



Comparative efficacy of improved crop management technologies of wheat (*Triticum aestivum*) in Bihar

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ABSTRACT

Wheat (*Triticum aestivum* L.) is the world's most widely cultivated cereal crop. It is commonly eaten in both time meals in major wheat growing states. Field experiments were conducted at eight KVKs of Bihar during year 2016-2018 based on different agro ecological situations. In the field experiment it was found that early wheat sowing has emerged as the most important variable for increasing the grain yield (5 t/ha) than late sown. Data shows that instead of skipping irrigation at grain filling stage, one irrigation applied at grain filling stage increased the wheat grain yield by 13% when the sowing was done with zero tillage and 16% when sowing was done by conventional method. With irrigation, the average grain yield of wheat with zero tillage was 5.30 t/ha compared to 4.54 t/ha under conventional tillage. To trace the impact of different herbicide application technologies, it was found multiple boom nozzle fitted with flat fan nozzles and tractor mounted sprayer provided similar wheat grain yield (5.1-5.3 t/ha) than hollow cone nozzles with grain yield of 4.6 t/ha. It was referred that grain yield of wheat were 4.51, 4.60 and 4.38 t/ha following the application of glyphosate at 24, 48 h or 7-10 days before seeding wheat, respectively. Total 304 replications have been conducted to study the effect of ZT on the productivity of wheat sown at different times and was found that ZT wheat (HD-2967) planted from 1-15 November gives highest yield than other sowing date.

Key words: Crop management, Sowing schedule, Wheat productivity, Zero tillage

In India, wheat (*Triticum aestivum* L.) is considered as a staple food with an area, production and productivity of 30.7 mha, 97.4 t and 3172 kg/ha, respectively (Waheddullah 2018). As a result of technological innovation, the country which produced only 5.6 million tonnes at the time of independence (1947-48) is now producing 92.46 million tonnes from 29.62 million ha (2012-13) with average productivity of 3.12 tonnes/ha (Anonymous 2013). Nevertheless, the progress should not make us contented as the country face countless challenges in the form of population growth coupled with decreasing arable land, depleting water resources and climate change. Increasing population leads to an increase demand of wheat with no possibility in further increase in area due to growing urbanization. Wheat is the main crop of winter and require specific temperature and light for emergence, growth and flowering (Dabre *et al.* 1993, Kaur 2017). Sowing of wheat in Bihar generally starts from Nov and ends in late Dec depending on the weather; topography and harvesting of

the preceding crop. Under late sown conditions, wheat face low temperature in the earlier part and high temperature in the later part of the growing season and require favourable moisture for better growth and development. In Bihar, late planting of wheat expressed to high temperature at reproductive stage causes reduced grain yield. About 80% of the wheat crop cultivated at late sown condition after harvesting the transplanted rice and this problem will be further increased due to global warming. Therefore, the study has been conducted to estimate the variation of wheat yield on different treatment which ultimately enhances the productivity of the crop in the region.

MATERIALS AND METHODS

A field experiment on different crop management technologies was conducted through on farm trail at eight KVKs of Bihar under guidance of ATARI, Patna during year 2016-2018. Among the 8 KVKs, 5 KVKs (Buxar, Rohtas, Bhojpur, Lakhisarai and Madhepura) comes under Bihar Agricultural University (BAU) and 3 KVKs (Begusarai, East Champaran, and Muzaffarpur) comes under Dr Rajendra Prasad Central Agricultural University (DRPCA). During 2016-17 and 2017-18, two groups of varieties; Normal Maturing Wheat Varieties (NMWVs) and Early Maturing Wheat Varieties (EMWVs) were tested in 555 replication plots under different sowing schedules to measure the performance in terms of yield across ecologies. To measure

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the role of additional irrigation during terminal heat stress period, during grain filling stage to beat stress and its effect on wheat productivity, a field experiment was conducted in total of 409 trails. Impact of herbicide application technology on the performance of herbicide in wheat yield has been measured by 177 trails in different locations. To judge the potential of using pre-seeding herbicide like glyphosate applied immediately before sowing wheat under zero tillage, trials were conducted. To quantify the effect of ZT on the productivity of wheat, a total of 304 sites representing 8 districts were selected for the study. Average grain yield of wheat under different rates on Nitrogen, Phosphorous and Potash applied into wheat seeded at different times has been measure by total of 1083 trails. All other agronomic practices during experiment were kept normal and uniform for all the treatments.

RESULTS AND DISCUSSION

Performance of normal maturing wheat varieties (NMWV) and early maturing wheat varieties (EMWV) under different sowing schedules across ecologies: It was reported from 5 KVKs of BAU that the average grain yield of wheat sown during Nov 1 to 20 was always more than wheat sown at later dates. The average grain yield of NMWVs of wheat edged down from 5.0 t/ha in Nov 1-10 sowing schedule to 4.65, 4.15, 3.75 and 3.37 t/ha in the sowing windows of 11-20 Nov, 21-30 Nov, 1-15 Dec and 16-30 Dec, respectively (Table 1). The grain yield of EMWVs when grown in last three sowing windows also depended on the date of sowing. The yield decreased from 3.60 t/ha when sowing was done from 21-30 Nov to 3.31 and 2.83 t/ha when sowings were done in a sowing schedule of 1-15 Dec and 16-30 Dec, respectively (Table 1).

NMWVs group was better than EMWVs group even

under late sowings. It was found that Dec is too late to avoid the effect of terminal heat in wheat. At all locations, EMWVs were expected to perform better than NMWVs. However, NMWVs provided same yield to that of EMWVs. This data will open up the debate on why we focus more on the promotion of EMWVs in these ecologies. That means NMWVs should always perform better than EMWVs when the sowing is done on time or even late as was seen in this case. This contradicts the claim that EMWVs are better under late sowings. The evidence points to the fact that if NMWVs are performing same as EMWVs under late sown conditions then why put so much thrust on the evolution of EMWVs specially to beat the terminal heat. When averaged over years, sites (134 sites each for NMWVs and EMWVs) and sowing windows, the grain of wheat was 3.41 t/ha for NMWVs and 3.07 t/ha for EMWVs. The value that EMWVs would have added by less reduction in the 1000 grain weight due to terminal heat was probably compensated by more number of grains/ear head in NMWVs. On balance, data puts the spotlight on the combination of early wheat sowing and NMWVs. Both early wheat sowing and long duration wheat varieties during the first two weeks of Nov virtually can be seen as safe bet for beating the terminal heat in 5 districts under BAU, Sabour. BAU has taken a lead in recommending early wheat sowing- a milestone on its own. Now the stage is set for replacing early maturing wheat varieties with normal maturing wheat varieties.

Data from three KVKs (Begusarai, East Champaran, and Muzaffarpur) from Dr Rajendra Prasad Central Agricultural University (DRPCA) also noted that the early wheat sowing has emerged as the most important variable for increasing the grain yield of wheat.

Sowing done during 1-10 Nov reinforced its position in providing highest grain yield of wheat at 5.4 t/ha compared to 4.99, 4.39, 3.93, 3.46 t/ha when the sowings were done from 11-20 Nov, 21-30 Nov, 1-15 Dec and 16-31 Dec, respectively. It is also clear that when the sowing was done from 21-30 Nov, 1-15 Dec and 16-30 Dec, the grain yield of wheat were in the order of 3.90, 3.35 and 2.90 t/ha for EMSVs. The relative grain yields of EMWVs were 12-15% less than NMWVS with in each of three sowing windows given above. Under late sown conditions, even if the yields of both NMWVs and EMWVs remain same as is clear from the data, why then we spend so much time in evolving EMWVs. And since terminal heat leads to forced maturity, the reduction in the test weight of wheat in NMWVs is very well compensated by more number of grains/ear head. The question is for how long we will keep pursuing the case for EMWVs as a solution to beat the terminal heat.

Assessing the role of additional irrigation during terminal heat stress period during grain filling stage to beat stress and its effect on wheat productivity: Many factors including very high cost of diesel based irrigation and fear of lodging and risk associated with increased shrivelling of grain due to abrupt rise in temperature affect the decision of farmers not to irrigate at this stage. The tendency of

Table 1 Varieties sown in different date

Treatment	Description
T ₁	NMWV* planted under zero tillage from 1 to 10 November
T ₂	NMWV planted under zero tillage from 11 to 20 November
T ₃	NMWV planted under zero tillage from 21 to 30 November
T ₄	NMWV planted under zero tillage from 1 to 15 December
T ₅	NMWV planted under zero tillage from 16 to 31 December
T ₆	EMWV* planted under zero tillage from 21 to 30 November
T ₇	EMWV* planted under zero tillage from 1 to 15 December
T ₈	EMWV* planted under zero tillage from 16 to 31 December

*NMWV – HD 2967, HD 2733 & PBW 550 &†EMWV – PBW 373, HI 1563 & HD 2985

Table 2 Treatment details for irrigation scheduling at grain filling stage

Treatment	Description
T ₁	ZT* with additional irrigation at terminal heat stress
T ₂	ZT without additional irrigation at terminal heat stress
T ₃	CT+ with additional irrigation at terminal heat stress
T ₄	CT+ without additional irrigation at terminal heat stress

*ZT- Zero tillage, +CT- Conventional tillage and #irrigation at dough/milking stage

farmers to skip last irrigation depending on the sowing time was considered for finalising these treatments. Two sets of treatments were; ZT and CT with each one kept with/without last irrigation (Table 2). The last irrigation coincided with dough stage in most cases and with milk stage in some cases.

ATARI-Patna (Buxar, Rohtas, Bhojpur, Lakhisarai and Madhepura KVKs): In all districts, the sowing was done in 2nd and 3rd week of Nov. The additional irrigation was given from last week of Feb to 2nd week of March depending on the site. Sowing and irrigation were early in Buxar than in other districts. Data shows that instead of skipping irrigation at grain filling stage, one irrigation at this stage increased the wheat grain yield by 13% when the sowing was done with zero tillage and 16% when sowing was done by conventional method. With irrigation, the average grain yield of wheat with zero tillage was 5.30 t/ha compared to 4.54 t/ha under conventional tillage.

Once the kernels are set, the grain yield is proportional to kernel weight. The irrigation effect seen in trial was due to moderation in temperature and irrigation which in turn might have increased the grain filling period (flowering to ripeness of the kernels). Better yield in zero tillage plots was also because of moderation of temperature in the zero tillage fields. The terminal heat stress during grain filling stage reduces yields and is expected to further negatively impact yields over the coming decades.

ATARI-Patna (East Champaran, Muzaffarpur and Begusarai KVKs): Additional irrigation in most cases was done at dough stage. Out of these districts sowings were bit early in Begusarai. In most cases, the additional irrigation was given between 3-15 March except in one case in Begusarai where additional irrigation was given on 20th Feb. In CT, most sowings were done in the 2nd and 3rd week of Nov and additional irrigation was given from 2-15 March. In most cases the additional irrigation coincided with 100-110 days after sowing or at dough stage. Data from 3 KVKs from DRPCA shows that the yield levels in these districts were more than the average yield in 5 other KVKs given above. One additional irrigation given at grain filling stage provided 6.0 to 7.0% increase in yield, both under ZT and CT conditions. With additional irrigation, the gain yield of wheat was 5.38 and 5.03 t/ha under ZT and CT, respectively. The evidence clearly suggests that withholding irrigation at grain filling will harm the productivity of wheat especially

when the terminal heat is a bigger constraint towards low productivity in these ecologies.

Impact of herbicide application technology on the performance of herbicide in wheat: Herbicide use in Bihar has increased since last 10 years. The herbicide spray technique is being seen as a variable for low herbicide efficiency. Three treatments including herbicide application by hollow cone nozzles (as check), three flat fan nozzles boom spray, and tractor mounted spray fitted with flat fan nozzles. A total of 69 trials for treatment 1 and 2 each and 39 for treatment 3 (Tractor mounted spray) were conducted across 8 KVKs. Herbicides were applied 30-35 days after sowing (DAS) wheat. Most herbicides spray included sulfosulfuron+metsulfuron and 24-D in some cases. Since there was no large variation across districts, the data was pooled across all KVKs. Multiple boom nozzles fitted with flat fan nozzles and tractor mounted sprayer provided similar wheat grain yield (5.1-5.3 t/ha) but both methods were better than spray with hollow cone nozzles with grain yield of 4.6 t/ha. Farmers in Buxar district in Bihar have started using tractor mounted sprayer on custom hire basis.

Potential of using pre-seeding herbicide like glyphosate applied immediately before sowing wheat under zero tillage: Data in different trials under reference have confirmed that ZT is the useful technology for intensifying the RWCS in Bihar. The problem here is the already emerged weed population at the time of sowing. Glyphosate has been recommended as a pre-seeding herbicide. The recommendation, however, allows the spray of this herbicide after a waiting period of 2-3 weeks. Three treatments including, application of 1.5% glyphosate (v/v) 24 h, 48 h and 7-10 days before sowing the crop. Treatment 1 and 2 were kept to ensure that the residual moisture after the harvest of preceding crop is captured for sowing wheat under zero tillage. The study conducted at 74 sites show that glyphosate spray 24 or 48 h before seeding wheat did not cause injury to wheat. The grain yield of wheat were 4.51, 4.60 and 4.38 t/ha following the application of glyphosate at 24, 48 hrs or 7-10 days before seeding wheat, respectively.

Quantifying the gains in wheat productivity through zero tillage mediated advance sowing of wheat: In Bihar, due low land ecologies, late harvesting of rice and relatively high soil moisture at rice harvesting are important limiting factors to sow wheat early. ZT is considered more relevant for areas where wheat sowings are delayed beyond Nov, but this is not always the case. Four sowing schedules and two sowing methods including CT and ZT were employed, (Table 3). In all, 304 sites represented in 8 districts were selected to study the effect of ZT on the productivity of wheat sown at different times.

ATARI-Patna (Buxar, Rohtas, Bhojpur, Lakhisarai and Madhepura KVKs): Trials were conducted at 200 sites

across 5 KVKs. When compared within ZT across different sowing dates the grain yield of wheat in the above sowing schedules were 5.02, 4.51, 3.93 and 3.28 t/ha. respectively. The corresponding yield levels in CT fields were in the order of 3.97, 3.42, 3.17 and 2.82 t/ha, respectively. These responses are, however, much better under Nov sowings than in Dec sowings. The data therefore, suggests that we can expect much better gains from ZT when the seeding is done on time. The gains from ZT could be much higher if the sowing is advanced in these districts. ZT has provided business opportunities to farmers who have started taking-up custom hire services. This has now become very popular in Ara, Buxar and Rohtas districts.

ATARI-Patna (East Champaran, Muzaffarpur and Begusarai KVKs): Begusarai, Muzaffarpur and East-Champaran districts represent both upland and medium land ecologies with pockets of low-lands in some blocks. When compared with CT, ZT mediated gains in the productivity of wheat ranged from 0.35-0.74 t/ha with no major variation due to sowing time. The effect of sowing time on grain yield in ZT was 5.42, 4.84, 3.79 and 3.22 t/ha when the sowings were done from 1-15 Nov, 16-30 Nov, 1-15 Dec and 16-31 Dec, respectively. In Begusarai, early wheat sowing has been largely accepted by farmers. In East Champaran and Muzaffarpur, farmers have started taking up intensified cropping systems (300%). The intensified cropping system here include short duration rice followed by long duration wheat or mustard followed by mungbean.

Response of nitrogen and phosphorous applied to timely sown and late sown wheat: In this trial, sowing time has been kept as key component for variable response of externally applied fertilizer inputs. For wheat sown from 1-15 Nov and 16-30 Nov the doses for N: P₂O₅:K₂O were 150:60:40, 150:44:40, 120:60:40, 100:60:40, respectively. Doses for N: P₂O₅:K₂O were sequentially reduced to 120:40:20, 120:28:20, 80:40:20, 60:40:20, respectively for Dec sown wheat. Results for all three clusters are in Table 4.

ATARI-Patna (Buxar, Rohtas, Bhojpur, Lakhisarai and Madhepura KVKs): Fifteen days of delay in wheat sowing from 1-15 Nov to 16-30 Nov brought about 8.5-11.9% decrease in grain yield of wheat across fertilizer doses. With further delay in wheat sowing from 1-15 Dec and 16-31 Dec the decrease in yield at corresponding fertilizer rates were around 14-16%. In general, data represents a loss in yield due to each successive decrease in fertilizer dose but the magnitude of decrease didn't follow any trend. However, the magnitude of yield increase due to increase in the fertilizer doses fell with delayed sowings because the growth period had already reduced to realise the benefit of fertilizer.

ATARI-Patna (East Champaran, Muzaffarpur and Begusarai KVKs): The response of N:P₂O₅:K₂O in Begusarai, Muzaffarpur and East Champaran were almost same as was observed in cluster 1 represented by BAU KVKs. On an average, when the fertilizer dose is kept constant the decrease in yield due to delay in sowing from 1-15 Nov and 16-30 Nov were in the range of 7-10%. However when the

Table 3 Treatment Details

Treatment	Description
T ₁	ZT* wheat (HD-2967) planted from 1 to 15 November
T ₂	CT+ wheat (HD 2967) planted from 1 to 15 November
T ₃	ZT wheat (HD-2967) planted from 16 to 30 November
T ₄	CT+ wheat (HD 2967) planted from 16 to 30 November
T ₅	ZT* wheat (HD-2967) planted from 1 to 15 December
T ₆	CT+ wheat (HD 2967) planted from 1 to 15 December
T ₇	ZT* wheat (HD-2967) planted from 1 to 15 December
T ₈	CT+ wheat (HD 2967) planted from 16 to 31 December

*ZT – Zero tillage & +CT – Conventional tillage

sowings were further delayed from 1-15 Dec to 16-31 Dec the decrease in wheat yield at constant dose of N:P₂O₅:K₂O was 18-27%. The decrease in the dose of phosphorous from 60 Kg to 44 Kg in November sown wheat and 40 Kg to 28 Kg in Dec sown wheat decreased wheat yield by 3% and 6%, respectively. That means decrease in phosphorous didn't exhibit much difference in Nov sown crop but that decrease did show its impact in the Dec sown crop.

Three years' validation trial indicated that sowing times significantly affected grain yield of wheat under different conditions. It was found that the average grain yield of wheat from early wheat sowing between Nov 1 to Nov 20 was always more than the sowing done at later dates. It was

Table 4 Average grain yield of wheat under different rates on Nitrogen, Phosphorous and Potash applied into wheat seeded at different times (N=1083)

Date	Fertilizer Rates (N: P ₂ O ₅ :K ₂ O) Kg/ha	Yield (t/ha)	
		Average of 5 KVKs of BAU(*)	Average of 3 KVKs of RAU(*)
01-15 November	150:60:40	5.23	5:34
	150:44:60	4.98	5:20
	120:60:40	4.59	4.93
	100:60:40	4.32	4.60
16-30 November	150:60:40	4.67	4.88
	150:44:60	4.39	4.73
	120:60:40	4.20	4.50
	100:60:40	3.9	4.30
01-15 December	120:40:20	4.06	3.95
	120:28:20	3.86	3.71
	80:40:20	3.67	3.74
	60:40:20	3.45	3.30
16-31 December	120:40:20	3.47	3.21
	120:28:20	3.27	3.01
	80:40:20	3.07	2.74
	60:40:20	2.97	2.65

found that additional irrigation during dough filling stage provided more grain yield in both the ZT and CT methods than the control. The grain yield of wheat were 4.51 t/ha, 4.60 t/ha and 4.38 t/ha following the application of glyphosate 24 h, 48 h or 7-10 days before seeding wheat, respectively. It was found that the grain yield of wheat where no boron was applied increased from 4.43 t/ha to 4.75 t/ha with 2 irrigations and 5.04 t/ha with 3 and 4 irrigations, respectively. Application of 0.5% boron increased the wheat yield by 4.0-7.5% across irrigation treatments. It was found that the application of N: P₂O₅:K₂O has varied response in yield due to delay in sowing from 1-15 Nov and 16-30 Nov were in the range of 7-10%. However, when the sowings were further delayed from 1-15 Dec to 16-31 Dec the decrease in

wheat yield at constant dose of N:P₂O₅:K₂O was 18-27%.

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