AN AJSS
An Asian Journal of Soil Science
Volume 12 | Issue 1 | June, 2017 | 1-9 | e ISSN–0976–7231 ■ Visit us : www.researchjournal.co.in

Research Article

DOI : 10.15740/HAS/AJSS/12.1/1-9

Effect of nutrient management approaches on maximizing productivity, nutrient uptake, soil fertility and economics of maize (*Zea mays* L.)-chickpea (*Cicer arietinum* L.) cropping sequence

■ B. V. SHREENIVAS, M. V. RAVI AND H. S. LATHA

Received : 17.02.2017; **Revised :** 01.04.2017; **Accepted :** 15.04.2017

MEMBERS OF RESEARCH FORUM:

Corresponding author :
B. V. SHREENIVAS, Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, RAICHUR (KARNATAKA) INDIA

Co-authors :
M.V. RAVI AND H.S. LATHA, Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, RAICHUR (KARNATAKA) INDIA

Summary

Present investigation was conducted during *Kharif* and *Rabi* seasons of 2013-14 and 2014-15 at ARS, Raddewadagi, dist. Kalaburagi, UAS, Raichur, Karnataka to study the effect of nutrient management approaches on maximizing productivity, nutrient uptake, soil fertility and economics of maize-chickpea cropping sequence. Application of nutrients through SSNM for targeted yield of 7.0 or 8.0 t ha^{-1} recorded significantly higher growth attributes, yield and yield attributes and uptake of N, P_2O_5 and K_2O in maize-chickpea cropping system as compared to farmers practice, RDF and STL method. However, it was at par with STCR approach targeted yield of 7 or 8.0 t ha^{-1}. Organic carbon content was non-significant in maize-chickpea sequence cropping system. However, significantly higher available N, P_2O_5 and K_2O (301.05, 62.93 and 439.38 kg ha^{-1}, respectively) were noticed with nutrients applied through 125 per cent SSNM approach for targeted yield of 8.0 t ha^{-1} as compared to absolute control, farmers practice, state recommendation, STL method and 125 per cent SSNM approach for targeted yield of 7.0 t ha^{-1} after harvest of second crop in maize-chickpea sequence cropping system and it was on par with SSNM or STCR approach for targeted yield of 7.0 or 8.0 t ha^{-1}. The cost of cultivation of maize-chickpea sequence was higher (Rs. 50,542 ha^{-1}) with nutrients applied through 125 per cent SSNM approach for targeted yield of 8.0 t ha^{-1}. However, the higher maize-equivalent yield, gross returns, net returns and BC ratio (19083 kg ha^{-1}, Rs.2,53,985, Rs. 2,04,279 ha^{-1} and 5.11, respectively) could be achieved in SSNM approach targeted yield of 8.0 t ha^{-1} followed by STCR approach targeted yield of 8.0 t ha^{-1} (18751 kg ha^{-1}, Rs. 2,49,360, Rs. 1,99,828 ha^{-1} and 5.03, respectively) in maize-chickpea sequence cropping system.

Key words : Targeted yield, Productivity, Nutrient uptake, Soil fertility, Economics

How to cite this article : Shreenivas, B. V., Ravi, M. V. and Latha, H. S. (2017). Effect of nutrient management approaches on maximizing productivity, nutrient uptake, soil fertility and economics of maize (*Zea mays* L.)-chickpea (*Cicer arietinum* L.) cropping sequence. *Asian J. Soil Sci.*, **12** (1) : 1-9 : **DOI : 10.15740/HAS/AJSS/12.1/1-9.**

Introduction

Maize-chickpea cropping sequence has been growing interest as a potential tool in improving and sustaining soil health as well as productivity and

profitability. Cropping sequence is traditionally a low cost input agriculture system. Information on nutrient management on individual crops is available, while cropping system, it is lacking. Moreever, the single nutrient approach has been replaced by multinutreint to proved balanced nutrients to boost up crop productivity and nutrient use efficiency. Beside nutrient management in cropping system is more efficient and judicious than individual crop, as following crop take care of the residual effects of nutrients. Maize-chickpea is the predominant cropping sequence of UKP command area. Applications of nutrients based on the soil test results in SSNM and STCR under field situation had been found to be more useful and profitable and it provides balanced nutrient application in cropping system. The SSNM and STCR approach provide principles and tools for supplying crop nutrients as and when needed to achieve higher yield. The SSNM and STCR approach not specifically aim to either reduce or increase fertilizer use. Instead, they aim to apply nutrients at optimal rates and time to achieve higher yield and high efficiency of nutrient use by the crop, leading to more net returns per unit of fertilizer invested. A judicious use of fertilizers is essential since the cost of fertilizers has gone up very high in recent years. The targeting of crop yields is of importance so as to obtain varying production levels and to monitor the stress on soil fertility, since exhaustion of the nutrients from the soil is directly proportional to the yield level obtained. This also ensures judicious use of fertilizers and allows altering the profit per unit investment of fertilizers. Fertilizer best management practices with due importance of inclusion of legumes will be required for sustainable management of emerging maize based cropping system in the country. Hence, the study on yield potential, nutrient uptake, soil fertility as well as their economics is needed in maize-chickpea sequence system on Vertisol of UKP command area.

Resource and Research Methods

Field experiments were conducted during *Kharif* and *Rabi* seasons of 2013-14 and 2014-15 at ARS, Raddewadagi, dist. Kalaburagi, UAS, Raichur, Karnataka on Vertisols. The soil was medium black with clayey in texture having pH 8.21 and electrical conductivity 0.29 dSm^{-1}. The soil was low in available nitrogen (224.20 kg ha^{-1}), medium in available phosphorus (50.60 kg ha^{-1}) and high in available potassium (340.80 kg ha^{-1}). The organic carbon content of soil was low (4.5 mg kg^{-1}). The experiment was repeated on the same site for two years. The experiment was laid out in Randomized Complete Block Design (RCBD) and the treatments were replicated thrice. The treatment includes targeted yield of maize through SSNM, STCR along with absolute control (No NPK and FYM), farmers practice (109:58: 38 kg N: P_2O_5: K_2O ha^{-1}), state recommendation (150: 75: 39 kg N: P_2O_5: K_2O ha^{-1}), STL method (175: 75: 26, N, P_2O_5 and K_2O kg ha^{-1}). The quantity of fertilizers was calculated based on targeted yield equations developed by STCR scheme (Anonymous, 2007) for maize crop *viz.*, FN=3.41 T- 0.08 SN ($KMnO_4$ - N); FP_2O_5 = 1.94T - 0.41 SP_2O_5 (Olsen's - P_2O_5) and FK_2O = 2.28T - 0.072 SK_2O (NH_4OAC - K_2O). Accordingly, the quantity of N, P_2O_5 and K_2O for 7.0 and 8.0 t ha^{-1} were 220.78: 114.89: 135.05 and 254.88: 134.29: 157.85 kg ha^{-1}, respectively. Similarly for SSNM, the quantity of N, P_2O_5 and K_2O required were calculated based on the nutrient removal by maize crop per tonne. The average removal of N, P_2O_5 and K_2O from the soil to produce one tonne of maize grain was 26.3, 13.9 and 35.8 kg ha^{-1}, respectively (Singh *et al.*, 2005). Accordingly, N, P_2O_5 and K_2O required were calculated by multiplying targeted yield with nutrient removal. After calculating, the soil nutrient ratings (low and high) are considered for recommendation of fertilizers @ $\pm$ 30 % (IPNI, 2010). Accordingly, the quantity of N, P_2O_5 and K_2O for 7.0 and 8.0 t ha^{-1} were 239.30: 97.30: 175.42 and 273.52: 111.2: 200.48: N, P_2O_5, K_2O kg ha^{-1}, respectively. Similarly, for 125 per cent SSNM targeted yield of 7 and 8 t ha^{-1}, the quantity of N, P_2O_5, K_2O required were 299.13: 121.63: 219.28 and 341.9: 139: 250.6: N, P_2O_5, K_2O kg ha^{-1}, respectively. Maize (NK 6240) was sown on 25th and 12th July and harvested on November 10th and October 31th during 2013-14 and 2014-15, respectively. Basal dose of fertilizers (50 % N and 100 % P and K) were applied and mixed with soil at the base of seed row based on the treatments at 4-5 cm deep and 5 cm away from the seed as basal dose. Remaining half dose of nitrogen in the form of urea was top dressed at 30 days after sowing (DAS). The required amount of FYM @ 10 t ha^{-1} was applied for all treatments uniformly for main crop (except T_1 and T_2) during both the years of experimentation. The residual effects of maize crop treatments were studied using chickpea crop in the same plot during 2013 and 2014. After harvest of maize, chickpea (JG 11) was sown on 14th and 5th November and harvested on 18th and 2nd February during

first and second year, respectively. The yield and yield attributes of both the crops were recorded at harvest. The plant samples were oven dried and analyzed for nitrogen by Microkjeldhal, phosphorus by Vanadomolybdic and potassium by flame photometer (Piper, 1966) and total crop uptake was worked out. Soil samples collected after harvest of maize crop were analyzed for organic carbon, available N, P_2O_5 and K_2O by wet digestion method, alkaline potassium permanganate method (Subbiah and Asija, 1956), Olsen's and flame photometry method, respectively (Jackson, 1973).

Research Findings and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Yield and yield attributes of maize :

Pooled results registered significantly higher yield and yield attributes with the nutrient application through targeted yield approach. The grain yield of maize was recorded higher (8.62 t ha^{-1}) with treatment receiving SSNM approach targeted yield of 8.0 t ha^{-1} as compared to absolute control (2.91 t ha^{-1}), farmers practice (4.74 t ha^{-1}), state recommendation (5.82 t ha^{-1}) and soil test laboratory (STL) method (6.25 t ha^{-1}) and it was found at par with STCR approach targeted yield of 8.0 t ha^{-1} (8.37 t ha^{-1}), SSNM approach targeted yield of 7.0 t ha^{-1} (7.59 t ha^{-1}), STCR approach targeted yield of 7.0 t ha^{-1} (7.46 t ha^{-1}), 125 per cent SSNM approach targeted yield of 8.0 t ha^{-1} (6.45 t ha^{-1}) and 125 per cent SSNM approach targeted yield of 7.0 t ha^{-1} (6.35 t ha^{-1}) (Table 1). The higher yield can be attributed to the ability of targeted yield approaches to satisfy the nutrient demand of crop more efficiently. Further, higher grain yield of maize could be due to superior yield components like, length of cob, number of grain rows per cob and hundred seed weight. Significant increase in the yield and yield components with the application nutrients through SSNM / STCR might be due to balanced supply of nutrients that might have contributed to better translocation of photosynthate from source to sink and higher growth attributing characters like higher number of leaves and dry matter production and its accumulation into different parts of plant and yield attributing characters. The results are in collaboration with the findings of Biradar *et al*. (2006) that nutrient application on the basis of SSNM principles resulted in significantly higher grain yields over farmer practice and recommended dose of fertilizers. The studies are also confirmed with the findings of Biradar and Jayadeva (2013) and Dhillon *et al.* (2006) that application of nutrients through SSNM for targeted yield recorded significantly higher grain yield as compared

Table 1 : Yield and yield attributes of maize as influenced by different nutrient management approaches

Treatments	Length of cob (cm)			Number of grain rows cob^{-1}			100 seed weight (g)			Grain yield (t ha^{-1})		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1	15.47	18.09	16.78	10.20	11.67	10.93	19.62	25.50	22.56	2.70	3.12	2.91
T_2	15.77	19.45	17.61	12.53	12.73	12.63	22.12	26.70	24.41	4.53	4.95	4.74
T_3	16.47	19.99	18.23	13.00	13.07	13.03	23.74	27.83	25.79	5.59	6.05	5.82
T_4	17.53	20.19	18.86	13.13	13.27	13.20	25.44	28.73	27.09	6.06	6.45	6.25
T_5	19.90	21.01	20.45	13.60	13.80	13.70	28.92	30.32	29.62	7.22	7.71	7.46
T_6	20.57	21.27	20.92	14.40	14.47	14.43	29.97	31.51	30.74	8.12	8.63	8.37
T_7	20.23	21.07	20.65	13.87	14.00	13.93	29.67	31.25	30.46	7.36	7.83	7.59
T_8	21.09	21.51	21.30	14.47	14.93	14.70	31.07	32.19	31.63	8.43	8.81	8.62
T_9	19.07	20.41	19.74	13.33	13.73	13.53	27.33	29.65	28.49	6.15	6.55	6.35
T_{10}	19.23	20.71	19.97	13.40	13.77	13.58	27.82	29.97	28.90	6.23	6.67	6.45
S.E.±	1.17	0.43	0.79	0.43	0.54	0.48	1.85	1.12	1.49	0.77	0.76	0.78
C.D. (P=0.05)	3.51	1.29	2.42	1.30	1.65	1.46	5.60	3.43	4.52	2.33	2.30	2.33

T_1: Absolute control (No NPK and FYM)
T_2: Farmers practice
T_3: State recommendation
T_4: STL method
T_5: STCR approach (Targeted yield : 7.0 t ha^{-1})
T_6: STCR approach (Targeted yield : 8.0 t ha^{-1})
T_7: SSNM approach (Targeted yield : 7.0 t ha^{-1})
T_8: SSNM approach (Targeted yield : 8.0 t ha^{-1})
T_9: 125% SSNM approach (Targeted yield : 7.0 t ha^{-1})
T_{10}: 125% SSNM approach (Targeted yield : 8.0 t ha^{-1})
Note: FYM @ 10 t ha^{-1} and deficient nutrients were applied for all treatments except T_1 and T_2

to farmers practice, RDF and STL method. Mandal *et al*. (2009) reported that SSNM based nutrient management recorded significantly higher grain yield which may be due to better nutrient availability during the crop growth period. These results are in conformity with the findings of Al Zubaidi and Al Semak (1992) and Kumar *et al*. (2012).The number of grains per cob differed significantly due to application of nutrients through SSNM approach targeted yield of 8.0 t ha^{-1} (397.30) followed by STCR approach targeted yield of 8.0 t ha^{-1} (366.10) over absolute control (180.20) and farmers practice (237.70).This might be due to significant difference in the number of grains per cob of maize obtained by higher amounts of nutrients supplied through targeted yield approaches. These findings are in agreement with the findings of Jayaprakash *et al.* (2006); Umesh (2008) and Madhusudhan (2013). The higher hundred seed weight of maize grain (31.63 g) was recorded with SSNM approach targeted yield of 8.0 t ha^{-1} over absolute control (22.56 g) followed by farmers practice (24.41 g) and it was at par with STCR approach targeted yield of 8.0 t ha^{-1} (30.74 g) and SSNM approach targeted yield of 7.0 t ha^{-1} (30.46 g) and was attributed to higher dry matter production in plants. This might also due to supply of required photosynthates to the reproductive parts more precisely to the seed which resulted in bolder seeds. Biradar *et al*. (2013) reported nutrients application through SSNM for targeted yield of 10 t ha^{-1} was recorded significantly higher test weight (32.9 g).

Growth, yield and yield attributes of chickpea :

The significantly higher plant height and number of branches, respectively was observed in residual effect of nutrients through SSNM approach targeted yield of 8.0 t ha^{-1} (36.55 cm and 29.57) followed by STCR approach targeted yield of 8.0 t ha^{-1} (36.20 cm and 28.87) as compared to other treatments. All these growth parameters could have been promoted by higher residual quantity of nutrients made available by the different treatments to chickpea crop. This was also evidenced through higher uptake of nutrients (Table 2). The pooled results showed significantly superior seed yield (29.90 q ha^{-1}) of chickpea due to residual effect of nutrient through SSNM approach targeted yield of 8.0 t ha^{-1} over absolute control (19.32 q ha^{-1}), farmers practice (27.73 q ha^{-1}), state recommendation (28.70 q ha^{-1}) and STL method (29.12 q ha^{-1}) and it was found at par with STCR approach targeted yield of 8.0 t ha^{-1} (29.65 q ha^{-1}), SSNM approach targeted yield of 7.0 t ha^{-1} (29.63 q ha^{-1}), STCR approach targeted yield of 7.0 t ha^{-1} (29.54 q ha^{-1}), 125 per cent SSNM approach targeted yield of

Table 2 : Growth, yield and yield attributes of chickpea as influenced by residual effect of different nutrient management approaches

Treatments	Plant height (cm)			Total number of branches $plant^{-1}$			TDP (g $plant^{-1}$)			100 seed weight (g)			Seed yield (q ha^{-1})		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled			
T_1	29.80	36.00	32.90	18.76	22.19	20.48	10.03	12.63	11.33	19.67	20.50	20.08	19.80	18.83	19.32
T_2	30.60	36.33	33.47	22.18	23.50	22.84	12.10	13.40	12.75	22.00	22.33	22.17	28.48	26.98	27.73
T_3	31.13	36.52	33.83	24.78	26.60	25.69	12.25	15.00	13.63	23.00	23.00	23.00	28.75	28.65	28.70
T_4	31.80	36.67	34.23	25.70	28.08	26.89	12.97	15.70	14.33	23.17	23.33	23.25	29.06	29.17	29.12
T_5	32.80	38.20	35.50	26.72	29.26	27.99	14.40	17.63	16.02	23.67	24.00	23.83	29.34	29.73	29.54
T_6	33.33	39.07	36.20	27.35	30.38	28.87	16.23	18.68	17.46	24.33	24.48	24.41	29.41	29.88	29.65
T_7	33.07	38.60	35.83	27.03	29.84	28.44	15.10	18.15	16.63	23.72	24.17	23.94	29.40	29.87	29.63
T_8	33.53	39.57	36.55	28.45	30.69	29.57	19.45	18.80	19.13	24.67	25.83	25.25	29.64	30.15	29.90
T_9	31.87	37.10	34.48	26.02	28.48	27.25	13.55	16.82	15.18	23.33	23.50	23.42	29.14	29.68	29.41
T_{10}	32.67	37.77	35.22	26.30	28.82	27.56	13.60	17.47	15.53	23.38	23.67	23.53	29.26	29.73	29.50
S.E.±	0.55	0.86	0.72	0.91	0.85	0.88	2.15	1.01	1.57	0.48	0.81	0.65	0.17	0.30	0.24
C.D. (P=0.05)	1.70	2.62	2.20	2.73	2.59	2.67	6.46	3.08	4.78	1.48	2.48	1.99	0.56	0.96	0.75

T_1: Absolute control (No NPK and FYM)
T_2: Farmers practice
T_3: State recommendation
T_4: STL method
T_5: STCR approach (Targeted yield : 7.0 t ha^{-1})
T_6: STCR approach (Targeted yield : 8.0 t ha^{-1})
T_7: SSNM approach (Targeted yield : 7.0 t ha^{-1})
T_8: SSNM approach (Targeted yield : 8.0 t ha^{-1})
T_9: 125% SSNM approach (Targeted yield : 7.0 t ha^{-1})
T_{10}: 125% SSNM approach (Targeted yield : 8.0 t ha^{-1})

8.0 t ha^{-1} (29.50 q ha^{-1}) and 125 per cent SSNM approach targeted yield of 7.0 t ha^{-1} (29.41 q ha^{-1}). The better performance of succeeding chickpea could be due to higher amount of available nitrogen, phosphorus and potassium after harvest of maize. The results are in conformity with the findings of Gawai and Pawar (2005) that the residual effect of application of 100 per cent RDF and 5 t FYM ha^{-1} to proceeding crop sorghum resulted in significantly higher grain and haulm yield of chickpea. Seed yield is also have direct influence on the yield components *viz.*, number of pods per plant, hundred seed weight etc. Significantly higher (25.25 g) 100 seed weight was recorded in the treatment receiving SSNM approach targeted yield of 8.0 t ha^{-1} as compared to absolute control (20.08 g), farmers practice (22.17 g), state recommendation (23.00 g) and STL method (23.25 g) and it was found at par with STCR approach targeted yield of 8.0 t ha^{-1} (24.41 g), SSNM approach targeted yield of 7.0 t ha^{-1} (23.94 g), STCR approach targeted yield of 7.0 t ha^{-1} (23.83 g), 125 per cent SSNM approach targeted yield of 8.0 t ha^{-1} (23.53 g) and 125 per cent SSNM approach targeted yield of 7.0 t ha^{-1} (23.42 g). The total dry matter produced in the chickpea plant differed significantly due to target yield approach and was higher in residual effect of nutrients through SSNM approach targeted yield of 8.0 t ha^{-1} (19.13 g plant^{-1}), which was at par with STCR approach targeted yield of 8.0 t ha^{-1} (17.46 g plant^{-1}) and these are significantly higher as compared to other treatments. The increased dry matter was usually associated with higher number of branches per plant which led to greater accumulation of photosynthesis. The similar results were reported by Chaudhary *et al.* (1998) that higher dry matter in chickpea at higher application of nutrients based on SSNM approach which leads to increased nutrient status in the soil.

Nutrients uptake by maize crop :

Significantly higher total uptake (grain + stover) of N, P and K was recorded with the application of nutrients through SSNM for targeted yield of 8.0 t ha^{-1} (310.96, 52.65 and 243.12 kg ha^{-1}, respectively) followed by STCR approach targeted yield of 8.0 t ha^{-1} (299.44, 50.44 and 230.74 kg ha^{-1}, respectively) as compared to other treatments (Table 3). This might be due to application of balanced fertilization based on target yield resulting in higher uptake. The higher nutrient uptake is also well reflected in terms of higher grain yield of maize. The results are in line with Singh and Sarkar (2001) that application of 210:90:150 kg NPK ha^{-1} recorded significantly higher NPK uptake 158:13:160.70 kg ha^{-1} compared to state recommended dose of 100:60:40 kg NPK ha^{-1} under wheat-maize cropping system. Biradar and Jayadeva (2013) reported significantly higher nutrient

Table 3 : Effect of different nutrient management approaches on total nitrogen, phosphorus and potassium uptake by maize after harvest

Treatments	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1	97.17	112.63	104.90	12.17	14.39	13.28	73.89	86.96	80.43
T_2	149.75	168.08	158.92	19.98	23.90	21.94	113.15	126.47	119.81
T_3	203.69	220.91	212.30	31.25	33.30	32.28	154.54	165.58	160.06
T_4	217.14	229.75	223.44	33.11	35.60	34.36	163.15	175.70	169.43
T_5	253.26	272.24	262.75	40.15	46.22	43.19	194.15	214.02	204.08
T_6	287.66	311.23	299.44	45.66	55.22	50.44	216.27	245.22	230.74
T_7	263.01	283.41	273.21	41.97	47.78	44.87	199.70	221.62	210.66
T_8	301.37	320.54	310.96	47.39	57.92	52.65	232.09	254.14	243.12
T_9	220.19	232.55	226.37	34.31	36.78	35.54	168.93	179.65	174.29
T_{10}	223.83	235.58	229.71	34.78	39.84	37.31	173.43	180.50	176.96
S.E.±	17.24	17.90	17.55	2.57	4.63	3.77	13.23	14.92	14.39
C.D. (P=0.05)	51.75	53.78	52.71	7.76	13.92	11.39	39.75	44.81	43.24

T_1: Absolute control (No NPK and FYM)
T_2: Farmers practice
T_3: State recommendation
T_4: STL method
T_5: STCR approach (Targeted yield : 7.0 t ha^{-1})
T_6: STCR approach (Targeted yield : 8.0 t ha^{-1})
T_7: SSNM approach (Targeted yield : 7.0 t ha^{-1})
T_8: SSNM approach (Targeted yield : 8.0 t ha^{-1})
T_9: 125% SSNM approach (Targeted yield : 7.0 t ha^{-1})
T_{10}: 125% SSNM approach (Targeted yield : 8.0 t ha^{-1})
Note: FYM @ 10 t ha^{-1} and deficient nutrients were applied for all treatments except T_1 and T_2

uptake (504.8, 103.1 and 212.3 N, P and K kg ha^{-1}, respectively) in SSNM through fertilizers for targeted yield of 10 t ha^{-1} over 100 per cent RDF (219.4, 32.2 and 73; N, P and K kg ha^{-1}). Thakur *et al.* (1998) found that the nitrogen uptake by plants increased significantly upto 150 kg N ha^{-1}, whereas N uptake by baby corn recorded significant increase upto 200 kg N ha^{-1}. Chandel *et al.* (2014) reported that the uptake of N, P, K and S by wheat (200, 23.8, 184 and 30.4 kg ha^{-1}) and maize (104, 16.7, 182 and 20.2 kg ha^{-1}) was highest at 150 kg N + 20 kg S + 10 t FYM ha^{-1} and the lowest in control. The increased N, P and K uptake might be due to the higher nutrient supply as compared to RDF, framers practice and STL method. The results are in conformity with outcome of Umesh *et al*. (2014) who reported that the targeted yield based fertilizer application either by SSNM or STCR approach recorded significant improvement in uptake of N, P and K. Doberman *et al.* (2000) reported that site specific nutrient management improved the plant uptake of N, P and K by 10 to 20 per cent and achieved balanced plant nutrition.

Chickpea :

The total uptake (seed + haulm) of N, P and K was significantly highest with the residual effect of nutrients through SSNM for targeted yield of 8.0 t ha^{-1} (118.25, 26.63 and 102.09 kg N, P_2O_5 and K_2O ha^{-1}, respectively) followed by STCR approach targeted yield of 8.0 t ha^{-1} (113.41, 25.37 and 99.33 kg N, P_2O_5 and K_2O ha^{-1}, respectively) over absolute control (62.71, 11.86 and 57.93 kg N, P_2O_5 and K_2O ha^{-1}, respectively) (Table 4). The higher uptake of nitrogen, phosphorus and potassium by chickpea might be due to higher biomass production coupled with higher availability of nitrogen, phosphorus and potassium after harvest of maize crop. The better performance of growth and yield of chickpea further traced back to the improvement in nutrient uptake. Chaudhary *et al.* (1998) observed higher dry matter in chickpea resulted in higher uptake of nutrients in SSNM approach.

Soil chemical fertility :

Organic carbon content and available nutrients increased in the soil from first to second year of maize and chickpea cultivation in sequence (Table 5). There was no significant difference in organic carbon of soil with the adaptation of different nutrient management approaches. Among them, higher (4.55 g kg^{-1}) organic carbon was resulted with treatment receiving T_{10}: 125 per cent SSNM approach targeted yield of 8.0 t ha^{-1} (4.55 g kg^{-1}) as compared to other treatments. Lowest organic carbon (0.48 g kg^{-1}, each) was noticed with absolute control, farmers practice and state recommendation may be due to addition of less amount of biomass than other treatments. The results are in line with the findings of Singh *et al.* (2012). The significantly

Table 4: Residual effect of different nutrient management approaches on total nitrogen, phosphorus and potassium uptake by chickpea after harvest

Treatments	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1	63.68	61.74	62.71	11.54	12.19	11.86	58.50	57.36	57.93
T_2	95.78	93.08	94.43	17.82	18.40	18.11	86.31	84.16	85.24
T_3	102.51	103.88	103.20	22.65	23.97	23.31	92.84	92.79	92.81
T_4	106.21	107.80	107.01	22.58	24.10	23.34	94.33	95.00	94.67
T_5	110.08	112.63	111.35	23.75	25.48	24.62	97.37	98.43	97.90
T_6	111.12	115.69	113.41	23.89	26.85	25.37	98.02	100.64	99.33
T_7	110.70	113.17	111.93	23.84	25.60	24.72	97.80	99.21	98.50
T_8	116.12	120.38	118.25	24.06	29.20	26.63	100.85	103.33	102.09
T_9	107.86	110.50	109.18	22.72	24.17	23.44	95.59	96.13	95.86
T_{10}	108.85	111.67	110.26	23.37	25.16	24.26	96.44	97.71	97.08
S.E.±	2.25	2.63	2.43	0.36	1.37	0.89	1.52	1.93	1.70
C.D. (P=0.05)	6.79	7.93	7.33	1.10	4.12	2.69	4.56	5.83	5.10

T_1: Absolute control (No NPK and FYM)
T_2: Farmers practice
T_3: State recommendation
T_4: STL method
T_5: STCR approach (Targeted yield : 7.0 t ha^{-1})
T_6: STCR approach (Targeted yield : 8.0 t ha^{-1})
T_7: SSNM approach (Targeted yield : 7.0 t ha^{-1})
T_8: SSNM approach (Targeted yield : 8.0 t ha^{-1})
T_9: 125% SSNM approach (Targeted yield : 7.0 t ha^{-1})
T_{10}: 125% SSNM approach (Targeted yield : 8.0 t ha^{-1})

higher available N, P_2O_5 and K_2O, (301.05, 62.93 and 439.38, kg ha^{-1}, respectively) were noticed with nutrients applied through 125 per cent SSNM approach for targeted yield of 8.0 t ha^{-1} as compared to absolute control, farmers practice, state recommendation, STL method and 125 per cent SSNM approach for targeted yield of 7.0 t ha^{-1} after harvest of second crop in maize-chickpea sequence cropping system and it was at par with SSNM or STCR approach for targeted yield of 7.0 or 8.0 t ha^{-1}. Biradar and Jayadeva (2013) reported significantly higher nutrient uptake (504.8, 103.1 and 212.3 N, P and K kg ha^{-1}, respectively) in SSNM through fertilizers for

Table 5: Organic carbon, available N, P_2O_5 and K_2O in soil after harvest of second crop in maize-chickpea sequence as influenced by different nutrient management approaches

Treatments	Organic carbon (g kg^{-1})			Available N (kg ha^{-1})			Available P_2O_5 (kg ha^{-1})			Available K_2O (kg ha^{-1})		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1	4.47	4.48	4.48	178.22	182.00	180.11	23.11	26.11	24.61	298.44	313.44	305.94
T_2	4.47	4.48	4.48	235.02	250.02	242.52	35.88	37.88	36.88	347.00	357.00	352.00
T_3	4.47	4.48	4.48	240.02	255.02	247.52	38.55	43.55	41.05	350.13	363.13	356.63
T_4	4.50	4.50	4.50	243.88	261.88	252.88	41.48	49.48	45.48	351.00	368.00	359.50
T_5	4.50	4.50	4.50	254.51	277.51	266.01	53.03	56.85	54.94	363.44	383.44	373.44
T_6	4.52	4.53	4.53	262.75	291.75	277.25	55.41	60.13	57.77	375.03	410.03	392.53
T_7	4.51	4.52	4.52	260.05	282.72	271.38	53.88	56.03	54.96	365.00	391.00	378.00
T_8	4.52	4.53	4.53	264.25	292.25	278.25	55.85	56.88	56.37	394.00	432.00	413.00
T_9	4.52	4.53	4.53	275.81	306.81	291.31	56.13	60.41	58.27	400.05	441.05	420.55
T_{10}	4.54	4.55	4.55	284.55	317.55	301.05	58.93	66.93	62.93	416.88	461.88	439.38
S.E.±	0.32	0.34	0.22	11.82	14.76	13.28	2.86	3.53	3.17	19.45	27.36	23.42
C.D. (P=0.05)	NS	NS	NS	35.50	44.32	39.92	8.52	10.65	9.56	58.42	82.10	70.23

T_1: Absolute control (No NPK and FYM)
T_2: Farmers practice
T_3: State recommendation
T_4: STL method
T_5: STCR approach (Targeted yield : 7.0 t ha^{-1})
T_6: STCR approach (Targeted yield : 8.0 t ha^{-1})
T_7: SSNM approach (Targeted yield : 7.0 t ha^{-1})
T_8: SSNM approach (Targeted yield : 8.0 t ha^{-1})
T_9: 125% SSNM approach (Targeted yield : 7.0 t ha^{-1})
T_{10}: 125% SSNM approach (Targeted yield : 8.0 t ha^{-1})
Note: FYM @ 10 t ha^{-1} and deficient nutrients were applied for all treatments except T_1 and T_2 for maize crop NS: Non-significant

Table 6: Maize-equivalent yield (MEY) and economics of maize-chickpea sequence as influenced by different nutrient management approaches

Treatments	MEY (kg ha^{-1})			Cost of cultivation (Rs. ha^{-1})			Gross returns (Rs. ha^{-1})			Net returns (Rs.ha^{-1})			B:C		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1	9630	9711	9670	45923	46810	46367	122020	130917	126469	76097	84107	80102	2.66	2.80	2.73
T_2	14498	14393	14446	46088	46975	46532	182580	192808	187694	136492	145833	141163	3.96	4.10	4.03
T_3	15653	16078	15865	47378	48265	47822	199120	216960	208040	151742	168695	160219	4.20	4.50	4.35
T_4	16231	16660	16445	47346	48233	47790	206533	224718	215626	159187	176485	167836	4.36	4.66	4.51
T_5	17489	18116	17802	48634	49521	49078	223747	246772	235260	175113	197251	186182	4.60	4.98	4.79
T_6	18414	19088	18751	49089	49976	49533	236953	261767	249360	187864	211791	199828	4.83	5.24	5.03
T_7	17650	18285	17967	48836	49723	49280	226364	249318	237841	177528	199595	188562	4.64	5.01	4.82
T_8	18804	19363	19083	49263	50150	49707	242400	265570	253985	193137	215420	204279	4.92	5.30	5.11
T_9	16349	16938	16644	49575	50462	50019	208313	228432	218373	158738	177970	168354	4.20	4.53	4.36
T_{10}	16471	17076	16773	50098	50985	50542	209987	230459	220223	159889	179474	169682	4.19	4.52	4.36

T_1: Absolute control (No NPK and FYM)
T_2: Farmers practice
T_3: State recommendation
T_4: STL method
T_5: STCR approach (Targeted yield : 7.0 t ha^{-1})
T_6: STCR approach (Targeted yield : 8.0 t ha^{-1})
T_7: SSNM approach (Targeted yield : 7.0 t ha^{-1})
T_8: SSNM approach (Targeted yield : 8.0 t ha^{-1})
T_9: 125% SSNM approach (Targeted yield : 7.0 t ha^{-1})
T_{10}: 125% SSNM approach (Targeted yield : 8.0 t ha^{-1})
Note: FYM @ 10 t ha^{-1} and deficient nutrients were applied for all treatments except T_1 and T_2 for maize crop

targeted yield of 10 t ha^{-1} over 100 per cent RDF (219.4, 32.2 and 73; N, P and K kg ha^{-1}). It could be due to enhanced nutrient pool at elevated fertility level which might have contributed to higher residual nutrient status of soil by retaining part of external applied nutrients in soil. Similar opinion of elevated fertility levels increased the available nutrient status of the soil after harvest of crop by several researchers. This might be due to nodulation of legume crop which fixes atmospheric N and intern increases 'N' in soil was more with SSNM treatments. It was also in accordance with Tomar *et al.* (1990) that inclusion of pulses in intensive agriculture is beneficial and improves the soil fertility and crop productivity. The benefits of including legumes in cropping cycle which improves the soil fertility status. Similarly, Varalakshmi *et al.* (2005) reported that the legume cropping helped to increase the available N, P_2O_5 and K_2O content of the soil. Vidyavathi *et al.* (2011) reported that the available N, P_2O_5 and K_2O were significantly higher in legume based cropping systems during both the seasons of the study than non-legume system.

Economics :

Economic analysis is one of the major criteria for evaluating efficient and economically available nutrient management practices. In the present study, higher cost of cultivation (Rs. 50,542 ha^{-1}) was observed with 125 per cent SSNM approach targeted yield of 8.0 t ha^{-1} followed by application of 125 per cent SSNM approach targeted yield of 7.0 t ha^{-1} (Rs. 50,019 ha^{-1}) and lowest cost of cultivation noticed in absolute control (Rs. 46,367 ha^{-1}). The pooled data on economics studies of maize-chickpea cropping sequence under all nutrient management approaches revealed that the highest gross returns and net returns (Rs. 2,53,985 ha^{-1} and Rs. 2,04,279 ha^{-1}, respectively) were obtained with SSNM approach targeted yield of 8.0 t ha^{-1} followed by STCR approach targeted yield of 8.0 t ha^{-1} (Rs. 2,49,360 ha^{-1} and Rs.1,99,828 ha^{-1}, respectively) and the maximum benefit cost ratio (5.11) was obtained with SSNM approach targeted yield of 8.0 t ha^{-1} followed by STCR approach targeted yield of 8.0 t ha^{-1} (5.03) (Table 6). This might be due to higher returns under SSNM and STCR approaches. Yield increases under SSNM resulted in a vast improvement in the economic feasibility of food crop production. The results are in agreement with the Dhillon *et al.* (2006) reported that the higher BC ratio of wheat (6.9), maize (5.12) and raya (6.19) and suggested that the target yield concept gave higher yield and hence, better economic returns than farmers practice and general recommended dose. Sonar *et al.* (1982) also reported that application of fertilizer for yield targets of 4.5 and 6.0 t ha^{-1} of sorghum resulted in higher yields and benefit cost ratio than the application of recommended fertilizer rates. Bangarwa *et al.* (1989) stated that in *Rabi* maize, application of 60, 120 and 180 kg N ha^{-1}, the average yield and net returns obtained during two years were (48.34 q ha^{-1} and Rs. 1836 ha^{-1}, respectively) and the maximum net profit of Rs. 4916 was obtained with the application of 180 kg N ha^{-1}. The findings are in line with Yadhav and Nand (2004) that SSNM practice increased net returns of 35 and 109 per cent in pigeonpea and pearlmillet over state recommendations. These findings are also in agreement with the findings of Rajashekara *et al.* (2010); Madhusudhan (2013) and Umesh *et al.* (2014).

Conclusion :

It may be concluded that under maize-chickpea sequence cropping system application of fertilizers through SSNM approach targeted yield of 8.0 t ha^{-1} (274:111:201, kg N, P_2O_5 and K_2O ha^{-1}, respectively) is the best option for higher productivity, beside improving soil fertility, total nutrient uptake and also higher economic returns.

Literature Cited

Al Zubaidi, A.H. and Al Semak, K. (1992). Interactive effect of soil salinity and potassium fertilizer on the growth and salt tolerance of corn. *J. Agric. Res.,* **2** (1): 10-27.

Anonymous (2007). STCR an approach for fertilizer recommendations based on targetted yield concept. *Tec. Bultn.,* AICRP on STCR. University of Agricultural Sciences Bangalore (KARNATAKA) INDIA.

Bangarwa, A.S., Kairon, M.S. and Singh, K.P. (1989). Effect of plant population and nitrogen application on yield and economics of winter maize. *Indian J. Agron.,* **34**(4): 393-395.

Biradar, Ashok and Jayadeva, H.M. (2013). Influence of targeted yield approach on yield, yield attributes, nutrient uptake and economics of maize. *Madras Agric. J.,* **100**(1-3): 146-149.

Biradar, Ashok, Jayadeva, H.M., Shakaralingappa, B.C. and Vishwanath, A.P. (2013). Effect of targeted yield approach on growth, yield and nutrient uptake at flowering of maize. *Mysore J. Agric. Sci.,* **47**(4): 707-712.

Biradar, D.P., Aladakatti, Y.R., Rao, T.N. and Tiwari, K.N.

(2006). Site-specific nutrient management for maximization of crop yields in Northern Karnataka. *Better Crops,* **90**(3): 33-35.

Chandel, Bandana Singh, Singh, Sandeep, Singh, Harvendra and Singh, Vinay (2014). Direct and residual effect of nutrient management in wheat-maize cropping sequence. *J. Indian Soc. Soil Sci.,* **62**(2) : 126-130.

Chaudhary, R.K., Patel, T.D., Patel, J.B. and Patel, R.H. (1998). Response of chickpea cultivars to irrigation, nitrogen and phosphorus on sandy clay loam soil. *Int. Chickpea, Pigeonpea Newslett.,* **5**: 24-26.

Dhillon, N.S., Brar, B.S., Benipal, D.S. and Mavi, M.S. (2006). Economics of various soil test based fertilization approaches for different crops. *Crop Res.,* **32**(3): 377-381.

Doberman, A., Witt, C., Robert, P.C. and Larson, W.E. (2000). SSNM concept for irrigated via system. *Proc. of 5th International Con. on Presis,* **25**: 1-7.

Gawai, P.P. and Pawar, V.S. (2005). Production, potential and economics of sorghum-chickpea cropping sequence under irrigated nutrient management system. *Crop Res.,* **30**(3): 345 - 348.

Jackson, M.L. (1973). *Soil chemical analysis,* Prentice Hall of India (Pvt) Ltd., NEW DELHI, INDIA.

Jayaprakash, T.C., Nagalikar, V.P., Pujari, B.T. and Setty, R.A. (2006). Effect of organics and inorganics on growth and yield of maize under irrigation. *Karnataka J. Agric. Sci.,* **18**(3): 798.

Kumar, A., Majumdar, K., Jat, M.L., Pampolino, N., Kamboj, B.R., Bishnoi, D.K., Kumar, V. and Johnston, A.M. (2012). Evaluation of nutrient expert for wheat. *Better Crops South Asia.,* 27-29.

Madhusudhan (2013). Assessment of soil test based nutrient management approaches in maize (*Zea mays* L.). M. Sc. (Ag.) Thesis, University of Agricultural Sciences, Raichur, KARNATAKA (INDIA).

Mandal, M.K., Pati, R., Mukhopadhyay, D. and Majumdar, K. (2009). Maximizing yield of cowpea through soil test-based nutrient application in Terai Alluvial soils. *Better Crops,* **3**(1): 28-30.

Piper, C.S. (1966). *Soil and plant analysis.* Hans Publisher, Bombay (M.S.) INDIA.

Rajashekara, R., Wani, S.P., Sahrawat, K.L. and Pardhasaradhi (2010). Integrated nutrient management to enhance on-farm productivity of rainfed maize in India. *Int. J. Soil Sci.,* **5**(4): 216-224.

Singh, A.K., Bhatti, B.P., Sundaram, P.K., Kumar, Santosh, Bahrati, R.C., Naresh, C. and Rai, Mathura (2012). Study of site specific nutrients management of cowpea seed production and their effect on soil nutrient status. *J. Indian. Agril. Sci.,* **4** (10): 191-198.

Singh, J., Bajaj, J.C. and Pathak, H. (2005). Quantitative estimation of fertilizer requirement for maize and chickpea in the alluvial soil of the Indo-Gangetic plains. *J. Indian Soc. Soil Sci.,* **53**(1): 101-106.

Singh, Surendra and Sarkar, A.K. (2001). Balanced use of major nutrients for sustaining higher productivity of maize-wheat cropping system in acidic soils of Jharkhand. *Indian J. Agron.,* **46**(4): 605-610.

Sonar, K.R., Kumbhar, D.D., Patil, B.P., Shinde, S.S., Wandre, S.S. and Zende, G.K. (1982). Fertilizer requirements for yield targeting of sorghum (*Sorghum bicolor* L. Moench) based on soil test values. *J. Maharashtra Agric.Univ.,***7**(1): 4 - 6.

Subbiah, B.V. and Asija, G.L. (1956). A rapid procedure for the estimation of the available nitrogen in soil. *Curr. Sci.,* **25** (8): 259 - 260.

Thakur, D.R., Prakash, B.M., Kharwar, P.C. and Bhalla, S.K. (1998). Effect of nitrogen and plant spacing on yield, nitrogen uptake and economics in baby corn (*Zea mays*). *Indian J. Agron.,* **43**(4): 668-671.

Tomar, S., Suresh and Timari, A.S. (1990). Production potential and economics of different cropping sequences. *Indian J. Agron.,* **35**: 30-35.

Umesh, M.R. (2008). Investigation on balanced fertilization for maize-pigeon pea cropping sequence in Alfisols of Karnataka. Ph.D. Thesis, University of Agricultural Sciences Bangalore, KARNATAKA (INDIA).

Umesh, M.R., Manjunatha, N., Shankar, M.A. and Jagadeesha, N. (2014). Influence of nutrient supply levels on yield, nutrient uptake, grain quality and economics of corn (*Zea mays* L.) in Alfisols of Karnataka. *Indian J. Dryland Agric. Res. & Dev.,* **29** (1): 73-78.

Varalakshmi, L.R., Srinivasamurthy, C.A. and Bhasakar, S. (2005). Effect of integrated use of organic manures and inorganic fertilizers on organic carbon, available N, P and K in sustaining productivity of groundnut-finger millet cropping system. *J. Indian Soc. Soil Sci.,* **53**(8): 315-318.

Vidyavathi, Dasog, G.S., Babalad, H.B., Hebsur, N.S., Gali, S.K., Patil, S.G. and Alagawadi, A.R. (2011). Influence of nutrient management practices on crop response and economics in different cropping systems in a Vertisol. *Karnataka J. Agric. Sci.,* **24**(4): 455-460.

Yadhav, K.S. and Nand, Hira (2004). Site specific nutrient management for optimal food grain production in Haryana. *Better Crops Int.,* **88**(2): 21-22.