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Response of Wheat Planted with Different Techniques to Foliar of Potassium Nitrate, Water and Extra Irrigation

Abstract

Field studies were conducted on wheat at the Punjab Agricultural University, Ludhiana during 2005-06 to 2008-09. The results revealed that wheat sown at 25 November gave the highest grain yield than 10 December sowing. In both the experiments, statistically same grain yield was obtained with different planting methods. In the first experiment, wheat sown with zero tillage and conventional tillage with crop residue gave higher average grain yield. The foliar application of KNO_3 (1%) during anthesis, extra irrigation and spray of irrigation water during post anthesis gave higher grain yield but in the first experiment, average yield was higher than recommended practices of irrigation. Sowing at 25 November with conventional tillage without and with mulching produced significantly same but significantly higher grain yield than other treatment combinations. The 25 November sowing with zero tillage in standing stubbles after removal of loose straw and one foliar spray of KNO_3 (1%) was at par with conventional tillage without mulching + two foliar spray of KNO_3 (1%) during anthesis, conventional tillage without mulching with one additional irrigation, conventional tillage with mulching + one additional irrigation and conventional tillage with mulching + recommended irrigation. The sowing with zero tillage in standing stubbles and one foliar spray of KNO_3 (1%) gave the highest grain yield which was at par with conventional tillage without mulching + two foliar spray of KNO_3 (1%) and conventional tillage without mulching + one additional irrigation. The magnitude of temperature changes the maturation of the crop resulting in small and shrunken grains during 2005-06 and 2007-08. The bulk density (0-15 cm depth) at harvest was slightly more and infiltration rate was higher under zero tillage under zero tillage.

Keywords: Conventional Tillage, Crop Residue, Foliar Application of KNO_3, Temperature and Zero Tillage

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Introduction

India ranks second in the world in respect of wheat production next to china. In India, wheat is the second most important food crop after rice and has played a very vital role in increasing and stabilizing the food production of the country (Bhat and Mahal, 2006). The crop is best suited to temperate climate, however, is mainly produced and consumed in the tropical and sub-tropical regions of the developing world. It is cultivated on an area of 27.7 mha with an annual production of 80.5 million tones and average yield of 2.8 t ha^{-1}. (Anonymous 2010). In Punjab, wheat was cultivated on an area of 3.5 mha with an annual production of 15.7 mt having an average productivity of 4.5 t ha^{-1} during 2007-08, which was the highest in the country. (Anonymous 2009). It has been projected that to feed 1.3 billion population and diversified uses, India will have to produce at least 109 million tones of wheat by 2020 AD, which might be possible through elevating the productivity up to 40 q ha^{-1} (Kulhari *et al.,* 2003).

Overcoming age-old prejudices about “more tillage giving better yields” and changing the mind set of farmers is an important problem. Making good quality machinery available in sufficient numbers has also hampered adoption. However, this is quickly being corrected. A “tillage revolution” is under way in Indo-Gangetic plains that will help maintain food security and improve farmers’ welfare. In rice-wheat system, timeliness of planting is very important for optimizing yield. In wheat, any delay in sowing after the end November results in 1-1.5 per cent loss in yield per day (Ortiz-Monasterio *et al*., 1994). Tillage operations consume lot of time. Sowing crops by zero tillage may save lot of time, resulting in timely sowing operation. Brar and Kumar (2000) confirmed that growing crops without tillage is possible and the technique can be continued for longer period of 25 years for growing maize and wheat in sequence provided weeds are effectively controlled. Similar yields of wheat under zero tillage and conventional tillage after rice have also established that zero tillage technology can be adopted on much wider scale. No till farming is becoming popular and an essential component of rice-wheat cropping system of South Asia as farmers struggle to make farming profitable (Hobbs, 2002). It provides an opportunity to farmers to grow more food at less cost and thus improve their livelihoods. It also has several important benefits in regard to the environment, as 1 liter of diesel on burning produces 2.6 kg of CO_2. So, the reduction in carbon dioxide emission is due to less burning of fuel for field preparation in zero tillage.

Sowing time is one of the most important management factors involved in obtaining higher yield. Timely sowing of wheat crop generally gives higher yield as compared to late sown crop. Late-sown wheat crop faces high temperature stress during ripening phase. Late planting reduces the tillering period and hot weather during critical period of grain filling lead to forced maturity thereby reduces the grain yield. The rate of dry-matter accumulation remains faster at higher temperature than at lower temperature. Spike dry weight increases due to the deposition of grain protein and carbohydrates, which are partially on the expense of, assimilate transfer from stem and root (Tewari and Singh, 1995). Under late sowing situations, wheat yield is adversely affected due to low temperature during germination, causing delayed emergence and during early crop establishment period resulting in slow growth and reduced number of tillers and its exposure to higher temperature during reproduction phase reducing the period of grain filling (Sardana *et al.,* 2005). Agronomic manipulations like spray of potassium nitrate, extra irrigation, spray of irrigation water may also play important role to increase the productivity of wheat under climate change environment. The objective of this study was to find out the suitable method of planting and agronomic practice to increase the productivity of wheat.

Materials and Methods

Field studies were carried out to determine the effect of different planting methods and agronomic manipulations on the productivity of wheat at Punjab Agricultural University, Ludhiana for four consecutive years from 2005-06 to 2008-09. In first experiment, the treatments consist of three methods of planting in main plots such as zero tillage, conventional tillage and conventional tillage with mulching at 5 tha^{-1} of paddy straw and four treatments as foliar spray of Potassium nitrate (1%) during anthesis, one extra light irrigation, spray of irrigation water during post anthesis and recommended practices of irrigation in the sub-plots. The experimental soil was sandy loam having pH 8.0, organic carbon 0.26 %, available phosphorus 14.7 $kgha^{-1}$ and available potassium 298 $kgha^{-1}$, therefore, the fertility status was low. The experiments were laid out in strip plot design and treatments were replicated three times in gross plot size of 10 m x 2.10 m. The variety PBW 343 of wheat was sown on 30-11-2006 and 01-12-2007 during 2006-07 and 2007-08, respectively but in 2005-06, it was sown on 16-12-2005. Under the zero tillage treatment, the crop was sown with zero till drill, in the conventional tillage seed bed was prepared by giving two time discing and two time cultivators and one time planking and crop was sown with the traditional drill. In the mulching treatments, after sowing the crop immediately apply the mulching. All the other practices followed recommended to raise the crop. The crop was harvested manually on 24-04-2006, 03-05-2007 and 25-04-2008.

Another experiment was laid out in split plot design keeping two dates of planting (25 November and 10 December, three methods of planting as zero tillage in standing stubbles after removal of loose straw (ZT), Conventional tillage with mulching (CWM) and conventional tillage without mulching (CWOM) in main plots and four agronomic practices as KNO_3 (1%) foliar spray during anthesis, KNO_3 (1%) foliar spray two times during anthesis, one additional irrigation during post anthesis and recommended irrigation in sub plots with three replications. The variety PBW 509 of wheat was sown as per treatments. Other practices were followed recommended for raising the crop. The crop was harvested on 13 and 16 April, 2009 which was grown on 25 November and 10 December, 2008, respectively.

After threshing, the grain yield was recorded from the net plot harvested area and expressed in q ha-1. The infiltration rate was measured before sowing and after crop harvest of wheat crop with the help of double ring infiltrometer of 35 and 55 cm diameter and 28 cm height following the procedure of Bertrand (1965) from plots receiving different treatments.

Soil samples after harvest of crop were taken to determine the bulk density of soil using 5 cm long scoop having 2.5 cm internal diameter. The samples were taken from 0-15 depth from the plots receiving different treatments. The samples were oven dried bulk density expressed as gcm-3. The experiment data collected on various aspects of the investigation were statistically analyzed with the procedure as described by Corchan and Cox (1963). The comparisons were made at 5 per cent level of significance.

Results and Discussion

Grain Yield

The grain yield of a crop is the net resultant of interaction of various factors and is a valid criterion for comparing the efficiency of different treatments. Effective tillers, number of grains, ear length and grain weight are the grain yield contributing factors. Moreover, grain yield reflects the resultant impact of all crop parameters, yield characteristics and economic component of the crop which are affected by various treatments. Grain yield of wheat was not influenced by different crop establishment methods during 2005-06 and 2007-08 but it was influenced in 2006-07 (Table 1). Similar results were reported by Singh et al. (2010). The crop sown with zero tillage and conventional tillage gave the similar grain yield in but in 2006-07, the grain yield was significantly higher under conventional tillage with crop residue. The increase in grain yield with the crop residue could be due to higher growth and yield contributing attributes. A significantly higher grain yield in 2006-07 could be due to the favourable mean monthly temperature and well distribution of rainfall during the growing season. However, an average grain yield of wheat sown with zero tillage (48.4 qha^{-1}) and conventional tillage with crop residue (45.7 qha^{-1}) recorded higher, which was 10.8 and 4.6 % more than conventional tillage (43.7 qha^{-1}), respectively. Surface-applied mulches provide several benefits to crop production through improving water, heat energy and nutrient status in soil, preventing soil and water loss, preventing soil salinity from flowing back to surface, and controlling weed (Bu *et al*. 2002). The studies also showed that mulch wheat increases grain yield in comparison with unmulched wheat. The main causative reasons for mulch increasing wheat yield are soil and water conservation, improved soil physical and chemical properties, and enhanced soil biological activity (Ramakrishna *et al*., 2006). Tripathi and Chauhan (2000) also reported similar grain yields with no-tillage and conventional tillage treatments. In rice-wheat system, no-tillage increased wheat yield by 10 % over conventional tillage because of better number of tillers, better establishment and lesser weeds.

Different agronomic manipulations did not influence the grain yield during 2005-06 and 2007-08 but had significant influence on grain yield during 2006-07 (Table1). However, the foliar spray of potassium nitrate (1 %) during anthesis, application of one extra irrigation and sprinkling of water during post anthesis stage produced higher grain yield of wheat in all the years of study but these treatments produced the significantly more grain yield as compared to the recommended practices of irrigation during 2006-07 because of well distribution of rainfall during the growing season.

The overall lower grain yield during 2005-06 was due to the delayed sowing (16-12-2005) and high mean monthly temperature in the month of February (18.7^0C) and March (20.0), and in 2007-08 was due to abrupt increase in the temperature from 13.3 to 22.2^0C in the month of March means the high temperature during the grain filling period, which ultimately cause the reduction in grain yield due to lower 1000-grain weight with the advancement in the maturity (Table 1). They reported that wheat exposed to high temperature during the grain filling period typically produces smaller kernels. This is especially important during the grain filling period; since grain growth is greatly reduced by environmental conditions that adversely affect assimilate supply (Evans *et al*., 1975) or utilization (Bhullar and Jenner, 1986).

Time of planting is one of the most important factors that govern the crop phenological development and efficient conversion of biomass into economic yield (Kaur and Pannu, 2008). Grain yield of wheat under early sown crop of 25 November was significantly higher than late sown crop of 10 December (Table 2 &3). The higher grain yield could be attributed to better basic infrastructural frame work of plants in early sowing. Similar findings reported by Sardana *et al.* (2005) Planting of wheat at 10 December its grain yield was adversely affected due to low temperature during germination, causing delayed emergence and during early crop establishment period resulting in slow growth. Whereas, in case of delayed sowing, the wheat crop is exposed to sub-optimal temperature at reproductive phase that leads to advanced maturity (126 days) and reduction in the grain yield. Khichar and Niwas (2007) also reported the wheat sown on 20 December gave the lower grain yield. Planting of wheat with zero tillage in standing stubbles after removal of loose straw, conventional tillage with mulching and conventional tillage without mulching produced the statistically similar grain yield. Among the agronomic practices, grain yield was significantly higher with one foliar spray of KNO_3 (1%) than two foliar spray of KNO_3 (1%) during anthesis and recommended irrigation but statistically at par with one additional irrigation during post anthesis. This was due to beneficial effects of NO_3^- in delaying synthesis of abscisic acid and promoting cytokinin activity (Brevedan and Hodges, 1973) and of K^+ on photosynthesis, carbohydrates redistribution and starch synthesis in storage organs (Ismunadji 1976) were presumed to be responsible higher grain yield. Bhattachartta *et al.* (2006) reported significant increase in grain yield with the application of additional irrigation to wheat crop.

The interaction effect of planting dates and methods of planting on grain yield was significant (Table 2). The crop sown on 25 November with conventional tillage without mulching and with mulching produced significantly higher grain yield as compared to the crop sown on 25 November and 10 December with other different methods of planting but the differences were non-significant among conventional tillage without mulching and with mulching. The crop sown late on 10 December with Zero tillage in standing stubbles after removal of loose straw gave the highest grain yield which was significantly more than crop sown with other methods of planting. However, the interaction effect of dates of planting and agronomic practices was non-significant.

The crop sown on 25 November with zero tillage in standing stubbles after removal of loose straw and one foliar spray of KNO_3 (1%) during anthesis was at par in grain yield than those obtained with conventional tillage without mulching + two foliar spray of KNO_3 (1%) during anthesis, conventional tillage without mulching with one additional irrigation during post anthesis, conventional tillage with mulching + one additional irrigation during post anthesis and conventional tillage with mulching + recommended irrigation (Table 3). It was significantly higher than the crop sown on 25 November and 10 December with other methods of planting and agronomic practices. When crop sown very late on 10 December gave the maximum yield when sown by zero tillage in standing stubbles after removal of loose straw with one foliar spray of KNO_3 (1%) during anthesis which was at par with zero tillage in standing stubbles after removal of loose straw followed by two foliar spray of KNO_3 (1%) during anthesis or one additional irrigation during post anthesis conventional tillage without mulching followed by two foliar spray of KNO_3 (1%) during anthesis, and conventional tillage without mulching followed by one additional irrigation during post anthesis and conventional tillage with mulching with one additional irrigation during post anthesis but significantly higher than crop sown 10 December with other methods of planting as well as agronomic practices.

The interaction effect of methods of planting and agronomic practices on grain yield was found to be significant (Table 4). The crop sown with zero tillage in standing stubbles after removal of loose straw and one foliar spray of KNO_3 (1%) during anthesis gave the highest grain yield which was at par with crop sown with conventional tillage without mulching + two foliar spray of KNO_3 (1%) during anthesis and crop sown with conventional tillage without mulching + one additional irrigation during post anthesis.

Mean Monthly Temperature

Mean monthly temperature was increased 6.2, 3.4 and 2.6^0 C in the month of February than January and 1.3, 4.1 and 8.9 ^{0}C in the month of March than February during 2005-06, 2006-07 and 2007-08, respectively (Table 5). It shows crop exposed to high temperature in the month of February and March during 2005-06 and 2007-08, respectively however, the temperature increased gradually in the month of February and March during 2006-07. In this year (2006-07), overall yield was quite high than the other years because of gradual increase in temperature in the grain-fill period, distribution of rainfall during the growing season which resulted in better plant growth, ear length, 1000 grain weight and effective tillers. However, in 2005-06 and 2007-08 the temperature was high during the grain filling stage of the crop which results in lower growth and yield contributing characters like plant height, ear length, 1000-grain weight and effective tillers. In these years of study, these are the main reasons of low productivity of wheat.

1000-Grain Weight

Grain test weight varied non-significantly with different crop establishment methods during all the years of study but numerically higher under conventional tillage with crop residue as compared to zero tillage and conventional tillage (data not given). Mulching creates the favorable conditions like increase the availability of moisture for longer period and keep the low soil temperature in the post anthesis and grain-fill period. The grain test weight values were higher under the potassium nitrate, one extra irrigation and sprinkling of water during post anthesis stage than the recommended practices and green manuring treatments in all the years of study. Difference in grain test weight between the three years indicates high temperature stress during the grain fill period of wheat crop. Since many reports (Wiegand and Cuellar, 1981) have documented the negative effects of post anthesis high temperature stress on grain weight and consequently, grain test weight. Tashiro and wardlaw (1989) reported that the approximate reduction in kernel weight of 4% per 1°C increase in mean temperature from 20 (20/20) to 27.5 (35/20)°C from 10 days after anthesis equaled the losses in kernel weight and grain yield of 3 to 5% per 1°C increase above 15°C from 6 days after anthesis.

Duration of Crop

The maturity of a crop depends upon the temperature during the grain filling period. In 2005-06, the mean monthly temperature had increased by 6.2^{0}C and 1.3^{0}C in the month of February than January and in March than February, respectively**.** In 2007-08 mean monthly temperature had increased by 2.6^{0}C and 8.9^{0}C in February and March, respectively. However, in 2006-07, the temperature increased gradually in the month of February and March about 3.4^{0}C and 4.1^{0}C than January and February, respectively. This magnitude of temperature during grain-fill period hastened maturation of the crop resulting in small and shrunken grains during 2005-06 and 2007-08. The crop took 129, 154 and 145 days to maturity during 2005-06, 2006-07 and 2007-08, respectively. This reduced duration in 2005-06 and 2007-08 due to heat stress lowered the kernel weight of wheat**.** The lowest duration in 2005-06 was also due to the crop sown on 16-12-2005. Similar results were reported by Warrington *et al*. (1977).

Soil Properties

The bulk density (0-15 cm depth) at harvest was slightly more under zero tillage treatment as compared to conventional tillage and conventional tillage with crop residue in all the years of study due to the skipping of tillage operations (Table 6). The lowest bulk density was observed in the conventional tillage with crop residue treatment at harvest of wheat during 2005-06, 2006-07 and 2007-08. Similarly, the infiltration rate was higher in case of zero tillage and conventional tillage with crop residue at harvest than conventional tillage (Table 7). It could be the minimum disturbance of soil in case of zero tillage treatment means no breakage of water capillaries in the soil and in case of mulching treatment loosening of soil due to decomposition of mulching material which conserved more water. Singh (1977) reported that highest value of cumulative intake of water for six hours under zero tilled plots followed by one cultivation and four cultivations on a sandy soil at Ludhiana. Similarly, Derpsch *et al*. (1986) in Brazil indicated that higher in filterability of oxisol (low in exchangeable cations, 76-80 per cent clay content, high iron oxide) under no tillage than conventional tillage or chisel plough. Surface-applied mulches provide several benefits to crop production through improving water, heat energy and nutrient status in soil, preventing soil and water loss, preventing soil salinity from flowing back to surface, and controlling weed (Bu *et al*., 2002).

Conclusions

On the basis of results of this investigation, we can recommend that zero tillage, zero tillage in standing stubbles of rice, rice straw mulching can be used in conventional tillage for sowing of wheat and can also used the spray of potassium nitrate (1%) during anthesis or supply one extra irrigation or sprinkling of irrigation water during post anthesis stage to increase the productivity of wheat.

References

1. Anonymous 2010. Area and production of wheat in India. http: www.indiastat.com.
2. Anonymous 2009. *Package and practices for Rabi Crops of Punjab*. Punjab Agricultural University Ludhiana.
3. Bertrand, A. R. 1965. Rate of water intake in the field In: Black C A (Ed.), *Methods of soil analysis*, Part I, Agron 9, Am Soc Agron Inc, Madson. USA.
4. Bhat, M. A. and Mahal, S. S. 2006. Performance of wheat (*Triticum aestivum* L.) genotypes under different planting and weed control methods. *Crop Res* 32: 153-56.
5. Bhullar, S. S. and Jenner, C. F. 1986. Effects of temperature on conversion of sucrose to starch in the developing wheat endosperm. *Aust. J. Plant Physio*. 13: 605-615.
6. Brar, S. S. and Kumar, S. 2000. Experience with no-tillage in Indian Punjab. *International conference managing natural resource for sustainable agricultural production in the 21st century, proc* 2: 313-14, New Delhi.
7. Brevedan, E. R. and Hodges, M. A. 1973. Effect of moisture deficit on 14 tranlocation in corn (*Zea mays* L.). *Plant Physiol* 52: 436-39.
8. Bu, Y.S., Shao, H. L. and Wang, J. C. 2002. Effects of different mulch materials on corn seeding growth and soil nutrients' contents and distributions. *J Soil Water Cons.* 16(3): 40–42. (in Chinese).
9. Cochran, W. G. and Cox, G. M. 1967. Experimental designs. John Wiley and Sons, Inc., New York.
10. Derpsch, R., Sidiras, N. and Roth, C. H. 1986. Results of studies made from 1977 to 1984 to control erosion by cover crops and no tillage techniques in Parana, Brazil. *Soil Tillage* 8: 253-256.
11. Evans, L. T., Wardlaw, I. F. and Fischer, R. A. 1975. Wheat. P. 101-149. In L.T. Evans (ed.) Crop physiology, Cambridge Univ. Press, London
12. Hobbs, P. R. 2002. Resource conservation technologies- A second revolution in South Asia. *Proceedings international workshop on "Herbicide resistance management and zero tillage in rice-wheat cropping system"*. pp 67-76. Dept of Agronomy, CCS Haryana Agricultural University, Hisar, India.
13. Ismunadji, M. 1976. Rice disease and physiological disorders related to potassium deficiency In: Fertilizer use and plant health. Proc 12th Colloq Intern Potash Inst Izmix Turkey.
14. Kaur, Anureet and Pannu, R. K. 2008. Effect of sowing time and nitrogen schedules on phenology, yield and thermal-use efficiency of wheat (*Triticum aestivum*). *Indian J Agric Sci* 78: 366-69.
15. Khichar, M. L. and Niwas, R. 2007. Thermal effect on growth and yield of wheat under different sowing environments and planting systems. *Indian J Agric Res* 41: 92-96.
16. Kulhari, S. C., Sharma, S. L. and Kantwa, S. R. 2003. Effect of varieties, sowing dates and nitrogen levels on yield, nutrient uptake and quality of *durum* wheat. *Ann Agric Res* 24: 332-36.
17. Ortiz Monasterio, J. I., Dhillon, S. S. and Fisher 1994. Date of sowing effects on grain yield and yield components of irrigated spring wheat cultivars and relationship with radiation and temperature in Ludhiana India*. Field Crops Res* 37: 169-84.
18. Ramakrishna, A., Tam, H. M., Wani, S. P. and Long, T. D. 2006. Effect of mulch on soil temperature, moisture, weed infestation and yield of groundnut in northern Vietnam. *Field Crops Res.* 95 (2-3) : 115–125. doi: 10. 1016/j.fcr.2005. 01.030.
19. Sardana, V., Singh, R. P., Gupta, S. K. and Chakraborty, D. 2005. Influence of sowing time and nitrogen on productivity and quality of duram wheat. *Ann Agric Res* 26: 411-15.
20. Singh, Avtar, Kang, J.S., Kaur Maninder and Goyal, Ashu 2010. Irrigation scheduling in zero-till and bed-planted wheat (*Triticum aestivum*). *Indian J. Soil Conservation.* 38 (3):194-198.
21. Singh, G. K. 1977. Effect of crop rotation sown under varying levels of cultivation on the production potential and physic-chemical properties of soil. *Ph.D. dissertation, PAU, Ludhiana*
22. Tashiro, T. and Wardlaw, I. F. 1989. A comparison of the effect of high temperature on grain development in wheat and rice. *Ann Bot* 64: 59-65.
23. Tewari, S. K. and Singh, M. 1995. Influence of sowing date on phase duration and accumulation of dry matter in spikes of wheat (*Triticum aestivum* L.). *Indian J Agron* 40: 43-46.
24. Tripathi, S. C. and Chauhan, D. S. 2000. Evaluation of fertilizer and seed rate in wheat under different tillage conditions after transplanted rice*. Indian J Agric Sci* 70: 574-76.
25. Warrington, I. J., Dunstone, R. L. and Green, L.M. 1977. Temperature effects at three developmental stages on the yield of the wheat ear. *Aust. J. Agric. Res*. 28: 11-27.
26. Weigand, C. L. and Cuellar, J. A. 1981. Duration of grain filling and kernel weight of wheat as affected by temperature. *Crop Sci* 21: 95-101.

Table 1
Influence of Methods of Planting and Different Agronomic Manipulations on Grain Yield of Wheat

Treatment	Grain yield(qha^{-1})			Mean
	2005-06	2006-07	2007-08	
Method of Planting				
Zero tillage	-	54.7	42.1	48.4
Conventional tillage	33.3	55.5	42.4	43.7
Conventional tillage with residue	35.9	56.9	44.4	45.7
CD (p=0.05)	NS	0.8	NS	-
Agronomic manipulation				
Spray of KNO_3 (1%) during anthesis	36.4	58.9	43.8	46.4
Extra one irrigation during post anthesis	35.5	57.8	43.3	45.5
Recommended practice	33.1	52.9	41.7	42.6
Spray of irrigation water during post anthesis	35.0	56.7	43.6	45.1
CD(p=0.05)	NS	3.3	NS	-

Table 2
Interaction Effect of Date of Sowing and Methods of Planting on Grain Yield (q ha^{-1}) of Wheat

Treatment	25 November	10 December	Mean
Zero tillage in standing stubbles after removal of loose straw	42.00	32.40	37.20
Conventional tillage with mulching	45.90	27.80	36.90
Conventional tillage without mulching	46.40	29.80	38.10
Mean	44.70	30.00	
CD (p=0.05)	2.30		

Table 3
Interaction Effect of Date of Planting and Agronomic Practices on Grain Yield (q ha^{-1}) of Wheat

Treatment	KNO_3 (1%) Foliar Spray During Anthesis	KNO_3(1%) Foliar Spray Two Times During Anthesis	One Additional Irrigation During Post Anthesis	Recommended Irrigation	Mean
25 November	46.67	42.67	44.93	43.77	44.70
10 December	30.50	29.43	31.8	28.23	30.00
Mean	39.10	36.10	38.40	36.0	
CD (p=0.05)	NS				

Table 4
Interaction Effect of Methods of Planting and Agronomic Practices on Grain Yield (q ha^{-1}) of Wheat

Treatment	KNO_3 (1%) foliar spray during anthesis	KNO_3(1%) foliar spray two times during anthesis	One additional irrigation during post anthesis	Recommended irrigation	Mean
Zero tillage in standing stubbles after removal of loose straw	43.40	34.60	34.60	36.30	37.20
Conventional tillage with mulching	37.80	32.30	39.60	37.90	36.90
Conventional tillage without mulching	36.10	41.40	41.00	33.90	38.10
Mean	39.10	36.10	38.40	36.00	
CD (p=0.05)	3.36				

Table 5
Mean Monthly Temperature and Rainfall Monthly During the Growing Season

Month	Mean temperature(^{0}C)			Rainfall (mm)		
	2005-06	2006-07	2007-08	2005-06	2006-07	2007-08
October	24.5	25.3	23.8	-	6.8	-
November	18.6	19.6	19.4	-	14.0	1.3
December	12.6	13.7	12.0	-	8.7	17.7
January	12.5	11.8	10.7	16.8	10.0	16.3
February	18.7	15.2	13.3	0.8	84.7	3.2
March	20.0	19.3	22.2	32.5	41.3	-
April	27.1	28.1	25.9	5.1	26.2	50.2

Table 6
Bulk Density of Soil (0-15 cm Depth) at Harvest of Wheat Under Different Methods of Planting

Treatment	Bulk density(g cm^{-3})		
	2005-06	2006-07	2007-08
Method of planting			
Zero tillage	1.56	1.55	1.56
Conventional tillage	1.55	1.54	1.54
Conventional tillage with crop residue	1.54	1.53	1.53

Table 7
Influence of Crop Establishment Methods on Infiltration Rate (cm) at Harvest During 2007-08

Time (minutes)	Zero tillage	Conventional Tillage	Conventional Tillage with Crop Residue
5	1.7	2.0	2.0
10	3.4	2.9	3.3
15	5.5	5.0	5.4
30	8.6	7.4	7.4
45	10.2	9.4	9.5
60	13.4	11.4	12.8
120	15.8	13.6	14.5
180	18.6	16.2	16.8