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Meenakshi Seth
Ph.D., Scholar, Department of Agronomy, Forages and Grassland Management, COA, CSK HPKV, Palampur, Kangra, Himachal Pradesh, India

DR. Thakur
Principal Scientist, Department of Agronomy, Forages and Grassland Management, COA, CSK HPKV, Palampur, Kangra, Himachal Pradesh, India

Sandeep Manuja
Professor, Department of Agronomy, Forages and Grassland Management, COA, CSK HPKV, Palampur, Kangra, Himachal Pradesh, India

Sukhchain Singh
Ph.D., Scholar, Department of Agronomy, Forages and Grassland Management, COA, CSK HPKV, Palampur, Kangra, Himachal Pradesh, India

Abha Sharma
Ph.D., Scholar, Department of Agronomy, Forages and Grassland Management, COA, CSK HPKV, Palampur, Kangra, Himachal Pradesh, India

Correspondence
Meenakshi Seth
Ph.D., Scholar, Department of Agronomy, Forages and Grassland Management, COA, CSK HPKV, Palampur, Kangra, Himachal Pradesh, India

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Effect of site specific nutrient management on growth indices in wheat in rice-wheat cropping system

Meenakshi Seth, DR. Thakur, Sandeep Manuja, Sukhchain Singh and Abha Sharma

Abstract
Rice-wheat is the most predominant cropping system, occupying in India, especially in North India. Under the scenario emphasis are being given on the resource conservation technologies, hence, it has become imperative to develop technologies that are specific to the particular field or particular set of resources. Therefore, the present investigation was conducted for two years from *Rabi* (wheat) season of 2015-16 through *Kharif* (rice) season of 2017 at Experimental Farm of Rice and Wheat Research Centre, Malan. 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 dosewith 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 tested in strip plot design, replicated three times. Results revealed that tillage options had no significant effect on growth indices of wheat while conventional tillage significantly increased the growth indices of rice over zero tillage. Among nutrient management practices, N-rich plot in which 150% of recommended nitrogen was added produced significantly taller plants and higher dry matter accumulation in wheat. However, plant height and dry matter accumulation of succeeding rice was not significantly influenced by nutrient management practices.

Keywords: Nutrient expert, rice, SSNM, tillage, wheat

Introduction
Among the various cropping systems practiced in India, rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L.) is considered most important because to its area coverage and contribution to total food grain production and mainly practiced in entire Indo-Gangetic plains. Both these crops are heavy nutrient feeders and their intensive cropping leads to large withdrawal of plant nutrients from soil, thereby accentuating the problem of nutrient disorders and affecting crop yields. Continued puddling for rice cultivation over decades has led to deterioration of soil physical properties through structural breakdown of soil aggregates and capillary pores and clay dispersion thereby restricting germination and rooting of succeeding crops (Tomar *et al.*, 2006) [1]. Huge labours are needed to accomplish transplanting of rice seedlings and mostly it is delayed to a greater extent due to unavailability of adequate labours during transplanting peak. Thus, late planted rice takes more time to reach the maturity, which not only reduces the rice yield but also delays sowing of succeeding crop particularly wheat but direct seeding of rice can reduce the labour and water requirement, shorten the duration of crop by 7-10 days and provide comparable yield with transplanted rice (Mishra *et al*., 2012) [2].
The tillage practices play an important role in influencing crop growth, yield and crop's micro-environment. It is an integral part of cropping system aimed at optimizing crop production by solving specific soil related ecological constraints. Soil tillage systems such as zero and conventional tillage are considered important soil management practices.

These practices alter the soil physical environment and affect the plant and root growth, thereby, water and nutrient uptake and crop yields.

With the developing concept of Precision Agriculture, it is imperative that the right quantity of fertilizers is to be applied to the crop at the right time and through the right source. Thus it has become important that quantity of nutrients applied to a particular field should be based on the inherent nutrient supplying capacity of the soil of that field, thus the concept of Site Specific Nutrient Management gained importance. Nutrient Expert-Wheat is software developed by International Plant Nutrition Institute (IPNI) and CIMMYT that gives nutrient recommendations for targeted yield on the basis of the soil test values. The present investigation was therefore carried out in the state of Himachal Pradesh, where fertilizer doses recommended by the software Nutrient Expert-Wheat were tested against the fertilizer doses recommended for irrigated wheat both under conventional tillage as well as under zero tillage conditions.

Materials and Methods

A 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 at an altitude of 950 m above mean sea level. 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 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. Since data followed the homogeneity test, pooling was done over the seasons. Different crop indices were calculated by following formulae:

$$\text{Absolute growth rate (AGR)} = \frac{h_2 - h_1}{t_2 - t_1} = \text{cm day}^{-1}$$

Where, h_1 and h_2 are the plant height at t_1 and t_2 times, respectively.

$$\text{Crop growth rate (CGR)} = \frac{w_2 - w_1}{t_2 - t_1} = \text{g m}^{-2}\text{ day}^{-1}$$

Where, w_1 and w_2 are whole plant dry weight at t_1 and t_2 time, respectively.

$$\text{Relative growth rate (RGR)} = \frac{(\log_e w_2 - \log_e w_1)}{(t_2 - t_1)} = \text{mg g}^{-1}\text{ day}^{-1}$$

Where, w_1 and w_2 are dry weight of whole plant at times t_1 and t_2, respectively.

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

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

Results and Discussion

Growth indices

Plant height and dry matter accumulation of wheat

Differences in plant height due to tillage options were not significant at all stages of crop growth. Longer plants were recorded under conventional tillage than zero tillage. Plant height was significantly influenced at all crop growth stages except at 30 days after sowing (DAS). N-rich plot with top dressing of nitrogen before irrigation produced significantly taller plants but

Table 2: Effect of tillage and nutrient management on plant height and dry matter accumulation of wheat

Treatment	Plant height (cm)						Dry matter accumulation (g m^{-2})					
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	Maturity	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	Maturity
Tillage												
Conventional	12.0	21.8	45.1	77.2	79.3	80.3	37.9	143.3	600.6	751.3	895.7	1028.7
Zero	11.5	20.1	41.6	72.3	75.5	76.6	37.6	139.9	589.3	733.6	875.9	1000.6
$SE_m\pm$	0.2	0.5	0.9	1.3	1.0	1.0	0.2	0.9	4.7	6.2	6.8	7.4
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nutrient Management												
RFD – AI	12.0	21.4	44.5	77.3	79.6	80.5	38.3	143.6	602.0	752.1	894.4	1029.1
RFD – BI	11.8	20.9	43.6	74.5	76.5	77.5	37.8	140.8	593.1	740.5	883.7	1009.7
SSNM Nutrient Expert – BI	11.5	20.7	42.3	72.7	75.3	76.6	37.2	139.5	587.0	734.6	876.6	1005.1
SSNM + Green Seeker – BI	11.5	19.9	41.3	71.2	74.6	75.2	36.3	138.8	582.0	726.4	864.3	991.0
150% RFD – BI	12.2	21.9	45.0	78.0	81.1	82.4	39.3	145.1	610.7	759.1	909.9	1038.3
$SE_m\pm$	0.3	0.5	1.1	1.9	1.9	1.8	0.6	2.4	8.4	9.4	11.3	11.4
CD (P=0.05)	NS	1.5	3.2	5.5	5.4	5.2	2.0	NS	24.3	27.1	32.6	32.9

remained statistically at par with the application of recommended NPK where nitrogen was top dressed both after and before irrigation at 60, 90, 120, 150 DAS and at maturity as compared to SSNM + Green Seeker with top dressing of nitrogen before irrigation. However, it was also statistically at par with SSNM Nutrient Expert with top dressing of nitrogen before irrigation at 60, 90 DAS and 120 DAS. It might be due to higher availability of nitrogen throughout the growth period of crop. Plant height was superior under higher dose of nitrogen, phosphorus and potassium due to better nutrient availability and reduced interplant competition in the community. More supply of nitrogen, phosphorus and potassium is favorable for increasing growth of wheat plants (Pandey and Sinha, 2006) [3].

Tillage options did not result in significant variation in dry matter production at various growth stages. Higher dry matter accumulation was recorded in N-rich plot over SSNM + Green Seeker with top dressing of nitrogen before irrigation, but it remained statistically at par with the application of recommended NPK where nitrogen was top dressed both after and before irrigation at all stages except at 60 DAS. It was also at par with SSNM Nutrient Expert with top dressing of nitrogen before irrigation at 90 and 120 DAS. It might be due to direct effect of higher availability and translocation of nutrients particularly nitrogen during development phase of growth which facilitated more photosynthesis process and resulted in higher dry matter accumulation. Barthwal *et al.* (2013) [4] also reported that increasing rate of nitrogen application from 120 to 180 kg ha^{-1} along with other nutrients enhanced the dry matter accumulation. More crop growth at higher level of nutrients resulted in accumulation of more dry matter through increased photosynthetic activity.

Plant height and dry matter accumulation of rice

Plant height was significantly influenced by conventional tillage over zero tillage at all stages of crop growth. Higher plant height in case of conventional tillage might be due to more vigorous and healthy seedling at initial growth period of crop. Hazarika and Sarmah (2017) [5] reported that conventional tillage improve the physical condition by manipulating and pulverizing the soil, which not only provides suitable environment to the germinating seeds and emerging seedlings, but also supplies free oxygen, availability of higher soil moisture and essential nutrients to plants and ultimately improve the growth of plant. Nutrient management practices adopted in wheat had no significant influence on plant height of succeeding rice.

Gradual increase was recorded in dry matter accumulation and maximum dry matter was observed at harvest stage. The tillage options had significant effect on dry matter accumulation at all the stages. At all the stages of crop growth, higher dry matter was obtained with conventional tillage which was significantly higher than zero tillage. Higher dry matter under conventional tillage may be due to more plant population. Dry matter accumulation of succeeding rice was not significantly influenced by nutrient management practices.

Table 3: Effect of tillage and nutrient management on plant height and dry matter accumulation of rice

Treatment	Plant height (cm)				Dry matter accumulation (g m^{-2})		
	30 DAS	60 DAS	90 DAS	Maturity	60 DAS	90 DAS	Maturity
Tillage							
Conventional	44.9	84.6	107.0	108.2	618.3	910.7	1010.3
Zero	42.2	79.6	101.3	102.2	581.9	849.2	942.1
$SE_m\pm$	0.3	0.5	0.7	0.7	4.8	8.2	10.7
CD (P=0.05)	1.1	2.0	2.7	2.6	18.9	32.2	42.0
Nutrient Management							
RFD – AI	42.5	79.9	102.6	103.5	593.6	869.1	962.1
RFD – BI	43.0	80.4	102.0	103.0	593.8	869.8	964.0
SSNM Nutrient Expert – BI	44.0	83.5	105.0	106.2	603.7	888.0	984.3
SSNM + Green Seeker – BI	43.1	81.7	103.2	104.0	597.2	874.4	971.4
150% RFD – BI	45.1	85.0	107.7	109.3	612.1	898.5	998.9
$SE_m\pm$	1.0	1.7	2.3	2.2	8.7	12.5	13.3
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS

AGR, CGR and RGR of wheat

CGR is the rate of daily increment in accumulation of dry matter by the crop of a particular area. CGR was not significantly influenced by different tillage and nutrient management practices at successive growth intervals except at 60-90 DAS where N-rich plot with top dressing of nitrogen before irrigation resulted in higher CGR of wheat. However, it was statistically at par with application of recommended NPK where nitrogen was top dressed both after and before irrigation and SSNM Nutrient Expert with top dressing of nitrogen before irrigation. Higher CGR may be due to higher production of dry matter owing to greater LAI and higher light interception. The RGR values were highest at early growth interval under all treatments. Thereafter these values were sharply declined with the advancement in the growth intervals up to 60-90 DAS. The RGR is the rate of increase in the dry matter production over the dry matter already previously accumulated in the plants. Thus relative growth rate represents the increment in biomass per unit of biomass present. AGR was not significantly influenced by different tillage and nutrient management practices at various growth intervals. However, AGR was higher in N- rich plot as AGR is directly related to plant height so more plant height in N-rich plot resulted in higher AGR of wheat.

Table 4: Effect of tillage and nutrient management on AGR of wheat

Treatment	AGR (cm day^{-1})					
	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	Maturity
Tillage						
Conventional	0.40	0.33	0.78	1.07	0.07	0.03
Zero	0.38	0.29	0.72	1.02	0.11	0.04
SEm±	0.008	0.010	0.018	0.022	0.015	0.006
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Nutrient Management						
RFD – AI	0.40	0.31	0.77	1.09	0.08	0.03
RFD – BI	0.39	0.30	0.76	1.03	0.07	0.03
SSNM Nutrient Expert – BI	0.38	0.31	0.72	1.01	0.09	0.04
SSNM + Green Seeker – BI	0.38	0.28	0.71	1.00	0.11	0.02
150% RFD – BI	0.41	0.32	0.77	1.10	0.10	0.04
SEm±	0.014	0.016	0.026	0.034	0.016	0.010
CD (P=0.05)	NS	NS	NS	NS	NS	NS

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

Table 5: Effect of tillage and nutrient management on CGR and RGR of wheat

Treatment	CGR (g m^{-2} day^{-1})						RGR (mg g^{-1} day^{-1})					
	0-30 DAS	30-60 DAS	60-90 DAS	90-120 DAS	120-150 DAS	Maturity	0-30 DAS	30-60 DAS	60-90 DAS	90-120 DAS	120-150 DAS	Maturity
Tillage												
Conventional	1.26	3.51	15.24	5.02	4.81	4.43	121.2	44.3	47.8	7.5	5.9	4.6
Zero	1.25	3.41	14.98	4.81	4.74	4.16	120.9	43.8	47.9	7.3	5.9	4.4
S.Em±	0.04	0.09	0.30	0.17	0.12	0.11	1.0	1.6	0.9	0.3	0.2	0.2
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nutrient Management												
RFD – AI	1.28	3.51	15.28	5.00	4.74	4.49	121.5	44.1	47.8	7.4	5.8	4.7
RFD – BI	1.26	3.43	15.08	4.91	4.77	4.20	121.1	43.8	47.9	7.4	5.9	4.4
SSNM Nutrient Expert – BI	1.24	3.41	14.92	4.92	4.73	4.28	120.5	44.1	47.9	7.5	5.9	4.6
SSNM + Green Seeker – BI	1.21	3.42	14.77	4.81	4.60	4.22	119.7	44.7	47.8	7.4	5.8	4.6
150% RFD – BI	1.31	3.53	15.52	4.95	5.03	4.28	122.4	43.5	47.9	7.3	6.0	4.4
S.Em±	0.07	0.20	0.25	0.16	0.15	0.11	1.4	1.2	0.7	0.2	0.2	0.2
CD (P=0.05)	NS	NS	0.70	NS	NS	NS	NS	NS	NS	NS	NS	NS

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

Conclusion

Based on findings of present investigation, it was concluded that top dressing of nitrogen after irrigation gave higher value of growth indices of wheat than top dressing of nitrogen before irrigation application.

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