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Effect of crop diversification and residue management techniques on yield attributes, yield and soil nutrient

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Abstract
Green revolution prompts the development of rice wheat cropping system over the South Asian Indo-Gangetic Plains. This system is comprehensive in nature and prompts malicious consequences on soil health which is the most disturbing issue these days and the other issue which takes individuals consideration is the is the loads of residue generation. To Find the potential approaches to counter these issue an examination was directed at held during the *Kharif* season of 2017 at N. E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, US Nagar, Uttarakhand to consider the impact diversification and different residue management technique on yield attributes, yield and soil health. Through this study it has been notified that the crop diversification through legumes leads to better soil property and increases the yield.

Keywords: Diversification, Revolution and approaches

Introduction
Rice-wheat cropping system (RWCS) is most dominant and mainstay of food self-sufficiency in many Asian countries by contributing 23% of food grain production (Verma *et al.,* 2016) [27]. It covers an area of 13.5 million hectares across South Asian Indo-Gangetic Plains (IGP) (Ladha *et al.,* 2003) [16] and is the spine of social and economic growth of millions of people (Chauhan *et al.,* 2012) [5]. However, this system has shown the sign of stagnant yield and declining soil health. The sustainability of the system has been questioned due to yield stagnation, soil health deterioration in the environment for more than two decades now (Das *et al.,* 2017) [6]. Conventional RWCS leads to loads of issues such as ecological (declining underground water level, groundwater contamination, diverse weed flora, disease outbreak and insect pest); farming (degrading soil structure, declining soil health, residue management, least attended interim period, labor shortages, multiple nutrient deficiencies, declining crop response); livelihood (high energy requirement, reduce land productivity, lower water production, lower water efficiency, low wages) and climate (environmental pollution and global warming) (Bhatt *et al.,* 2016) [3]. Intensive tillage, removal or burning of rice residues accelerates soil erosion, contamination of the atmosphere, soil depletion and affects functions of the ecosystem (Srinivasan *et al.,* 2012) [23]. These constraints are widely found in rice-based cropping systems in the Indo- Gangetic plain where poor residue management, extensive fertilizer use and lack of diversification are normal practice. Sustainable module therefore requires an hour not only to mitigate these constraints but also to boost the efficiency of the ricebased cropping system for a projected 1.3billion population increase by 2025 in India (UNEP, 2008) [25]. Residue is another challenge which needs attention, particularly at RWCS. Approximately 500 Mt of crop residues are produced annually according to the MNRE report (Agarwal *et al.,* 2016) [1]. Cereal crops (corn, wheat, maize, millets) contribute 70% of the residue produced, while corn crops alone contribute 34% to crop residues, while wheat ranks second with 22% of crop residue. Hence, the removal of residues may have a direct effect on the depletion of soil nutrients. Residue control also affects the supply of micronutrients such as zinc and iron, which is an important factor in preserving the total balance of Silicon in rice (Dobermann which Fairhurst, 2000) [8]. Burning the rice residues causes environmental pollution, global warming, killing beneficial insects, generating net negative nutrient

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balance and also degrading the soil, reducing levels of organic matter and eventually contributing to degradation of soil health. Rice straw burning gaseous emissions are 70 percent CO_2, 7 percent CO, 0.66 percent CH4 and 2.09 percent N2O. Roughly 12 Mt of rice straw is burned annually in Punjab alone, which causes about 0.7 Mt of N losses (Samra *et al.,* 2003) [21]. Alternative uses for rice straw management are possible to ensure maximum benefit without burning rice residues, for example using crop residues for manure, energy production, ethanol, biogas, residue gasification, pyrolysis (Yadwinder & Sindhu, 2014) [28]. Residue incorporation also improves aggregate stability (Keller *et al.,* 2007) [15] and total porosity, resulting in increased soil moisture content as well as availability of water content (Jemai *et al.,* 2013) [13], with residue incorporation also improving aggregate stability (Keller *et al.,* 2007) [15] and total porosity and as a result, soil moisture content increases, as well as the amount of water content (Jemai *et al.,* 2013) [13]. In view of all these issues and problems with the traditional rice wheat program, there is an urgent need to develop a technology that can resolve the issue of crop diversification and intensification and better use of crop residues for soil fertility improvement. In view of this, the present experiment was conceived with three different types of cropping method i.e. Rice- wheat, Rice- vegetable pea- maize (cob + fodder) and Rice- yellow sarson- groundnut by intensifying and diversifying crops to improve both soil and crop productivity.

Material and methods
Experimental detail
Experiment was conducted in Split Plot Design with three cropping systems viz. rice-wheat, rice-vegetable pea-maize and rice-yellow Sarson-groundnut in main plot and five residue management techniques viz. farmer's practice, 30% residue recycling, 30% residue recycling + FYM @ 5 t ha-1, 30% residue recycling + Biogas slurry @ 2 t ha-1 and 30% residue recycling + Vermicompost @ 2 t ha-1 replicated thrice. The residue was incorporated in the field in all the treatments except control (C_1T_1, C_2T_1 and C_3T_1). Based on crop rotation, 30 % crop residue of the preceding crop was incorporated i.e. 30 % of the total residue produced as depicted below. The residue was incorporated by ploughing followed by harrowing.

Table 1: Amount and date of residue incorporated and the percentage of nutrient present in organics applied

Crop	Residue produced (q/ha)		Amount applied (q/ha)		Date of residue application
Wheat	60		18		15/04/2017
Groundnut	40.5		12.15		28/06/2017
Maize	116.7		35.01		18/06/2017
Organics	**C%**	**N%**	**P%**	**K %**	**C: N**
FYM	16.2	0.59	0.26	0.50	27
Vermicompost	24.5	1.21	0.78	0.90	20
Biogas slurry	15.96	1.05	0.45	0.55	15

The organics used in the experiment were FYM, vermicompost and biogas slurry. FYM @ 5t/ha, vermicompost @ 2t/ha and biogas slurry @ 2t/ha; was applied just before puddling as per the treatment so that it gets mixed in the soil. The samples of organics were taken and through laboratory analysis, the N, P and K percentage present in organics was calculated.
The treatments were replicated with size 3×8.3 m^2. Twenty-two days old rice seedlings of "HKR-47" were transplanted in

July. In all the treatments nitrogen, phosphorus, potassium and zinc were supplied through urea, diammonium phosphate, muriate of potash and zinc sulphate, respectively. The nitrogen is applied in three split doses. Entire P and K and 50kg N were applied as basal. However, the 1st top dressing was done at 28 DAT and 2nd top dressing was done at 49 DAT through Green seeker. The foliar zinc was sprayed 10 and 20 days after transplanting of rice. Harvesting was done manually when more than 90 per cent of grains in the panicle were fully ripe and free from greenish tint. The observation for growth, development was recorded from the sampling area under field condition.

Yield attributes
Yield attributing were recorded at maturity is given in table 1. Number of panicles m^{-2} was counted. The total number of grain per panicle was calculated by dividing the total number of grain to the total number of panicles. The panicle length measured with the help of meter scale in centimetre. One thousand grains were counted from each plot and weighed to get thousand grains weight in grams. Ten panicles were harvested and threshed manually. After cleaning and drying the weight was recorded and converted to m^{-2}. The grain weight per panicles was obtained by grain weight m^{-2} divided by number of panicles m^{-2}. Grain yield is obtained after threshing and cleaning. The grain yield was converted to t ha^{-1} after adjusting grain moisture at 10%.

Soil parameters
Composite soil sample of each plot was collected by core from 0-15 cm. The samples were air dried in shade on polythene sheets. After drying, samples were crushed on hard wooden slab with the help of wooden roller and passed through 2 mm sieve and stored in labelled polythene bags for further chemical analysis. Available N was determined by alkaline $KMnO_4$ method given by Subbiah and Asija (1956) [24]. Available P was extracted by Olsen's method (Olsen *et al.,* 1954) [19]. Available K in soil was determined by extraction with 1 N ammonium acetate of neutral pH and K concentration in soil extract was determined by flame photometer (Hanway and Heidel, 1952) [11]. Soil parameter is given in table 2.

Result and discussion
Yield and Yield attributes
Residue management through organics and diversification through legumes have significant effect over different yield parameter and grain yield. The number of panicles m^{-2} was recorded maximum in C_3 which was significantly higher than C_1 and C_2. The percent increase in number of panicles in C_3 was 7.22 and 3.48 percent over C_1 and C_2, respectively. The panicle length (cm) was observed maximum in C_3 (28.4 cm) and was at par with C_2. The minimum panicle length was observed in C_1 (26.0). However, there was no significant response of number of grain panicle^{-1} and thousand grain weights (g). The maximum grain weight panicle^{-1} was notified in C_3 (3.2g). The percent increase in grain weight panicle^{-1} in C_3 was 14.3 and 10.3 per cent over C_1 and C_2, respectively. The maximum grain yield was observed under C_3 but was statistically at par with C_2. The percent increase in the grain yield in C_3 over C_1 is 11.23%. Diversification through legumes results in addition of nitrogen to the soil through biological nitrogen fixation thereby help in enhancing the nutrient availability, enhaces the microbial activity (numbers of bacteria, fungi, and actinomycetes) and results in

better growth and yield supported by (Davari *et al.,* 2002) [7]. They reported that under rice-wheat-maize cropping system (RWMCS) the activity of microbes were higher i.e. numbers of bacteria, fungi, and actinomycetes in soil and improves soil health than under rice-wheat cropping system (RWCS) and results in higher number of panicles m^{-2}. Further, supported by Sharma and Sharma, 2003 [22] that after two cycles of rice-potato-mungbean, rice-wheat-mungbean, rice-rapeseed-mungbean and rice-clover cropping systems, respectively results in better availability of nutrients and increased the number of panicle m^{-2}, panicle length, number of grains per panicle, grain weight panicle^{-1} and thousand grain weight.

Table 2: Yield attributes of rice as influenced by different cropping sequence and residue management techniques

Treatments	Number of panicle m^{-2}	Panicle length (cm)	Number of grain panicle^{-1}	Grain wt. Panicle^{-1} (g)	1000 grain wt. (g)	Grain yield (t ha^{-1})
Cropping System						
C$_1$-Rice-wheat	277	26.0	82	2.8	29.7	5.79
C$_2$- Rice-vegetable pea-maize	287	27.9	82	2.9	29.7	6.21
C$_3$- Rice- yellow sarson-groundnut	297	28.4	84	3.2	29.8	6.44
SEm($\pm$)	2.16	0.40	0.43	0.04	0.05	0.19
CD at 5%	8.50	1.56	NS	0.17	NS	0.36
Residue management techniques						
T$_1$- Farmer's practice	261	25.5	81	2.8	29.2	5.42
T$_2$-30% residue recycling	272	26.9	81	2.9	29.6	5.35
T$_3$-T$_2$ +FYM	300	27.2	82	3.0	29.8	6.45
T$_4$-T$_2$+biogas slurry	296	28.3	83	3.0	29.8	6.38
T$_5$-T$_2$+vermicompost	306	29.3	84	3.1	30.1	7.12
SEm($\pm$)	4.29	0.46	0.44	0.05	0.07	0.11
CD at 5%	12.53	1.34	1.29	0.15	0.19	0.33

Among the different residue management techniques, the maximum number of panicles m^{-2} were obtained in T$_5$ (306) which were significantly higher than T$_1$ and T$_2$ but was statistically at par with T$_3$ and T$_4$. The number of panicles m^{-2} in T$_5$ was increased to the tune of 17.24 percent, respectively over T$_1$. The maximum panicle length was observed in T$_5$ (29.3cm) and the minimum was under T$_1$ (25.5cm). T$_5$ and T$_4$ have statistically similar panicle length. The maximum, number of grains panicle^{-1} and grain weight panicle was observed in T$_5$ i.e. 84 and 3.1g respectively and which was increased by 3.70 and 10.71 percent, respectively over T$_1$. However, significantly higher thousand grain weight was observed in T$_5$ above all the other residue management techniques using organics. The thousand grain weight was increased in T$_5$ to the tune of 3.08 percent, respectively over T$_1$. grain yield was significantly higher in T$_5$ than all other treatments. The lowest grain yield was observed in T$_2$ (30 % residue recycling) which was at par with T$_1$ (farmer's practice). The increase in grain yield in T$_5$ over T$_1$ was 31.36%. Among residue management techniques through organics the yield attributes increased. Number of panicles m^{-}

^{2} were higher due to higher number of shoots per m^{-2} whereas, the better height and dry matter production helps in proper photosynthesis and translocation of photosynthates whereas, the nutrient availability was also higher due to incorporation of residue + organics which might have resulted in enhanced yield attributes. Bilkis *et al.* (2015) [4] at Bangladesh reported that, maximum number of tiller hill^{-1}, panicle length, grain panicle^{-1} and 1000 grain weight was observed in tricompost + chemical fertilizer but was statistically at par with vermicompost + chemical fertilizer followed by cow dung slurry + chemical fertilizer. Haque *et al.* (2014) [12] reported that effective tillers hill^{-1}, panicle length and grains panicle^{-1} and 1000-grain weight were enhanced significantly due to the application of organics along with soil test based chemical fertilizers over control. Bejbaruah *et al.* (2013) [2] reported that yield attributes i.e. number of panicles m^{-2} was significantly increased by application of vermicompost (VC). Lungmuana *et al.* (2016) [17] reported that, the length of panicle of rice was significantly higher under integrated use of vermicompost and chemical fertilizer over control.
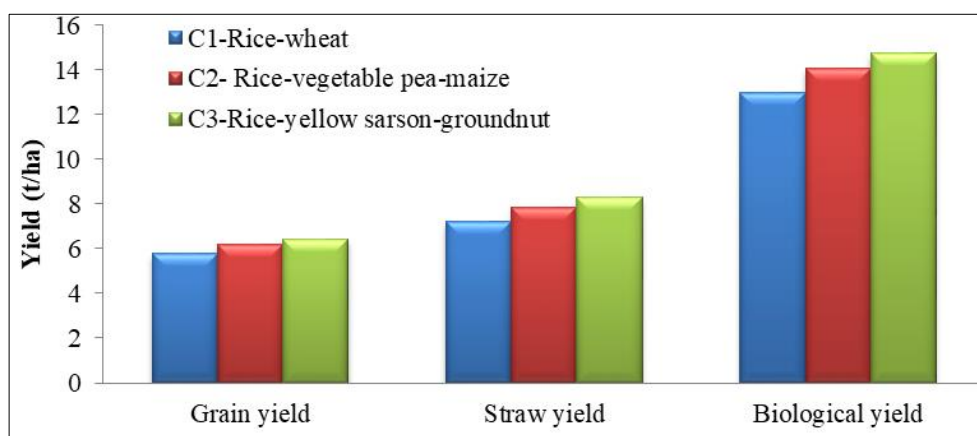

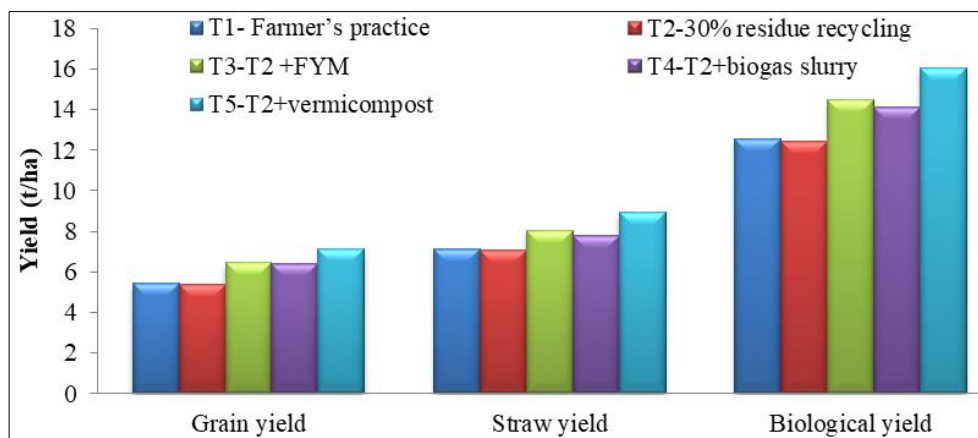**Fig 1:** Grain, straw and biological yield as influenced by different cropping system

Fig 2: Grain, straw and biological yield as influenced by different residue management techniques

Soil nutrient

Among different diversified treatments the highest available nitrogen in soil was registered under C_3 (230.07 kg ha^{-1}) which was significantly higher in C_1 but was statistically at par with C_2. Available soil nitrogen in C_3 and C_2 was increased by 11.18 and 4.64 percent, over C_1. The same trend is followed in available potassium in the soil. The maximum available soil potassium was under C_3 which was increased to the tune of 24.3 per cent over C_1. However, the available phosphorus was significantly higher in C_3 (20.3 kg ha^{-1}) than C_2 and C_1, respectively. Available soil phosphorus in C_3 and C_2 was increased by 24.05 and 2.88 percent, respectively over C_1.Among different residue management techniques, the T_5 was significantly higher available soil nitrogen, phosphorus and potassium than T_1, T_2 and T_3 but was statistically at par with T_4. In residue management techniques i.e. T_5 available nitrogen in soil was increased to the tune of 17.16 percent respectively; available phosphorus in soil was increased by 41.73 percent respectively; whereas available potassium in soil was increased to a tune of 52.73 percent, respectively over T_1.

Table 3: Available nitrogen, phosphorus and potassium in soil (kg ha^{-1}) as influenced by different cropping sequence and residue management techniques

Treatments	Available soil nutrients (kg ha^{-1})		
	N	P	K
Cropping System			
C_1-Rice-wheat	206.93	16.30	130.69
C_2- Rice-vegetable pea-maize	219.53	16.80	161.09
C_3- Rice-yellow sarson-groundnut	230.07	20.30	162.49
SEm($\pm$)	4.33	0.53	4.20
CD at 5%	17.01	2.10	16.49
Residue management techniques			
T_1- Farmer's practice	201.44	14.76	114.70
T_2-30% residue recycling	208.00	16.18	136.44
T_3-T_2 +FYM	220.89	17.95	160.09
T_4-T_2+biogas slurry	227.89	19.22	170.67
T_5-T_2+vermicompost	236.00	20.92	175.18
SEm($\pm$)	3.68	0.94	2.54
CD at 5%	10.75	2.75	7.40

Crop diversification through legumes and residue management through organics showed higher available soil NPK. The probable reason might be due to higher organic matter in the soil because of residue incorporation in every season. Legumes have the ability of biological nitrogen–fixation (BNF), leaf shedding, and higher root biomass, can enrich soil organic carbon (SOC), soil fertility, and redistribute of nutrients in the soil profile (Ganeshamurthy 2009; Kamanga *et al*. 2014) [9, 14]. The poor SOC stock in soils is one of the main reasons for poor soil nutrient supply (Mandal *et al*. 2007) [18] pulse crop residue with lower C:N ratio could serve as important plant nutrient source and recycling of these residues help in supplying the nutrient demand of the crop (Grant *et al*. 2002) [10] and therefore residue of pulse crop increases the avialble nutrient in the soil. Including pulses in rotation may significantly effects the nutrient cycling in the soil–plant system because of its influence on soil residual fertility, and nutrient acquisition by the next crop in the rotation Vankatesh *et al*. (2017). Porpavai *et al*. (2011) [20] at Thanjavur reported that inclusion of legume in rice-based cropping sequence contributed 0.04% increase in organic carbon. Sharma and Sharma (2003) [22] reported that, available N content in soil decreased by 1.5 kg ha^{-1} after two cycles of rice-wheat cropping system but increased by 9.6, 13.8 and 14.1 and 3.5 kg ha^{-1} after two cycles of rice-potato-mungbean, rice-wheat-mungbean, rice-rapeseed-mungbean and rice-clover cropping systems, respectively.

Conclusion

Diversification of rice-wheat system as rice-yellow sarson-groundnut and rice-vegetable pea-maize and residue managements techniques where the organics are used to increase the rate of decomposition of the residue by lowering the C:N ratio results in increased number of panicle m^{-2}, panicle length, number of grain panicle^{-1}, grain wt. panicle^{-1} results in better grain yield. Among these residue management techniques the treatment where 30% residue management through vermicompost @ 2 t ha^{-1} was applied performed best in terms of both yield and soil nutrient availabilty.

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