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Effect of tillage and nitrogen management on water use and productivity of late-sown wheat under mid hill conditions of Himachal Pradesh

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Abstract

A field experiment was conducted for three successive years from 2006 to 2009 to assess the effect of tillage (conventional, conservation and zero tillage) and nitrogen management (recommended, 125 % of recommended and 150 % of recommended nitrogen) on late sown wheat due to introduction of short season radish crop in between two crops of maize-wheat cropping system. Conservation tillage used 10.2 % less water than conventional and zero tillage and increased WUE by 35.8 per cent. It also resulted in significantly higher grain yield compared to conventional and zero tillage (about 13 and 22 %). The application of 125 % of recommended nitrogen increased water use efficiency by 17 % than recommended nitrogen. Further increase to 150 % of recommended nitrogen increased WUE by 6 %.The application of 150 % of recommended nitrogen resulted in significantly higher grain yield (17 %) than recommended nitrogen.

Key words: Tillage, nitrogen, water use efficiency.

Introduction

Among different maize based cropping systems, maize-wheat (*Triticum aestivum* L.) ranks 1st having 1.8 m ha area mainly concentrated in rainfed ecologies. In Himachal Pradesh, maize –wheat is taken on 70 % of net sown areas mostly under rainfed conditions. The expansion of irrigation facilities for covering large area is not possible due to scattered small land holdings on undulating topography of the region.

Maize is generally planted after getting pre monsoon showers in the last week of May or first week of June. The crop matures in September – October depending upon the withdrawal pattern of monsoon. In this region, wheat is normally sown, after 15 November. The land remains vacant for almost one and a half months. This period can be effectively used for planting short duration crop like radish if farmer has small quantity of water for 2-3 irrigations. This can be easily done by storing surface runoff during monsoon in small poly lined tank. However, introduction of such crop will result in delayed sowing of following wheat crop. This is going to result in lower yield due to shorter growing period and poor growth of wheat plant. The length of growing period can be increases by growing wheat under zero tillage as emphasized by Singh *et al.* (2002). Any technique that facilitates rapid development and enables the crop to cover soil surface, shade out weeds, and reduce wind speed may, in most circumstances, increase crop competitiveness and water productivity (Cooper and Gregory, 1987). The growth of late sown wheat can be improved by managing moisture and nutrient supply, particularly nitrogen. Hence, the present experiment was planned to evaluate the effect of tillage and nitrogen management in wheat whose sowing was delayed due to the introduction of short duration radish crop in between maize and wheat.

Materials and Methods

To study the effect of tillage and nitrogen management on late sown wheat a field experiment was conducted for three successive years from 2006 to 2009 at the Research Farm of Water Management section of Soil Science, Department of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur (32^0 6' N latitude, 76 3' E longitude and located at 1290.8 m above mean sea level) Kangra, Himachal Pradesh.

The soil of experimental site was silty clay loam with pH 6.3, low in organic carbon (0.95 %), low in available nitrogen (173.4 kg/ha) medium in available P (9.2 kg/ha) and K (107.8 kg/ha). The experiment was initiated in *kharif* 2006 with sowing of general crop of maize followed by general crop of radish in all the plots. Nine treatments comprising of all possible combination of three tillage systems

(conventional, zero and conservation tillage) and three nitrogen levels (recommended nitrogen, 125 % of recommended nitrogen and 150 % of recommended nitrogen) were laid in randomized block design with three replications. A general crop of rainfed maize (cv Kanchan) was raised with recommended package of practices during 2006, 2007 and 2008. Immediately after harvest of maize, residual moisture was utilized for sowing of radish (cv Japanese white) during respective years. Small ridges were made after emergence of radish crop. After uprooting of radish, wheat cultivar recommended for late sown conditions (HS-295) was sown by just opening small furrows with hand plough in zero and conservation tillage (zero tillage + mulching) plots. In conservation tillage rice straw was applied as surface mulch immediately after sowing at the rate of 10 t ha^{-1}. Conventional tillage included two ploughing with soil turning plough and sowing of HS-295 after opening furrows with hand plough. The 1/3 rd nitrogen (as per treatment) and whole of phosphorus and potassium were band placed at the time of sowing in all the plots. Remaining nitrogen was top dressed in two equal splits, each at CRI and flowering stage. Soil moisture content was gravimetrically determined for 0-15 cm, 15-30 cm and 30-45 cm soil depth at sowing, CRI and flowering stage of wheat. Total water used was calculated using irrigation water applied and effective rainfall during the growing season of wheat. Since, per day rainfall never exceed 5 cm. So the entire rainfall is considered effective. Water use efficiency was then calculated using following formula;

$$\text{Water use efficiency (kg ha-mm}^{-1}\text{)} = \frac{\text{Grain yield (kg ha}^{-1}\text{)}}{\text{Total water used (mm)}}$$

Results and Discussion

General crop yield

A general crop of rain-fed maize resulted in average yield of 2.45, 2.46 and 2.82 Mg/ha during 2006, 2007 and 2008, respectively. Radish crop gave an average yield of 36.0, 29.07 and 30.45 Mg/ha during 2006, 2007 and 2008, respectively, with total water use of 201 mm (50 mm irrigation + 151 mm rainfall), 244 mm (200 mm irrigation + 44 mm rainfall) and 323 mm (250 mm irrigation + 73 mm rainfall) during three years.

Water regime

Conventional tillage recorded the lowest soil moisture content at all soil depths at sowing and at all growth stages of wheat (Table 1). On the other hand, conservation tillage (Zero tillage + Mulch) recorded the highest values of soil moisture at all soil depths at all growth stages of wheat crop as mulch

Table 1. Effect of tillage on soil moisture content at different growth stages of wheat crop

Treatment	Soil moisture content (%)											
	0-15 cm				15-30 cm				30-45 cm			
	06-07	07-08	08-09	Mean	06-07	07-08	08-09	Mean	06-07	07-08	08-09	Mean
	At sowing											
Con. tillage	24.3	24.6	24.9	24.6	24.8	24.8	25.0	24.9	24.5	25.0	24.8	24.8
Zero tillage	24.9	25. 8	25.8	25.5	25.2	25.0	25.4	25.2	24.7	25.5	25.2	25.0
Cons. tillage	25.8	25.8	26.0	25.9	25.3	26.3	25.8	25.8	25.3	25.9	25.8	25.7
	At crown root initiation											
Con. tillage	24.4	24.8	24.6	24.6	24.3	24.7	24.5	24.5	22.7	23.8	23.9	23.5
Zero tillage	24.6	25.1	24.8	24.8	24.4	24.9	24.9	24.7	23.2	24.5	24.2	24.0
Cons. tillage	24.7	25.8	25.3	25.3	24.7	24.9	25.0	24.9	23.8	24.9	24.3	24.3
	At flowering											
Con. tillage	21.6	22.2	22.0	21.9	22.1	22.1	21.4	21.9	21.0	22.1	21.8	21.6
Zero tillage	22.1	23.1	22.6	22.6	22.4	23.4	22.9	22.9	21.8	22.9	22.8	22.5
Cons. tillage	22.7	23.8	23.8	23.4	25.2	24.4	23.9	24.5	24.4	24.8	23.8	24.3
	At harvest											
Con. tillage	15.1	19.2	17.1	17.1	15.2	16.8	17.5	16.5	16.4	17.5	18.8	17.6
Zero tillage	15.7	16.7	19.8	17.4	17.4	20.2	18.7	18.8	17.3	18.7	18.0	18.0
Cons. tillage	15.7	20.0	19.9	18.5	17.0	21.8	20.0	19.6	17.4	19.4	17.5	18.1

Conv. = Conventional and Cons. = Conservation

helped in conservation of soil moisture. Hatfield *et al*. (2001) reported a 34-50% reduction in soil water evaporation as a result of crop residue mulching.

Wheat crop yield

Cultivation of radish as a catch crop between maize and wheat delayed wheat planting until mid-December. As a result, wheat grain yield in general was low. Tillage significantly influenced grain yield of wheat during all the years (Table 2). Conservation tillage resulted in significantly higher grain yield compared to conventional (28 and 15 %) and zero tillage (38 and 22%) during 2007-08 and 2008-09; during 2006-07 conventional and conservation tillage were at par. On mean basis also conservation tillage resulted in significantly higher grain yield compared to conventional and zero tillage by about 13 and 22 %. Superiority of conservational tillage over conventional tillage was also reported by Acharya *et.al.* (1998). Zero tillage resulted in about 8 and 18 per cent lower grain yield than conventional tillage and conservation tillage, respectively. These results are in conformity with the findings of Bhattacharyya *et al*. (2008). They also recorded lower (6 %) grain yield of wheat under zero tillage than under conventional tillage. Arora et al. (2010) also recorded lower grain yield of wheat under no till-direct planting than under conventional tillage and this yield reduction could be overcome by adding 30 kg ha^{-1} more fertilizer nitrogen.

Tillage did not affect straw yield of wheat during first year. However, during later years, it had significant effect on straw yield. Conservation tillage resulted in significantly higher straw yield compared to conventional (18 and 12 %) and zero tillage (22 and 19 %). On mean basis, conservation tillage resulted in significantly higher straw than zero tillage (11 %).

Nitrogen management had a significant effect on both grain and straw yields of late-sown wheat during first year and on grain yield alone, during later years. During all the years, there was a progressive increase in grain and straw yields with increasing nitrogen level above the recommended level. However, increase in grain yields during first year was significant only when nitrogen level was increased from 125 % to 150 % and during second and third year, when nitrogen was increased from recommended to 150% of recommended nitrogen. On mean basis also, 150 % recommended nitrogen resulted in significantly higher grain yield (17 %) than recommended nitrogen. This may be due to the extended root system The fertilizer improved the

Table 2. Effect of tillage and nitrogen management on grain and straw yield of wheat

Treatment	Grain yield (Mg/ha)				Straw yield (Mg/ha)			
	06-07	07-08	08-09	Mean	06-07	07-08	08-09	Mean
Tillage management								
Conventional tillage	1.63	1.41	1.77	1.60	2.46	2.27	2.84	2.52
Zero tillage	1.47	1.31	1.66	1.48	2.44	2.18	2.67	2.43
Conservation tillage	1.59	1.81	2.03	1.81	2.22	2.67	3.19	2.69
CD (P = 0.05)	0.09	0.17	0.25	0.10	NS	0.37	0.33	0.17
Nitrogen management								
Rec. nitrogen	1.50	1.40	1.57	1.49	2.22	2.16	2.74	2.37
125 % of Rec. nitrogen	1.54	1.49	1.91	1.65	2.28	2.36	2.94	2.53
150 % of Rec. nitrogen	1.65	1.63	1.98	1.75	2.62	2.60	3.02	2.75
CD (P = 0.05)	0.09	0.17	0.25	0.10	0.33	NS	NS	0.17

Rec. = Recommended

extension of the root system. The ameliorated root system was able to improve crop water use and nutrient absorption and hence, crop yield and water productivity was increased.

Like grain yield, straw yield of first year crop increased significantly, only when nitrogen was increased from 125 % to 150 % of recommended level. Application of 150 % of recommended nitrogen produced about 10, 16 and 26 % more grain than application of recommended nitrogen during first, second and third years, respectively. Respective percentages for straw yield were 18, 20 and 10. On mean basis, application of 150 % of recommended N resulted in significantly higher straw yield (16 %) than application of recommended nitrogen. The interaction between different tillage systems and N application rates for grain and straw yield was not significant. Similar results were reported by Sharma (1985) for green and dry matter production in fodder oats.

Water use efficiency

Conservation tillage always used less water and results in higher WUE than conventional and zero tillage. However, the difference in WUE of conservation and conventional tillage was not significant in 2006-07. Conservation tillage increased WUE over zero tillage by 15.4, 49.7 and 49.5 % during 2006-07, 2007-08 and 2008-09, respectively. On mean basis, conservation tillage used 10.2 % less water than conventional and zero tillage and increased WUE by 35.8 per cent (Table 3). Zero tillage always results in lower WUE than conventional and conservation tillage. However, WUE, in zero and conventional tillage was statistically similar during 2007-08 and 2008-09.

During all the years, there was a progressive increase in WUE with increasing nitrogen level above the recommended level. However, increase in WUE was significant only when nitrogen level was increased from recommended to 150% of recommended nitrogen. The percent increase in WUE with increase in nitrogen from recommended to 150 % of recommended nitrogen was about 9, 16 and 26 % during 2006-07, 2007-08 and 2008-09, respectively. On mean basis, every increment of nitrogen above recommended resulted in significantly increase in WUE. The WUE increased by 17 % with increase in nitrogen from recommended to 125 % of recommended nitrogen and by 6 % with further increase to 150 % of recommended nitrogen. Hatfield et al. (2001) showed that the addition of N and P have an in direct effect on water use through the physiological efficiency of the plant.

Table 3. Effect of tillage and nitrogen management on total water use and water use efficiency in wheat

Treatment	Total water use (mm)				Water use efficiency (kg/ha-mm)			
	06-07	07-08	08-09	Mean	06-07	07-08	08-09	Mean
Tillage management								
Conv. tillage	754.8	656	554.8	656	2.16	2.15	3.19	2.44
Zero tillage	754.8	656	554.8	656	1.95	1.99	2.99	2.26
Cons. tillage	704.8	606	454.8	589	2.25	2.98	4.47	3.07
CD (P = 0.05)					0.12	0.26	0.48	0.15
Nitrogen management								
Rec. nitrogen	738.1	639.3	521.5	633.7	2.04	2.21	3.07	2.37
125 % of Rec. nitrogen	738.1	639.3	521.5	633.7	2.10	2.35	3.73	2.62
150 % of Rec. nitrogen	738.1	639.3	521.5	633.7	2.23	2.56	3.86	2.78
CD (P = 0.05)					0.12	0.26	0.48	0.15

Conv. = Conventional, Cons. = Conservation, Rec. = Recommended

Conclusion

Water productivity could be enhanced by introducing a radish crop in between maize and wheat crops by utilizing residual soil moisture, and 4-5 irrigations of 5 cm depth each. However, introduction delays sowing of succeeding crop of wheat (Second fortnight of December). Cultivation of late-sown wheat with conservation tillage resulted in about 13 and 22% higher crop productivity, and 26 and 36% higher WUE compared to conventional and zero tillage.

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