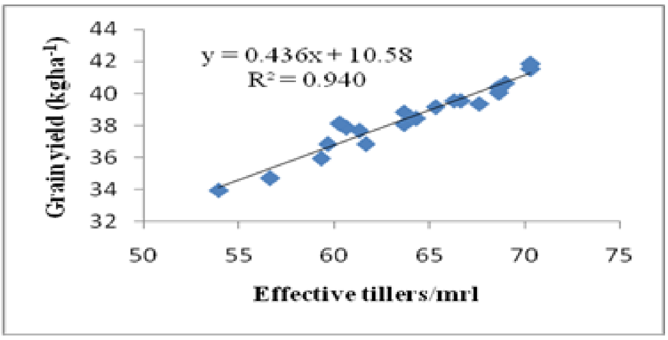
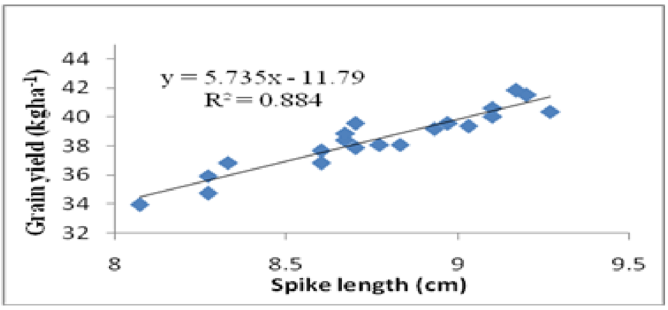
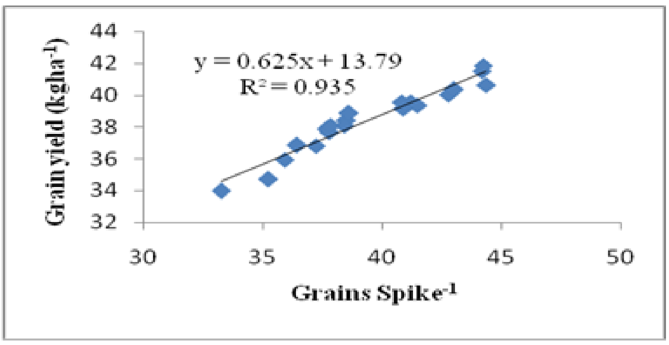


Fig 2: Effect nitrogen levels on per cent increase in grain and straw yields







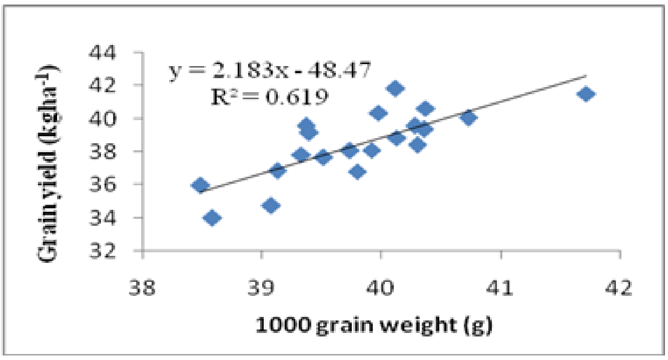


Fig 3: Relatioship between yield attributes and grain yield

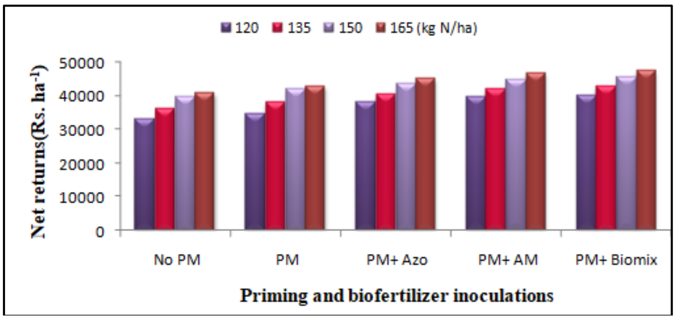


Fig 4: Integrated effect of seed priming, bio-fertilizers and nitrogen levels on net returns of wheat

Conclusion

The grain and straw yields and economic returns increased significantly with inoculations of water primed seed with Biomix and AM fungi biofertilizers. Late sown crop of wheat yielded significantly higher with increasing nitrogen dose up to 150 kg N ha^{-1}. However, water primed seed inoculated with biomix in integration with 135 kg N/ha and gave yield and economic returns at par to 165kg N ha^{-1} alone in late sown wheat crop.

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