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Effect of integrated nutrient management on nutrient uptake and grain yield of wheat (*Triticum aestivum* L.) under irrigated conditions

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Abstract
The experiment was conducted during *Rabi* season of 2015-2016 at Research Farm of the Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab India to study the effect of integrated nutrient management on nutrient uptake and grain yield of wheat (*Triticum aestivum* L.) under irrigated conditions. The experiment was laid out in randomized block design with seven integrated nutrient management treatments namely, 50% RDF, 50% RDF + Vermicompost (2 t ha^{-1}), 100% RDF + Vermicompost (2 t ha^{-1}), 100% RDF + Vermicompost (2 t ha^{-1}) + PSB, 75% RDF + Vermicompost (2 t ha^{-1}) + PSB, 75% RDF + PSB and 50% RDF + PSB, with three replications for each treatment. The maximum improvement in yield attributes and yield of crop were recorded with the application of 100% RDF + Vermicompost (2 t ha^{-1}) + PSB which was at par with 75% RDF + Vermicompost (2t ha^{-1}) + PSB and100% RDF +Vermicompost (2 t ha^{-1}). Similarly, maximum highest nutrient uptake was recorded with the application of treatments having 100% RDF + Vermicompost (2 t ha^{-1}) + PSB.

Keywords: Integrated nutrient management, nutrient uptake, yield, irrigation

1. Introduction
Wheat (*Triticum aestivum* L.) being a major cereal crop has been cultivated in India and belong to family Poaceae. India has 30.22 mha area under wheat cultivation with production of 93.50 mt (Anonymous, 2018a) [1]. In Punjab, area under wheat production is 3.46 mha with production of 17.63 mt (Anonymous, 2018b) [2]. Wheat and rice serve as life sustaining crops for our population and thus, considered to be the cornerstone of nation's food security system. Adoption of intensive cropping system is essential to meet the food demands of increasing population, which require high input energy. It is not only responsible for environment degradation but also increases the cost of cultivation. The recent energy crisis, high fertilizer cost and low purchasing power of the farming community have made it necessary to find the alternatives. Indiscriminate use of fertilizers adversely affects the physicochemical properties of the soil resulting in poor rice-wheat production. The declining response to inputs has been received to be the major issue challenging the sustainability of wheat based cropping system (Desai *et al*., 2015) [5]

Under this situation, integrated nutrient management (INM) is a better approach for supplying nutrition to the crop by including organic and inorganic sources of nutrients. Integration of inorganic fertilizers with organic manures and bio-fertilizers will not only help sustain the crop productivity but also will be effective in improving soil health and hastening the nutrient-use efficiency (Verma *et al.*, 2006) [17]. The highest yields were recorded under the treatments of vermicompost at 15 t ha^{-1} and recommended dose of NPK (Nehra and Hooda, 2002) [9]. In terms of the C storage capacity, the soil system triples the atmosphere and all living terrestrial plants (Naresh *et al.*, 2017) [8] Soil also contain some specific group of soil micro-organisms which increase the availability of phosphate to plants, not only by mineralizing organic phosphorus compounds but also by rendering inorganic phosphorus compounds more available to plant (Soleimanzadeh *et al.*, 2013) [16]. PSB reside in a plant rhizosphere, increase the availability of P for the plants by solubilization of bound P in soil (Illmer *et al.*, 1995) [7]. The application of organic manuring and crop residue had significant effects on physical properties of the soil under the rice - wheat system in Punjab (Singh *et al.*, 2007) [15]. Organic manures supports soil biological activities besides improving soil structure, water holding capacity and other physicochemical properties of soil Devi *et al.* (2013) [6].

Integrated nutrient management (INM) means judicious and efficient use of mineral fertilizers, organic manures and bio-fertilizers in an integrated manner, to get the maximum productivity and to maintain soil fertility. Addition of organic manures along with chemical fertilizers sustained the yield through increased nutrients availability and nutrient use efficiency.

Use of organic manures in INM helps in mitigating multiple nutrient deficiencies (Satyanayarana *et al.*, 2002) [14]. Application of organic manures, i.e., FYM@ 10 t ha^{-1} and vermicompost 5 t ha^{-1} with 60 kg P_2O_5 ha^{-1} or 40 kg P_2O_5 ha^{-1} + PSB and 40 kg S ha^{-1} produced maximum wheat grain and straw yield (Patel, *et al.*, 2014) [11]. Application of biofertilizers which is environment friendly and low cost input, with organic and inorganic fertilizers as a part of the integrated nutrient management strategy and play significant role in plant nutrition (Patel *et al.*, 2011) [10]. The role of biofertilizers is perceived as growth regulators besides biological nitrogen fixation collectively leading to much higher response on various growth and yield attributing characters (Saiyad, 2014) [12]. Thus judicious use of organic manure, biofertilizer and organic fertilizer helps in sustain production of wheat.

2. Materials and Methods

A field experiment was conducted at the Student's Research Farm, Mata Gujri College, Fatehgarh sahib during Rabi season of year 2015-2016. The experiment was laid down in randomized block design with three replications. The soil of the experimental field was Gangetic alluvial having sandy clay loam texture with *p*H7.6. It was moderately fertile, with available nitrogen (216.9 kg ha^{-1}), available phosphorus (23.8 kg ha^{-1}), available potassium (121.12 kg ha^{-1}), organic carbon (0.48 per cent) and electrical conductivity (0.54 dSm^{-1} at 250^0C). The seven treatment i.e. T_1- 50% Recommended Dose of Fertilizer (RDF), T_2- 50% RDF + Vermicompost (2 t ha^{-1}), T_3- 100% RDF + Vermicompost (2 t ha^{-1}), T_4- 100% RDF + Vermicompost (2 t ha^{-1}) + Phosphorus Solubilizing Bacteria (PSB), T_5- 75% RDF + Vermicompost (2 t ha^{-1}) + PSB, T_6- 75% RDF + PSB and T_7- 50% RDF + PSB were applied.HD-3086 variety was sown by *pora* method with a spacing of 22.5 cm and seed rate was 100 kg/ha. The recommended dose of fertilizers for wheat are 120, 60, 40 kg of N, P_2O_5 and K_2O ha^{-1} respectively. Full dose of P_2O_5,K_2O and 30% of N was applied at the time of sowing. Remaining doses of nitrogen were applied at 4, 6 and 8 weeks respectively after sowing in equal proportion. The amount of vermicompost and PSB was applied as per treatment wise. The field was kept free from weeds by manual hoeing. Plant protection measures and irrigations, whenever required were provided in same manner for all the treatments. Regular biometric observations were recorded at periodic intervals of 30DAS, 60DAS, 90 DAS and at harvest stage of selected plants. Yield attribute parameters were recorded just before harvesting of crop. Harvesting was done when the spikes became matured and plant was dried up. Thus grain yield of each plot was recorded as kg/plot and then converted into q/ha. After that threshing of the crop was done with mini thresher, straw was collected separately. Recorded data was analyzed statistically as per randomized block design (Cochran and Cox, 1963) [4], using CPCS-1 software developed by the department of Mathematics and Statistics, PAU, Ludhiana.

3. Results and Discussion

3.1 Yield

From the data shown in table 1 it is clear that the highest grain yield was recorded with the application of 100% RDF + Vermicompost (2 t ha^{-1}) + PSB which was at par with application of 75% RDF + Vermicompost (2 t ha^{-1}) + PSB and 100% RDF + Vermicompost (2 t ha^{-1}). It was significantly superior over all the treatments. However, the lowest grain yield was recorded with the application of T_1- 50% RDF treatment. The improvement in grain yield is having 32.86% with 100% RDF + Vermicompost (2 t ha^{-1}) + PSB as compared to 50% RDF is observed. Further, the data in table 1 indicates that application of treatment having 100% RDF + Vermicompost (2 t ha^{-1}) + PSB gave the highest straw yield which was statistically at par with application of treatment having 75% RDF + Vermicompost (2 t ha^{-1}) + PSB and 100% RDF + Vermicompost (2 t ha^{-1}). Overall the treatment containing 50% RDF gives the lowest straw yield. The improvement in straw yield with the application of treatment having 100% RDF + Vermicompost (2 t ha^{-1}) + PSB is 24.98% high as compared to 50% RDF was observed.

The data pertaining to Effect of integrated nutrient management on yield of Wheat (*Triticum aestivum* L.) is presented in Table 1. The biological yield was significantly influenced by these vermicompost and bio-fertilizer applications. Among the treatments, maximum biological yield was recorded with the application of treatment having 100% RDF + Vermicompost (2 t ha^{-1}) + PSB which was found to be statistically at par with the application of 75% RDF + Vermicompost (2 t ha^{-1}) + PSB and 100% RDF + Vermicompost (2 t ha^{-1}) which was superior than all the other treatments. The lowest biological yield was recorded with the application of 50% RDF treatment. The improvement in biological yield was observed 28.42% more with the application of 100% RDF + Vermicompost (2 t ha^{-1}) + PSB over 50% RDF. Similar, findings were reported by Yadav *et al*. (2018) [18].

Table 1: Effect of Integrated nutrient management on crop yield (q ha^{-1}) and harvest index (%)

Treatments	Grain yield (q ha-1)	Straw yield (q ha-1)	Biological yield (q ha-1)	Harvest Index (%)
50% RDF	32.52	46.98	79.50	40.85
50%RDF+Vermicompost (2 t ha^{-1})	42.17	56.00	98.17	42.95
100%RDF+Vermicompost (2 t ha^{-1})	44.66	58.72	103.38	43.19
100%RDF+Vermicompost (2 t ha^{-1}) + PSB	48.45	62.62	111.07	43.61
75% RDF+Vermicompost (2 t ha^{-1}) + PSB	46.98	61.57	108.28	43.38
75% RDF + PSB	38.55	52.83	91.65	42.07
50% RDF + PSB	36.27	50.14	87.41	41.54
SEm±	1.38	1.62	2.81	0.41
CD (p=0.05)	4.24	5.00	8.66	1.27

Similarly, maximum harvest index was recorded with the application of 100% RDF + Vermicompost (2 t ha^{-1}) + PSB which shows statistical parity with 75% RDF + Vermicompost (2 t ha^{-1}) + PSB and 100% RDF + Vermicompost (2 t ha^{-1}). However, all the treatments had significantly higher harvest index over 50% RDF which resulted in minimum harvest index. This result has been also confirmed by Sharma *et al*., (2007) [13] and Devi *et al*., (2013) [6].

The higher biological yield of wheat crop with integrated nutrient management practices may be due to the favourable soil physicochemical properties like soil structure, water-holding capacity and synchronized release of plant nutrients throughout the crop growth period, which increased the yield contributing characters.

3.2 Nutrient uptake

The data pertaining to nutrient uptake in grain and in straw by crop as affected significantly by integrated nutrient management treatments is presented in Table 2. Influence of INM on nutrient uptake was studied in terms of parameters as discussed. The maximum uptake of N, P and K by grain was with the application of treatment having 100% RDF + Vermicompost (2 t ha^{-1}) + PSB which shows statistical parity with treatments having 75% RDF + Vermicompost (2 t ha^{-1}) + PSB and 100% RDF + Vermicompost (2 t ha^{-1}), which was found significantly superior over rest of the treatments. The minimum uptake of N, P and K by grain was recorded in treatment having 50% RDF treatment. Among the treatments, maximum uptake of N, P and K by straw was with the application of 100% RDF + Vermicompost (2 t ha^{-1}) + PSB which was statistically at par with application of 75% RDF + Vermicompost (2 t ha^{-1}) + PSB and 100% RDF + Vermicompost (2 t ha^{-1}), which was found significantly superior over rest of the treatments. But the minimum uptake of N, P and K by straw was recorded in 50% RDF plots.

Table 2: Effect of Integrated nutrient management on nutrient uptake by grain and straw

Treatments	Grain (kg ha^{-1})			Straw (kg ha^{-1})		
	N	P	K	N	P	K
50% RDF	52.82	10.20	8.64	37.86	2.42	64.45
50%RDF+Vermicompost (2 t ha^{-1})	72.53	13.56	11.97	47.80	3.05	76.73
100%RDF+Vermicompost (2 t ha^{-1})	77.60	14.54	12.91	50.68	3.35	81.00
100%RDF+Vermicompost (2 t ha^{-1}) + PSB	85.36	16.28	14.59	55.23	3.51	87.79
75% RDF+Vermicompost (2 t ha^{-1}) + PSB	82.00	15.52	13.85	53.67	3.45	86.00
75% RDF + PSB	65.71	12.24	10.91	44.64	2.82	73.16
50% RDF + PSB	59.36	11.42	9.98	41.82	2.71	69.13
SEm±	2.68	0.57	0.42	2.00	0.14	2.45
CD (*p*=0.05)	8.27	1.77	1.29	6.18	0.45	7.55

3.3 Total nutrient uptake by crop plants

The data pertaining to total nutrient uptake by crop plant as affected significantly by integrated nutrient management is depicted in Table 3.

The maximum uptake of N, P and K by crop plant was with the application of treatment having 100% RDF + Vermicompost (2 t ha^{-1}) + PSB closely followed by application of 75% RDF + Vermicompost (2 t ha^{-1}) + PSB and 100% RDF + Vermicompost (2 t ha^{-1}), which was found significantly superior over rest of the treatments. The minimum uptake of N, P and K by crop was recorded in treatment 50% RDF plots. These are in confirmation with findings of Chesti *et al.*, (2013) [3] and Yadav *et al*. (2018) [18].

Table 3: Effect of Integrated nutrient management on total Nutrient uptake by crop at harvest stage

Treatments	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
50% RDF	90.68	12.62	73.09
50%RDF+Vermicompost (2 t ha^{-1})	120.33	16.61	88.70
100%RDF+Vermicompost (2 t ha^{-1})	128.28	17.88	93.91
100%RDF+Vermicompost (2 t ha^{-1}) + PSB	140.59	19.79	102.38
75% RDF+Vermicompost (2 t ha^{-1}) + PSB	135.67	18.97	99.85
75% RDF + PSB	110.35	15.06	84.07
50% RDF + PSB	101.18	14.13	79.11
SEm±	4.50	0.68	2.75
CD (*p*=0.05)	13.87	2.10	8.48

This might be due to (i) increased supply of all essential nutrients directly through organic and inorganic source to crop, (ii) indirectly through checking the losses of nutrient from soil solution and (iii) by increasing in the nutrient use efficiency.

4. Conclusion

Application of 100% RDF + Vermicompost (2 t ha^{-1}) + PSB gave best results in aspects of yield attributes, yield and nutrient uptake by crop followed by treatment having75% RDF + Vermicompost (2t ha^{-1}) + PSB.

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