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ML Jat
Ph.D. Scholar, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India

PC Chaplot
Professor, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India

J Choudhary
Assistant Professor, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India

Dhayal BC
Ph.D. Scholar, Department of Agronomy, College of Agriculture, AU, Jodhpur, Rajasthan, India

RL Meema
Ph.D. Scholar, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India

Corresponding Author
ML Jat
Ph.D. Scholar, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India

Effect of organic, inorganic and biofertilizer on nutrient content, uptake and nutrient status of soil in barley (*Hordeum vulgare* L.)

ML Jat, PC Chaplot, J Choudhary, Dhayal BC and RL Meema

Abstract
A field experiment was conducted in *rabi* season during 2017-18 and 2018-19 to study the nutrient status of plant and soil as influenced under integrated nutrient management in barley at Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur. The experiment was laid out Randomized Block Design (Factorial) with comprised combinations of six fertility levels and four liquid bio inoculants. The results indicate that significantly higher N, P and K content in grain and straw of barley thereby total uptake was recorded under the influence 125% RDF + 5 t FYM ha^{-1} over rest of fertility levels but remained at par with 100% RDF + 5 t FYM ha^{-1} during both years. The barley crop under influence of conjoint inoculation with liquid bio fertilizers consisting combination of *Azotobacter* + *Azospirillum* + Phosphates solubilizer + PGPR accumulated maximum N, P and K content in grain and straw thereby total uptake which was found at par with inoculation of *Azotobacter* + PSB inoculation and both these treatment significantly enhanced N, P and K content in grain and straw thereby total uptake over inoculation of *Azotobacter* and PSB alone during investigation.
Further, data indicated that maximum available N, P and K content of soil was recorded under application of 125% RDF + 5 t FYM ha^{-1} which was significantly higher over application of 100% RDF + 5 t FYM ha^{-1}, 75% RDF + 5 t FYM ha^{-1}, 125% RDF, 100% RDF and 75% RDF during experimentation.

Keywords: barley, RDF, *Azotobacter, Azospirillum,* PSB, PGPR, content, uptake

Introduction
Barley (*Hordeum vulgare* L.) is an important rabi cereal crop of India. Being the most dependable crop in areas where soils are alkali, frost or drought occurs, it is cultivated in almost all parts of the world. Among the cereals, it ranks fourth with respect to area and production after wheat, rice and maize. Barley grain is also valued for smothering and cooling effect on the body for easy digestion. Besides these conventional uses, it is an important industrial crop as it is used as raw material for beer, whisky and brewing industries. In India, barley is mainly grown in the northern plains and concentrated in the states of Utter Pradesh, Haryana, and Rajasthan etc. In India, barley was cultivated on 618.4 thousand ha area with 1590 thousand tons of production at an average productivity of 25.73 q ha-1. Rajasthan and U.P. are two major barley-producing states in the country. In India, Rajasthan is the largest state having more than 52% in production and 46% area followed by U. P. In Rajasthan, barley was cultivated on 288.2 thousand ha area with 831.2 thousand tons of production at an average productivity status of 28.84 q ha-1 (IIWBR, 2019-20) [8].
The average productivity of barley in the state is far behind the attainable yield of 4.0-5.0 t ha^{-1}, the reasons being water and nutritional stresses. Being a cereal crop, it requires considerable amounts of major nutrients particularly N and P for harnessing potential yield. Adequate mineral fertilization is considered to be one of the most important prerequisite in this respect. Despite the application of recommended quantities of major nutrients, the increase in yield is not encouraging. Nitrogen is the most important nutrient for plant growth and development. It is an integral part of chlorophyll, which is essential for photosynthesis. Being the constituent of protoplasm and chlorophyll, it is also associated with the activity of every living cell. Phosphorus nutrition plays key role in plant metabolism. Being involve in various biochemical processes, it ensures transfer and storage of energy as ADP and ATP, permits conversion and transmission of genetic characters as it is a constituent of DNA and RNA. In plant nutrition, organic manures are potential sources of micro nutrient, improves soil structure by providing binding action to soil aggregates, increases water holding and buffering capacity of soils. Among these farm yard manure is a traditional source, most readily available and widely used

by the farmers since time immemorial. Under these circumstances, integration of chemical and organic sources and their management have shown promising results not only in sustaining the productivity but have also proved to be effective in maintaining soil health and enhancing nutrient use efficiency (Thakur *et al.* 2011) [34]. FYM supplies all major nutrients (N, P, K, Ca, Mg, S,) necessary for plant growth, as well as micronutrients (Fe, Mn, Cu and Zn). Hence, it acts as a mixed fertilizer. FYM improves soil physical, chemical and biological properties. FYM also improves soil water holding capacity.

Biofertilizers play a very significant role in improving soil fertility by fixing atmospheric nitrogen, both, in association with plant roots and without it, solubilize insoluble soil phosphates and produces plant growth substances in the soil. They are in fact being promoted to harvest the naturally available biological system of nutrient mobilization. On the other hand bio-fertilizers are cheaper, pollution free and renewable source of nutrients supply. Besides providing nutrients, it also adds biomass into the soil to prevent it from deterioration. Azotobacter are abiotic, free living soil microbes which play an important role the nitrogen cycle in nature and binding atmospheric nitrogen which is inaccessible to plants. Inoculation with Azotobacter has been found to reduce the requirement of chemical fertilizer upto 50 per cent (Soleimanzadeh and Gooshchi, 2013) [31]. Phosphorus solubilizing bacteria (PSB) plays an important role in converting insoluble phosphate chemically fixed and applied phosphorus into available form resulting in higher crop yields (Gull *et al.* 2004) [7]. Among the whole microbial population in soil, PSB constitute 1 to 50 per cent in P solubilization potential (Chen *et al.* 2006) [4]. The favorable effect of combined inoculation of Azotobacter and PSB could be attributed to synergistic interaction among phosphate solubilizing microorganism and free living organism, which lead to increased availability of nutrients (Khatkar *et al.* 2007) [14].

Plant Growth Promoting Rhizobacteria (PGPR) are a heterogeneous group of bacteria that can be found in the rhizosphere, at root surfaces and in association with roots, which can improve the extent or quality of plant growth directly or indirectly (Joseph *et al.* 2007) [11]. In direct effect, PGPR help by enhancing biological nitrogen fixation through promotion of nodule formation, phosphorus solubilization, production of phytohormones like cytokinins, gibberellins and indole acetic acid (Yadav and Verma, 2014) [37] and in indirect effect, show antagonism against phytopathogens by production of siderophores, celluloses and antibiotics (Kaur and Sharma, 2013) [13].

Continuous application of nitrogenous fertilizers has depleted soil organic matter, resulting in inherent loss of native soil N, available P, available K and lower production (Behera *et al.*, 2007) [3]. Integrated nutrient management (INM) techniques have been suggested for the replenishment of chemicals removed by the crop from the soil, maintenance of humus level in the soil.

Materials and Methods

A field experiment on Barley (*Hordeum vulgare* L.) in *rabi* seasons of the year 2017-18 and 2018-19 at Rajasthan College of Agriculture, MPUAT, Udaipur. The soils of experimental site was clay loam in texture, slightly alkaline in reaction, low in available nitrogen (287.60 to 288.30 kg ha^{-1}), medium in available phosphorus (18.80 to 20.50 kg ha^{-1}) and high in available potassium status (338.70 to 346.40 kg ha^{-1}). In both season crop was sown on 19 and 21 November during 2017-18 and 2018-19 respectively and harvested 18 March in 2018 and 23 March 2019. The total rainfall in the year of 2017-18 was 6.4 mm, whereas it was 1.0 mm in 2018-19. The maximum and minimum temperature during crop growing season ranged between 23.5 to 37.8 °C and 5.2 to 19.8 ºC during *rabi* 2017-18, respectively. The corresponding temperature fluctuations during second year of experimentation *i.e. rabi*, 2018-19 were between 21.6 to 39.4 °C and 4.1 to 20.1 °C, respectively. The experiment was laid out Randomized Block Design (Factorial) with comprised combinations of six fertility levels 75% RDF, 100% RDF, 125% RDF, 75% RDF + 5 t FYM ha^{-1}, 100% RDF + 5 t FYM ha^{-1} and 125% RDF + 5 t FYM ha^{-1} and four liquid bio inoculants *Azotobacter*, PSB, *Azotobactor* + PSB and *Azotobactor* + *Azospirillum* + Phosphates solubilizer + PGPR (Plant Growth Promoting Rhizobacteria). These 24 treatment combinations were replicated thrice. Barley variety "RD 2786" was used as a test crop. The seed were sown in furrow opened at the depth of about 4-5 cm using seed rate of 100 kg ha^{-1} with inter row spacing of 22.5 cm.

The grain and straw sample collected from each plot at harvest were dried in oven at 65 ºc till a constant weight. These samples were grounded in laboratory mill, passed through 40 mm mesh sieve and used for estimating of N, P and k contents. The following standard methods of analysis were used.

Nitrogen: Nesseler's reagent colorimetric method (Snell and Snell, 1949) [30]

Phosphorus: Ammonium vanadomolybdate phosphoric yellow colour method (Jackson, 1973) [9]

Potassium: Flame photometric method (Jackson, 1973) [9]

Uptake of N, P and K by grain and straw was estimated by using following formula.

$$\text{Nutrient uptake by grain (kg ha}^{-1}) = \frac{\text{Nutrient content (\%) x Grain yield (kg ha}^{-1})}{100}$$

$$\text{Nutrient uptake by grain (kg ha}^{-1}) = \frac{\text{Nutrient content (\%) x Grain yield (kg ha}^{-1})}{100}$$

The soil samples were taken up to a depth of 0-15 cm from each plot after crop harvest. The samples were analyzed for pH, EC, organic carbon, N, P and K as per methods mentioned bellow.

The samples were analyzed for pH, EC, organic carbon, N, P and K as per methods mentioned bellow.

EC (dSm^{-1} at 25ºC)	:	Conductivity bridge (Richards, 1968)
pH (1:2.5 soil: water)	:	Blackman's pH meter (Piper, 1950) [22]
Organic carbon (%)	:	Walkley and Black (1947) [36]
Available nitrogen (kg ha^{-1})	:	Alkaline KMnO4 method (Subbiah and Asija, 1956) [32]
Available phosphorus (kg ha^{-1})	:	Olsen's method (Olsen *et al.* 1954) [20]
Available potassium (kg ha^{-1})	:	Flame photometer method (Jackson, 1973) [9]

Results and Discussion
Nutrient Content and uptake
Fertility levels

Data (Table 1 & 2) reveals that fertility levels exhibited significant improvement in N, P and K content and uptake in grain and straw thereby total uptake during both the years of experimentation as well as in pooled analysis. The barley crop fertilized with 125% RDF + 5 t FYM ha^{-1} recorded maximum N, P and K content and uptake in grain and straw thereby total uptake which was found at par with application of 100% RDF + 5 t FYM ha^{-1}, however, both these fertility levels significantly elevated N, P and K content and uptake in grain and straw thereby total uptake over application of 75% RDF + 5 t FYM ha^{-1}, 125% RDF, 100% RDF and 75% RDF during both years. On pooled basis, application of 100% RDF + 5 t FYM ha^{-1} significantly improved total N, P and K uptake by 23.05, 30.77, 41.17, 80.83, 19.07, 26.14, 35.49, 59.55 and 13.51, 20.60, 28.17, 48.01 per cent, respectively over application of 75% RDF + 5 t FYM ha^{-1}, 125% RDF, 100% RDF and 75% RDF. The positive influence of conjoint application of NPK + FYM on nutrient status of plant parts seems to be due to their increased availability in the root zone. Secondarily it can be attainuted to their efficient extraction/translocation due to increase in root ramification/activities as organic manure play vital role in maintaining physic-chemical and biological properties of soil. It is generally believed that in the plants extracted nutrients are used for maintaining their critical concentration that can be used for plant growth as evident from higher accumulation of dry matter under the influence of RDF + FYM fertilization. Further reveals that there was adequate supply of photosynthates from shoot to root. This might have promoted growth of roots as well as their functional activity leading to higher extraction of nutrients from soil to plant parts.

In this direction Michael and beringer (1980) [17] ascribed that expanded root promotes shoot growth which enhanced root metabolism. Since most of nutrients (N, P and K) grain is relocated their reserves in vegetative parts, better nutritional condition of grain with integrated nutrient management seems to be on accent of their higher concentration in plant. The results are in close agreement with finding of several researchers (Meena *et al.* 2012, Shantveerayya *et al.* 2016, Singh and Chauhan, 2016 choudhary *et al.* 2018 and Jat *et al.* 2018) [16, 28, 29, 5, 10]. They also ascribed marked improvement in nutritional status of plants under integrated nutrient management due to their increase availability in root zone and higher extraction due to batter growth of roots. It is well established fact that uptake of nutrient by the crop is primarily governed by total biomass production and secondarily on nutrient status at cellular levels. Thus, improvement in both these under integrated nutrient management results in higher uptake of added nutrients.

Table 1: Effect of integrated nutrient management on N, P and K content of barley

	N content (%)						P content (%)						K content (%)					
	Grain			Straw			Grain			Straw			Grain			Straw		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
Fertility levels																		
75% RDF	1.346	1.384	1.365	0.258	0.263	0.261	0.345	0.347	0.346	0.069	0.073	0.071	0.402	0.423	0.413	1.185	1.186	1.185
100% RDF	1.543	1.610	1.577	0.280	0.288	0.284	0.360	0.363	0.362	0.073	0.078	0.076	0.440	0.445	0.443	1.242	1.244	1.243
125% RDF	1.587	1.655	1.621	0.290	0.298	0.294	0.368	0.373	0.371	0.075	0.080	0.078	0.449	0.456	0.452	1.270	1.272	1.271
75% RDF + 5 t FYM ha^{-1}	1.624	1.686	1.655	0.299	0.306	0.303	0.376	0.380	0.378	0.077	0.082	0.080	0.455	0.463	0.459	1.298	1.299	1.298
100% RDF + 5 t FYM ha^{-1}	1.784	1.856	1.820	0.325	0.335	0.330	0.399	0.403	0.401	0.083	0.087	0.085	0.477	0.483	0.480	1.358	1.360	1.359
125% RDF + 5 t FYM ha^{-1}	1.819	1.876	1.847	0.333	0.341	0.337	0.409	0.412	0.410	0.085	0.089	0.087	0.484	0.489	0.487	1.371	1.374	1.372
S.Em.±	0.020	0.026	0.016	0.005	0.006	0.004	0.005	0.005	0.003	0.001	0.001	0.001	0.005	0.006	0.004	0.018	0.018	0.013
C.D. (P=0.05)	0.058	0.074	0.046	0.014	0.017	0.011	0.014	0.014	0.010	0.003	0.003	0.0021	0.014	0.016	0.010	0.052	0.052	0.036
Liquid bio inoculants																		
Azotobacter	1.419	1.476	1.448	0.292	0.295	0.294	0.339	0.342	0.341	0.074	0.078	0.076	0.374	0.411	0.393	1.258	1.258	1.258
PSB	1.401	1.466	1.434	0.287	0.289	0.288	0.347	0.349	0.348	0.075	0.079	0.077	0.369	0.405	0.387	1.235	1.231	1.233
Azotobacter + PSB	1.813	1.869	1.841	0.304	0.317	0.311	0.407	0.412	0.410	0.080	0.084	0.082	0.527	0.505	0.516	1.321	1.327	1.324
Azotobazter + Azospirillum + Phoaphates solubilizer + PGPR	1.836	1.901	1.869	0.307	0.320	0.314	0.412	0.416	0.414	0.080	0.085	0.083	0.535	0.519	0.527	1.334	1.341	1.338
S.Em.±	0.017	0.021	0.013	0.004	0.005	0.003	0.004	0.004	0.003	0.001	0.001	0.001	0.004	0.005	0.003	0.015	0.015	0.011
C.D. (P=0.05)	0.047	0.061	0.038	0.012	0.014	0.009	0.011	0.012	0.008	0.002	0.003	0.002	0.011	0.013	0.008	0.042	0.043	0.030

Table 2: Effect of integrated nutrient management on N uptake (kg ha^{-1}) by grain and straw of barley

	N uptake (kg ha^{-1})						P uptake (kg ha^{-1})						K uptake (kg ha^{-1})					
	Grain			Straw			Grain			Straw			Grain			Straw		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
Fertility levels																		
75% RDF	49.44	51.03	50.24	15.77	16.16	15.96	12.65	12.78	12.71	4.23	4.48	4.35	14.81	15.59	15.20	72.35	72.82	72.59
100% RDF	64.11	67.63	65.87	18.53	19.34	18.93	14.90	15.20	15.05	4.85	5.23	5.04	18.39	18.69	18.54	82.19	83.50	82.85
125% RDF	69.27	73.14	71.21	19.85	20.82	20.33	16.02	16.41	16.21	5.15	5.58	5.37	19.69	20.12	19.90	86.98	88.70	87.84
75% RDF + 5 t FYM ha^{-1}	73.32	77.66	75.49	21.34	22.24	21.79	16.85	17.41	17.13	5.51	5.96	5.73	20.73	21.31	21.02	92.54	94.36	93.45
100% RDF + 5 t FYM ha^{-1}	90.73	97.63	94.18	24.87	26.19	25.53	20.17	21.10	20.63	6.36	6.80	6.58	24.44	25.36	24.90	103.77	106.30	105.04
125% RDF + 5 t FYM ha^{-1}	94.72	101.24	97.98	25.77	26.87	26.32	21.16	22.11	21.63	6.59	7.02	6.81	25.37	26.37	25.87	106.00	108.22	107.11
S.Em.±	3.21	2.99	2.19	0.76	0.92	0.60	0.60	0.66	0.45	0.17	0.21	0.13	0.76	0.75	0.53	2.68	3.17	2.07
C.D. (P=0.05)	9.13	8.51	6.16	2.15	2.62	1.67	1.71	1.87	1.25	0.48	0.59	0.38	2.15	2.13	1.50	7.6	9.01	5.83
Liquid bio inoculants																		
Azotobacter	56.19	59.81	58.00	19.87	20.35	20.11	13.38	13.81	13.60	5.02	5.37	5.19	14.76	16.58	15.67	85.26	86.42	85.84
PSB	53.34	56.52	54.93	18.95	19.16	19.05	13.18	13.42	13.30	4.94	5.24	5.09	14.01	15.56	14.78	81.22	81.47	81.35

Azotobacter + PSB	90.76	95.84	93.30	22.22	23.48	22.85	20.26	21.00	20.63	5.83	6.22	6.03	26.24	25.70	25.97	96.16	98.09	97.12
Azotobazter + Azospirillum + Phoaphates solubilizer + PGPR	94.10	100.06	97.08	23.04	24.76	23.90	21.00	21.77	21.39	6.00	6.56	6.28	27.28	27.12	27.20	99.92	103.30	101.61
S.Em.±	2.62	2.44	1.79	0.62	0.75	0.49	0.49	0.54	0.36	0.14	0.17	0.11	0.62	0.61	0.43	2.19	2.59	1.69
C.D. (P=0.05)	7.46	6.95	5.03	1.76	2.14	1.37	1.39	1.53	1.02	0.39	0.48	0.31	1.76	1.74	1.22	6.23	7.36	4.76

Liquid bio inoculation

Across the years as well as in pooled analysis, inoculation of barley seed with liquid bio fertilizer consisted combination of *Azotobacter* + *Azospirillum* + Phosphates solubilizer + PGPR recorded maximum N, P and K content and uptake in grain and straw thereby total uptake which was found at par with *Azotobacter* + PSB inoculation, however, both these treatments significantly improved N, P and K content and uptake in grain and straw thereby total uptake over inoculation of *Azotobacter* and PSB alone during both years and pooled basis. The increase in N, P and K uptake was mainly due to the fact that nutrient uptake followed the yield pattern which increase due to seed inoculation of barley with different combinations of biofertilizers. Higher microbial activities due to seed inoculation with biofertilizers results in release of more nutrient which are easily taken up by the plants and results in higher nutrient content and uptake by grain as well as straw. Similar results for N, P and K uptake were reported by Ram *et al.* (2014) [26]. Further increase in nutrient content of plant ascribed to the beneficial role of organic manure and biofertilizer in mineralization of native as well as nutrients in soil through added fertilizers in addition to its own nutrient content which enhanced the available nutrient pool of the soil application. The results are in close agreement with the findings of several researchers (Prakash *et al.* 2015 and Tomar *et al.* 2016) [23, 35].

On the other hand, application of organic manures reduces phosphorus fixation by releasing considerable amounts a variety of organic acid during decomposition as well as inducing chelating effect of micronutrients which probably enhance the availability of phosphorus (Behra and Singh, 2010) [2]. Seed inoculation with PSB increased availability of phosphorus by solubilizing of native phosphorus which reflected into profuse root growth and development, thereby, increase in root traversing area in the soil facilitate more absorption of nutrient and PSB also produce organic acid which make acidic condition in microenvironment of soil thus increased availability of nutrients to plants. The beneficial effect of organic manure and inoculants on barley crop could be attributed to heterotrophic nature of organism used for inoculation which helped in their survival and multiplication. The improved physic-chemical properties with manures incorporation and the nutrients supplied or its transformation had positive effect on decomposed organisms as well as indirectly plant growth. Similar findings have been also reported by Bahadur *et al.* (2013) [1] and Prakash *et al.* (2015) [23]. It is well established fact that uptake of nutrient by crop is primarily governed by total biomass production and secondarily on nutrient status at cellular level. It also might be on account of proliferous root system developed under integrated nutrient management resulting in batter absorption in water and nutrient besides improved physical environment. Miller *et al.* (1987) [18] have also reported significant improvement in uptake of nutrients due to application of chemical fertilizer in conjunction with organic manures under different soil, crop and climate conditions. The regression studies also substantiated dependence of nutrient uptake on grain and straw yields and unit increase in grain and straw yield increased nutrient uptake. The results confirmed the finding of Rai *et al.* (2013) [25], Shantveerayya *et al.* (2016) [28] Shantveerayya *et al.* (2017) [27] and Neelam *et al.* 2018 [19].

Soil analysis

A reference of data (Table 3) indicates that application of fertility levels and liquid bio inoculants did not significantly influence pH and EC of soil after crop harvest from 0-15 cm soil depth during both the years of study as well as in pooled analysis.

Data show that fertility levels had significant effect on organic carbon, N, P and K content in soil after crop harvest during both the years of investigation as well as in pooled analysis. The barley crop fertilized with 125% RDF in conjunction with 5 t FYM ha^{-1} recorded significantly higher organic carbon, N, P and K content in soil after crop harvest over application of 75% RDF + 5 t FYM ha^{-1}, 125% RDF, 100% RDF and 75% RDF but remained at par with the application 100% RDF + 5 t FYM ha^{-1} during both years. Further analysis of data reported that application of 100% RDF + 5 t FYM ha^{-1} significantly higher organic carbon, N, P and K content in soil after crop harvest over application of 125% RDF, 100% RDF and 75% RDF but was on par with the application 75% RDF + 5 t FYM ha^{-1} during both years.

The positive influence of conjoint application of inorganic and organic fertilizer on nutrient status of plant parts seems to be on account of enrichment of nitrogen, phosphorus and potassium in the soil ecosystem. Further it can be attributed to their efficient extraction/translocation due to increase in root ramification/activities as organic manures play vital role in maintaining physico-chemical and biological properties of soils. In this direction Michael and Beringer (1980) [17] ascribed that expanded root promotes shoot growth which enhanced root metabolism. It is generally believed that in the plants, extracted nutrients used for maintaining their critical concentration that can be used for plant growth or development structures. The significant increase in available Nitrogen, phosphorus and potassium content in soil after harvest of crop may be ascribed to the beneficial role of FYM in the mineralization of native as well as its own nutrients which enhanced the available nutrient pool of the soil. As a matter of fact, all the available nutrients are not taken up by the plant and the rest remains in the soil which increases the available nutrient status of soil after harvesting of crop. The favorable condition for microbial as well as chemical activity due to addition of organic manures integrated with other nutrients augmented the mineralization of nutrients and ultimately increased the available nutrient status of soil. The use of organic manures being a store house of almost all the macro and micro nutrients required for plant growth, improved the soil environment by the way of improving physic-chemical properties of soil. Due to addition of organic manures the available nutrient status of soil increased considerably due to mineralization of native as well as applied nutrients through organics. The increased availability is also due to formation of organic chelates of higher stability with organic in the legends, which have longer susceptibility to adsorption, fixation and precipitation in soil.

Thus greater availability of nutrient with integrated nutrient management seems to have maintained critical concentration of these nutrients at cellular level after fulfilling their requirement for plant growth along with translocation toward sink components. Due to application of high level of fertilizers, more nutrient availability might have increased the cation exchange capacity of roots thereby increase the nutrient absorption and cellular contents in plants (Kumar *et al.*, 2002) [15]. The increase in uptake of nutrient was mainly due to the fact that nutrient uptake followed the yield pattern which increased with increasing the level of fertilization. Meena *et al.* 2012 [16], Shantveerayya *et al.* 2016 [28] and Jat *et al.*, 2018 [10] significantly increase in grain and straw uptake with increased fertility levels. Similarly, Katiyar and uttam (2003) [12] reported that the higher fertility levels increased the concentration and uptake of N, P and K in grains and straw.

Irrespective of year as well as in pooled analysis, barley seed treated with liquid bio fertilizer consisted combination of *Azotobacter* + *Azospirillum* + Phosphates solubilizer + PGPR recorded highest organic carbon, N, P and K content in soil after crop harvest which remained at par with *Azotobacter* + PSB inoculation, however, both these significantly enhanced organic carbon, N, P and K content in soil after crop harvest over inoculation of *Azotobacter* and PSB alone during both years and in pooled analysis. The improvement in soil status due to *Azotobacter* and PSB seed treatment could be attributed due to release of some organic acid and enzymes in soil and resulted in favorable condition in rhizosphere and thereby enhance nutrients availability. The significant increase in soil available N could be attributed to increased activity of nitrogen fixing bacteria there by higher accumulation of N in soil (Parmer *et al.* 1998) [21]. Further, P status of soil increased with increasing level of fertilizer due to limited utilization of P by crop from applied source, which resulted in building of soil phosphorus status (Prasad, 1994) [24]. Similar findings have been reported by (Swarup and Wanjari, 2000 and Gogoi, 2011) [33, 6].

Table 3: Effect of integrated nutrient management on total N, P and K uptake (kg ha^{-1}) of barley

Fertility levels	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})		
	2018	**2019**	**Pooled**	**2018**	**2019**	**Pooled**	**2018**	**2019**	**Pooled**
75% RDF	65.21	67.19	66.20	16.88	17.25	17.06	87.17	88.41	87.79
100% RDF	82.63	86.96	84.80	19.74	20.43	20.09	100.58	102.19	101.38
125% RDF	89.12	93.96	91.54	21.17	21.99	21.58	106.66	108.82	107.74
75% RDF + 5 t FYM ha^{-1}	94.65	99.91	97.28	22.36	23.36	22.86	113.27	115.67	114.47
100% RDF + 5 t FYM ha^{-1}	115.60	123.83	119.71	26.53	27.90	27.22	128.22	131.66	129.94
125% RDF + 5 t FYM ha^{-1}	120.49	128.11	124.30	27.75	29.13	28.44	131.37	134.60	132.99
SEM	3.82	3.88	2.72	0.64	0.73	0.49	3.65	3.69	2.59
CD	10.9	11.04	7.65	1.81	2.09	1.36	10.39	10.50	7.29
Liquid bio inoculants									
Azotobacter	76.06	80.15	78.11	18.41	19.18	18.79	100.02	103.00	101.51
PSB	72.29	75.68	73.98	18.12	18.65	18.38	95.23	97.03	96.13
Azotobacter + PSB	112.98	119.32	116.15	26.09	27.22	26.66	122.40	123.79	123.09
Azotobazter + Azospirillum + Phoaphates solubilizer + PGPR	117.15	124.82	120.98	27.01	28.33	27.67	127.20	130.42	128.81
SEM	3.12	3.17	2.22	0.52	0.60	0.40	2.98	3.01	2.12
CD	8.89	9.02	6.25	1.48	1.70	1.11	8.49	8.57	5.95

Table 4: Effect of integrated nutrient management on pH, EC, Organic carbon available N, P_2O_5 and K_2O of soil after crop harvest

Fertility levels	pH	EC	OC	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})
75% RDF	7.67	0.502	0.628	243.55	22.51	292.46
100% RDF	7.68	0.512	0.647	250.26	22.84	294.29
125% RDF	7.68	0.517	0.672	259.30	24.60	306.71
75% RDF + 5 t FYM ha^{-1}	7.62	0.512	0.712	274.50	25.88	317.77
100% RDF + 5 t FYM ha^{-1}	7.63	0.515	0.717	278.69	26.13	319.53
125% RDF + 5 t FYM ha^{-1}	7.64	0.519	0.742	292.49	28.60	332.15
SEM	0.13	0.009	0.009	3.06	0.29	3.32
CD	NS	NS	0.026	8.59	0.80	9.32
Liquid bio inoculants						
Azotobacter	7.65	0.528	0.690	256.87	23.79	299.77
PSB	7.63	0.518	0.675	250.24	24.04	302.79
Azotobacter + PSB	7.66	0.505	0.690	276.11	26.12	317.29
Azotobazter + Azospirillum + Phoaphates solubilizer + PGPR	7.67	0.502	0.690	282.99	26.43	322.10
SEM	0.11	0.008	0.008	2.50	0.23	2.71
CD	NS	NS	NS	7.01	0.66	7.61

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