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Research Article

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Effect of targeted yield approaches on growth, yield, yield attributes and nutrient uptake in maize (*Zea mays* L.)-chickpea (*Cicer arietinum* L.) cropping sequence in UKP command area of Karnataka

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Summary

Field experiments were conducted during *Kharif* and *Rabi* seasons of 2013-14 and 2014-15 at Agricultural Research Station, Raddewadagi, dist. Kalaburagi, University of Agricultural Sciences, Raichur, Karnataka to study the effect of targeted yield approach on growth, yield, yield attributing and nutrient uptake in maize-chickpea cropping sequence by involving SSNM, STCR targeted yield approaches. Application of nutrients through SSNM for targeted yield of 8.0 t ha^{-1} recorded significantly higher plant height (235.23 cm), number of leaves per plant (12.43), leaf area index (0.70), total dry matter production per plant (249.88 g plant^{-1}), grain yield (8.62 t ha^{-1}), length of cob (21.30 cm), number of grains per cob (397.30), hundred seed weight (31.63 g) and uptake of nitrogen, phosphorus and potassium by maize crop as compared to other treatments except STCR through fertilizers for targeted yield of 8.0 t ha^{-1}. The growth parameters of chickpea crop *viz*., plant height, total number of branches per plant and total dry matter production (36.55 cm, 29.57 and 19.13 g plant^{-1}, respectively), yield attributes *viz.*, seed yield and 100 seed weight (29.90 q ha^{-1} and 25.25 g, respectively) and total uptake of N, P and K was significantly higher (118.25, 26.63 and 102.09 kg ha^{-1}, respectively) with the residual effect of nutrients applied through SSNM approach for targeted yield of 8.0 t ha^{-1} followed by STCR approach targeted yield of 8.0 t ha^{-1} as compared to other treatments.

Key words : Maize-chickpea cropping sequence, SSNM, STCR targeted yield approaches, Growth, Yield, Yield attributes, Nutrient uptake

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Introduction

Maize and chickpea are the most important commercial crops grown in Vertisols of Upper Krishna Project command area of Karnataka.For increasing the profitability of maize in economic point of view, farmers are cultivating the crop intensively with the huge amount of chemical fertilizers, pesticides, weedicides etc. A judicious use of fertilizers is essential since the cost of fertilizers has gone up very high in recent years. The actual yield potentiality of maize and chickpea had not been achieved because of conventional low input production technologies. The systematic research towards evolving advanced production technology is also lacking. Existing fertilizer recommendation for maize and chickpea consist of fixed rates and timing of N, P and K for vast areas of production. Such recommendations are in practice over the years in large areas. 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. This research provides a synthesis of current information on maize-chickpea production systems, pros and cons of existing nutrient management strategies and the fertilizer best management practices for bridging yield gaps in maize-chickpea sequence cropping systems in the command area under irrigated condition. Applications of nutrients based on targeted yield approach found to be more useful and it provides balanced nutrient application in maize-chickpea sequence cropping system by measuring the growth, yield and yield attributes and uptake.

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 included 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%. 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 25[th] and 12[th] July and harvested on November 10[th] and October 31[th] 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 14[th] and 5[th] November and harvested on 18[th] and 2[nd] February during first and second year, respectively. The growth, yield and yield attributes of both the crops were recorded at harvest. The plant samples were collected at the harvest of maize and chickpea crop and analyzed for their nutrient concentration of N, P and K by adopting standard methods (Jackson, 1973) and total crop uptake was worked out.

Research Findings and Discussion

The crop growth, yield, yield attributes and uptake of both maize and chickpea crops were slightly better in the second season crop (2014-15) than first season crop (2013-14) and it might be due to better crop establishment and congenial weather conditions during crop growth. However, the pattern of response was similar in both the years and hence, only pooled data of two years are discussed in this paper.

Growth attributes of maize :

Pooled results showed that, application of nutrients through SSNM and STCR showed taller plant height and more number of leaves over absolute control, state recommendation, farmers practice and STL method (Table 1). The plant height also contributed for total dry matter was significantly higher in application of nutrients through SSNM approach targeted yield of 8.0 t ha^{-1} (235.23 cm) followed by STCR approach targeted yield of 8.0 t ha^{-1} (233.79 cm) at harvest. The reduction in the plant height in absolute control (208.43 cm) at harvest might be due to inadequate supply of nutrients and the results are also in conformity with the findings of Subramaniyan *et al*. (1987) who reported that the application of nitrogen @150 kg ha^{-1} recorded significantly higher plant height (180 cm) and plant dry matter (15300 kg ha^{-1}) in maize as compared to lower doses. These results are also in conformity with the findings of Jemal Abdulahi (2010) and Madhusudhan (2013) that morphological characters like plant height and number of leaves were improved substantially due to the application of nutrients based on SSNM. The significantly higher number of leaves per plant was observed with SSNM approach targeted yield of 8.0 t ha^{-1} (12.43) followed by STCR approach targeted yield of 8.0 t ha^{-1} (11.63) at harvest. This has helped in accumulation of higher dry matter in stem. These results are in concordance with the findings of Biradar *et al*. (2013) that nutrient application through SSNM for targeted yield of 10 t ha^{-1} recorded significantly higher number of leaves per plant (6.4). The total dry matter produced in maize plant was higher in SSNM approach targeted yield of 8.0 t ha^{-1} (249.88 g plant^{-1} at harvest) which was at par with STCR approach targeted yield of 8.0 t ha^{-1} (247.35 g plant^{-1}) and these were significantly higher as compared to control, farmers practice, RDF and STL method. The increased dry matter was usually associated with taller plant height, more number of leaves per plant and leaf area index, which led to greater accumulation of photosynthesis. These results are also in line with the Biradar *et al*. (2013) that nutrient application through SSNM for targeted yield of 10 t ha^{-1} recorded significantly higher total dry matter production per plant (501.4 g) and Setty (1981) that every increase in nitrogen level from 75 to 225 kg ha^{-1} increased the dry matter production of maize from 266 to 323 g plant^{-1}. The leaf area index (LAI) was significantly higher in SSNM/

Table 1 : Growth parameters of maize as influenced by different nutrient management approaches

Treatments	Plant height (cm)			Number of leaves plant^{-1}			Leaf area index			Total dry matter production (g plant^{-1})		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1	202.19	214.67	208.43	9.20	9.38	9.29	0.57	0.59	0.58	120.33	151.38	135.86
T_2	203.51	223.20	213.36	10.33	10.40	10.37	0.60	0.61	0.60	137.87	163.73	150.80
T_3	204.33	252.13	228.23	10.40	10.73	10.57	0.61	0.62	0.61	152.45	168.99	160.72
T_4	204.67	254.18	229.42	10.60	10.80	10.70	0.61	0.63	0.62	163.65	177.41	170.53
T_5	205.43	258.34	231.89	11.00	11.13	11.07	0.65	0.67	0.66	201.59	248.52	225.06
T_6	206.71	260.87	233.79	11.60	11.67	11.63	0.69	0.69	0.69	228.74	265.95	247.35
T_7	206.31	258.70	232.51	11.30	11.33	11.31	0.64	0.68	0.66	209.80	262.51	236.16
T_8	207.45	263.00	235.23	12.27	12.60	12.43	0.70	0.70	0.70	232.62	267.14	249.88
T_9	204.75	256.51	230.63	10.80	10.93	10.87	0.63	0.67	0.65	192.28	222.81	207.55
T_{10}	205.03	257.44	231.24	10.90	10.93	10.91	0.64	0.64	0.64	165.62	196.85	181.24
S.E.±	0.90	2.91	1.91	0.53	0.57	0.55	0.02	0.03	0.02	22.96	23.65	23.00
C.D. (P=0.05)	2.75	8.79	5.72	1.60	1.72	1.68	0.08	0.06	0.07	68.94	71.02	69.00

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

STCR approach targeted yield of 8.0 t ha^{-1} (0.70/0.69) followed by 125 per cent SSNM approach targeted yield of 7.0 or 8.0 t ha^{-1} (0.65 or 0.64) at harvest due to increase in nitrogen application. The results are in confirmation with the findings of Shivay *et al.* (2002); Jemal Abdulahi (2010) and Prasad *et al.* (1985) in maize crop.

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 2). 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 *et al*. (2013) and Dhillon *et al.* (2006) that application of nutrients through SSNM for targeted yield recorded significantly higher grain yield as compared 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

Table 2 : Yield and yield attributes of maize as influenced by different nutrient management approaches

Treatments	Length of cob (cm)			Number of grains 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	170.40	190.00	180.20	19.62	25.50	22.56	2.70	3.12	2.91
T_2	15.77	19.45	17.61	217.20	258.20	237.70	22.12	26.70	24.41	4.53	4.95	4.74
T_3	16.47	19.99	18.23	238.20	276.00	257.10	23.74	27.83	25.79	5.59	6.05	5.82
T_4	17.53	20.19	18.86	253.47	291.80	272.63	25.44	28.73	27.09	6.06	6.45	6.25
T_5	19.90	21.01	20.45	317.40	328.80	323.10	28.92	30.32	29.62	7.22	7.71	7.46
T_6	20.57	21.27	20.92	360.60	372.00	366.10	29.97	31.51	30.74	8.12	8.63	8.37
T_7	20.23	21.07	20.65	325.20	355.60	340.40	29.67	31.25	30.46	7.36	7.83	7.59
T_8	21.09	21.51	21.30	382.73	411.87	397.30	31.07	32.19	31.63	8.43	8.81	8.62
T_9	19.07	20.41	19.74	261.47	301.00	281.23	27.33	29.65	28.49	6.15	6.55	6.35
T_{10}	19.23	20.71	19.97	288.80	308.73	298.77	27.82	29.97	28.90	6.23	6.67	6.45
S.E.±	1.17	0.43	0.79	40.50	38.35	39.50	1.85	1.12	1.49	0.77	0.76	0.78
C.D. (P=0.05)	3.51	1.29	2.42	122.15	115.07	118.50	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

(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 3). 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 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

Table 3 : 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})

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

Table 4 : 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

Table 5: 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})

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 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 4). 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 (Table 1). 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 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 5). 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.

In conclusion application of nutrients through SSNM approach for targeted yield of 8.0 t ha^{-1} (274:111:201, kg N, P_2O_5 and K_2O ha^{-1}, respectively) was superior in maize-chickpea sequence to produce higher growth and yield attributes, productivity and nutrient uptake in Vertisol under irrigated condition.

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