American-Eurasian J. Agric. & Environ. Sci., 15 (12): 2432-2436, 2015
ISSN 1818-6769

DOI: 10.5829/idosi.aejaes.2015.15.12.12646

Morpho- Physiological Changes in Wheat (*Triticum aestivum*) Associated with Different Cropping Sequence and Nutrient Management Practices

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Abstract: To feed the increasing population of the country, India would require intensified cropping system which performed better under suitable nutrient management practices. With this view two years field experiments were conducted in split plot design at the Norman E Borlague Crop Research Center of G.B. Pant University of Agriculture and Technology, Pantnagar, India, to find out the effect of cropping sequences and nutrient management practices on the morpho- physiological characteristics of wheat crop. Two cropping sequence *viz.* rice-wheat and rice- mustard- wheat was kept in main plot, while the sub plot contained five nutrient management practices (*viz.* control, application of 10 t/ha FYM before wheat, green manuring with dhaincha (Sesbania aculeata) before rice, rice straw incorporation without starter dose of N and rice straw incorporation with starter dose of 20 kg N/ha.). The morphological characters of wheat (*viz.* plant height at maturity, numbers of tillers, ear bearing shoots and leaf area index) and physiological parameters (*viz*. leaf nitrogen content, chlorophyll content, rate of photosynthesis and nitrate reductase) were significantly higher in rice-wheat cropping sequences than rice- mustard- wheat cropping sequences. Simultaneously, yield and yield contributing characters and economic returns were also significantly higher in rice-wheat cropping sequences. Among nutrient management practices, superior morphological parameters, physiological parameters, yield attributing characters, grain yield and economic return were noticed in the plots received either FYM or crop residue with starter dose than the other nutrient management practices. The rice- wheat cropping system was found to be higher economical feasible cropping system with rice straw incorporation without starter dose of N and rice straw incorporation with starter dose of 20 kg N/ha by increasing the morpho- physiological determinants, thereby increase wheat yield and profit.

Key words: Cropping sequences · Crop residue · FYM · Green manure · Nutrient mangement · Wheat

INTRODUCTION

The rice (*Oryza sativa* L.)- wheat (*Triticum aestivum* L.) cropping system covers an area of 10.5 million hectares which is a dominant cropping sequence in Indo- Gangetic plains. Stable production system and less labour requirement in rice wheat sequence made them widely adopted but the continuous adoption of the sequence has led to the problem of specific weeds, reduced soil fertility in specific root zone and ultimately resulted in declining the efficiency and productivity of the system. Intercropping of oilseed and pulse crops is one of the ways to increase their production because intercropping is more advantageous than sole cropping of either oilseeds or pulses. Hence, farmers dwelling in Indo- Gangetic plains are trying to adopt an intensive cropping system which includes pulse, oilseed and green manuring crops to maximize profitability, but they are not always in positive side of economics by fitting these crops with conventional methods in their own cropping sequence *i.e.* rice-wheat sequence. Wheat followed by lentil and mustard (*Brassica campestris* L.) are the main choice of farmers of mid-hills of north-west Himalayas for winter (*rabi*) season under rainfed condition. They grow these crops mainly in mixed cropping system in improper way, which is one of the reasons for low productivity of these crops in the region. Hence the need of establishing economically efficient cropping system (with sequential cropping) is remarkable with considering the local climate and available resources.

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Current generalized recommendations with respect to NPK fertilizers alone are pointing to soil fatigue, proving their decreased efficiency and thus need upward refinement and proper balance among the required nutrients. The concept of balanced fertilization cannot be confined to N, P and K alone. Balanced fertilization includes application of all plant nutrients essential for high agricultural productivity and health of the soil. Integrated use of organic manures and chemical fertilizers has been found to be promising in arresting the decline in productivity through the correction of marginal deficiencies of some secondary and micronutrient elements and its beneficial influence on the physical and biological properties of the soil.

The continuously following of rice- wheat sequence led to development of many problems related to soil fertility, physical health of soil and crop productivity which proves hazardous in long term. There are many reports of yield stagnation and declined in soil productivity. Rice-wheat cropping system annually remove more than 690 kg/ha of N, P, K and 0.7 kg/ha Zn, 2.6 kg/ha Fe and 3.9 kg/ha Mn and therefore the long-term productivity is threatening. Consequently farmers have to use increased fertilizer doses each year to realize the same yield levels which were obtained with relatively lower amounts of fertilizers in the past.

A long term experiment on wheat crop at Pantnagar revealed that, wheat yield declined, when rotation was vogue from 7-9 years [1]. The decline in crop yield could be minimized by the introduction of green manure in rice-wheat crop rotation for diversification of this system. So under such a situation, crop diversification and nutrient management may help in mitigating such problems. Low input sustainable agriculture [2] and reduced chemical inputs [3] concept which focus on green manuring, recycling crop residue in rotation is important. However in the present scenario, adequate quantity of organic manures like FYM and compost are difficult to obtain due to mechanization of agriculture, results considerable decrease in farm animal. Inclusion of short duration oil seed crop in rice-wheat system has shown in augmenting productivity of the system and maintaining good soil health [4]. Therefore a need to identify an alternative cropping system, which retained higher and stable yield [5]. Considering the above shebang the experimental efforts were undertaken to find out the most practically efficient and economically feasible cropping sequence and nutrients management practices for the best performance of wheat crop in rice-wheat system.

MATERIALS AND METHODS

The present study was carried out during 2001-02 and 2002-03 at the Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar (29° 1' 7" N latitudes and 79° 28' 52" E longitudes). The soil of the experimental site was silty clay loam in texture with pH- 7.2, organic carbon 0.81%, total nitrogen 1723.8 kg/ha, available nitrogen 231.4 kg/ha, available phosphorus 19.7 kg/ha and available potassium 269.8 kg/ha. The experiment was laid out in spit plot design with four replications. The main plots contained two cropping sequence *viz*. rice- Wheat cropping sequences and rice- mustard (*Brassica campestris* L. var. Toria)- wheat sequence. The sub plot treatment contained nutrient management practices viz. control, application of 10 t/ha FYM before wheat, green manuring with dhaincha (Sesbania aculeata) before rice, rice straw incorporation without starter dose of N and rice straw incorporation with starter dose of 20 kg N/ha. The application of organic sources and their contribution in soil nutrient supply is given in Table 1 and the details of the crop are given in

Table 1: Particulars about FYM, Dhaincha (GM) and rice straw

		Mean data two years						
Sl.No.	Organic source	N%	P%	K%	O.C.%	C:N ratio	Fresh biomass (t/ha)	Dry biomass (t/ha)
1.	FYM	0.66	0.21	1.96	26.8	41:1	10.0	6.9
2	Dhaincha	2.27	0.36	2.03	38.6	17:1	21.0	4.4
3	Rice straw	0.54	0.09	1.38	39.2	73:1	5.0	3.9

Table 2: The details of crops

Crop	Variety	Seed rate (Kg/ha)	Row spacing (cm)
Rice	Pant Dhan-12	40	20
Wheat	PBW-343	100	23
MUSTARD	PT-507	6	30
Dhaincha	Pant Ses.-1	50	20

Table 2. The control treatment followed only the application of recommended dose of fertilizers which was 150 kg N, 60 kg P_2O_5 and 40 kg K_2O per hectare for each rice and wheat, while it was 90, 40 and 20 kg per hectare of N, P_2O_5 and K_2O, respectively for mustard. Urea, diammonium phosphate and muriate of potash were used as source of nitrogen, phosphorus and potassium respectively. Full doses of FYM, phosphorus, potassium and half doses of nitrogen were applied at the time of sowing. The remaining half dose of nitrogen was top dressed after first irrigation. Crop residue was retained after harvesting of rice crop. The experimental data obtained during the course of study was subjected to standard statistical analysis.

RESULTS AND DISCUSSION

Morphological Parameters: All the morphological parameters *viz.* plant height at maturity, numbers of tillers at maximum tillering, ear bearing shoots at maturity, leaf area index, was significantly influenced by the cropping sequences, except leaf nitrogen content at 60 DAS during 2001-02 (Table 3). All morphological parameters were significantly higher in rice- wheat cropping sequences than rice- mustard- wheat sequences for both the years of experiment. The data in pooled reveals that rice- wheat cropping sequence produced 25.18, 0.78, 21.48, 17.65 and 25.23 percent higher plant height at 90 DAS, dry matter at harvest, number of tillers and number of ear bearing shoots at 90 DAS and leaf area index at heading stage, respectively. Significantly lower vegetative growth of plant in respect of height and dry matter in rice-mustard-wheat system was might be due to the expose of crop to high temperature by mid and late sowing [6].

Considering the nutrient management practices, rice straw incorporation with starter dose of 20 kg N/ha recorded taller plants, however all the treatments were to found to be at par with each other except rice straw incorporation without starter dose of N. Treatment application of 10 t/ha FYM before wheat recorded significantly higher dry matter, number of tillers and tiller bearing shoots and leaf area index over all the other treatments, however it was found to be at par with rice straw incorporation with starter dose of 20 kg N/ha in case of all these parameters. Addition of FYM produced taller plant and higher vegetative growth because of nutrient supplying throughout the cropping season [7]. Similar effect of cropping sequences and nutrient levels on morphological parameters were also reported by Singh [8] and Mishra [9].

Physiological Parameters: Significantly higher amount of leaf nitrogen content at 60 DAS, chlorophyll content (SPAD reading) and rate of photosynthesis (μ moles cm^{-2} s^{-1}) at 10 days after heading and Nitrate reductase activity (μ moles/g fresh weight/hr.) at 10 days after anthesis was observed in rice- wheat cropping sequences which was 12.47, 22.37, 16.55 and 55.01 per cent higher over Rice- Mustard- Wheat sequence, respectively as in pooled data in Table 4.

Application of 10 t/ha FYM before wheat recorded significantly higher amount of chlorophyll content (in terms of SPAD reading) and Nitrate reductase activity (μ moles/g fresh weight/hr.) at 10 days after anthesis over rest of the treatments, however it was found to be on par with rice straw incorporation with starter dose of 20 kg N/ha. Chlorophyll content was higher in rice- wheat sequence might be due to atmospheric temperature and plant age during cropping season which played important role in the synthesis of chlorophyll. Effect of FYM on chlorophyll content was similar as found by Mishra [9]. Nitrate reductase activity in wheat was higher in rice- wheat cropping sequences, because this system might be produced more amino acid and finally converted into the protein [10]. The similar effect of nutrients levels on nitrate reductase activities was also reported by Mishra [9]. Photo synthesis process depends on chlorophyll content, provides metabolic energy for crop growth and development. The effect of nutrient levels could be explained clearly by the report of Lawlor *et al*. [11].

Yield Contributing Characters: Table 5 depicted that the entire yield contributing characters was significantly affected by cropping sequences except spike length and 1000 grains weight during 2001-02. The pooled data shows that rice- wheat cropping sequences resulted into the 115.55, 14.95, 38.30, 79.63 and 18.10 percent higher spike length, number of fertile spikelets per spike, number of grain per spike, grain weight per spike and 1000 grains weight, respectively over rice- mustard- wheat sequence at the time of harvesting. However nutrient levels showed significant differences only on number of grain per spike, grain weight per spike and 1000 grains weight. The yield contributing characters obtained with application of 10 t/ha FYM before wheat and rice straw incorporation with starter dose of 20 kg N/ha were statistically similar. These yield contributing characters of wheat also showed better response to green manuring before rice.

Table 3: Effect of cropping sequences and nutrient management on morphological parameters of wheat crop (pooled data of two years)

Treatment	Plant height at 90 DAS	Dry matter at harvest (g/m^2)	Number of tillers at 90 DAS	Ear bearing shoots at 90 DAS	Leaf area index at heading stage
Cropping sequence					
Rice- Wheat	87.0	1206.75	640.7	473.2	4.02
Rice- Mustard- Wheat	69.5	1197.4	527.4	402.2	3.21
LSD (0.05)	2.29	8.66	24.32	41.24	0.15
Nutrient Management					
Control	77.3	1110.1	545	387.4	3.35
Application of 10 t/ha FYM before wheat	79.4	1246.2	614.5	445.7	3.49
Green manuring with dhaincha before rice	78.4	1132.3	566.5	411.4	3.23
Rice straw incorporated without starter dose of N	75.0	1167.3	529.5	392.3	3.17
Rice straw incorporation with 20 kg/ha N as starter dose	79.7	1198.3	612.0	443.5	3.68
LSD (0.05)	3.21	39.56	64.29	26.20	0.19

Table 4: Effect of cropping sequences and nutrient management on physiological parameters of wheat crop (pooled data of two years)

Treatment	Leaf nitrogen content at 60 DAS (% of dry matter)	Chlorophyll content (SPAD reading) at 10 DAH*	Rate of Photosynthesis (μ moles cm^{-2} s^{-1}) at 10 DAH*	Nitrate reductase activity (μ moles/g fresh weight/hr.) at 10 DAA**
Cropping sequence				
Rice- Wheat	4.42	48.30	18.17	1.378
Rice- Mustard- Wheat	3.93	39.47	15.59	0.889
LSD (0.05)	0.29	1.71	0.75	0.205
Nutrient Management				
Control	3.90	39.08	15.23	0.769
Application of 10 t/ha FYM before wheat	4.25	44.83	17.82	1.036
Green manuring with dhaincha before rice	3.82	41.83	15.92	0.889
Rice straw incorporated without starter dose of N	3.91	38.83	15.11	0.799
Rice straw incorporation with 20 kg/ha N as starter dose	4.20	44.00	16.84	0.985
LSD (0.05)	0.16	1.05	1.10	0.200

(* Days after heading ** Days after anthesis)

Table 5: Effect of cropping sequences and nutrient management on yield contributing characters of wheat crop (pooled data of two years)

Treatment	Spike length (cm)	No of fertile spikelets /spike	Number of grains / spike	Grain weight/spike (g)	1000 grains weight (g)
Cropping sequence					
Rice- Wheat	10.62	19.30	47.3	1.94	41.1
Rice- Mustard- Wheat	9.52	16.79	34.2	1.08	34.8
LSD (0.05)	0.38	0.78	3.95	0.12	5.31
Nutrient Management					
Control	9.97	17.25	36.8	1.32	34.1
Application of 10 t/ha FYM before wheat	10.25	17.80	41.1	1.56	39.9
Green manuring with dhaincha before rice	10.24	17.35	40.2	1.39	36.6
Rice straw incorporated without starter dose of N	9.90	17.41	38.9	1.34	33.7
Rice straw incorporation with 20 kg/ha N as starter dose	10.16	17.73	40.2	1.52	38.1
LSD (0.05)	NS	NS	3.56	0.12	4.40

Grain Yield: Grain yield of wheat was recorded significantly higher in rice- wheat cropping sequences which produced 47.60% more yield over rice- mustard-wheat sequence. (Table 6). Application of 10 t/ha FYM before wheat before wheat and rice straw incorporation with starter dose of 20 kg N/ha were produced significantly higher grain yield over rest of the nutrient management practices. The addition of FYM and Crop residue with starter dose gave higher yield contributing characters and finally yield. The reason behind this, the availability of nutrients from FYM for longer period provides 30 per cent of nitrogen, 60-70 per cent phosphorus and 70 per cent of potassium are available to the first crop [12]. Similar to this starter dose activate the flora and fauna in soils, which are responsible for decomposition and releasing of nutrients. In the present investigation FYM was evolved as superior amendment, but the rice straw with starter doses can be used under constraint availability of FYM. Similar observations were recorded by Katyal *et al.* [13] and Singh [8].

Table 6: Effect of cropping sequences and nutrient levels on wheat profitability (pooled of two years)

Treatment	Grain yield (q/ha)	Cost of cultivation	Gross return (Rs)	Net return (Rs)	B:C Ratio (mean of two years)
Cropping sequence					
Rice- Wheat	46.08	13685	43776	30091	2.20
Rice- Mustard- Wheat	31.22	13685	29659	15974	1.17
LSD (0.05)	5.58	--	--	--	--
Nutrient Management					
Control	34.38	12804	32661	19857	1.55
Application of 10 t/ha FYM before wheat	42.78	15804	40641	24837	1.57
Green manuring with dhaincha before rice	36.73	14500	34893.5	20393.5	1.41
Rice straw incorporated without starter dose of N	37.21	13500	35349.5	21849.5	1.62
Rice straw incorporation with 20 kg/ha N as starter dose	42.15	13600	40042.5	26442.5	1.94
LSD (0.05)	2.94	--	--	--	--

(Selling rate of wheat grain= Rs. 950 per quintal, 1 Rs.= 0.02 USD)

Economics: Similar to other parameters, rice- wheat cropping sequences is more profitable which gave 47.60% and 88.37% higher gross and net monetary return, respectively than rice-mustard-wheat sequence with highest B:C ratio of 2.20 (Table 6). In the case of nutrient management, though the highest gross return was obtained from application of 10 t/ha FYM before wheat, the treatment rice straw incorporation with starter dose of 20 kg N/ha was found to be more economical as it produce highest net monetary return (Rs. 26442/ha) and B:C ratio (1.94).

From the present study it can be concluded that the rice- wheat cropping sequence is better cropping system in term of yield and benefits. The application of 10 t/ha FYM before wheat gives statistically similar results on grain yield obtained at rice straw incorporation with starter dose of 20 kg N/ha. Thus it can be in case of limited FYM availability, residue of previous rice crop will be viable option for higher wheat grain production.

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