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Nutrient management as influenced by tillage and crop residues on yield of maize (*Zea mays* L.)

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Abstract
Global food security, global environmental preservation as well as farmer level increased livelihood should be the main goals of a sustainable farming system in today's world plagued by degraded soils as a result of unsustainable crop management practices. Current agricultural management systems are threatened by increasing competition for ever-scarce water resources combined with continued use by most farmers of highly inefficient irrigation systems. The objective of this study was develop suitable tillage, crop residues and nutrient management practice in maize. Maize crop was raised in a split plot design with tillage as main and nutrient management as a sub treatments. Tillage treatments included Conventional tillage (CT), Zero tillage (ZT) and zero tillage with mulch (ZTM). Nutrient management treatments *viz:* nutrients required for a targeted yield of 8 and 10 ton per ha, state recommendation (SR), farmers practice (FP) and treatments where N, P and K omitted. Among the tillage practices, ZT recorded a highest grain (9.32 t ha^{-1}) and straw yield (11.73 t ha^{-1}) but ZTM maintained better physical, chemical and biological properties compared to other tillage practices. In case of nutrient management practices targeted yield 10 ton per ha which recorded highest grain yield of 11.01 t ha^{-1} validated the target based application concept ,Omitting potassium (10.32 t ha^{-1}) and targeted yield 8 ton per ha (9.90 t ha^{-1}) closely following it. In this study nutrient management strategy increased crop yield and profitability compared with treatments based on existing recommendation and farm practices with different tillage practices.

Keywords: Conservation agriculture, site-specific nutrient management

Introduction
In achieving food security for the ever growing population, a significant effect on our environment has been observed throughout the world. Persistent deployments of conventional excessive tillage, unscientific use of water and fertilizers have eroded the quality of natural resources over the years. Many agriculturally productive soils have been subjected to various soil degradative processes and have thus become unproductive due to increasing soil erosion and nutrient loss. The unsustainable practices involving excessive ploughing without retaining surface crop residues have posed serious challenges for the required achievement of food security to the ever growing population. Conservation agriculture and its principles have become vocal point for increasing crop production. These include mantainence of a permanent or semi permanent soil cover with plant residues to conserve, improve and make more efficient use of resources like soil, water and nutrients. The required extra productivity from the current 240 million tons target to over 350 million tons required has to be from regions of declining water tables, increasing soil degradation and experiencing climate change etc. We cannot achieve food security unless paradigm shift in the current agricultural production practices

Site-specific nutrient management (SSNM) is seen as one of the main focussed areas of precision agriculture. It is easiest, cheapest and most relevant techniques for the Indian farmers to maximize the resources and improve crop production besides bridging yield gap and break the stagnation in productivity. The present investigation was planned to deploy CA based effects of tillage and residue management on target based nutrient management in maize to attract attention of rice farmers.

Material and Methods
A field experiment on "Nutrient management as influenced by tillage and crop residues on yield of maize (*Zea mays* L.)" was conducted at the Agricultural College Farm, Bheemarayana Gudi during *kharif* season of 2012-13. The farm is situated in North Eastern Dry Zone (Zone 2) between 16º 43' N latitude and 76º 51' E longitude with an altitude of 412 MSL.

Soil samples collected (0-15 and 15-30 cm), before initiation of the experiment. were air dried, powdered to pass through 2 mm sieve for analysis of various physical and chemical properties by using standard protocols.

Available nitrogen was determined by modified alkaline permanganate method as described by Subbaiah and Asija (1956) [20] and expressed in kg ha^{-1}. Available phosphorus was determined by Olsen's method as described by Jackson (1973) [9] and expressed in kg ha^{-1}. Available potassium was extracted with neutral normal ammonium acetate (pH 7.0) and potassium present in the solution was estimated by Flame Photometer (Jackson, 1973) [9] and expressed in kg ha^{-1}. The experiment was laid out in split plot design with three main plots having eight treatments which was replicated three times. Main plots includes S_1 : Conventional tillage S_2 : Zero tillage S_3 : Zero tillage with mulch and Sub Plots includes T_1 : SSNM for target yield of 8ton per ha [150:46:60:25 (N:P:K:Zn)] T_2: State recommendation [150:75:45:25 (N:P:K:Zn)] T_3: Farmers practice [109:58:38:25 (N:P:K:Zn)] T_4 : Absolute control [0:0:0:0 (N:P:K:Zn)] T_5 : SSNM for target yield of 10 ton per ha [191:64.4:81:25 (N:P:K:Zn)] T_6 : N omission in T_5 treatment [0:64:81:25 (N:P:K:Zn)] T_7 : P omission in T_5 treatment [191:0:81:25 (N:P:K:Zn)] T_8 : K omission in T_5 treatment [191:64.4:0:25 (N:P:K:Zn)]. Fisher's method of analysis of variance was applied for analysis and interpretation of data to calculate the critical difference. The level of significance used in 'f' and 't' test was P = 0.05 or 5% (Panse and Sukhatme, 1976) [15].

Results and Discussion

Straw yield: The combined effects of both growth and yield attributing parameters significantly influenced maize straw yield (Table 1). A highest straw yield was in ZT (11.93 t ha^{-1}) followed by ZTM (11.14 t ha^{-1}) and CT (11.10 t ha^{-1}). However, nutrient management strategies resulted in a significant effects with highest yield (13.97 t ha^{-1}) in case of SSNM with target yield of 10 t per ha. Surprisingly supplying recommended fertilizers and omitting potassium (13.53 t ha^{-1}) did not cause any effects but results remained comparable treatment that was aimed at yield target of 10 t per ha.

Sessiz *et al.* (2010) [17] also reported significant effects of tillage on straw yield and agreed with the results of the present investigation. A significant increase in straw yield was due to significant effect on growth parameters (plant height, plant population, days to flowering, number of leaves, leaf area etc. and yield parameters (test weight, cob girth, seed arithmetic's). Similar effects of SSNM in maize on straw yield reported by from Bhagawandas *et al.* (1997) [13].

Grain yield: Grain yield remained in consonant with straw yield as far as the effect of tillage was concerned and effect of tillage on grain yield was significant. A highest grain yield was in ZT (9.3 t ha^{-1}) followed by CT (8.6 t ha^{-1}) in contrast ZTM had a significantly lower (8.4 t ha^{-1}) grain yield. A glance at the nutrient management strategies yielded significant differences between the various treatments. A highest grain yield (11.0 t ha^{-1}) was observed by the crop receiving SSNM based nutrients for yields target of 10 t per ha (Table 1). This recommendation is based in NE and yield obtained in the present investigation validated agreed with a targeted yield. Nutrient management controlled grain yield and had a direct bearing on the parameter. There was a direct relation between grain yield and most of the growth and yield parameters (Doberman *et al.* (2002) [6], and Kaushik Majumdhar *et al.* (2012) [10].

Available nitrogen: Soil available nutrients were measured to understand the effects of tillage and nutrient management strategies. Both in surface and sub-surface soils available nitrogen was not influenced by tillage practices (Table 2). Higher available nitrogen was observed in the surface soil where ZTM (215.9 kg ha^{-1}) was practiced followed by ZT (202.4 kg ha^{-1}). On the contrary lowest available nitrogen was observed in CT (202.2 kg ha^{-1}) at harvest. Similar effect of tillage was also noticed in the sub-surface samples.

SSNM based nutrient management significantly affected available nitrogen, both in surface as well as sub-surface soils when measured at harvest. At harvest, a highest available nitrogen was in where nutrient application was with a target yield of 10 t per ha (242.7 kg ha^{-1}) followed by nutrient application with a target yield of 8 t per ha (230.2 kg ha^{-1}). A similar status of available nitrogen in sub-surface samples was also noticed. . Nitrogen availability is related to the carbon addition to the soil and an increased organic carbon addition in this investigation had a direct effect on soil nitrogen. Similar increases in soil nitrogen due to tillage have been reported by Lal *et al.* (1994) [12] and Singh *et al.* (2012) [18].

Available phosphorous: Data on available phosphorus is provided in Table 3. From the results, it is quite clear that effects of tillage practices remained significant, in both the depth (0-15, 15-30) at harvest. Available phosphorus was significantly higher in ZTM (51.4 kg ha^{-1}) than ZT (50.3 kg ha^{-1}) and CT (48.3 kg ha^{-1}). Later treatments recorded significantly lower available phosphorus compared to ZTM. Such a significant difference was also noticeable in the sub-surface soils. . In zero tillage without mulch though contributed for the carbon in surface soil (0-15 cm), non-disturbance of soil through tillage itself elevated biomass and available nutrients contributing to the increased extractable phosphorous. Results showing similar effects of tillage on soil extractable phosphorous have been reported from many workers including Singh *et al.* (2005) [19], He *et al.* (2008) [8], Chen *et al.* (2008) [5] and Malecka *et al.* (2012) [13].

Available phosphorus changed as nutrient management strategies also changed. A highest level of available phosphorus (57.6 kg ha^{-1}) was observed in the surface soils that received SSNM based nutrients required for the targeted yield of 10 t per ha, followed SR (57.4 kg ha^{-1}) and treatment where potassium was omitted (56.1 kg ha^{-1}). . the retention of mulch in ZT plots provided energy for the soil microbial biomass leading to greater carbon addition, in addition to plant nutrients including phosphorous SSNM based nutrient management remained superior to other treatments, especially when yield target was 10 t per ha. Omission of nitrogen and potassium did not differ but the available phosphorous, where phosphorous omission showed lower phosphorous because of mining of phosphorous from the soil recording nearly 37 per cent decline in available phosphorous. Results depicting similar effects of SSNM on soil available phosphorous status in agreement with Ahlawat and Shivkumar, (2005) [1].

Available potassium: Data on available potassium is provided in Table 4 and tillage practices remained significant, in both the depth (0-15, 15-30), at harvest. ZTM (336.3 kg ha^{-1}) recorded significantly higher available K than in ZT (327.4 kg ha^{-1}) and CT (325.4 kg ha^{-1}). The latter treatments recorded significantly lower compared to ZTM. Such significant differences were also noticed in the sub-surface soils. The higher available potassium was noticed in ZTM with lowest in ZT but such significant differences observed was not observed by Murillo *et al* (1998) [14]. However, Alam *et al.*

(2002) [2] reported significant effect of tillage on soil available potassium.

Influence of different nutrient management strategies revealed a significant effect on available potassium. Available potassium changed as nutrient management strategies followed changed. A highest level of available potassium (360.6 kg ha^{-1}) was in surface that received SSNM based nutrients required for the targeted yield of 10 t per ha followed by treatment where nitrogen was omitted (355.5 kg ha^{-1}) from full supply nutrients and treatment where phosphorus was omitted (354.0 kg ha^{-1}) from supply. Omission of potassium decreased the potassium availability in soil but level of soil potassium was still higher enough to meet the crop demand. This indicated the inherent potential of soil to supply potassium. Omission of N and P did not affect potassium supply and remained on par. Results with similar views on available potassium have been reported by Fatokum (2000) [7] and Singh *et al.* (2005) [19].

Table 1: Maize yield parameters as influenced by tillage, crop residues and site specific nutrient management practices

Treatments	Grain yield (t. ha^{-1})				Straw yield (t.ha^{-1})			
	CT	**ZT**	**ZTM**	**MEAN**	**CT**	**ZT**	**ZTM**	**MEAN**
T_1 - SSNM for 8 ton per ha	9.73	10.65	9.32	9.90	12.30	13.81	12.58	12.90
T_2 - State recommendation	9.45	10.17	8.93	9.52	12.16	13.09	11.81	12.35
T_3 – Farmers practice	9.04	9.73	8.78	9.18	12.04	12.54	11.80	12.13
T_4 – Control	5.18	5.72	5.51	5.47	6.50	7.38	7.50	7.13
T_5 - SSNM for 10 ton per ha	10.99	11.62	10.41	11.01	13.50	14.76	13.64	13.97
T_6 - N omission in T 5	6.07	6.61	5.94	6.21	7.70	7.99	7.97	7.88
T_7 - P omission in T 5	8.17	9.18	8.39	8.58	10.53	11.44	10.93	10.97
T_8 - K omission in T 5	10.02	10.86	10.07	10.32	13.27	14.47	12.85	13.53
Mean	8.58	9.32	8.42		11.10	11.93	11.14	
For comparing	C.D. at 5%		S. Em±		C.D. at 5%		S. Em±	
Tillage practices (T)	0.11		0.04		0.16		0.04	
Nutrient management (N)	0.14		0.05		0.30		0.11	
T at same level of N	0.26		0.09		0.52		0.18	
N at same or different level of T	0.25		0.08		0.52		0.18	

NS: Non-significant

Table 2: Effect of tillage, crop residues and Site specific nutrient management on Available nitrogen (kg ha^{-1})

Treatments	0 – 15 cm				15 – 30 cm			
	CT	**ZT**	**ZTM**	**MEAN**	**CT**	**ZT**	**ZTM**	**MEAN**
T_1 - SSNM for 8 ton per ha	228.5	223.3	238.9	230.2	203.2	192.6	209.5	201.8
T_2 - State recommendation	212.5	213.2	227.2	217.6	190.0	185.3	200.9	192.1
T_3 – Farmers practice	203.2	211.2	222.7	212.4	182.4	184.6	199.3	188.8
T_4 – Control	146.7	150.0	153.3	150.0	133.5	141.9	144.4	139.9
T_5 - SSNM for 10 ton per ha	242.0	235.7	250.5	242.7	207.7	207.3	217.7	210.9
T_6 - N omission in T 5	143.3	148.3	152.9	148.2	135.4	138.6	155.2	143.1
T_7 - P omission in T 5	211.9	214.6	234.5	220.3	192.8	195.6	205.8	198.1
T_8 - K omission in T 5	229.3	222.5	246.9	232.9	200.5	207.5	216.7	208.2
MEAN	202.2	202.4	215.9		180.7	181.7	193.7	
For comparing	S. Em ±		C.D. at 5%		S. Em ±		C.D. at 5%	
Tillage practices (T)	NS		7.77		2.91		NS	
Nutrient management (N)	22.34		7.83		4.69		13.40	
T at same level of N	NS		13.56		8.13		NS	
N at same or different level of T	NS		14.87		8.14		NS	

NS: Non significant **S:** At sowing **CT:** Conventional tillage **ZTM:** Zero tillage with mulch **H:** At harvest **ZT:** Zero tillage

Table 3: Effect of tillage, crop residues and Site specific nutrient management on Available phosphorus (kg ha^{-1})

Treatments	0 – 15 cm				15 – 30 cm			
	CT	**ZT**	**ZTM**	**MEAN**	**CT**	**ZT**	**ZTM**	**MEAN**
T_1 - SSNM for 8 ton per ha	51.9	53.9	54.6	53.5	46.9	51.1	50.2	49.4
T_2 - State recommendation	56.7	58.2	57.2	57.4	53.1	54.4	52.7	53.4
T_3 – Farmers practice	49.0	48.3	51.6	49.7	45.3	46.1	46.1	45.8
T_4 – Control	34.1	37.4	39.1	36.9	29.9	31.9	36.3	32.7
T_5 - SSNM for 10 ton per ha	56.1	58.2	58.6	57.6	52.3	54.7	54.9	54.0
T_6 - N omission in T 5	50.5	53.2	54.0	52.6	45.5	49.3	49.6	48.1
T_7 - P omission in T 5	34.1	36.5	38.7	36.4	30.4	32.7	35.3	32.8
T_8 - K omission in T 5	53.8	57.0	57.5	56.1	51.1	53.6	54.3	53.0
Mean	48.3	50.3	51.4		44.3	46.7	47.4	
For comparing	S. Em ±		C.D. at 5%		S. Em ±		C.D. at 5%	
Tillage practices (T)	0.35		0.96		0.71		2.29	
Nutrient management (N)	0.31		0.88		0.49		1.39	
T at same level of N	0.53		1.53		0.84		2.40	
N at same or different level of T	0.56		1.71		1.00		3.24	

NS: Non significant **S**: At sowing **CT:** Conventional tillage **ZTM:** Zero tillage with mulch **H:** At harvest **ZT:** Zero tillage

Table 4: Effect of tillage, crop residues and Site specific nutrient management on Available potassium (kg ha^{-1})

Treatments	0 – 15 cm				15 – 30 cm			
	CT	ZT	ZTM	MEAN	CT	ZT	ZTM	MEAN
T_1 - SSNM for 8 ton per ha	341.8	343.8	350.1	345.2	339.7	340.7	347.1	342.5
T_2 - State recommendation	333.2	333.6	344.8	337.2	331.4	331.9	342.0	335.1
T_3 – Farmers practice	331.6	334.6	341.7	336.0	328.8	332.2	338.7	333.2
T_4 – Control	270.5	273.3	275.4	273.1	279.8	281.6	285.1	282.2
T_5 - SSNM for 10 ton per ha	355.8	355.9	370.1	360.6	353.2	353.6	366.8	357.9
T_6 - N omission in T 5	348.8	351.9	365.8	355.5	345.9	348.9	362.8	352.5
T_7 - P omission in T 5	347.8	349.3	365.0	354.0	344.7	346.6	361.5	350.9
T_8 - K omission in T 5	273.7	277.1	277.4	276.1	280.6	283.9	286.3	283.6
Mean	325.4	327.4	336.3		325.5	327.4	336.3	
For comparing	S. Em ±		C.D. at 5%		S. Em ±		C.D. at 5%	
Tillage practices (T)	0.77		3.03		1.03		NS	
Nutrient management (N)	15.90		45.37		13.05		37.24	
T at same level of N	27.54		NS		22.60		NS	
N at same or different level of T	25.77		NS		21.17		NS	

NS: Non significant **S:** At sowing **CT:** Conventional tillage **ZTM:** Zero tillage with mulch **H:** At harvest **ZT:** Zero tillage

Conclusion

In conclusion, it is observed that conservation agriculture based practices such as zero tillage, with or without mulch provided better soil physical, chemical and biological environment and nutrients (both macro and micronutrients). These hospitable changes provided better platform for appreciable mobilization of nutrients and their availability to crops resulting in significant improvement in growth and maize yield. SSNM with a target of 10 t per ha recorded significantly higher grain and stover yield compared to rest of nutrient management practices and on par where potassium was omitted. Nutrient based on target yield and yield obtained validated SSNM approach. The approach supplies right dose of nutrients at right time, right place and source to save, reduce cost and increase farm gate income of the farmers.

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