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Effect of integrated nutrient management on the performance of barley (*Hordeum vulgare* L.)

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Abstract
The experiment entitled "Effect of integrated nutrient management on the performance of barley (*Hordeum vulgare* L.)" was carried out in Randomized Block Design (RBD) with four replications at Agronomy Research Farm, Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.) during Rabi season 2016-17 with the objective of **1)** Effect of combined use of organic manures and inorganic fertilizers on growth, yield attributes and yields of barley **2)** Effect of various treatments on the nutrients uptake and quality of barley **3)** Economics of various treatment combination. The experiment containing six treatments *viz.* 100% R.D.F (60 kg N + 30 kg P_2O_5 ha^{-1}), 75% R.D.F + 25% N through FYM, 50% R.D.F + 50% N through FYM, 75% R.D.F + 25% N through Vermicompost, 50% R.D.F + 50% N through Vermicompost, 50% N through FYM and 50% N through Vermicompost on silt loam soils having low organic carbon (3.8 g kg^{-1}), nitrogen (145.9 kg ha^{-1}), medium phosphorus (16.60 kg ha^{-1}) and potassium (250.20 kg ha^{-1}). All the growth and yield parameters increased significantly with75% R.D.F + 25% N through Vermicompost. The growth characters like plant height, dry matter accumulation, number of shoots, leaf area index were significantly higher under 75% R.D.F + 25% N through Vermicompost as compared to other nutrient combinations. The yield components like spike length (cm), number of grains $spike^{-1}$, spike weight (g), grain yield (kg ha^{-1}) and straw yield (kg ha^{-1}) were significantly higher under 75% R.D.F + 25% N through Vermicompost. Harvest index and 1000-grain weight (g) were not influenced significantly due to different nutrient combinations The nitrogen and protein content in grain were obtained higher with 75% R.D.F + 25% N through Vermicompost which was significantly higher than rest of treatments. The maximum net return (Rs.29020.00 ha^{-1}) and B-C ratio (1.30) were obtained at 100% R.D.F. Thus, it can be concluded that a dose of 75% R.D.F + 25% N through Vermicompost may be most suitable nutrient combination for achieving higher yield and economics of barley.

Keywords: Integrated, vermicompost, R. D. F., FYM

Introduction
Barley (*Hordeum vulgare* L.) Belonging to Poaceae family, is one of the most important staple food crops in the world. It is an important cereal crop after wheat, rice and maize in the world. Barley has the widest ecological range of adaptation among the cereals. It is a cool season, most dependable and early maturing cereal crop with relatively high yielding potential in diverse agro-ecologies including marginal areas where other cereal crops are not adapted (Martin *et al.*, 2006) [7]. Its low cost of production and input requirement, it is preferred by the resource poor farmers in the country. It can also be cultivated successfully in areas where less irrigation water is available.

It is grown in a wider range of climate as compared to other cereals. In the world, barley occupies an area of 47.54 million hectares with a production of 123.70 million tonnes and with a productivity of 2658 Kg ha^{-1}. In India, barley is cultivated in an area of 0.624 million hectares and a production of 1.355 million tonnes with average productivity of 2172 $Kgha^{-1}$ (Anonymous, 2015) [1].

Increased use of N fertilizer threaten to the human and animal life. Imbalance use of fertilizers depleted soil organic matter resulting inherent loss of native soil N, available P, available K and lower production. The fertilizer consumption in India is grossly unbalanced and tilted more towards nitrogen, followed by phosphorus. This has implications on yield response to fertilizer as it decreases the crop quality and adversely affects the overall soil fertility and productivity. The over or imbalanced use of major nutrients and neglect of organic manures which otherwise provide imbalanced supply of nutrients to plants, rendered micro-nutrient deficiencies resulting into decreasing trend in fertilizer use efficiency.

Integrated nutrient management (INM) has been suggested for the replenishment of nutrients which removed by the crop from the soil, maintenance of humus level in the soil, i.e. physical texture of the soil, avoidance of weeds, pests and diseases and control of soil acidity and toxicity. The role of soil biota in these principles of INM cannot be undermined, since soil microbes contribute in a big way to the soil organic matter dynamics, nutrient use. Integration of inorganic and organic sources of nutrients was found to give higher productivity and more monetary returns (Hari Ram *et al.*, 2012) [4]. Therefore, use of balance fertilization is essential in integrated manner to sustain the crop production and soil fertility. The production potential of barley can be increased with the application of manures in combination with chemical fertilizers.

Materials and Methods

The present investigation entitled "Effect of integrated nutrient management on the performance of barley (*Hordeum vulgare* L.)" was conducted at Agronomy Research Farm, Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.), during *rabi* season 2016-2017. The experiment was conducted in Randomized Block Design having four replications with the six treatments *viz.*, 100% Recommended dose of fertilizers (60 kg N + 30 kg P_2O_5 ha^{-1}) (T_1), 75% R.D.F + 25% N through FYM (T_2), 50% R.D.F + 50% N through FYM (T_3), 75% R.D.F + 25% N through Vermicompost (T_4), 75% R.D.F + 50% N through Vermicompost (T_5), 50% N through FYM and 50% N through Vermicompost (T_6). The treatments were allocated to different plots at random in all the three replications using the random table. For this experiment observations were recorded on the growth parameter *viz.*, Initial plant population (m^{-2}), Plant height (cm), Number of shoots $m^{-2,}$ Leaf area index (LAI), Dry matter accumulation (gm^{-2}), Days to 50% spike emergence, Days to maturity; yield attributes i.e. Number of spikelets $spike^{-1,}$ Spike length (cm), Number of grains $spike^{-1,}$ 1000-grain weight (g); Grain yield (q ha^{-1}), Straw yield (q ha^{-1}), Harvest index (%) and one quality studies i.e. Nitrogen content and uptake in grain and straw.

The allocation of treatment in the plots was done randomly. The data recorded on different characters during the course of investigation were subjected to statistical analysis by using the analysis of variance technique for randomized block design as suggested by S.R.S Chandel (1999). The treatment differences were tested by "F" test of significance at 5% level of significance; critical differences were calculated to compare the significant differences between the treatments.

Result and Discussion

For this experiment the data were statistically analysed and presented with the help of tables. Following result should be obtained in this experiment.

Growth attributes

Maximum numbers of tillers were recorded under 75% R.D.F + 25% N through Vermicompost at 90 days after sowing. Reduction in number of tillers after 90 days of sowing may be due to mortality of shoots. Similar results have been reported by Azad *et al.* (1998) [2] and Patra *et al.* (1998).

Maximum plant height was recorded under 75% R.D.F + 25% N through vermicompost at all the crop growth stages which was mainly due to more availability of nitrogen and other essential nutrients due to higher mineralization rate of vermicompost compared to FYM. Similar results were also observed by Zagonel *et al.*, (2002) [14].

Perusal of table-4 the leaf area index increased with increasing nutrient availability and was recorded maximum under 75% R.D.F and 25% N through Vermicompost at all the crop growth stages, except 30th day stage. This may be due to increased rate of light absorption, high photosynthetic activities and increased absorption of nutrients from the soil. The lowest LAI was recorded under T_6 treatment where nitrogen was applied from only through organic source. It was possibly due to the poor plant height, less number of leaves, low rate of light absorption, low photosynthetic activities and low absorption of nutrients from the soil due to lower availability.

Maximum dry matter accumulation was recorded under T_4 (75% R.D.F and 25% N through Vermicompost) at all stages, except at 30 DAS. This might be due to higher collective contribution of various growth characters like plant height, number of shoot, leaf area index and yield of vegetative part. Similar findings were reported by Singh and Mishra (1980) [11] and Singh (1981) [12].

Table 1: Effect of INM on plant height at various growth stages of barley.

Symbol	Treatments	Plant height (cm)			
		30 DAS	60 DAS	90 DAS	At Harvest
T_1	100% R.D.F (60 kg N + 30 kg P_2O_5 ha^{-1})	27.2	54.2	86.2	86.7
T_2	75% R.D.F + 25% N through FYM	26.2	52.1	79.0	80.2
T_3	50% R.D.F + 50% N through FYM	25.2	46.2	78.2	78.7
T_4	75% R.D.F + 25% N through Vermicompost	26.7	60.2	92.2	93.5
T_5	50% R.D.F + 50% N through Vermicompost	25.5	51.2	78.5	79.1
T_6	50% N through FYM and 50% N through Vermicompost	23.0	48.0	73.25	74.0
S.Em±		1.13	1.47	1.64	1.72
CD at 5%		NS	4.43	4.94	5.17

R.D.F – Recommended dose of fertilizers

Table 2: Effect of INM on number of tillers at various growth stages of barley.

Symbol	Treatments	Number of tillers m^{-2}			
		30 DAS	60 DAS	90 DAS	At harvest
T_1	100% R.D.F (60 kg N + 30 kg P_2O_5 ha^{-1})	273	357	365	360
T_2	75% R.D.F + 25% N through FYM	260	348	358	350
T_3	50% R.D.F + 50% N through FYM	237	318	330	322
T_4	75% R.D.F + 25% N through Vermicompost	265	364	380	371

T_5	50% R.D.F + 50% N through Vermicompost	249	340	351	345
T_6	50% N through FYM and 50% N through Vermicompost	210	293	306	298
S.Em±		0.83	1.67	4.93	3.33
CD at 5%		2.51	5.02	14.86	10.05

Table 3: Effect of INM on dry matter accumulation at various growth stages of barley.

Symbol	Treatments	Dry matter production (g m^{-2})			
		30 DAS	60 DAS	90 DAS	At harvest
T_1	100% R.D.F (60 kg N + 30 kg P_2O_5 ha^{-1})	73.84	143.25	545.10	579.50
T_2	75% R.D.F + 25% N through FYM	72.06	133.52	530.01	560.75
T_3	50% R.D.F + 50% N through FYM	70.83	120.10	460.10	510.10
T_4	75% R.D.F + 25% N through Vermicompost	72.49	162.00	605.20	646.25
T_5	50% R.D.F + 50% N through Vermicompost	71.34	125.50	485.00	518.50
T_6	50% N through FYM and 50% N through Vermicompost	65.83	108.01	423.75	473.22
S.Em±		0.25	10.72	13.64	6.65
CD at 5%		0.75	32.32	41.11	20.16

Table 4: Effect of INM on leaf area index (LAI) at various growth stages of barley.

Symbol	Treatments	Leaf area index		
		30 DAS	60 DAS	90 DAS
T_1	100% R.D.F (60 kg N + 30 kg P_2O_5 ha^{-1})	1.15	5.48	4.59
T_2	75% R.D.F + 25% N through FYM	1.11	4.76	3.95
T_3	50% R.D.F + 50% N through FYM	1.01	3.32	3.22
T_4	75% R.D.F + 25% N through Vermicompost	1.12	6.07	5.10
T_5	50% R.D.F + 50% N through Vermicompost	1.02	3.47	2.92
T_6	50% N through FYM and 50% N through Vermicompost	1.01	3.20	3.02
S.Em±		0.01	0.24	0.34
CD at 5%		0.03	0.72	1.02

Table 5: Effect of INM on days taken to 50% spike emergence and days taken to maturity of barley.

Symbol	Treatment	Days taken to 50% spike emergence	Days taken to maturity
T_1	100% R.D.F (60 kg N + 30 kg P_2O_5 ha^{-1})	67	118
T_2	75% R.D.F + 25% N through FYM	66	116
T_3	50% R.D.F + 50% N through FYM	66	116
T_4	75% R.D.F + 25% N through Vermicompost	72	120
T_5	50% R.D.F + 50% N through Vermicompost	65	115.25
T_6	50% N through FYM and 50% N through Vermicompost	64	113
S.Em±		0.77	0.49
C.D.at 5%		2.33	1.49

Table 6: Effect of INM on yield contributory characters of barley.

Symbol	Treatments	No. of ear heads m^{-2}	Spike length (cm)	No. of grains $spike^{-1}$	1000-grain weight (g)	Spike weight (g)
T_1	100% R.D.F (60 kg N + 30 kg P_2O_5 ha^{-1})	355	8.10	24.13	42.30	3.50
T_2	75% R.D.F + 25% N through FYM	346	7.94	24.07	41.90	3.40
T_3	50% R.D.F + 50% N through FYM	316	7.10	22.05	40.30	2.92
T_4	75% R.D.F + 25% N through Vermicompost	363	8.71	26.77	42.69	3.85
T_5	50% R.D.F + 50% N through Vermicompost	328	7.42	22.26	40.60	3.02
T_6	50% N through FYM and 50% N through Vermicompost	290	6.16	20.00	40.01	2.30
S.Em±		6.63	0.28	1.05	1.52	0.24
C.D. at 5%		19.98	0.84	3.17	NS	0.72

Table 7: Effect of INM on grain yield, straw yield and harvest index of barley.

Symbol	Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological Yield (kg ha^{-1})	Harvest Index (%)
T_1	100% R.D.F (60 kg N + 30 kg P_2O_5 ha^{-1})	2500.00	3350.00	5850.00	42.73
T_2	75% R.D.F + 25% N through FYM	2412.50	3312.50	5070.00	47.58
T_3	50% R.D.F + 50% N through FYM	2357.00	2675.00	5105.00	47.60
T_4	75% R.D.F + 25% N through Vermicompost	2712.50	3812.50	6525.00	41.57
T_5	50% R.D.F + 50% N through Vermicompost	2357.50	2712.50	5725.00	41.17
T_6	50% N through FYM and 50% N through Vermicompost	1912.50	2450.00	4362.50	43.89
S.Em±		80.41	112.07	158.47	0.87
C.D.at 5%		242.35	337.78	477.61	2.61

Table 8: Effect of INM on nitrogen content, nitrogen uptake and protein content of barley

Symbol	Treatments	N content (%)		N uptake (kg ha^{-1})		Protein content in grain (%)
		grain	straw	grain	Straw	
T_1	100% R.D.F (60 kg N + 30 kg P_2O_5 ha^{-1})	1.67	0.57	41.75	19.09	10.43
T_2	75% R.D.F + 25% N through FYM	1.66	0.56	40.03	18.54	10.37
T_3	50% R.D.F + 50% N through FYM	1.62	0.55	38.18	14.75	10.12
T_4	75% R.D.F + 25% N through Vermicompost	1.73	0.58	46.91	22.10	10.81
T_5	50% R.D.F + 50% N through Vermicompost	1.65	0.55	38.89	14.91	10.31
T_6	50% N through FYM and 50% N through Vermicompost	1.54	0.52	29.44	12.75	9.62
S.Em±		0.03	0.01	0.52	0.67	0.24
C.D.at 5%		0.08	0.02	1.57	2.03	0.72

Table 9: Economics of barley as influenced by INM.

S. No.	Treatments	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
T_1	100% R.D.F (60 kg N + 30 kg P_2O_5 ha^{-1})	21654	49875	28221	1.30
T_2	75% R.D.F + 25% N through FYM	23323	48525	25202	1.08
T_3	50% R.D.F + 50% N through FYM	25157	45572	20415	0.82
T_4	75% R.D.F + 25% N through Vermicompost	26473	54994	28521	1.07
T_5	50% R.D.F + 50% N through Vermicompost	30887	44790	13903	0.45
T_6	50% N through FYM and 50% N through Vermicompost	34419	37584	3165	0.09

Yield attributes and yield

The number of grains $spike^{-1}$ was affected by various treatments. The maximum number of grains $spike^{-1}$ was recorded under 75% R.D.F and 25% N through Vermicompost in comparison to other treatments. The number of grains $spike^{-1}$ determined primarily by the amount of nutrient observed and secondary by the amount of carbohydrate produced at the time of spikelets differentiation. Maximum length of spike, spike weight and test weight were recorded with 75% R.D.F and 25% N through Vermicompost was significantly superior over rest of the treatment. The lowest value of yield attributing characters were obtained under T_6 treatment because plants were subjected to utilize the least amount of available nitrogen which resulted into reduced translocation of photosynthesis from source to sink. The results are in line with those of Sardana *et al.* (2002) [10] and Khiriya and Singh (2003) [6].

The yield was recorded significantly higher under 75% R.D.F + 25% N through vermicompost as compared to other treatments. This might be due to adequate nitrogen availability which contributed to increase dry matter accumulation. Better vegetative growth coupled with high yield attributes resulted into higher grain yield due to higher availability of macro, micronutrients and plant growth promoters present in the vermicompost. Reduced nutrient supply as in case of rest of the treatment, recorded lowest yield due to both poor growth and yield attributes. The results are in conformity with Reddi and Patil (2003) [9] and Stoeva and Tonev (2003) [13].

Maximum straw yield was recorded under 75% R.D.F and 25% N through Vermicompost. This may be probably due to higher density of tiller and increased rate of dry matter production per unit area as a result of better performance of vegetative growth caused due to efficient assimilation and absorption of nutrients from the soil during entire period of growth, unlike the lowest straw yield was recorded in the treatment T_6 where nitrogen was applied through organic source.

Harvest index of barley was not affected significantly due to different combinations of organic and inorganic nutrient sources. However, the performance was better in T_3 (50% R.D.F and 50% N through FYM) treatment.

Nitrogen and protein content in grain (%)

The maximum protein content was recorded at 75% R.D.F and 25% N through Vermicompost. Villers *et al.* (1988) reported that nitrogen application increased total nitrogen, free amino nitrogen and alfa and beta amylase activities in barley grain. Protein content of grain increased due to increase in nitrogen content of grain.

Nitrogen uptake by crops (kg ha^{-1})

Nitrogen uptake by crop was affected significantly due to different nutrient combinations. It was recorded maximum under 75% R.D.F and 25% N through Vermicompost. Adequate supply of nitrogen in the root zone increased the movement of nutrient in soil solution and ultimately their grater absorption and utilization by growing plants. The lowest uptake of nitrogen recorded in nitrogen application through organic source was due to poor root growth, nitrogen mobilization, grain and straw yields. The results are in confirmation with the findings of Chaudhary *et al.* (1997) [3], Kaushik and Sharma (1997) [5].

Economics

The highest gross return of Rs 54994 ha^{-1} was obtained in T_4 treatment where 75% R.D.F and 25% N through Vermicompost was applied followed by Rs. 49875 ha^{-1} under T_1 treatment where 100% R.D.F was applied due to maximum grain and straw yield. The lowest gross return Rs 37584 ha^{-1} was recorded in 50% N through FYM and 50% N through Vermicompost due to lowest yields. Maximum cost of cultivation Rs. 34419 ha^{-1} was recorded under T_6 followed by T_5 and T_3, respectively.

Highest net return of Rs 28521.00 ha^{-1} was recorded in T_4 followed by Rs 28221.00 ha^{-1} in T_1 treatment. The lowest net return of Rs. 3165 ha^{-1} was recorded in T_6 (50% N through FYM and 50% N through Vermicompost) due to lowest gross return.

Maximum benefit cost ratio Rs. 1.30 was recorded in T_1 treatment, where 100% R.D.F was applied followed by Rs. 1.08 in T_2 treatment.

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