



Wheat (*Triticum aestivum*) productivity under different tillage practices and legume options in rice (*Oryza sativa*) and wheat cropping sequence

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ABSTRACT

Screening of suitable tillage practices and legumes between rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.) is the need of hour to maintain the wheat productivity, which is hampering in rice wheat sequence. Considering this, experiments were conducted during 2006-07 to 2009-10, at Norman E Borlough Crop Research Centre of G B Pant University of Agriculture & Technology, Pantnagar. The experimental plots were silty clay loam, medium in organic carbon, available phosphorus and low in nitrogen, however the pH was slightly alkaline. Pooled analyses were done for four years considering the years as main plot of split plot design. However, sub plot contained three tillage practices, i.e zero tillage (ZT), raised bed system (RBS) and conventional tillage (CT). Three legumes namely greengram (*Vigna radiata* L.), cowpea [*Vigna unguiculata* (L.) Walp.] and vegetable pea (*Pisum sativum* var *hortense*) were kept in sub sub plots. The findings revealed that, over the years, wheat yield markedly influenced by maximum temperature as compared to other weather attributes. Simultaneously, tillage and legume interaction was non-significant on wheat yield. Mean effect of the treatments vindicated that metric parameters, viz plant height, dry matter accumulation, biological yield, grain yield, straw yield, grain straw ratio and harvest index were significantly influenced by years, tillage practices and legume inclusion. Year 2007-08 was the good year for wheat performance. Among the tillage practices conventional tillage retained maximum metric traits than the other tillage practices, however in case of legume inclusion; cowpea gave maximum metric traits. Significant effects of treatments were also noticed on NPK uptake, available N in soil, net returns and benefit cost ratio and system productivity. Maximum values of these parameters were noticed during 2007-08. Maximum available N, NPK uptake were observed in zero tillage. Greengram containing plots had maximum available N but vegetable containing plots had higher nutrient content and uptake. Net return, benefit cost ratio were maximum under zero tillage and vegetable pea containing plots. Conventional tillage and vegetable pea contained plots gave maximum system productivity. Therefore, conventional tillage and cowpea inclusion is good for wheat yield but for economics point of view zero tillage practices and inclusion of vegetable pea is better.

Key words : Raised bed system, Legumes, Wheat, Zero tillage

The rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L.) cropping system is the dominant system in the Indo-gangetic plains region, covering an area of 10.5 million hectares (Gupta and Seth 2007), contributed mostly in green revolution and food security of the nation. Crop productivity was the major concern during green revolution period which results in the ignorance or over exploitation of other factors like soil and water. Now the soils are sick and failed to maintain productivity under same management conditions, caused stagnation in factor productivity. This has led the search for the technologies that conserve resources and other manages

other production management effect (Erenstein *et al.* 2008). Consequently some promising technologies came, and tillage management and legume inclusion emerged as one of the most important technology (Paikaray *et al.* 2001). Wheat productivity is always under threat in rice-wheat cropping system, due to different rhizospheric requirement of both the crops. Conventional tillage requires ample amount of energy to facilitate seed bed preparation for wheat after rice, but in this tillage soils becomes loosens and aerated, allows deeper root penetration, controls weeds, mixes organic matter, fertilizer and manures. This results in increased system productivity but also increases the production cost. Therefore farmers are seeking alternative to conventional tillage. Zero tillage technique for wheat sowing is emerging as an alternative for conventional tillage. Studies revealed that,

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bed planting technique in wheat save energy, water and seed with other inputs. However, zero tillage saves planting time, fuel and water, improves efficiency of applied fertilizers nutrients, and weakens the weed population (Erenstein and Laxmi 2008).

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 (Akhtar *et al.* 2009). In such system that legumes can play an increasingly important role in improving crop productivity and maintaining soil fertility. There is about 40 to 70 days fallow period between harvest of wheat and planting of rice, can be used effectively for raising a suitable summer legumes. This practice not only provides pulse grains but also benefits the succeeding cereal crops through improvement in N status of the soil. Tarai farmers of Uttarakhand, are taking vegetable pea in between rice harvest and wheat sowing for improving their income. However, mungbean and cowpea are the potential legume during summers, but the role of legumes in rice-wheat cropping system are limited and therefore comprehensive studies are needed to test wide spectrum of potential legumes for sustainable rice-wheat system. This paper provide insight information on wheat productivity in rice-wheat system in relations with the conventional tillage, zero tillage, bed planting practice in wheat, and legume like greengram, cowpea and vegetable pea in between rice and wheat.

MATERIALS AND METHODS

Field experiments were conducted at Norman E Borloug Crop Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (US Nagar, Uttarakhand, India) during 2006 to 2010. The experimental site was located at 29°N latitude, 79.3°E longitude and an attitude of 243.84 metre above mean sea level. The climate of the region is subtropical and humid with very hot summers and very cold winters. The monsoon usually starts from third or fourth week of June and extends up to last week of September. The details of weather attribute during wheat growing period are given in Fig 1. The experimental site classified as *Mollisols*, subgroup *Aquic hapludols* was medium in organic carbon (0.61%), medium in available phosphorus (20.5 kg/ha), low in available nitrogen (201.0 kg/ha) and potassium (107 kg/ha) and pH (7.9). Originally the experiment was laid out in randomized block design with 9 treatment combinations and three replications. But statistical pooled analysis were done in split-split plot design where the year were kept in main plots and tillage practices were kept in sub plots and legume inclusions were retained in sub sub plots. In tillage practices, three practice like conventional tillage (CT), zero tillage (ZT) and raised bed

system (RBS) were tested. Three legumes namely greengram, cowpea and vegetable pea were selected for legume inclusion studies. Cowpea and greengram were sown after harvesting of wheat, however vegetable pea were sown after harvesting of rice. The crop rotation in different plots were as i) rice-wheat-cowpea, ii) rice- vegetable pea -wheat and iii) rice- wheat -greengram. In conventional tillage (CT) practice, one mould board plowing up to 25 cm depth followed by 2 harrowings, one planking and 2 levelling were done to pulverized seedbed. Zero tillage (ZT) treatment consisted of sowing of seeds was done with zero-till-ferti-seed drill and in raised bed system (RBS) treatment, 60 cm raised beds and 30 cm furrow were formed manually. Wheat (cv. PBW 550) was sown at the rate of 100 kg/ha in rows 22.5 cm apart in the month of November in case of cowpea and greengram in the system, while in case of vegetable pea, wheat was sown in the month of January. Harvesting was done in month of April. Transplanting of rice (cv PD 12) were done in month of June and harvested in October. The seeding rate of rice was 25 kg/ha and 2-3 plants/hill at 20 cm row spacing were maintained. Cowpea (cv Pant Lobia 2) at the rate of 75 kg/ha were sown at 30 cm row to row spacing and 10 cm plant to plant spacing, in month of April and harvested in June. Vegetable pea (cv Arkil) at the seed rate of 100 kg/ha were sown at 30 cm row spacing and 15 cm plant spacing in the month of October and harvesting in the month of December. Greengram (cv Pant Moong 5) was sown at the seed rate of 20 kg/ha with 30 cm row spacing and 15 cm plant spacing in month of April and harvest in June. Nitrogen (N), phosphorus (P) and potassium (K) fertilizers were applied as per crop requirement in the form of urea, SSP and MOP. As in case of rice, 100:60:40 kg N:P:K/ha was applied in which half nitrogen and full dose of phosphorus and potassium were applied as basal and remaining 1/4th dose was applied at tillering stage and remaining 1/4th at booting stage. In case of wheat crop, N: P: K was applied at the rate of 120:60:40 kg N: P: K/ha, 1/3 dose of nitrogen and full dose of P and K was applied at the time of sowing and remaining two third of nitrogen was top dressed after first irrigation and at first node formation stage. In cowpea, vegetable pea and greengram crops N: P: K was applied at the rate of 20:60:40 kg N: P: K/ha as basal. In wheat crop, the first irrigation was given at crown root initiation (CRI) stage, i.e. 21 days after sowing. Further irrigations were given as per physiological growth stages taking rainfall into consideration. For controlling the weeds, two manual weedings were done as per need of crop requirement with the help of hand hoe. The crops were harvested manually when more than 90 per cent grains were full ripened and the leaves and stems turned yellow and become fairly dry. Observations were made as per standard protocols. Statistical analyses were done by using software STPR 320, developed by Department of Maths and Computer of G B Pant University, Pantnagar.

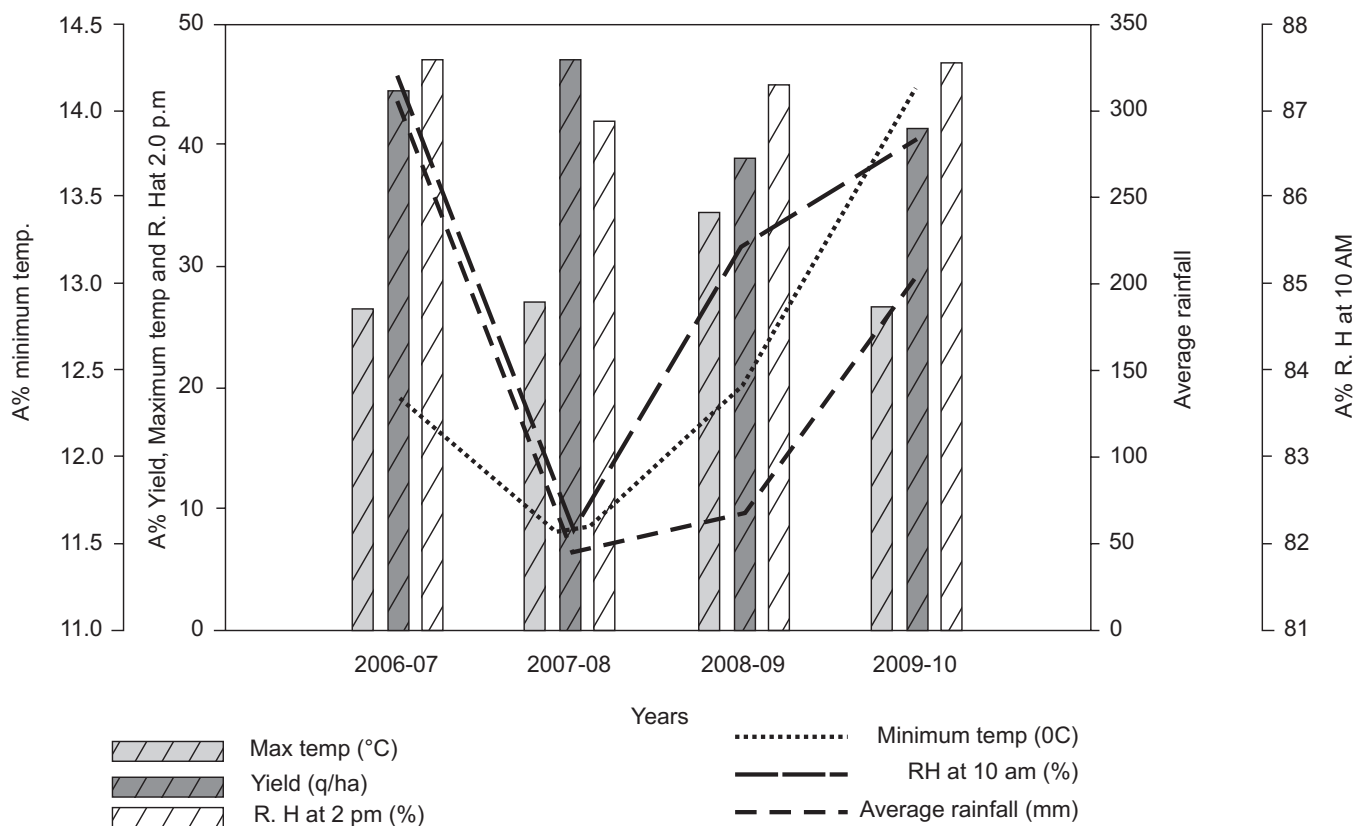


Fig 1 Yield in relation to average of weather attributed during four years of wheat season

RESULTS AND DISCUSSION

Wheat crop and weather

The variation in yield over the years in relation to weather attributes is shown in Fig 1. Figure revealed that the average maximum temperature had maximum effect on wheat grain yield and had inverse relation. During 2008-09 when average maximum temperature during wheat season was increased the wheat yield was decreased. However, during 2007-08, the average minimum temperature, relative humidity and average rain fall during the wheat season was lowest, which ultimately affect the wheat yield positively which in turn the maximum wheat yield in the year 2007-08.

Wheat growth characters, yield and yield attributes

Pooled result revealed that, the year, tillage practices, and legume inclusion had significant effect on plant height, dry matter accumulation, spike per square metre, grains per spike, 1000 grain weight, grain yield, straw yield, gross return, net return, B:C ratio and system productivity. However, non significant effect of years on harvest index, tillage practices and legume inclusion on grains per spike were noticed (Table 1). The maximum value of above parameters was found during 2007-08, which was significantly higher than the other years. In tillage practices, conventional tillage gave

significantly higher plant height, dry matter accumulation, 1000 grain weight, straw yield, gross return, net return and system productivity than the zero tillage and raised bed system. However, spikes/m² were significantly higher under raised bed system than the zero tillage system, but it was at par with conventional tillage. Zero tillage gave maximum benefit cost ratio, which was at par with raised bed system but significantly higher than conventional tillage. Maximum value of plant height, dry matter accumulation, spikes/m², 1000 grain weight, grain yield, straw yield, gross return, net return from wheat were obtained in cowpea grown plots. However, net return, B:C ratio and system productivity were maximum under vegetable pea grown plots. The effect of cowpea on wheat performance in term of metric parameters were significantly higher than vegetable pea but at par with greengram. Contrast to this, the effect of vegetable pea on wheat performance in terms of economic parameters was significantly higher than cowpea and at par with greengram. Non-significant interaction effect of tillage and legume was noticed on wheat yield (Fig 2). The effect of years was totally directed by the climatic condition during the wheat growing season and temperature was the major player for good yield during 2007-08. The variation in grain yield under various tillage practices can be attributed to the ability of crop to produce the dry matter and its portioning to

Table 1 Wheat performance in respect to year, tillage practices and legume inclusion (Pooled data of 4 years 2006-10)

Treatment	Plant height (cm)	DMA at harvest (g/m ²)	Spike/m ²	Grains/spike	1000 grain weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index	System performance			
									Gross return (₹/ha)	Net return (₹/ha)	B:C ratio	System productivity
<i>Year</i>												
2006-07	87.7	1122.8	408.9	42.4	38.5	44.5	74.0	0.37	40 028	27 891	3.29	89.2
2007-08	94.1	1327.7	417.6	36.7	38.1	47.0	74.7	0.38	47 252	34 681	3.75	110.9
2008-09	88.5	1208.5	404.9	27.8	34.5	38.7	74.7	0.34	52 096	37 062	3.49	92.2
2009-10	86.2	1286.4	415.9	28.7	35.3	41.4	70.6	0.36	55 578	39 515	3.46	104.4
SEm±	0.6	8.0	4.4	2.2	1.2	1.3	1.0	0.03	425.1	423.1	0.0	1.0
CD (P = 0.05)	1.6	22.2	12.5	6.2	3.4	1.1	1.9	NS	1 186	1 186	0.08	2.7
<i>Tillage practices</i>												
ZT	87.1	1167.1	403.6	33.1	34.6	39.2	71.0	0.55	45 701	32 586	3.48	94.9
RBS	89.1	1237.4	417.7	34.0	35.1	44.1	72.9	0.60	49 032	34 653	3.43	100.6
CT	91.2	1304.3	413.7	34.5	39.1	45.5	74.3	0.61	51 483	37 123	2.86	101.9
SEm±	0.5	6.7	4.3	0.08	1.4	0.3	0.6	0.1	360.4	357.8	0.0	0.8
CD (P = 0.05)	1.3	19.2	12.3	NS	4.1	0.9	1.7	0.18	1 027	1 027	0.07	2.4
<i>Legume inclusion</i>												
Greengram	88.9	1243.41	425.0	33.8	38.0	47.4	74.2	0.64	52 232	38 512	3.79	94.0
Vegetable pea	87.9	1215.47	380.6	34.2	32.5	33.8	69.7	0.48	49 032	40 148	3.84	107.2
Cowpea	90.4	1250.06	429.0	33.6	38.5	47.5	74.3	0.64	51 483	25 703	2.86	96.2
SEm±	0.4	6.4	6.4	1.8	1.8	0.2	0.6	0.1	351.0	349.0	0.02	0.8
CD (P = 0.05)	1.2	18.0	18.2	NS	5.2	0.7	1.8	0.2	1 011	998	0.05	2.2

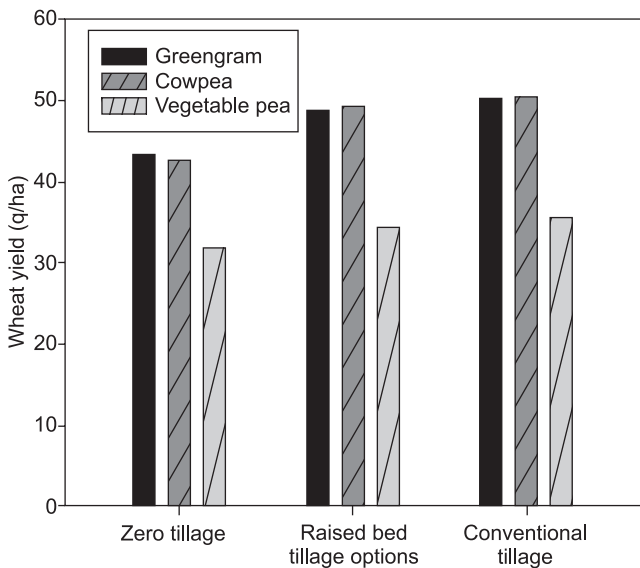


Fig 2 Tillage options and Legume interaction on wheat yield

economically important plant part. Conventional tillage results maximum grain yield of wheat might be due to the higher dry matter accumulation and higher N uptake by wheat crop. Conventional tillage produced highest grain yield of wheat followed by raised bed system and lowest was recorded with zero tillage system. The addition of legume in rice-wheat rotation increased the fertility status. Growing a short duration summer crop of greengram or cowpea gave significantly

higher wheat grain yield compared to vegetable pea, which adversely affected the wheat yield attributes. The wheat yield was lower after vegetable pea because the delayed wheat sowing after vegetable pea caused significant reduction in yield attributes. These findings were close to the findings of Saraswat *et al.* (2013) and Sweta *et al.* (2011).

Soil status

Organic carbon content and available nitrogen,

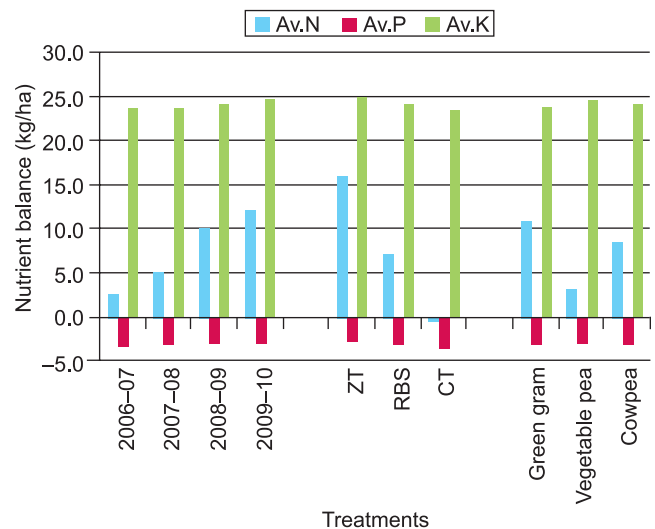


Fig 3 Nutrients balance after four year of experimentation

Table 2 Organic carbon content, available nitrogen, phosphorus and potassium in soil after harvest of wheat crop (Pooled data of 4 years 2006-10)

Treatment	Organic carbon (%)	Available nutrient (kg/ha)			Total nutrient uptake (kg/ha)		
		N	P	K	N	P	K
2006-07	0.73	203.7	17.2	130.6	107.0	16.1	117.7
2007-08	0.74	205.9	17.3	130.7	112.8	16.9	121.2
2008-09	0.75	211.2	17.5	131.1	99.2	14.8	114.6
2009-10	0.76	213.1	17.5	131.6	104.6	15.6	116.2
SEm±	0.07	3.08	0.80	0.07	1.08	0.14	1.47
CD (0.05)	NS	NS	NS	NS	3.10	0.40	4.20
ZT	0.77	217.0	17.8	131.7	100.3	15.1	115.7
RBS	0.74	208.1	17.3	131.0	108.8	16.2	118.0
CT	0.71	200.4	17.0	130.2	108.6	16.3	118.5
SEm±	0.07	4.70	0.77	0.06	0.90	0.14	2.1
CD (0.05)	NS	14.8	NS	NS	2.6	0.4	NS
Greengram	0.76	211.8	17.3	130.7	113.5	17.1	121.0
Vegetable pea	0.73	204.1	17.5	131.3	89.9	13.4	110.1
Cowpea	0.75	209.5	17.4	131.0	114.4	17.1	121.1
SEm±	0.06	1.30	0.72	0.90	0.90	0.50	1.29
CD (0.05)	NS	4.81	NS	NS	2.60	1.40	3.60

phosphorus and potassium in soil did not affect significantly due to years, tillage practices and legume inclusion, except available nitrogen which affected significantly only due to tillage practices and legumes (Table 2). Significantly higher available nitrogen in soil was observed under zero tillage system than conventional tillage system. Organic carbon level and available NPK in soil increased over the years might be due to inclusion of legumes. Under zero tillage, organic carbon level in soil enhanced due to presence of crop residue while under conventional tillage the lower value of organic carbon might be due to removal of organic matter. Tillage operations reduced the organic carbon however no tillage with crop residue increased the soil organic carbon. The findings of this experiment that the soil fertility status in terms of available NPK was higher in zero tillage. Zero tillage favors to manage crop residue resulted enhanced nutrient status. Zero tillage also produced higher phosphorus might be attributed to greater storage, solubility and cycling of phosphorus in organic matter. Total NPK uptake in wheat crop differed significantly in all the years due to different tillage practices and legume inclusion. Total NPK uptake was found highest during 2007–08 while significantly lowest during 2008–09, which was significantly higher than the other years, might be good crop yield during this year was responsible for maximum nutrient uptake. Conventional tillage gave maximum NPK uptake, which was at par with raised bed system and significantly higher with zero tillage system, reason might be better nourishment under conventional tillage. Among the legume inclusion,

significantly higher total nutrient uptake was recorded in greengram followed by cowpea and cowpea which was significantly higher than vegetable pea grown plot. The nutrient balance after four year of sequence is depicted in Fig 3, which revealed that the phosphorus had negative balance, reason might be good use of phosphorus by legume in the system. Similar results were also noticed by Saha *et al.* (2012). Hence, it is concluded from the experiment that wheat crop showed their potential performance under conventional tillage system and cowpea inclusion in the system, but economic point of view zero tillage and vegetable pea is the viable option for rice-wheat rotation.

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