International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(6): 3070-3076

Received: 22-09-2019
Accepted: 24-10-2019

Usha Kumari
Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru, Karnataka, India

A Sathish
Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru, Karnataka, India

Corresponding Author
Usha Kumari
Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru, Karnataka, India

Assessment of crop productivity and soil nutrient status under different levels of nitrogen in cereal-pulse based cropping system

Usha Kumari and A Sathish

Abstract
The effect of increasing level of nitrogen on grain yield of finger millet, maize and field bean, and available soil nutrient status was studied in the experiment. Two experiments were conducted at AICRPDA and AICRP on Agroforestry, under rainfed and irrigated conditions, respectively. Split plot design was used which consist of three levels of nitrogen viz., high (100% Recommended dose RD), medium (50% RD) and low (no application of nitrogen) as subplot and type of crop grown as finger millet, field bean and maize were grown as main plot under both irrigated and rainfed conditions. Apart from nitrogen, other cultural practices were followed as per the package of practices. Available nutrients of soil were analysed and grain yield were recorded after the harvesting of crop. It was found that increased level of nitrogenous fertilizer enhanced the grain yield in all the crops and impact was more pronounced under irrigated experiment. Available nitrogen and micronutrients were recorded in increasing trend with increase in the nitrogen level. However, the impact was more in maize crop. Available phosphorus and potassium content in soil a decreased in content with increase in level of nitrogen. The interaction effect of crop grown and level of nitrogen was recorded non-significant under available nutrients content in rainfed condition while in irrigated condition interaction was found significant for potassium and micronutrients except copper. Thus, it was concluded that higher nitrogen level increased the crop yield as well as maintained the soil nutrient status in the soil as compared to low level. Cultivation of different crops has differential impact on soil nutrient status and plays an important role in the soil fertility.

Keywords: Nitrogen level, crop type, available nutrient status, irrigated, grain yield

Introduction
Cereal-pulse based cropping system is one of the most adopted types of cropping system among the farmers of Karnataka. Finger millet, field bean and maize are among the major crops grown in the state under cereal pulse based cropping system. The cultivation of these crops affect the soil nutrient status differentially. Field bean being the nitrogen fixing crop improves the fertility of the soil in long term. Finger millet is the staple crop of Karnataka state and included in dietary routine along with maize. Finger millet in Karnataka occupies about 1 million ha area with production of 1.8 million tons. It is cultivated on varied soils and climatic conditions owing to wider adaptability and tolerance to stress situations. Similarly, Karnataka contributes in field bean nearly 90% of area and production in the country (Sultan Singh *et al*., 2010). It is grown annually in an area of 79,462 ha (66,976 ha in Kharif and 12,486 in Rabi / summer) with a production of 68014 tons (64,215 in Kharif and 3,799 tonnes Rabi / summer) in Karnataka. (Anon., 2010) [1]. India produces about 2% the world's maize produce. Karnataka is the leading producer of maize in India producing around 16% of India's total Maize production. Normal area under maize cultivation is 11.3 lakh ha in Karnataka and accounted highest production compared to whole of India. (Anon., 2017).
The crop growth is mainly governed by the nutritional status, specifically nitrogen as it is a structural constituent of plant cell and constitutes amino acids, proteins, nucleic is acids, etc. Nitrogen is normally a key factor in achieving optimum grain yields (Fageria *et al*., 1997) [4]. It is, however, one of the most expensive inputs and if used improperly, can pollute the ground water. Combined with low soil fertility, low nitrogen rates as a risk management strategy might contribute to nitrogen deficiency (Monjardino *et al*., 2013; Monjardino *et al*., 2015) [9]. The different level of nitrogen affects the yield as well soil nutrient status and it imparts its effect differentially among crop types.

Keeping these points in view, the study has been carried out to see the effect of different level of nitrogen on yield of finger millet, field bean and maize and their interactive effect on soil available nutrients.

Material and Methods

The present study was conducted in two different experimental plots, one under rainfed condition at AICRPDA and another irrigated at AICRP on Agroforestry, GKVK, UAS, Bengaluru during the season 2016-2017. The experimental field have been divided according to the split plot design into 36 plots which have three main treatments as cropping system which includes finger millet, field bean and maize crops. This main plots are further divided into three sub-plots which represents three levels of nitrogen high, medium and low and details of these treatments is mentioned in the table below. The cultivation practices followed as per the package and practices of UAS, Bengaluru prescribed for the above mentioned crops apart from the nitrogen application. The experimental details are:

Location: AICRPDA and AICRP on Agroforestry, GKVK, Bengaluru.

Crop: Finger millet, Maize, Field Bean/Lablab

Statistical Design : Split Plot

Number of Treatments 9

Number of Replications 4

Season: *Kharif* 2017

Table 1: Dimensional detail of the experimental plots

		Mains plot	Sub plot	Total dimension
Rainfed	Plot size (sq. m)	12×18	6×6	60×54
	Spacing (cm)	13.5 x 9 Finger millet	30×30 Maize	45×15 Field bean/lablab
Irrigated	Plot size (sq. m)	18×30	6×6	96×78
	Spacing (cm)	18×6 Finger millet	60×30 Maize	60×15 Field bean/ lablab

Treatment details: Three main plot treatments consist of cultivation of crops like maize, finger millet and field bean which are further divided into three subplots representing low dose of nitrogen that implies zero amount of nitrogen was applied, medium implies that 50% of the recommended dose of nitrogen had applied and high level which consist of 100% of recommended dose of nitrogen was applied. All other nutrients were applied as per the recommended doses of that particular crop. This set of experiment was conducted in this manner at both irrigated and rainfed condition at the respective selected fields.

Fertilizers details

Table 2: Fertilizers quantity applied

Crops varieties	Irrigated (kg ha -1)			Rainfed (kg ha -1)		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Finger millet MR-6	100	50	50	50	37.5	40
Field bean HA-4	25	50	25	25	50	25
Maize Nityashree	150	75	40	100	50	25

Layout of the experiment: Rainfed experiment

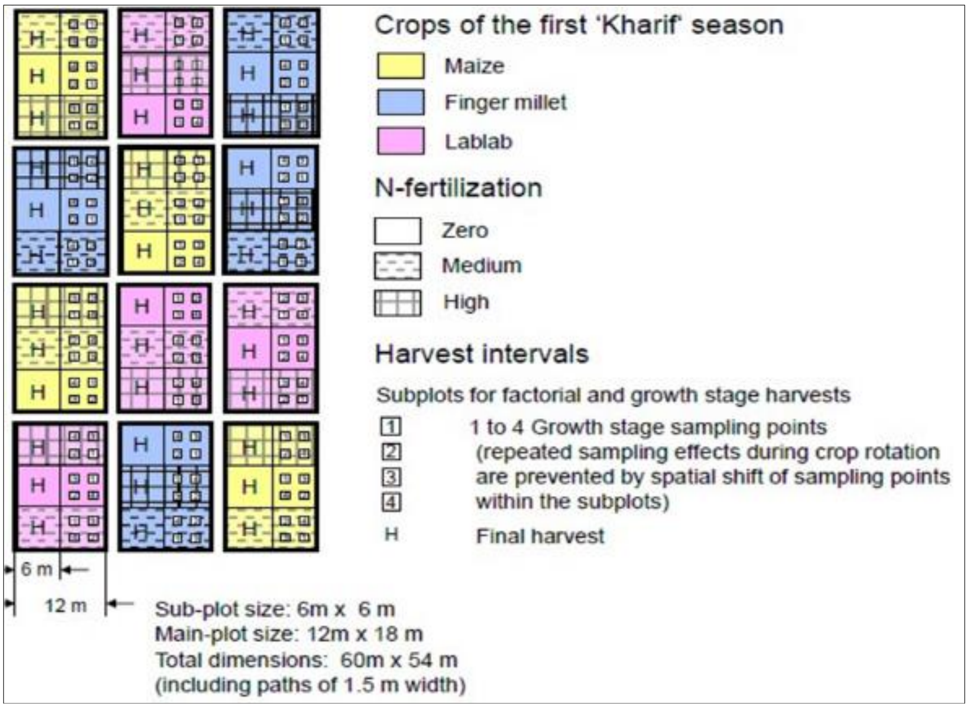

Fig 1: Layout of Irrigated experiment

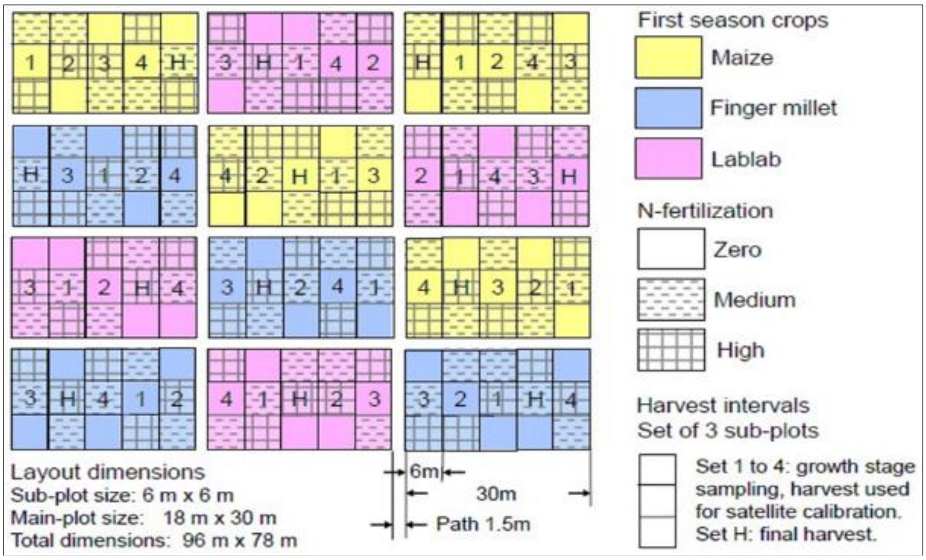

Fig 2: Layout of the experiment: irrigated experiment

Cultivation of crops: The crops were cultivated adopting the package of practices in the plots according to the given layout and carried out all the intercultural operation timely. Except the nitrogen all the nutrients were applied at the basal dose and nitrogen was applied in two splits, along 2/3 as basal and rest during tillering stage. The varieties sown are MR-6 for finger millet, HA-4 for field bean, Nityashree for maize. The crops were harvested at optimum stage (plot wise) and the yield were pooled crop wise under different level of nitrogen.
The rainfed experiment was carried out without the additional irrigation while timely additional supply was water was provided under irrigated field as per the crop demand (soil sensors and lysimetric reading). Each of the experiment was carried out differently under split plot design while merely mean of the data was compared.

Collection, processing and analysis of soil samples: The soil samples from each of the 36 plots have been collected from 0-15 cm depth after the harvest of crops and analysed for the soil physico-chemical properties and nutrient status to analyse the effect of different level of nitrogen as well as cropping system on soil nutrient status and soil properties. Initial soil samples were collected before the sowing of crop and analysed basic soil properties

Yield and yield attributes: Yield attributing parameters are different for different crops and were recorded at the respective stages of each of the crops. Yield of each of the crop was recorded plot wise and pooled in terms of kg ha-1.

Methodology used to determine available nutrients

Table 3: Methodology used to determine available nutrients

Parameter	Method	Reference
pH (1:2:Soil:water suspension)	Potentiometric method	Jackson, 1973
EC (1:2:Soil:water suspension)	Conductometric method	Jackson, 1973
Soil organic Carbon	Wet oxidation method	Walkey and Black, 1934
Available N	Kjeldahl-distillation	Subbaiah and Asija, 1956
Available P2O5	Brays extraction method	Bray and Kurtz. 1945
Available K2O	Flame photometry	Jackson, 1973
DTPA extractable Micronutrients	Atomic Absorption Spectrophotometer	Lindsay and Norvell, 1978

Statistical analysis
The data obtained was subjected to analysis using OPSTAT software with spilt plot analytical method without any transformation. Least square difference was used to compare the treatment effect at $P<0.05$.

Results and Discussion
Initial soil properties

Table 4: Initial soil properties

Parameters	Values
pH	5.90
EC(dSm-1)	0.13
Available Nitrogen (kg ha-1)	284
Available Phosphorus (P_2O_5) (kg ha-1)	21.66
Available potassium (K2O) (kg ha^{-1})	91.69
DTPA extracted iron (mg kg-1)	11.08
DTPA extracted manganese (mg kg-1)	16.22
DTPA extracted zinc (mg kg-1)	1.34
DTPA extracted copper (mg kg-1)	1.26
Exchangeable calcium (m eq/ 100g soil)	2.5
Exchangeable magnesium (m eq/ 100g soil)	0.5
Boron (ppm)	0.5

Available macronutrients

Available Nitrogen: The available nitrogen content under rainfed experiment was found significantly higher in the plot which receive higher dose of nitrogen (N3) fertilizer under field bean cultivation (498.86 kg ha-1) (Table 2). This might be due to the nitrogen fixing ability of the field bean crop which increases the available nitrogen content in the soil. This was followed by same level (N3) of nitrogen application under maize cultivated field with value of 416.71 kg ha-1. The lowest for available nitrogen was found with low nitrogen level i.e, no application of nitrogen (N1) under finger millet. These results are confirmatory with Mourya (2011) [10] who found linear increase in available nitrogen with increasing the dose of nitrogen fertilizers. Similarly, under irrigated experiment (Table 1), the significantly higher available nitrogen was recorded in N3 treatment under maize crop cultivation plot (285.07 kg ha-1). This may be due to the higher rate of fertilizer application leads to higher availability of nitrogen and as maize is an exhaustive crop, its nutritional demand was also higher. The amount of added fertilizers was higher in the maize crop as compared to other two crops and hence imparted higher amount of available nitrogen in the soil. The soil under finger millet at N_1 level of nitrogen was recorded with lowest amount of available nitrogen which might be due to no application of fertilizer (151.01kg ha-1). These results are also supported by the Goshu *et al*. (2015). However, there was no significant difference observed with the interaction of crop grown and nitrogen levels applied.

Available Phosphorus

Significantly higher amount (61.30 kg ha-1) of available phosphorus was recorded in the N_1 treatment under field bean (lablab) cultivation in rainfed experiment (Table2). The probable reasons may be low rate nitrogen application leads to poor vegetative and root growth which leads to low rate of nutrient absorption from the soil and hence more abundance of phosphorus in it. The lowest amount was observed in N_3 treatment with higher dose of nitrogen under maize crop as maize is an exhaustive crop and absorb higher amount of nutrient from the soil leaving lesser content in the soil. Similar results were in the favor of findings of Mourya (2011) [10] who found decrease in the phosphorus availability with increase in nitrogen dosage. In irrigated experiment, the trend followed was similar and significantly higher content (11.41 kg ha-1) was observed in N_1 treatment with lower nitrogen application under maize cultivation (Table 1). Lowest amount 6.86 kg ha-1 was observed under finger millet cultivation. Du Preez (1999) [2] and Eludoyin (2011) [3] also found decrease in available phosphorus under corn cultivation due to higher absorption by the crop.

Available Potassium

Available potassium was recorded significantly higher (153.89 kg ha-1) in maize crop followed by finger millet plot under N_1 low application of nitrogen while lowest amount of 70.39 kg ha-1 was observed under field bean cultivation with higher nitrogen (N_3) application in rainfed field experiment (Table 2). This might be due to the similar reason as observed in phosphorus, optimum supply of nitrogen flourished good vegetative growth and which in turn enhances the uptake of nutrient and deplete the available nutrient content in the soil. Similarly, under irrigated experiment the available potassium content (184.33 kg ha-1) (Table1) was found significantly higher in N_1 level of nitrogen under maize while lowest (70.39 kg ha-1) was observed in N_3 level of nitrogen under field bean. The lowest amount observed in N_3 level of nitrogen may be due to the more uptake of nutrients from the soil under all the crops. These result were in complimentary to Mourya (2011) [10] who also found decrease in potassium with increase in the nitrogen level under French bean.

However, the interaction of both the factor was found non-significant in the rainfed as well as under irrigated experiment.

Available micronutrients

DTPA extractable iron, manganese, zinc and copper analysed under rainfed experiment recorded significantly higher amount under (N_1) high dose of nitrogen application irrespective of the crops. However, among the different crops higher content of iron, zinc and copper was observed under maize crop with 15.31, 4.28 and 1.78 Kg ha-1, respectively. DTPA extractable Mn was found higher under field bean cultivation (21.89 Kg ha-1) at N_3 level of nitrogen. Similar, results were obtained by Rangaraj *et al*. (2007) and Sandhya *et al.* (2017) [14] who found higher available micronutrients in the treatment which receives higher doses of nitrogen in finger millet crop.

Manganese was reported significantly higher under field bean crop irrespective of dose of nitrogen and reported higher interactive value of 21.89 kg ha-1 in N_3 level of nitrogen in field bean crop. The lower amount of iron, zinc, manganese and copper micronutrient was observed under N_1 level of nitrogen irrespective of crops type grown and lowest value observed was 8.89, 1.04, 11.65, 0.95 mg kg-1 in case of iron, zinc, manganese and copper (Table no 4). The interaction of crop grown type and level of nitrogen application was found non-significant under both rainfed and irrigated conditions. The higher availability of micronutrients under N_3 level of nitrogen was due to the more vegetative growth of the crop due to more application of nitrogen which leads to increase activity of roots and microbes and secretions which may increase the availability of micronutrients.

The irrigated experiment also showed significantly higher DTPA extractable iron, manganese, zinc and copper under N_3 treatment high level of nitrogen irrespective of crop type and lower was observed under N_1 treatments which received low nitrogen. The crop wise higher contents of iron, manganese and zinc were observed as 17.89, 3.18, 41.1 mg kg-1 (Table 3) under maize cultivation while higher copper content of 2.23 mg kg-1 was recorded in finger millet crop. The interaction of the both the factors was observed non-significant for all of the micronutrients.

Grain yield

The treatments which received high level of nitrogen showed higher yield in all the three crops. The grain yield of field bean was found significantly highest in high level nitrogen treatment recorded as 1101 kg ha-1 while lowest (812 kg ha-1) was observed in treatment with low level of nitrogen. Similarly, finger millet and maize have recorded higher as 3254 kg ha-1 and 6854 kg ha-1 under high level of nitrogen and lowest as 2968 kg ha-1 and 5892 kg ha-1 respectively. Similar results were reported by Sultana *et al*., (2005) [16] and Khan *et al*. (1992) [6] who found higher dry matter yield when extra N fertilizer was applied to the land. In irrigated field experiment the recorded yield was significantly higher than the rainfed although not statically compared but on the basis of mean, reported 1112 kg ha-1, 4478 kg ha-1, 9142 kg ha-1for field bean, finger millet and maize respectively under high level of nitrogen. (Table 5). This may be due to increased kernel and Stover production with more nitrogen application which is due to higher nitrogen fertilization made the plants more efficient in photosynthetic activity, enhancing the carbohydrate metabolism and ultimately the increasing dry matter accumulation and yield of the crop. Taller plants with more number of leaves with higher dose of nitrogen might have resulted in the higher dry matter accumulation resulted in higher kernel and stover yield. These results are in accordance of the findings of Sharma *et al* (1988) [15], Ayub *et al.* (2013), Prathyusha and Hemalatha (2013), Maryam *et al.* (2013) and Kharbamon *et al.* (2017) [7]

Conclusion

The present study investigated the effect of different level of nitrogen on the yield of cereal-pulse based cropping system and found out increase in yield of finger millet, maize and field bean with increase in the level of nitrogen application. The amount of available nutrients was also affected by different levels of nitrogen along with the type of crop cultivated and significantly higher content of available nitrogen and micronutrients were also found significantly higher under high level of nitrogen application under maize crop. The available phosphorus and potassium was recorded in declining trend with increasing the level of nitrogen fertilizers. Among different crop type maize being exhaustive crop was reported with higher mining and lower availability of these nutrients. Field bean fixes atmospheric nitrogen and reported with higher content of available nitrogen. However, the interaction effect of nitrogen level and crop grown type was found non-significant.

Table 1: Available NPK status at irrigated experiment

Parameters kg ha-1	Crops	Nitrogen level		
		N_1	**N_2**	**N_3**
Available Nitrogen	Field bean	196.24	206.49	250.31
	Finger millet	151.01	181.51	244.51
	Maize	186.01	240.61	285.07
CD (p=0.05)	Crops: 24.89	Nitrogen level: 29.11	Interaction: NS	
Available Phosphorus (P_2O_5)	Field bean	10.21	9.01	8.58
	Finger millet	8.84	7.47	6.86
	Maize	11.41	9.35	8.41
CD (p=0.05)	Crops: 1.15	Nitrogen level: 1.22	Interaction: NS	
Available Potassium (K2O)	Field bean	112.93	84.44	70.39
	Finger millet	142.33	119.08	76.14
	Maize	184.33	110.34	85.65
CD (p=0.05)	Crops: 11.18	Nitrogen level: 19.56	Interaction: NS	

A: Crop type; B: Nitrogen level

Table 2: Available NPK status at rainfed experiment

Parameters kg ha-1	Crops	Nitrogen level		
		N_1	**N_2**	**N_3**
Available Nitrogen	Field bean	301.07	396.32	498.86
	Finger millet	251.84	312.86	371.59
	Maize	271.57	389.19	416.71
CD (p=0.05)	Crops: 54.74	Nitrogen level: 27.42	Interaction: NS	
Available Phosphorus	Field bean	61.30	51.81	41.16
	Finger millet	42.89	35.65	28.34
	Maize	35.14	34.88	29.69
CD (p=0.05)	Crops: 6.62	Nitrogen level: 5.09	Interaction: NS	
Available Potassium	Field bean	128.56	102.35	79.16
	Finger millet	102.18	86.25	73.79
	Maize	153.89	112.43	94.42
CD (p=0.05)	Crops: 20.70	Nitrogen level: 22.44	Interaction: NS	

Table 3: Available micronutrient status at irrigated experiment

Parameters mg kg-1	**Crops**	**Nitrogen level**		
		N_1	**N_2**	**N_3**
DTPA Extractable Iron	Field bean	5.71	5.82	6.72
	Finger millet	4.21	4.91	13.11
	Maize	6.03	8.41	17.89
CD (p=0.05)	Crops: 3.75	Nitrogen level: 1.81	Interaction: B at same level of A- 3.48 A at same level of B- 4.53	
DTPA Extractable Zinc	Field bean	1.56	1.88	2.83
	Finger millet	0.79	1.19	1.95
	Maize	0.72	0.91	3.18
CD (p=0.05)	Crops: 0.31	Nitrogen level: 0.32	Interaction: B at same level of A- 0.57 A at same level of B- 0.54	
DTPA Extractable Manganese	Field bean	14.54	28.59	32.35
	Finger millet	12.76	13.80	32.78
	Maize	15.89	23.07	41.10
CD (p=0.05)	Crops: 3.55	Nitrogen level: 3.01	Interaction: B at same level of A- 5.52 A at same level of B-5.53	
DTPA Extractable Copper	Field bean	0.65	0.82	1.56
	Finger millet	0.65	0.77	2.23

	Maize	0.93	1.18	2.09
CD (p=0.05)	Crops: 0.22	Nitrogen level: 0.293	Interaction: NS	

A: Crop type; B: Nitrogen level

Table 4: Available micronutrient status at rainfed experiment

Parameters mg kg-1	Crops	Nitrogen level		
		N_1	N_2	N_3
DTPA Extractable Iron	Field bean	8.89	9.83	10.72
	Finger millet	8.92	10.87	12
	Maize	10.25	12.83	15.31
CD (p=0.05)	Crops: 2.32	Nitrogen level: 1.08	Interaction: NS	
DTPA Extractable Zinc	Field bean	1.57	1.88	2.83
	Finger millet	1.04	1.66	3.01
	Maize	1.88	2.69	4.28
CD (p=0.05)	Crops: 0.84	Nitrogen level: 0.42	Interaction: NS	
DTPA Extractable Manganese	Field bean	15.33	17.05	21.89
	Finger millet	11.65	14.88	17.74
	Maize	14.46	16.73	18.46
CD (p=0.05)	Crops: NS	Nitrogen level: 2.11	Interaction: NS	
DTPA Extractable Copper	Field bean	0.95	1.15	1.25
	Finger millet	1.06	1.18	1.28
	Maize	1.5	1.28	1.78
CD (p=0.05)	Crops: NS	Nitrogen level: 0.12	Interaction: B at same level of A- 0.23 A at same level of B- 0.39	

A: Crop type; B: Nitrogen level

Table 5: Grain yield of crops under three levels of nitrogen (kg ha-1)

Experiment	Crops	Nitrogen level		
		N_1	N_2	N_3
Rainfed	Field bean	812	998	1101
	Finger millet	2968	3049	3254
	Maize	5892	6124	6854
CD (p=0.05)	Crops: 552.22	Nitrogen level: 31.71	Interaction: B at same level of A- 64.63 A at same level of B- 553.98	
Irrigated	Field bean	909	1009	1112
	Finger millet	4086	4253	4478
	Maize	7649	8341	9142
CD (p=0.05)	Crops: 761.24	Nitrogen level: 45.48	Interaction: B at same level of A- 92.66 A at same level of B- 763.86	

A: Crop type; B: Nitrogen level

References

1. Anonymous, A fully revised estimates of principle crops in Karnataka for the year of 2007-2008. Direct. Econ. & Stat., Govt. of Karnataka, Anonymous, 2010, 170. www.indiastat.com.
2. DU Preeza HG, Claassensb AS. Changes in inorganic and organic Phosphorus in soil under maize (*Zea mays*) cultivation. S Afr J Plant Soil. 1999, 4(16).
3. Eludoyin OS, Wokocha CC. Soil dynamics under continuous monocropping of maize (*Zea mays*) on a forest alfisol in south-western Nigeria. Asian J Agric. Sci. 2011; 3(2):58-62.
4. Fageria NK, Baligar VC, Jones CA. Growth and mineral nutrition of field crops, 2nded Marcel Dekker, Inc.: New York, 1997.
5. Jasemi M, Darabi F, Naseri R. Effect of planting date andnitrogen fertilizer application on grain yieldand yield components in maize (SC 704). Am-Eurasian. J Agric. and Environ. Sci. 2013; 13(7):914-919.
6. Khan MJ, Tareque AMM. Shajalal M. Effect of inoculation and nitrogen fertilizer on yield chemical composition, *in vitro* organic matter digestibility and energy content of cowpea (*Vigna unguiculata*) forage. Indian J Anim. Nutr. 1992; 9(3):177-180.
7. Kharbamon B, JHA AK, Verma VK, Choudhury BU, Nath A, Deka BC. Response of planting timeand phosphorus dosage on yield and nutrient uptake indolichos bean (*Lablab Purpureus* L.). Indian J Hill Farming. 2017; 30(1):28-34.
8. Monjardino M, Mcbeath TM, Brennan L, Llewellyn RS. Are farmers in low rainfall cropping regions under-fertilising with nitrogen? A risk analysis. Agric. Syst. 2013, 37-51.
9. Monjardino M, Mcbeath T, Ouzman J, Llewellyn R. Jones B. Farmer risk aversion limits closure of yield and profit gaps: a study of nitrogen management in the southern Australian wheat belt. Agric. Syst. 2015; 137:108-118.
10. Mourya BS. Effect of nitrogen levels on yield and quality of seed in French bean. Msc thesis, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, 2011.
11. Muhammad A, Muhammad T, Muhammad A, Abdul K. Yield and quality response of forage maize to nitrogen levels and inoculation with PGPRs. Crop and environ. 2013; 4(1):35-38.
12. Rangaraj T, Somasundaram E, Amanullah MM, Thirumurugan V, Ramesh S, 2013.
13. Ravi S. Effect of agro industrial wastes on soil properties and yield of irrigated finger millet (*Eleusine coracana* L.

Gaertn) in coastal soil. Res. J Agric. and Biol. Sci. 2007; 3:153-156.

14. Sandhya RY, Triveni U, Patro TSSK, Anuradha N. Effect of nutrient management on yield and quality of finger millet (*Eleusine coracana* (L.) Gaertn). Int. J. Chem. Std. 2017; 5(6):1211- 1216.
15. Sharma RB, Jain VK, Verma SK. Influences of different levels of N on yield and protein of different varieties of finger millet grown under rainfed conditions. Agric. Sci. Digest**.** 1988; 8(3):161-164.
16. Sultana MN, Khan MJ, Khandaker ZH, Uddin MM, Effects of rhizobium inoculums and nitrogen fertilizer on biomass production of cowpea (*Vigna unguiculata*) forage at different stages of maturity. Bangladesh J. Agri. Univ. 2005; 3(2):249-255.