Journal of Crop and Weed, 15(2): 115-119 (2019) ISSN- O : 2349 9400 ; P : 0974 6315

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Effect of tillage and site specific nutrient management on productivity of rice-wheat cropping system

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Received : 18.07.2019 ; Revised : 13.08.2019 ; Accepted : 19.08.2019

ABSTRACT

A field experiment was conducted to evaluate the effect of tillage and site specific nutrient management on productivity of rice-wheat cropping system on a silty clay loam soil. Results revealed that tillage options had no significant effect on the grain yield of wheat while significantly higher grain yield of rice was recorded in conventional tillage as compared to zero tillage. The wheat yield recorded with the application of fertilizer dose recommended by software Nutrient Expert – Wheat for a target of 5.5 Mg ha^{-1} was considerably lower than the targeted yield indicating the need to improve the software. Top dressing of nitrogen after irrigation gave better result than top dressing of nitrogen before irrigation though the differences were not significant.

***Keywords*:** Conventional tillage, nutrient management, rice, wheat and zero tillage

Of the 30 major cropping systems identified in India, rice-wheat based cropping system is the most predominant in India occupying around 10.5 million hectare area (Yadav and Prasad, 1998). Among cereals, rice and wheat are the most important crops, which account for about 60% of world's human energy requirement. Farmers realize much of their food security from this cropping system. Besides food security, the low production levels can jeopardize farmers' economic security to a considerable extent. To strengthen the economic conditions of the farmers, it is imperative to sustain the productivity of this system. The shift from puddle-transplanted rice and conventional intensive tilled wheat to direct seeded rice and wheat after zero-tillage on the flat or raised-bed system could affect the productivity and resource-use efficiency of the rice-wheat system (Ladha *et al*., 2009). However, the population benefits and constraints of alternative tillage and crop establishment methods need to be quantified on a short to long term basis to maximize yield and input-use efficiency. Zero tillage is being widely adopted by farmers in the North western Indo-Gangetic Plains of India, particularly in areas where rice is harvested late.

The use of blanket nutrient management recommendations in India has led to low nutrient use efficiencies, lowered profits and increased environmental problems (Pampolino *et al*., 2012). Nutrient recommendations in India are based upon crop response data averaged over large geographic areas and do not take into account the spatial variability in indigenous nutrient supplying capacity of soils (Majumdar *et al*., 2013). Site-specific nutrient management (SSNM), on the other hand, integrates information from different scales to make field specific decisions on N, P and K management. SSNM, which was developed for rice in Asia was later adapted for wheat in Asia. SSNM is an opportunity that exists to further enhance the yield, profitability and nutrient use efficiency. International Plant Nutrition Institute (IPNI) in collaboration with International Maize and Wheat Improvement Centre (CIMMYT) has recently developed Nutrient Expert (NE), a new nutrient decision support system for wheat, based on SSNM principles. Nutrient Expert, while providing fertilizer recommendations, considers yield response and targeted agronomic efficiency in addition to the contribution of nutrients from indigenous sources. Hence, the study was undertaken in which the fertilizer doses recommended by the software Nutrient Expert-Wheat were tested against the fertilizer doses recommended for irrigated wheat in the state of Himachal Pradesh, both under conventional tillage as well as under zero tillage conditions.

MATERIALS AND METHODS

The field experiment was conducted for two years from *Rabi* (wheat) season of 2015-16 through *Kharif* (rice) season of 2017 at Experimental Farm of CSK Himachal Pradesh Krishi Vishvavidyalaya, Rice and Wheat Research Centre, Malan situated at 32°07' N latitude, 76°23' E longitude and at an altitude of 950 m above mean sea level. The area receives a high rainfall that ranges between 1500-2500 mm per annum, of which 80 per cent is received during monsoon months from June to September. The soil of the experimental site was silty clay loam in texture, acidic in reaction, high in organic carbon, medium in available nitrogen, high in available phosphorus and medium in available potassium. The experiment was laid out in strip plot

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Table 1: Nutrient management in wheat for 2015-16 and 2016-17

Nutrient management	Tillage (2015-16)		Tillage (2016-17)	
	Conventional	Zero	Conventional	Zero
RFD – AI	120:60:30	120:60:30	120:60:30	120:60:30
RFD – BI	120:60:30	120:60:30	120:60:30	120:60:30
SSNM Nutrient Expert – BI	125:45:78	125:45:78	125:45:78	125:45:78
SSNM + Green Seeker – BI	101.4:45:78	100.3:45:78	94.1:45:78	95.9:45:78
N-rich plot – BI	180:60:30	180:60:30	180:60:30	180:60:30

Note: *RFD: Recommended fertilizers dose; AI: Top dressing of nitrogen after irrigation; BI: Top dressing of nitrogen before irrigation*

design with tillage in horizontal plot and nutrient management in vertical plot with three replications. The experiment consisted of 10 treatments combinations comprising five nutrient management practices in wheat *i.e.* recommended fertilizer dose (120:60:30 kg ha^{-1} NPK) with top dressing of nitrogen after irrigation; recommended fertilizer dose with top dressing of nitrogen before irrigation; fertilizer dose as recommended by software Nutrient Expert – Wheat (125:45:78 kg ha^{-1} NPK) with top dressing of nitrogen before irrigation; Nutrient Expert – Wheat guided fertilizer dose (70% nitrogen recommended by software and rest with green seeker technology) with top dressing of nitrogen before irrigation and N-rich plot which received 150% of recommended nitrogen with top dressing of nitrogen before irrigation with two tillage options *i.e.* conventional tillage and zero tillage. In rice only tillage practices were studied as trial was laid out in fixed plots. Rice was uniformly fertilized. Wheat crop variety HPW 349 was sown at a spacing of 20 cm using a seed rate of 100 kg ha^{-1}. HPR 2795 (Him Palam Lal Dhan 1) variety of rice was used for sowing. Nutrient management in wheat was as per the details given in Table 1. Rice was fertilized with uniform application of 60 kg N, 30 kg P_2O_5 and 30 kg K_2O per hectare in the form of urea (46%), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O), respectively. Wheat received five irrigations, first irrigation was given at CRI stage (21 days after sowing) and subsequent irrigations were applied at tillering stage (40–45 days after sowing), late jointing stage (70–75 days after sowing), flowering stage (90–95 days after sowing) and dough stage (110–115 days after sowing) and in each irrigation 5±0.5 cm water was applied. Rice was irrigated as and when needed. In zero tillage, glyphosate 3 l ha^{-1} was applied prior to wheat and rice to tackle weed menace. Productivity was worked out by dividing the grain yield with duration of crop. Since data followed the homogeneity test, pooling was done over the seasons.

RESULTS AND DISCUSSION

Yield attributes of wheat

Number of effective tillers per square meter, number of grains per spike, grain weight per spike and 1000 grain weight did not vary significantly with tillage options. Among nutrient management practices, N-rich plot with top dressing of nitrogen before irrigation produced significantly more number of effective tillers per square meter as compared to other treatments followed by application of recommended NPK with top dressing of nitrogen both after and before irrigation which were statistically at par with each other. This could be due to the fact that nutrients played a vital role in increased sink size. Nutrients are required throughout the grand growth period and hence adequate and regular supply might have a great role towards increased number of effective tillers per square meter. Other studies (Dou and Hons, 2006; Mitra *et al*., 2014) have also reported similar crop growth under different nutrient management practices. The other yield attributes *viz*. number of grains per spike, grain weight per spike and 1000 grain weight did not vary significantly with the application of various nutrient management practices.

Yield attributes of rice

Tillage options had significant effect on number of panicles per square meter. Conventional tillage produced significantly higher number of panicles per square meter over zero tillage. Tillage options and nutrient management practices failed to produce significant variation on number of grains per panicle, grain weight per panicle and 1000 grain weight. Numerically higher values of yield attributes were observed under conventional tillage might be due to better crop growth under improved soil physical and chemical properties like lower bulk density, higher macro and micro nutrient availability easily due to faster decomposition of crop residue throughout the crop growth stages. These results are in agreement with the findings of Gupta and Seth (2007).

Table 2: Effect of treatments on yield attributes of wheat

Treatment	No. of effective tillers m^{-2}	No. of grains $spike^{-1}$	Grain weight $spike^{-1}$ (g)	1000 grain weight (g)
Tillage				
Conventional	286.1	50.7	2.37	41.32
Zero	280.0	48.2	2.24	40.57
SEm (±)	**4.9**	**1.04**	**0.04**	**0.26**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**
Nutrient management				
RFD – AI	285.9	50.2	2.31	41.08
RFD – BI	285.7	49.1	2.29	41.02
SSNM Nutrient Expert – AI	278.1	48.5	2.26	40.90
SSNM + Green Seeker – AI	276.8	48.1	2.23	40.56
150% RFD – AI	288.6	51.4	2.41	41.15
SEm (±)	**2.8**	**1.44**	**0.09**	**0.32**
LSD (0.05)	**8.1**	**NS**	**NS**	**NS**

Table 3: Direct and residual effect of tillage and residual effect of nutrient management treatments applied to wheat on yield attributes of succeeding rice

Treatment	No. of effective tillers m^{-2}	No. of grains $spike^{-1}$	Grain weight $spike^{-1}$ (g)	1000 grain weight (g)
Tillage				
Conventional	265.3	86.4	2.62	26.2
Zero	253.9	81.7	2.50	25.2
SEm (±)	**1.3**	**1.2**	**0.03**	**0.3**
LSD (0.05)	**5.1**	**NS**	**NS**	**NS**
Nutrient management				
RFD – AI	253.5	80.9	2.51	25.4
RFD – BI	255.3	82.1	2.54	25.5
SSNM Nutrient Expert – AI	263.9	86.3	2.59	26.0
SSNM + Green Seeker – AI	258.6	82.3	2.55	25.5
150% RFD – AI	266.8	88.8	2.61	26.1
SEm (±)	**5.0**	**2.8**	**0.04**	**0.3**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**

Yield of wheat and rice

Tillage options failed to produce significant variation on grain yield and straw yield of wheat. This showed that wheat sown either in conventional or zero tillage gave similar wheat yield. Similar results were reported by workers from across the country in different wheat producing zones (Anonymous, 2016). Among nutrient management practices, N-rich plot while remaining at par with the application of recommended NPK where nitrogen was top dressed both after and before irrigation gave significantly higher grain yield and straw yield than the treatments which received fertilizer doses as recommended by Nutrient Expert – Wheat. The higher grain yield and straw yield recorded in nitrogen rich plot as well as with recommended dose may be due to the higher nitrogen application in these treatments (180 and 120 kg ha^{-1}) as compared to the nitrogen added on the basis of Nutrient Expert – Wheat and SSNM + Green Seeker which resulted in higher photosynthesis, which ultimately resulted in better growth and higher yield. Increase in grain yield of wheat with increasing nitrogen application has also been reported by Jat *et al*. (2013).

Conventional tillage significantly increased the grain yield and straw yield of rice over zero tillage. The yield

Table 4: Effect of treatments on yield of wheat and rice

Treatment	Wheat		Rice	
	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Tillage				
Conventional	4062	6450	4366	6354
Zero	3926	6255	4050	5928
SEm (±)	**52**	**122**	**51**	**69**
LSD (0.05)	**NS**	**NS**	**200**	**271**
Nutrient management				
RFD – AI	4111	6517	4156	6011
RFD – BI	3966	6300	4153	6034
SSNM Nutrient Expert – AI	3893	6213	4240	6213
SSNM + Green Seeker – AI	3858	6142	4189	6106
150% RFD – AI	4145	6590	4301	6342
SEm (±)	**73**	**112**	**68**	**124**
LSD (0.05)	**212**	**323**	**NS**	**NS**

Table 5: Effect of treatments on system productivity

Treatment	System productivity (kg ha^{-1}day^{-1})
Tillage	
Conventional	27.74
Zero	26.25
Nutrient management	
RFD – AI	27.21
RFD – BI	26.72
SSNM Nutrient Expert – AI	26.77
SSNM + Green Seeker – AI	26.48
150% RFD – AI	27.80

was higher with conventional tillage might be due to profuse root system and higher yield attributes under better soil condition as compared to zero tillage. In zero tillage higher immobilization of the nitrogen applied to wheat and high C: N ratio may be the reason of lower yield. Similar result was also reported by Singh *et al.* (2006). Nutrient management practices adopted in wheat had no significant influence on grain yield of succeeding rice.

Productivity of rice-wheat system

Conventional tillage produced higher system productivity as compared to zero tillage. Among nutrient management practices, N-rich plot recorded higher system productivity followed by other treatments. Lowest system productivity was recorded under SSNM + Green Seeker with top dressing of nitrogen before irrigation.

The study indicated that wheat yield recorded with the application of fertilizer dose recommended by software Nutrient Expert – Wheat for a target of 5.5 Mg ha^{-1} was considerably lower than the targeted yield. Therefore, for higher productivity from rice-wheat system in mid hill region of Himachal Pradesh there is needed to improve the software.

ACKNOWLEDGEMENT

The first author is grateful to the Innovation in Science Pursuit for Inspired Research (INSPIRE), New Delhi, India, for awarding fellowship and admissible financial support to carry out this study.

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