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Research Article

Response of Wheat Cultivars in Different Agricultural Practices Differed by Sowing Date

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Abstract

A field experiment with three wheat varieties at different sowing dates on two crop establishment methods was accomplished to identify the optimum sowing date at AFU Rampur during winter season of 2014/2015. Three wheat varieties namely: Tillotama, Danfe and Vijay sown on three dates: 14th November, 29th November, and 14th December under two crop establishment practices: Conservational and conventional agriculture were evaluated with strip –split plot design in three replications. The field data on yield attributes and yields were collected. Earlier sowing on 14th November gave the highest yield (3427.15 kg ha^{-1}), total dry matter (8154.44 kg ha^{-1}), with longest days to crop maturation (133.11 days). In case of varieties, Vijay gave the highest grain yield (3458.61 kg ha^{-1}) and total dry weight (4456.11 and 8832.42 kg ha^{-1} respectively) with earliest days to heading and maturity. The straw yield was the highest for 29th November sowing (5821 kg ha^{-1}) and for Danfe variety (5756 kg ha^{-1}). Vijay variety recorded the highest thousand grains weight (43.60 g) and highest harvest index (35.89%) even though with the lowest effective tillers per square meter (320.83), it proved to be the most promising variety.

Keywords: Wheat; date of planting; crop establishment; cultivars

Introduction

Wheat (*Triticum aestivum* L.) is one of the principal cereal crops of the world, growing in almost 215 million hectares of the land each year. It is the major staple food for the 2.5 billion people in 89 countries of the world and is the first in major three cereal crops for protein source in developing countries. The global wheat production for the year 2013 was 716 million tons, which was higher by 18.35% in comparison to the year 2007 (CIMMYT, 2013). China ranked the first among the wheat producers in the world with its share of 17.03% followed by India (FAO, 2013). Nearly US $50 billion-worth of wheat is traded globally each year (CIMMYT, 2013).

As wheat is the third important cereal crop after rice and maize in Nepal it plays a vital role in food security of the country. The area under wheat cultivation in Nepal is 0.7 million ha and the production is 1.8 million metric ton with the average productivity of 2.50 metric ton per hectare for the year 2013/14. This is mere 0.03% increase in area, but 9.01% increase in production comparing to the previous year (MoAD, 2015). The productivity of the wheat is far below than the world productivity i.e. 3.33 metric ton per hectare. The productivity of wheat in Nepal for the year 2015/16 was 2.59 tha^{-1} , which include the wheat production of 1975625 tonnes in total area of 672373 ha.

The terai part of Nepal including the strip of Shivalik hills (0.6 million hectare) falls under the Indo-Gangetic plains(IGP) where rice-wheat is the major cropping system and 84% of the total wheat is cultivated after rice harvesting (Chauhan *et al*., 2012; Timsina and Conner, 2001).With the increasing population and purchasing power, demand on food has also increased which is impossible to meet with the present varieties, technologies and management practices. Use of resource-conserving technologies, innovations on residue use, use of suitable agronomic practices not only increase productivity and profitability but also reduce risk due to environmental and economic factors (Chauhan *et al*., 2012).

Conservation agriculture (CA) defined as the minimal soil disturbance (no-till or minimum till), and permanent soil cover (mulch or residue retention) combined with diversifiedrotations is a more sustainable cultivation system for the future (Hobbs *et al.*, 2006). Adoptions of conservation agriculture based technology not only reduce the cost of cultivation and increased profit but also conserve the soil moisture for late stages of crops (Thierfelder and Wall, 2009).Wheat in case of Nepal is sown after rice and it grows and survives on the residual soil moisture, late monsoon rains and winter rain. Shrestha *et al*. (2013) simulated the rainfed yields of the wheat (1.7 t ha^{-1}) and showed that yields were predominantly constrained by water stress. Wheat in Nepal is generally sown from November to late December, and it is harvested in March-April (Joshi *et al*., 2007). The late planting is often due to difficulty in land preparation resulting by excess or lack of moisture, late maturing rice varieties or longer window period between rice harvesting and wheat sowing. So it is necessity to identify the optimum sowing dates for different varieties.

Materials and Methods

Location

The experiment was conducted at Agronomy Farm of the Agriculture and Forestry University (AFU), Rampur starting from November 2014 to April 2015. The average maximum temperature and the average minimum temperature for the cropping duration were 24.99^{o}C and 13.09^{o}C. The total rainfall during the cropping period was 119.70 mm. The maximum relative humidity for the cropping period was 69.24% and minimum was 17.15%.

Experimental Details

The experiment was laid out in Strip-split block design with the combination of 18 treatments comprising of two crop establishment methods in horizontal factor (conservation agriculture and conventional agriculture), three dates of sowing as vertical factor (November 14, November 29 and December 14, 2014) and three varieties as subplot factors (Tillotama, Danfe and Vijay). Each treatment was replicated thrice. Each individual subplot had 25 rows with spacing of 20 cm apart and total area of 4 m x 5 m. The central 10 rows with 8m^2 area (10 x 0.2 m x 4m) was treated as the net plot whereas inner 5 rows on the both sides of the plot were used for biometrical and phenological observations leaving single rows on both sides as the check boarder.

Crop Management Practices

The fertilizer was applied on the crops with the dose of 120:50:50 kg NPK ha^{-1} through Urea, Di-Ammonium Phosphate and Muriate of Potash, respectively. The seeds were sown continuously in the rows spaced at 20 cm. Seed sowing was done on three dates. First sowing was done on November 14 supposed to be early sowing. The second sowing was conducted on 29th November for normal sowing whereas late planting was done on 14th December, 2014. Weed management was done by spraying 2,4-D at 1.4 kg a.i ha^{-1} at 30 days after sowing for each dates.

Yield and Yield Attributing Characters

(i) Before harvesting, effective tillers per square meter was determined by counting the number of tillers from 2 entire lines of 4 m length from the net harvest area. These effective tillers were later worked out to express the number of effective tillers per meter square. (ii) Total number of grains were counted from twenty spikes and they were weighed in g. The mean was derived for weight and number of grains per spike. (iii) Total number of florets of twenty spikes of net plot was counted. The mean was derived for the number of florets per spike. (iv)Thousand kernels from each bulk of each net plot were separated and they were weighed in g with the help of electronic balance. (v) Total number of florets and number of grains per spike were counted from twenty randomly selected spikes from each plot before harvest, averaged and then sterility percentage were estimated using Lumle method as mentioned by Subedi *et al*., (1996) as follows.

Sterility Percentage

$$= \frac{\textbf{Number of florets per spike} - \textbf{Number of grains per spike}}{\textbf{Number of florets per spike}}$$

Grain and Straw Yield

The net plot consisting of 10 rows each 4m length was harvested for the record of grain yield. The net crop was dried, threshed, cleaned and sundried for 2 days to maintain moisture percentage. The yield obtained was computed for each treatment to obtain the yield per hectare. The straw yield was obtained by deducting the grain yield from total biomass yield. The grain yield from each net plot was checked for moisture percentage using moisture meter and then the grain yield from all the plots were adjusted at 12% moisture.

Grain yield ($Kgha^{-1}$) at 12% moisture

$$= \frac{(100-\text{MC})\text{x plot yield (kg)x } 10000}{(100-12)\text{x net plot area}}$$

Where MC = moisture content of the grain

Harvest Index

The harvest index (HI) was obtained by dividing the grain yield with the biological yield.

HI= (grain yield ×100)/ (grain yield +straw yield).

Statistical Analysis

All the collected data were entered into MS- Excel and further subjected to analysis of variance. GenStat and MSTAT-C package were used for the data analysis. All the data analyzed were put to DMRT for mean comparison by selecting 5% level of significance.

Results and Discussion

Yield Attributing Characters

Number of Effective Tillers per Square Meter

The number of effective tillers per meter square was also found insignificant for crop establishment methods and date of sowing. But it was higher in conservational agriculture than conventional one. The early sowing of wheat on 14th November produced higher numbers of effective tillers than sowing at 29th November and 14th December. Variety Tillotama produced significantly higher effective tillers (344.15) than Vijay (307.58) but at par with Danfe (332.63). The average number of effective tillers per meter square was 328.12 (Table 1).

The effective tillers per meter square meter is not affected significantly by crop establishment methods as for the first season the difference between conservational and conventional agriculture was not drastic. The first date of sowing (14th November) had produced higher number of effective tillers per square meter followed by 2nd and 3rd date of sowing which is reported earlier too. This is due to longer vegetative period obtained by early sowing and it is well established fact that early sowing and fertile soil produce more tillers. The delayed planting produced less tillers and tillers die between the start of stem extension and flowering with the last formed dying first which consequently resulted in less number of effective tillers per square meter on late sowing. Bradley *et al.* (2008) mentioned that tillers survival are significantly affected by varieties under 40 to over 70% which had also seen here with varieties Tillotama and Danfe producing significantly higher number of tillers than Vijay.

Number of Grains per Spike

The number of grains per spike was insignificant to establishment methods and sowing dates but varieties had significant influenced. Comparatively higher number of grains per spike was recorded under conservation agriculture and delaying on sowing reduced the grains per spike. Vijay (43.60) had significantly higher number of grains per spike than Tillotama (34.59) and Danfe (34.85) (Table 1).

Number of grains per spike is one of the yield components which determine the grain yield. The decreasing number of grains per ears with delay in sowing date could be explained by the decreasing number of days from booting to ear emergence available for them due to change in weather conditions. As Bradley *et al*., (2008) mentioned number of grains per spike are determined before flowering, the temperature plays crucial role on prolonging the ear formation period. Fischer (2011) and Hochman (1982) also reported that 10-15 days prior to anthesis is crucial for the grain number formation and Dolferus (2011) revealed that abiotic stress like increasing temperature minimizes the grain number. The less number of days avail for grain number formation could also be evident by significant difference in days to heading for 3rd date of sowing than earlier sowing. The variation in number of grains per spike for varieties is controlled by the genetic factors as Tillotama showed better performance than Danfe and Vijay.

Table 1: Number of effective tillers per square meter, number of grains per panicle, thousand grain weight (g) and sterility percentage (%) as influenced by establishment methods, sowing dates and varieties of wheat in 2014-15 at AFU, Rampur, Chitwan, Nepal

Treatments	Number of effective tillers per square	Number of grains per spike	Thousand grain weight (g)	Sterility percentage
Establishment methods				
CA	329.35	30.38	36.66	42.23
ConA	326.88	28.98	38.71	41.17
SEm (±)	7.86	0.81	0.83	1.36
LSD(=0.05)	ns	ns	ns	ns
Sowing dates				
14th Nov	343.87	31.88	38.06	39.54
29th Nov	330.45	30.57	38.02	43.44
14th Dec	310.04	26.59	36.96	42.11
SEm(±)	9.78	0.18	0.95	1.55
LSD(=0.05)	ns	0.70	ns	ns
Varieties				
Tillotama	344.15[a]	32.51	34.59[b]	38.51[a]
Danfe	332.63[a]	27.45	34.85[b]	43.44[b]
Vijay	307.58[b]	29.07	43.60 [a]	42.46[b]
SEm (±)	14.13	0.98	1.34	1.09
LSD (=0.05)	25.16	2.87	3.90	3.18
CV, %	8.62	14.00	15.10	11.10
Grand Mean	328.12	29.68	37.68	41.70

Note: CA, Conservation agriculture; ConA, conventional agriculture; ns, non-significance. Treatments means followed by common letter (s) are not significantly different among each other based on DMRT at 5% level of significance

Thousand Grain Weight

The thousand grain weight showed no influence by the difference crop establishment techniques and date of sowing but only by the cultivars. The thousand grain weight was higher for conventional agriculture than conservational agriculture and in case of sowing date the thousand grain weight decreased gradually with delay in seeding. The varieties showed significant effect on thousand grain weight and Vijay had highest thousand grain weight measured 43.60 g followed by Danfe and Tillotama while they are at par with each other weighing 34.85 and 34.59 g. The average thousand grain weight was found to be 37.68 g (Table 1).

The thousand grain weight is not significant for date of sowing and establishment methods. The thousand grain weight depends upon number of days available for grain filling and varietal genetic makeup. The thousand grain weight is not significantly different though delayed sown wheat varieties get less number of grain filling days and that might be due to differential grain filling rate which nullified the effect. In case of varieties, Vijay produced grains with significantly higher thousand grain weight was due to genetic reasons. Moreover, Bradley *et al.*, (2008) reported that a crop with sparse shoot density produce more grains per ear and heavier grains than thick crop which is evident in case of Vijay as it had significantly lower number of effective tillers per square meter than two other varieties.

Grain and Straw Yield and Harvest Index

Grain Yield

Among the two tillage practices comprising conservational and conventional, no any significant difference was seen on yield. However, Wheat sown on 14th Nov had significantly higher yield of 3427.15 kg per hectare followed by 29th Nov and 14th Dec date of sowing with recorded yield of 3134.68 and 2544.78 kg per hectare respectively. Variety Vijay proved to be the highest yielder with yield 3458.61 kg per hectare which was at par with Tillotama with 3173.96 kg per hectare yield. Variety Danfe was significantly lower for yield than both of the varieties with the lowest recorded yield of 2474.02 kg per hectare (Table 2).

Straw Yield

The two different tillage systems showed no any significant difference for straw yield but conservational tillage had greater straw yield of 5494 kg per hectare. Wheat sown at 29th Nov had highest straw yield of 5821kg per hectare which was at par with wheat sown on 14th Nov and significantly higher than wheat sown on 14th Dec. No varietal effect was seen significant for the straw yield though variety Danfe had highest straw yield of 5756 kg per hectare.

Harvest Index

The mean harvest index was found 32.32 percent and the tillage system had no effect on harvest index. The harvest index was seen maximum for the wheat sown on 14th Nov (35.02) which were significantly higher than wheat sown on 29th Nov (31.74). The harvest index of wheat on late planted condition, 14th Dec was found to be the lower significantly (30.21). Variety Vijay had significantly higher harvest index than variety Danfe but Tillotama was at par with it. (Table 3)

Table 2: Grain yield (kg ha^{-1}) as influenced by establishment methods, sowing dates and varieties of wheat in 2014-15 at AFU, Rampur, Chitwan, Nepal

Treatments	Sowing date			Percent reduction in yield due to change in sowing dates	
	November 14	November 29	December 14	Nov. 14 vs Nov. 29	Nov. 29 vs Dec. 14
CA					
Tillotama	3297.19	3573.26	2326.66	-8.37	34.89
Danfe	2983.94	2706.25	2259.6	9.31	16.50
Vijay	3995.63	3542.26	2756.37	11.35	22.19
Mean	3425.59	3273.92	2447.54	4.43	25.24
ConA					
Tillotama	3974.65	2976.66	2895.36	25.11	2.73
Danfe	2670.91	2430.59	1792.84	9.00	26.24
Vijay	3640.56	3579.03	3237.83	1.69	9.53
Mean	3428.71	2995.43	2642.01	12.64	11.80
GrandMean	3427.15	3134.68	2544.78	8.53	18.82

Note: CA, Conservation agriculture; ConA, conventional agriculture; ns, non-significance.

Table 3: Grain and straw yield (kg ha^{-1}) and harvest index (%) as influenced by establishment methods, sowing dates and varieties of wheat in 2014-15 at AFU, Rampur, Chitwan, Nepal

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
Establishment methods			
CA	3049.02	5427.00	32.63
ConA	3022.05	5494.00	32.02
SEm (±)	25.00	160.90	0.90
LSD(=0.05)	ns	ns	ns
Sowing dates			
14th Nov	3427.15^{a}	5442.00^{ab}	35.02^{c}
29th Nov	3134.68^{b}	5821.00^{a}	31.74^{b}
14th Dec	2544.78^{c}	5118.00^{b}	30.21^{a}
SEm(±)	53.40	97.20	0.22
LSD(=0.05)	209.8	381.80	0.87
Varieties			
Tillotama	3173.96^{b}	5314.00^{b}	33.94^{b}
Danfe	2474.02^{c}	5756.00^{a}	27.15^{a}
Vijay	3458.61^{a}	5312.00^{b}	35.89^{b}
SEm (±)	103.10	192.20	1.21
LSD (=0.05)	301.00	ns	3.54
CV, %	14.40	14.90	15.90
Grand Mean	3035.53	5461.00	32.32

Note: CA, Conservation agriculture; ConA, conventional agriculture; ns, non-significance. Treatments means followed by common letter (s) are not significantly different among each other based on DMRT at 5% level of significance.

The grain yield had been higher for conventional agriculture, which might be attributed by higher number of effective tillers per panicle produced and higher number of grains per spikes. The effects of CA on crop yield were variable (Farooq *et al*., 2011). In some instances, CA increased yield by improving soil fertility through soil and water conservation and sequestering organic carbon (Holland, 2004 and Govaerts *et al*., 2007). While under some instances, CA may have detrimental impacts on crop yield by altering soil physiochemical and biological conditions, such as decreasing soil temperatures in high latitude areas and seasons with low temperature and higher insect and disease incidence (Boomsma *et al*., 2010; Kaschuk *et al*., 2010 and Deubel *et al*., 2011). As all the yield attributing characters as number of effective tillers per square meter, number of grains per spike and thousand grain weight is higher for earlier sowing at 14thNovember, it is obvious and logically correct to have significantly greater grain yield than sowing at 29thNovember followed by 14thDecember. The longer crop duration and chance of escaping from terminal stress due to early sowing had been another reason for significant variation in grain yield. The variation within the varieties is purely genetic which showed Vijay is high yielder followed by Tillotama and Danfe.

The straw yield showed almost no difference for tillage differences whereas significant difference is seen for sowing date and varieties. The difference for straw yield for sowing date might be due to shorter vegetative period for delayed sowing, which resulted in less number of leaves, less tillers and less growth and development for delayed on sowing that resulted less straw yield. The varieties also showed the variation for straw yield. The variety Danfe had greater straw yield, significantly greater than Tillotama and Vijay could be the controlled by inbuilt genetic character. Moreover, the less harvest index of variety Danfe (27.15%) is evident enough to know that it had less photosynthates redistribution efficiency from stem and leaves to straw than two other variety (Table 3).

Conclusion

Wheat variety Vijay can be grown in conservation agriculture with higher yield and can also be sown up to 1st week of December. Earlier planting of the wheat in November 14 yield the highest production for the sowing date. Variety Vijay exceed the two other varieties for the wheat grain production but Danfe variety had highest straw production. The establishment method had no any influence on wheat yield and straw yield.

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