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Soil nutrient studies under integrated nutrient management in baby corn (*Zea mays* L.)

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Abstract
In race towards high production and profit from agriculture, the farmers are adopting abnormal production technologies like heavy and injudicious use of chemical fertilizers that have reduced the factor productivity due to negative effect on soil fertility status. Therefore, it's an urgent need to optimize the integrated nutrient management in different crops including baby corn. The present study was thus carried out during *Kharif* season 2015 at the Instructional Dairy Farm (IDF), Nagla, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand to study soil nutrient status under the effect of integrated nutrient management. The experimental design was Randomized Block Design with 11 treatments consisting of sole application of NPK fertilizer, sole application of *Azotobacter* and *Azospirillum*, and application of Azotobacter and Azospirillum along with NPK fertilizer. The different integrated nutrient management practices had significantly equal organic carbon, however the highest value was recorded at application of 100% NPK and 100% NPK+*Azot*+*Azos*. Significantly highest available N and K content was recorded at 100% NPK+*Azot*+*Azos* whereas available P was recorded significantly highest at 75% NPK+*Azot*+*Azos* in soil after crop harvest. Higher apparent nitrogen and potassium balance was recorded at 100% NPK+*Azot*+*Azos* while apparent phosphorus balance was found highest at application of 75% NPK+*Azot*+*Azos*. Application of biofertilizers also had better apparent nutrient balance than alone application of chemical fertilizers. The bacterial population differed significantly by different integrated nutrient management practices. The highest bacterial population was recorded at 100% NPK+*Azot*+*Azos* followed by 75% NPK+*Azot*+*Azos* but both remained non-significant with each other. INM thus showed positive effect on soil chemical and biological properties, and so maintained positive nutrient balance in soil.

Keywords: *Azotobacter*, *Azospirillum*, organic acrbon, bacterial population, integrated nutrient management

Introduction
Integrated use of nutrients including low cost biofertilizers, organic manures and chemical fertilizers and also other nutrient sources like crop residues, sewage and sludge, industrial effluents etc. are not only beneficial but also sustain the soil and crop productivity. (Ranjan *et al*., 2013, Mahajan *et al*., 2007 and Dadarwal *et al*., 2009) [11, 9, 3]. Integrated nutrient management (INM) refers to judicious application of different nutrient sources in balanced proportion for sustaining soil and crop productivity. Biofertilizers play vital roles in soil fertility, crop productivity and they are also ecofriendly because biofertilizers add 20-200 kg N/ha/year (eg- *Rhizobium spp,* 50-100 kg N/ha and *Azotobacter* / *Azospirillum*, 20-40 kg N/ha) under optimum soil condition and thereby increase 15-25% of total crop yield, (*http://www.agriinfo.in*, 2015) [7]. Biofertilizers help to increase the nutrient availability and to restore the soil fertility for better response of the crop. It is an important component of integrated nutrient management system because of its significant role in sustaining the soil properties. Dadarwal *et al.* (2009) [3] reported that continuous application of FYM enhanced the availability of NPK status of soil after harvest of baby corn. Singh *et al.* (2010) [10] revealed that with application of 180 Kg N + 38.7 Kg P_2O_5 + 74.7 Kg K_2O ha^{-1} and 50% N supplied through FYM resulted in significant increase in available NPK in soil after harvest of baby corn**.** *Azotobacter* and PSB alone or in combination increased N and P content in grain and stover yield which could be attributed to greater availability of nitrogen through biological nitrogen fixation by the *Azotobacter* and phosphorus through better solubilization of phosphorus and the uptake of Nitrogen and Phosphorus increased with combined inoculation of seeds with *Azotobacter* + PSB (Dadarwal *et al*., 2009 and Balai *et al*., 2011) [3, 2]. Ebrahimpour *et al.* (2011) [4] reported that significant increase in soil nutrients due to use of biofertilizers and non-chemical sources provided a reliable alternative to chemical fertilization

In organic crop production. Ghaffari *et al*. (2011) [4] reported that the nutrient use efficiency was improved up to 11.5% due to combined effect of recommended dose of NPK along with single spray of multinutrient. Ali *et al*. (2012) [1] revealed that integrated nutrient management was one of the good approach for nutrients management in the environmental balance. Kannan *et al.* (2013) [8] noticed that the integrated nutrient management significantly influenced the maximum increase in organic carbon as a result of integrated use of vermicompost and recommended dose of NPK. The integrated nutrient treatments might have resulted in sufficient amount of released nutrients by mineralization at a constant level and increased the nutrient uptake because of the better soil environment created owing to cumulative effect of organic sources combined with inorganic source of nutrients (Hashim *et al*., 2015) [6]. INM thus have positive effect on soil fertility but studies specific to INM in baby corn are few and so this study was planned to determine the soil nutrient status under integrated nutrient management in baby corn.

Material and methods

The experiment was conducted at the Instructional Dairy Farm (IDF), Nagla, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand, India. The Instructional Dairy Farm is located in the *Tarai* belt of Shivalik range of Himalayas with humid sub-tropical type of climate at latitude of 29°N and longitude of 79.3°E and situated at an altitude of 243.84 m above the mean sea level. The climate of the *Tarai* region is broadly humid sub-tropical with harsh winter and hot dry summers. The soil of the experimental field was slightly silty clay loam (Nagla series, Mollisol) in texture, from dark greyish brown to dark grey in humus with weak, fine to medium granular structure.

Eleven treatments were tested in a Randomized Block Design 3 replications the treatments were Control (no application), 50% NPK, 100% NPK(180:60:40), Seed treatment with Azotobacter @200g/10Kg seeds, Seed treatment with Azospirillum @200g/10Kg seeds, Seed treatment with Azospirillum + Azotobacter, 50% NPK + Seed treatment with Azotobacter, 50% NPK + Seed treatment with Azospirillum, 50% NPK+ Seed treatment with Azospirillum + Azotobacter, 50% NPK+ Seed treatment with Azospirillum + Azotobacter and 100%NPK+seed treatment with Azospirillum + Azotobacter. The variety sown was V.L. Baby corn-1 – released from Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, Uttarakhand.

Results and discussion

Organic carbon

The organic carbon after crop harvest was not affected significantly by different integrated nutrient management practices, however the highest organic carbon was recorded with application of 100% NPK+*Azot*+*Azos* and 100% NPK followed by 75% NPK+*Azot*+*Azos*.

Available nitrogen

The highest available nitrogen was estimated with application of 100% NPK+*Azot*+*Azos* that remained significantly at par with seed treatment with *Azospirillum*, seed treatment with *Azot* + *Azos*, 50% NPK+*Azot*, 50% NPK+*Azot*+*Azos* and 75% NPK+*Azot*+*Azos*. Among the treatments treated with biofertilizers, seed treatment with *Azot* + *Azos* recorded significantly higher available nitrogen that remained non-significant with seed treatment with either of *Azotobacter* and *Azospirillum*.

Available Phosphorus

The highest available phosphorus was measured with application of 75% NPK+*Azot*+*Azos* that was non-significant with seed treatment with *Azotobacter*, seed treatment with *Azot* + *Azos*, 50% NPK+*Azot*, 50% NPK+*Azot*+*Azos* and 75% NPK+*Azot*+*Azos*. All treatments treated with biofertilizers alone remained non-significant with each other's. However, the higher available phosphorus was recorded at both 50% NPK+*Azot* and 50% NPK+*Azot*+*Azos* treatments.

Available Potassium

100% NPK+*Azot*+*Azos* recorded significantly higher available potassium that remained statistically at par with seed treatment with *Azotobacter*, *Azot* + *Azos*, 50% NPK+*Azos*, 50% NPK+*Azot*+*Azos* and 75% NPK+*Azot*+*Azos*. The seed treatment with *Azot* + *Azos* had the higher available potassium among the biofertilizer treatments only but remained non-significant with seed treatment with *Azotobacter*.

Higher values of available nitrogen, phosphorus and potassium due to integrated nutrient sources might be a result of solubilzation of simple and available form of nutrients, action of biofertilizers on native phosphorus at the time of decomposition making more phosphorus available and reduction of potassium fixation. The data pertaining to soil test values i.e. organic carbon, available nitrogen, available phosphorus and available potassium after crop harvest is given in table 1.

Apparent nutrient balance

The highest apparent nitrogen balance was recorded under 100% NPK+*Azot*+*Azos* followed by 75% NPK+*Azot*+*Azos*, 50% NPK+*Azot*+*Azos* and seed treatment with *Azot* + *Azos* and. The apparent phosphorus balance was recorded highest under 75% NPK+*Azot*+*Azos* followed by 100% NPK+*Azot*+*Azos* and all treatments had negative apparent P balance with maximum under control followed by 50% NPK and 100% NPK application. The apparent K balance was also noticed highest under 100% NPK+*Azot*+*Azos* followed by 75% NPK+*Azot*+*Azos*, 50% NPK + Biofertilizers as well as seed treatment with *Azotobacter* and *Azot* + *Azos*. The lowest K balance was recorded under control. In general, the seed treatment with *Azotobacter* and *Azospirillum* and coupled with 50, 75 and 100% NPK had positive nutrient balance compared to alone application of chemical fertilizer. It might be due to the improvement in nutrient status either through fixation of atmospheric nitrogen, production of phyto hormones or mobilization of nutrients that resulted into more residual soil nutrients in the soil.

Bacterial population

The highest bacterial population was recorded at application of 100% NPK+*Azot*+*Azos* followed by 75% NPK+*Azot*+*Azos*, however both were non-significant with each other. The treatments treated with *Azotobacter*, *Azospirillum* or combined application remained non-significant with each other but the highest bacterial population was recorded under seed treatment with *Azotobacter* followed by *Azot* + *Azos*. The 50% NPK +*Azot* + *Azos* had the higher bacterial population among treatments having 50% NPK coupled with seed treatment with biofertilizers. The data pertaining to apparent nutrient balance and bacterial population is given in table 2

Conclusion

The seed treatment with *Azotobacter* and *Azospirillum* and coupled with 50, 75 and 100% NPK showed positive nutrient balance compared to alone application of chemical fertilizer. Significant increase in soil nutrients due to use of biofertilizers and non-chemical sources thus provide a reliable alternative to chemical fertilization in crop production.

Table 1: Effect of integrated nutrient management on organic carbon, available nitrogen, phosphorus and potassium in soil after crop harvest

Treatment	Organic carbon (%)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Available Potassium (kg/ha)
At initial level	0.72	278.48	27.80	233
Control	0.66	259.5	21.0	217.0
Azotobacter	0.68	275.0	27.0	236.0
Azospirillum	0.66	277.0	25.0	231.0
Azot +Azos	0.67	280.0	27.0	238.0
50% NPK	0.68	265.0	22.0	228.0
100% NPK	0.71	269.0	24.0	230.0
50% NPK + *Azotobacter*	0.67	277.0	27.5	234.0
50% NPK +*Azospirillum*	0.68	275.0	25.0	235.0
50% NPK + *Azot+ Azos*	0.69	281.5	27.5	237.0
75% NPK + *Azot+ Azos*	0.70	281.0	29.0	237.5
100% NPK + *Azot + Azos*	0.71	282.3	28.0	239.0
SEm±	.01	1.8	0.9	1.6
LSD (p=0.05)	ns	5.4	2.8	4.8

Table 2: Effect of integrated nutrient management on apparent nutrient balance in soil after crop harvest

Treatment	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Total Bacterial Population
				Bacteria (×10^6 cfu g^{-1} soil)
Control	-19.0	-6.8	-16.0	2.01
Azotobacter	-3.5	-0.8	3.0	2.29
Azospirillum	-1.5	-2.8	-2.0	2.10
Azot +Azos	1.5	-0.8	5.0	2.28
50% NPK	-13.5	-5.8	-5.0	2.10
100% NPK	-9.5	-3.8	-3.0	2.14
50% NPK + *Azotobacter*	-1.5	-0.3	1.0	1.94
50% NPK +*Azospirillum*	-3.5	-2.8	2.0	2.41
50% NPK + *Azot+ Azos*	3.0	-0.3	4.0	3.51
75% NPK + *Azot+ Azos*	2.5	1.2	4.5	3.90
100% NPK + *Azot + Azos*	3.9	0.2	6.0	4.08
SEm±	-	-	-	0.18
CD at 5%	-	-	-	0.54

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