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Response of Fertility Levels and Liquid Biofertilizers on Soil Chemical Properties and Nutrient Uptake under Wheat (*Triticum aestivum* L.) Crop

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ABSTRACT

A field experiment was conducted during *rabi* 2019-20 at Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur to examine the effect of fertility levels and liquid biofertilizers on soil chemical properties and nutrient uptake by wheat. The treatments comprised of four levels of fertility (i.e. control, 75, 100 and 125% RDF) and four levels of liquid biofertilizers (i.e. no inoculation, *Azotobacter*, PSB and *Azotobacter* + PSB). Experiment was laid out in Factorial Randomized Block Design with three replication taking wheat var Raj 4238 as test crop. The recommended dose of fertilizer (RDF) was 100:60:40 kg ha^{-1} of $N:P_2O_5:K_2O$. The results revealed that significant increase in available primary nutrient (nitrogen, phosphorus and potassium) in post harvest soil of wheat and also significantly increase in nitrogen, phosphorus, potassium, sulfur and micronutrients (Cu, Zn, Fe and Mn) uptake by wheat with increasing levels of fertility and liquid biofertilizers up to the 100% RDF and *Azotobacter* + PSB respectively.

Keywords RDF, Biofertilizers, Fertility levels, *Azotobacter*, PSB.

INTRODUCTION

The most significant crop for producing staple foods worldwide is wheat (*Triticum aestivum* L.). Wheat crop is cultivated over an area 17% of crop acreage. Wheat crop sharing about 50% calories in the human nutrition of our country. The chemical composition of wheat grain is 66–71.6% carbohydrates, 2.5–3.1% fats, 13–16.7% proteins and 2.5–3% crude fiber. There are different species of wheat out of which only three *Triticum* species are mostly cultivated all over the world. It is a self-pollinated crop originated from South West Asia. Globally, wheat (*Triticum* spp.) is cultivated over an area 220 million hectare and having the highest acreage position among all crops, with annual production of around 781 million tonnes. An estimated 101.20 million tonnes of grain

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(12.96% of the world's production) are produced in India on an area of 29.55 million hectares (13.43% of the world's total area with a productivity of 3424 kg ha^{-1} (Anonymous 2019). With a yield of 9.60 million tonnes of grain and a productivity of 3334 kg ha^{-1}, it occupies 2.88 million hectares in Rajasthan.

The physiological and metabolic processes of plants depend heavily on nitrogen. Additionally, it enhances the rate of photosynthesis, the length of time that leaves remain dark green, the amount of leaf area produced and net assimilation rate, the growth and development of stems and other vegetative elements, and the protein content of fodder crops. It raises agricultural output and improves food quality (Leghari *et al.* 2016, Bloom 2015 and Hemerly 2016).

A crucial nutrient component in the system of plants is phosphorus. It is referred to as the "key of life" since plants cannot complete their life cycles when this one ingredient is absent. For cell expansion, cell division, energy storage, seed maturation, seed development, photosynthetic activity, and delivery to the ripening grains, it is crucial (Hadis *et al.* 2018). It is a component of substances that are rich in energy, such as ATP, ADP, NADP, phytin, nucleic acid and phospholipids (Abdel-Aziz *et al*. 2018).

The plant growth-related enzymes are activated by potassium. It is crucial for stomatal function, nutrition and sugar transport, protein and starch synthesis, and stomatal activity. Potassium boosts plant resistance to drought, bug, pest, frost, lodging and disease incidence (Wang *et al.* 2013).

Conventional agriculture contributes significantly to feeding a growing world population, which has increased the use of pesticides and artificial fertilizers. The health of the soil has significantly decreased as a result of the indiscriminate and unbalanced use of chemical fertilizers, particularly urea, chemical pesticides and a lack of organic manure supplies. Eutrophication of water bodies caused by the overuse of phosphorus and nitrogen fertilizers pollutes the air and ground water (Youssef and Eissa 2014). Because of this situation, biofertilizers and other safe inputs are introduced. By fixing atmospheric nitrogen (N=N), converting insoluble phosphorus into usable form or mobilizing fixed macro and micronutrients for plants, biofertilizers serve a crucial role in preserving long-term soil fertility and sustainability. This increases the efficiency and availability of these nutrients for plants. Through the fixation of nitrogen, phosphate, and potassium, mineralization or solubilization, creation of antibiotics, release of chemicals that control plant growth, and biodegradation of organic materials in the soil, biofertilizers maintain a soil environment rich in all types of macro- and micro-nutrients (Sinha *et al.* 2014). They are eco-friendly and low cost inputs and can reduce chemical fertilizer dose by 25–50%. Liquid inoculants are particularly manufactured in nutrient-rich medium with specific compounds that protect live cells of the targeted microorganisms. These substances promote cell viability both during storage and during seed application. Additionally, it safeguards microbial cells from harsh soil conditions including desiccation and high temperature (Khandare *et al.* 2015). The microorganism population in liquid biofertilizers can reach 109 cells per ml for 12 to 24 months, and their dose is 10 times lower than in carrier-based biofertilizers. In comparison to carrier-based biofertilizers, the right use of liquid biofertilizers improves soil quality and crop output (Verma *et al.* 2018). As a free-living nitrogen-fixing bacterium with a variety of metabolic capabilities, *Azotobacter* is essential to the nitrogen cycle in nature (Sahoo *et al.* 2013). *Azotobacter* can also create plant hormones including indole acetic acid (IAA), cytokinins (CK) and gibberellins (GA), as well as vitamins like riboflavin and thiamine (Bhardwaj *et al.* 2014). Phosphate solubilizing bacteria (PSB) are helpful microorganisms that may solubilize organic substances by producing phosphatases into inorganic phosphorus compounds, such as phytase (Kalayu 2019).

MATERIALS AND METHODS

Site, soil and climatic conditions

The experiment was conducted during *rabi* 2019-20 at the Agronomy Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, India. The site was located at 24°35' north latitude, 73°42' east longitude and 582.17 meters above sea level.

The area is a part of Rajasthan's agro-climatic zone IVa (Sub-Humid Southern Plain and Aravalli Hills).

The composite soil sample was collected randomly before sowing of crop from the experimental field up to 15 cm depth. The composite sample was air dried under shade and passed through 2 mm sieve and then use for analysis. The soil of this area was clay loam (38.47%, silt 26.46% and clay 34.57%). The soil having pH 8.25, electrical conductivity 0.82 dSm^{-1}, soil organic carbon 0.56%, soil available nitrogen 253.80 kg ha^{-1}, phosphorus 20.09 kg ha^{-1} and potassium 380.03 kg ha^{-1}.

During cropping period of wheat, the corresponding mean weekly temperature fluctuations were observed during *rabi* season in year 2019, maximum and minimum temperature ranged between 37.3°C and 20.8°C, respectively. Total rainfall received during crope season is 42.6 mm was recorded.

According to the soil analysis, the experimental field's soil was a clay loam belonging to the *Typic haplustepts*, neutral alkaline in response, with medium levels of accessible nitrogen and phosphorus and a high level of potassium. Iron and zinc availability in the soil was poor.

Experimental design

The experiment was laid out in Factorial Randomized Block Design with replicated thrice in a plot of 5 m × 3 m (5 m^2). The treatments comprised of four levels of fertility viz., control, 75, 100 and 125% RDF and four levels of liquid biofertilizers viz., control, *Azotobacter*, PSB and *Azotobacter* + PSB. The wheat variety Raj 4238 was sown in line 22.5 cm apart.

Application of fertilizers

In wheat crop as per treatment required dose of nitrogen by subtracting the amount of N supplied through DAP and remaining by urea, P_2O_5 through DAP and K_2O through MOP was applied to the crop. The nitrogen dose (as per treatment) was applied in three splits the half was applied as basal and remaining half dose was applied in two equal splits during 1st and 3rd irrigation. The full quantity of phosphorus and potassium was applied as basal dose.

Seed treatment with liquid biofertilizers

A plastic bag was used to treat the seeds with liquid biofertilizers. The bag containing 1 kg of seeds and necessary amount of biofertilizers (@ 5 to 10 ml kg^{-1} seed of each biofertilizers) was applied. The bag was then sealed and squeezed to evenly moisten all the seeds. The bag was opened, and the seeds were left to dry in the shade for 20 to 30 minutes. Some plots have seeds that are treated with *Azotobacter* and PSB alone, whereas others have seeds that are treated with both.

Nutrient content and uptake

For the analysis of primary nutrients (N, P and K), sulfur and micronutrients (Zn, Mn, Cu and Fe) in the samples of grain and straw was taken during threshing of harvested wheat crop which was oven dried and then grinded by electrical grinder machine stainless steel Willey mill. Nutrient content in grain and straw were analyzed by using standard methods. The uptake of macronutrients (nitrogen, phosphorus, potassium and sulfur) was expressed in kg ha^{-1}, while their content in per cent. Micronutrients (Zn, Mn, Cu, and Fe) were discussed and their concentration was indicated in mg kg^{-1} or ppm, whereas their uptake was expressed in g ha^{-1}.

Uptake of macro and micro nutrients were calculated from the data of the macro and micro nutrients content in grain and straw by using the following formula :

For macronutrients

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%)} \times \text{Yield (kg/ha}^{-1}\text{)}}{100}$$

For micronutrients

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (mg kg}^{-1}\text{)} \times \text{Yield (kg ha}^{-1}\text{)}}{1000}$$

Statistical analysis

The obtained data were statistically analyzed with the techniques of analysis of variance as described by Steel and Torrie (1960). The comparison in the treatment mean was tested by critical difference (CD) at 5% (p=.05) level of significance.

RESULTS AND DISCUSSION

Soil chemical properties

Effect of fertility levels

The available nitrogen, phosphorus and potassium content in soil after harvest of wheat (Table 1) was significantly affected with increasing level of fertility. The highest available nitrogen (305.10 kg ha^{-1}), phosphorus (25.28 kg ha^{-1}) and potassium (445.80 kg ha^{-1}) content in soil was recorded with 125% RDF. However, 125% RDF remained at par with 100% RDF. The data further revealed that the percent increase in available N, P and K status of soil were in order of 12.88, 20.32 and 15.24 due to application of 100% RDF in comparison to control, respectively. The increase in available N, P and K in soil might be due to the increase in available N, P and K status of soil with application of inorganic fertilizers. The increase in NPK might be due to the increased enzymatic activity, microbial population and the organic recycling of plant nutrient which leading to greater mineralization of applied nutrients and thus increased the inherent nitrogen, phosphorus and potassium content in soil Gulser *et al.* (2019). Another reason could be the improvement in physico-chemical which helps in retention of nutrient in soil and prevent nutrients losses. The application of inorganic fertilization improve the soil pH for better nutrient availability.

Table 1. Effect of fertility levels and liquid biofertilizers on nutrient availability in soil after crop harvest.

Treatments	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
Fertility levels (RDF)			
Control (F_0)	270.28	21.01	386.82
75% RDF (F_1)	294.58	24.32	431.36
100% RDF (F_2)	305.1	25.28	445.8
125% RDF (F_3)	308.31	25.53	447.57
SEm±	3.29	0.29	4.68
CD (p = 0.05)	9.51	0.84	13.52
Liquid biofertilizers			
No inoculation (B_0)	276.36	21.09	378.14
Azotobacter (B_1)	293.2	22.72	414.5
PSB (B_2)	287.54	23.44	404.73
Azo + PSB (B_3)	303.73	25.20	447.08
SEm±	3.29	0.29	4.68
CD (p = 0.05)	9.51	0.84	13.52

Table 2. Effect of fertility levels and liquid biofertilizers on nitrogen, phosphorus, potassium and sulfur content of wheat.

Treatments	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)		Sulfur content (%)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Fertility levels (RDF)								
Control (F_0)	1.416	0.460	0.277	0.187	0.483	1.345	0.173	0.145
75% RDF (F_1)	1.490	0.512	0.311	0.203	0.521	1.435	0.193	0.153
100% RDF (F_2)	1.516	0.531	0.322	0.209	0.535	1.465	0.199	0.157
125% RDF (F_3)	1.519	0.533	0.326	0.211	0.545	1.468	0.202	0.158
SEm±	0.008	0.006	0.002	0.002	0.005	0.010	0.002	0.001
CD (p = 0.05)	0.023	0.018	0.005	0.005	0.014	0.029	0.006	0.004
Liquid biofertilizers								
No inoculation (B_0)	1.414	0.457	0.276	0.186	0.484	1.330	0.170	0.144
Azotobacter (B_1)	1.481	0.503	0.301	0.198	0.511	1.411	0.187	0.152
PSB (B_2)	1.470	0.488	0.297	0.195	0.499	1.387	0.183	0.150
Azotobacter + PSB (B_3)	1.518	0.532	0.325	0.208	0.538	1.466	0.203	0.161
SEm±	0.008	0.006	0.002	0.002	0.005	0.010	0.002	0.001
CD (p = 0.05)	0.023	0.018	0.005	0.005	0.014	0.029	0.006	0.004

Table 3. Effect of fertility levels and liquid biofertilizers on zinc, iron, manganese and copper content of wheat.

Treatments	Zinc content (ppm) Grain	Zinc content (ppm) Straw	Iron content (ppm) Grain	Iron content (ppm) Straw	Manganese content (ppm) Grain	Manganese content (ppm) Straw	Copper content (ppm) Grain	Copper content (ppm) Straw
Fertility levels (RDF)								
Control (F_0)	26.00	13.23	72.90	144.63	13.25	21.26	7.57	3.34
75% RDF (F_1)	26.45	13.43	74.86	146.88	13.59	21.74	7.72	3.50
100% RDF (F_2)	26.92	13.64	75.91	148.66	13.95	22.32	7.86	3.64
125% RDF (F_3)	26.95	13.65	76.09	148.89	13.97	22.51	7.87	3.66
SEm±	0.15	0.06	0.52	0.614	0.109	0.16	0.04	0.03
CD (p = 0.05)	0.44	0.19	1.50	1.774	0.313	0.46	0.13	0.10
Liquid biofertilizers								
No inoculation (B_0)	26.14	13.25	72.95	144.85	13.50	21.44	7.69	3.38
Azotobacter (B_1)	26.39	13.30	75.26	147.96	13.65	21.69	7.60	3.50
PSB (B_2)	26.36	13.29	73.99	146.88	13.52	21.45	7.60	3.58
Azotobacter + PSB (B_3)	26.47	13.43	75.57	148.84	13.89	21.70	7.78	3.50
SEm±	0.15	0.10	0.62	0.61	0.11	0.22	0.07	0.03
CD (p = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS

The increase in available phosphorus might be due to increased activity of microorganism leading to greater mineralization of applied and inherent phosphorus. Brar *et al.* (2015) reported that significant increase in soil available nutrient might be due to application of 100% RDF resulted more root biomass production and increased fertility status of soil which ultimately resulted more availability of nutrients. The increase in available P and K with application of nitrogen fertilization might be due to the synergistic effect between the N and P (Ibrahim *et al.* 2021). Similar results were also reported by Gourav *et al.* (2019) Muchhadiya *et al.* (2021).

Effect of liquid biofertilizers

The inoculation of seed with different liquid biofertilizers significantly increased the available nitrogen, phosphorus and potassium in soil after harvest of wheat (Table 1). The maximum available nitrogen (303.73 kg), phosphorus (25.20 kg ha^{-1}) and potassium (447.08 kg ha^{-1}) was recorded with inoculation of

Table 4. Effect of fertility levels and liquid biofertilizers on nitrogen, phosphorus, potassium and sulfur uptake by wheat.

Treatments	Nitrogen uptake (kg ha^{-1}) Grain	Nitrogen uptake (kg ha^{-1}) Straw	Phosphorus uptake (kg ha^{-1}) Grain	Phosphorus uptake (kg ha^{-1}) Straw	Potassium uptake (kg ha^{-1}) Grain	Potassium uptake (kg ha^{-1}) Straw	Sulfur uptake (kg ha^{-1}) Grain	Sulfur uptake (kg ha^{-1}) Straw
Fertility levels (RDF)								
Control (F_0)	43.03	23.20	8.41	9.43	14.67	67.83	5.25	7.31
75% RDF (F_1)	68.48	32.28	14.29	12.79	23.94	90.48	8.87	9.64
100% RDF (F_2)	74.54	35.30	15.83	13.89	26.30	97.41	9.78	10.43
125% RDF (F_3)	77.07	36.39	16.54	14.40	27.65	100.23	10.24	10.78
SEm±	1.47	0.66	0.33	0.26	0.52	1.88	0.19	0.23
CD (p = 0.05)	4.27	1.92	0.95	0.77	1.52	5.43	0.56	0.66
Liquid biofertilizers								
No inoculation (B_0)	43.43	22.93	8.47	9.33	14.86	66.75	5.22	7.22
Azotobacter (B_1)	65.81	30.86	13.37	12.15	22.70	86.58	8.31	9.32
PSB (B_2)	63.95	29.45	12.92	11.77	21.70	83.72	7.96	9.05
Azotobacter + PSB (B_3)	76.81	36.18	16.44	14.14	27.22	99.70	10.27	10.94
SEm±	1.47	0.66	0.33	0.26	0.52	1.88	0.19	0.23
CD (p = 0.05)	4.27	1.92	0.95	0.77	1.52	5.43	0.56	0.66

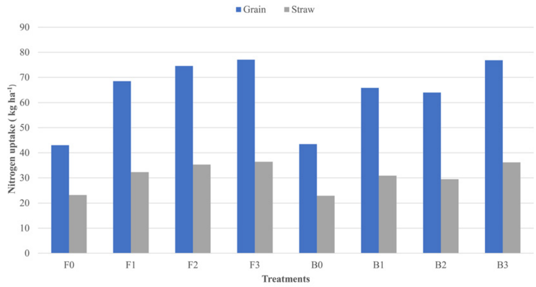

Fig. 1. Effect of fertility levels and liquid biofertilizers on nitrogen uptake by wheat.

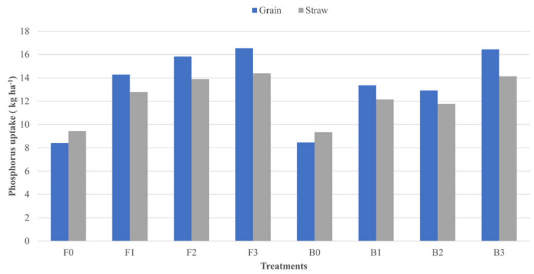

Fig. 2. Effect of fertility levels and liquid biofertilizers on phosphorus uptake by wheat.

seed with *Azotobacter* + PSB, respectively. The data further revealed that the percent increase in available N, P and K status of soil were in order of 9.90, 19.48 and 18.23 due to inoculation of *Azotobacter* + PSB in comparison to control, respectively. Co-inoculation of *Azotobacter* + PSB was found most effective in terms of increasing the available nitrogen and phosphorus status in soil. Organic acids secretion by PSB which can solubilize P from insoluble and fixed forms to plant available forms, whereas conversion of atmosphere nitrogen into plant available form of nitrogen in the soil by *Azotobacter* (Khandare *et al*. 2015). The increase in yield from biofertilizer inoculation may not be primarily attributable to nitrogen fixation and phosphorus solubilization, but also to a number of additional processes, including the production of hormones that promote development, the management of plant diseases and the expansion of beneficial organisms in the rhizosphere. Similar result was observed by Verma *et al.* (2023), Hindersah *et al.* (2018), Kumar *et al.* (2016).

Nutrient content and uptake

Effect of fertility levels

The application of increasing levels of fertility significantly improved the nutrient content and uptake by grain and straw of wheat (Tables 2, 3, 4, 5 and Figs. 1, 2 and 3). The maximum content and uptake (N 1.519% and 77.07 kg ha^{-1} in grain and 0.533% and 36.39 kg ha^{-1} in straw, P 0.326% and 16.54 kg

Table 5. Effect of fertility levels and liquid biofertilizers on zinc, iron, manganese and copper uptake by wheat.

Treatment	Zinc uptake (g ha^{-1})		Iron uptake (g ha^{-1})		Manganese uptake (g ha^{-1})		Copper uptake (g ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Fertility levels (RDF)								
Control (F_0)	79.01	66.72	221.55	729.47	40.28	107.25	23.02	16.85
75% RDF (F_1)	121.58	84.67	344.13	926.14	62.46	137.11	35.48	22.11
100% RDF (F_2)	132.37	90.69	373.31	988.46	68.61	148.40	38.65	24.26
125% RDF (F_3)	136.74	93.20	386.09	1016.69	70.89	153.75	39.93	25.03
SEm±	2.36	1.91	7.27	19.35	1.47	3.24	0.72	0.48
CD (p= 0.05)	6.83	5.58	21.007	55.91	4.26	9.38	2.10	1.40
Liquid biofertilizers								
No inoculation (B_0)	80.30	66.50	224.11	727.06	41.49	107.65	23.63	16.98
Azotobacter (B_1)	117.28	81.61	334.48	907.95	60.67	133.12	33.79	21.50
PSB (B_2)	114.67	80.22	321.89	886.69	58.83	129.49	33.07	21.62
Azotobacter + PSB (B_3)	133.94	91.33	382.42	1012.28	70.28	147.60	39.41	23.81
SEm±	2.36	1.91	7.273	19.35	1.47	3.24	0.72	0.48
CD (p = 0.05)	6.83	5.51	21.007	55.91	4.26	9.38	2.10	1.40

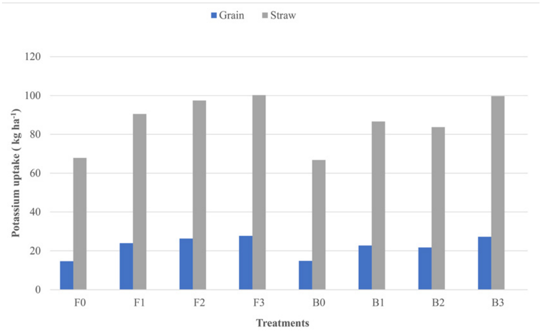

Fig. 3. Effect of fertility levels and liquid biofertilizers on potassium uptake by wheat.

ha^{-1} in grain and 0.211% and 14.40 kg ha^{-1} in straw, K 0.545% and 27.65 kg ha^{-1} in grain and 1.468% and 100.23 kg ha^{-1} in straw, S 0.202% and 10.24 kg ha^{-1} in grain and 0.158% and 10.78 kg ha^{-1} in straw, Zn 26.95 mg kg^{-1} and 136.74 g ha^{-1} in grain and 13.65 mg kg^{-1} and 93.20 g ha^{-1} in straw, Fe 76.09 mg kg^{-1} and 386.09 g ha^{-1} in grain and 148.89 mg kg^{-1} and 1016.69 g ha^{-1} in straw, Mn 13.97 mg kg^{-1} and 70.89 g ha^{-1} in grain and 22.51 mg kg^{-1} and 153.75 g ha^{-1} in straw, Cu 7.87 mg kg^{-1} and 39.93 g ha^{-1} in grain and 3.66 mg kg^{-1} and 25.03 g ha^{-1} in straw) of wheat was recorded under 125% RDF followed by 100% RDF and 75% RDF as compared to control. However, 125% RDF remained at par with 100% RDF. This might be due to adequate amount of NPK nutrient in the rhizosphere which enhanced root and shoot growth along with absorption of nutrient from deeper soil layers leading to enhanced translocation to reproductive structure such as seeds and other parts of plant. Availability of adequate amount of nitrogen increases the cation exchange capacity of roots thereby enabling them to absorb more nutrients from the soil (Jaswinder *et al.* 2019, Ibrahim and Voncir 2020). Meena *et al.* (2018) reported that uptake of nutrients by grain and straw increased due to higher availability of nutrients resulting higher yield of grain and straw. Similar result was observed by Sharma *et al.* (2013) and Singh and Singh (2017).

Effect of liquid biofertilizers

Liquid biofertilizers inoculation significantly enhanced the nutrient content and uptake by grain and straw of wheat (Tables 2, 3, 4, 5 and Figs. 1, 2 and 3). The highest content and uptake (N 1.518% and 76.81 kg ha^{-1} in grain and 0.532% and 36.18 kg ha^{-1} in straw, P 0.325% and 16.44 kg ha^{-1} in grain and 0.208% and 14.14 kg ha^{-1}in straw, K 0.538% and 27.22 kg ha^{-1} in grain and 1.466% and 99.70 kg ha^{-1} in straw, S 0.203% and 10.27 kg ha^{-1} in grain and 0.161% and 10.94 kg ha^{-1} in straw of wheat was recorded with inoculation of seed with *Azotobacter* + PSB, respectively. The micronutrient like Zn, Fe, Mn and Cu content in grain and straw was found to be non-significant with the inoculation of *Azotobacter* + PSB (Table 3), while uptake of Zn, Fe, Mn and Cu by grain and straw significantly increased due to inoculation of biofertilizers. The maximum nutrient uptake (Zn 133.94 g ha^{-1} by grain and 91.33 g ha^{-1} by straw, Fe 382.42 g ha^{-1} by grain and 1012.28 g ha^{-1} by straw, Mn 70.28 g ha^{-1} by grain and 147.60 g ha^{-1} by straw, Cu 39.41 g ha^{-1} by grain and 23.81 g ha^{-1} by straw) of wheat was recorded due to inoculation of seed with *Azotobacter* + PSB. The mineralization of organic nitrogen and phosphorus increases the availability of nitrogen and phosphorus in soil which have resulted in greater uptake of nutrients by plants by inoculation of nitrogen and phosphorus fixing bacteria (Bahadur *et al.* 2013). The increase in nutrient uptake with inoculation of *Azotobacter* might be due to production of growth hormones such as auxins and gibberellic acids that allowed better root development acquisition of more nutrients from soil (Khandare *et al.* 2019). Secretion of organic acids by PSB which solubilize the K in soil and might have increased the K uptake (Khandare *et al.* 2015). Thus synergistic effect of biofertilizers increased the content and uptake of nitrogen, phosphorus and potassium in grain and stover. These results are in close conformity with those of Singh *et al.* (2013), Maheswari and Elakkiya (2014) and Khan *et al.* (2015).

CONCLUSION

On the basis of findings, the it is concluded that the combine application of inorganic fertilizers with liquid biofertilizers significantly improve the soil nutrient content and nutrient uptake by crop. The application of 100% RDF + *Azotobacter* + PSB in wheat found significant in term of significant increase in available nitrogen, phosphorus and potassium in post harvest soil of wheat and also significantly increase in nutrient (N, P, K, S, Zn, Fe, Mn and Cu) content and uptake by wheat under the Sub-humid Southern Plain and Aravalli Hills of Rajasthan (Zone IVa) agro climatic condition.

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