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Jayanta Das
Department of Soil Science and Agricultural Chemistry, Post Graduate Institute, Akola, DR. Panjabrao Deshmukh Krishi Vidyapeeth, Krishnagar PO, Akola, Maharashtra, India

Arati S Ghatole
Department of Soil Science and Agricultural Chemistry, Post Graduate Institute, Akola, DR. Panjabrao Deshmukh Krishi Vidyapeeth, Krishnagar PO, Akola, Maharashtra, India

Jyoti Sharad Shirankar
Department of Soil Science and Agricultural Chemistry, Post Graduate Institute, Akola, DR. Panjabrao Deshmukh Krishi Vidyapeeth, Krishnagar PO, Akola, Maharashtra, India

NM Konde
Department of Soil Science and Agricultural Chemistry, Post Graduate Institute, Akola, DR. Panjabrao Deshmukh Krishi Vidyapeeth, Krishnagar PO, Akola, Maharashtra, India

Corresponding Author:
Jayanta Das
Department of Soil Science and Agricultural Chemistry, Post Graduate Institute, Akola, DR. Panjabrao Deshmukh Krishi Vidyapeeth, Krishnagar PO, Akola, Maharashtra, India

Effect of continuous adoption of conservation agriculture management practices on soil chemical properties under soybean in Vertisol

Jayanta Das, Arati S Ghatole, Jyoti Sharad Shirankar and NM Konde

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Abstract
A field experiment was conducted during *kharif* 2018/19 on farmer's field in three villages of Barshi takali tehsil under Department of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola (MS). The experiment consisted of ten treatments in randomized block design replicated thrice were each farmer has been treated as single treatment and each sample taken from a treatments has been treated as one replication. The soil of experimental site was Vertisol belonging to fine, smectitic, hyperthermic, Typic Haplusterts. It was calcareous in nature and moderately alkaline in reaction. The fertility status of the soil indicates that the soil was moderate in organic carbon, available nitrogen and phosphorus and very high in available potassium. Result revealed that the lower value of pH (7.77), higher value of EC (0.35 dS m^{-1}), highest value of organic carbon content (7.80 g kg^{-1}), and lowest value of calcium carbonate content (7.63%) was recorded in T_1 where, conservation agriculture management practices were followed since last 15 years. The highest value of available nitrogen (225.38 kg ha^{-1}), available phosphorus (23.81 kg ha^{-1}), available potassium (419.70 kg ha^{-1}) and available sulphur (12.00 kg ha^{-1}) were recorded in T_1 where, conservation agriculture management practices were followed since last 15 years.

Keywords: Conservation agriculture, chemical properties, organic carbon, Vertisols

Introduction
Ever-increasing global population, particularly in many developing countries requires increased supply of food, fiber, oil, which poses a grave challenge before the agricultural scientists to produce more and more from limited, shrinking, degraded land and water resources. Tilling soils continuously without adding organic matter has adverse effects on soil health and quality of produce. India alone needs to produce additional 64 million tonnes of food over the next decade to achieve targeted 294 million tonnes by 2020. Soil C and N sequestration need to be enhanced to sustain the resources, ensuring that earlier production grains are sustained and possibly further enhanced to meet the emerging needs. The concerns for erosion, soil-quality deterioration, and chemical hazards loom large in recent years and have compelled the scientists/researchers to look back to the past towards evolving conservation agriculture based systems/practices, which aim at higher productivity and profitability through rational and sustainable use of available resources on a long-term basis. Conservation agriculture, emphasizing the minimum soil disturbance, permanent soil cover through crop residues or other cover crops and diversified crop rotation using a legume, is a promising technology for rational use of available resources and sustainable productivity in the long-run. Conservation agriculture reverses soil degradation processes and builds up soil fertility through increase in water holding capacity and facilitating better infiltration of rainwater and enhancing groundwater storage, enrichment in soil organic carbon (SOC), and enhanced microbial diversity in the rhizosphere. It eliminates power-intensive soil tillage, thus reducing the drudgery and labor required for crop production by more 50% of the small-scale farmers. Conservation agriculture has a long-term and broader perspective, which goes beyond yield improvement.

Material and Methods
The field experiment was conducted on farmer's field in three villages *viz.*, Sukali, Alanda and Nimbhara under Barshi takali tehsil.

All the farmers have been following no tillage practices for last few years except one farmer who have been regularly following conventional agricultural practices. All the farmers have been following same cropping pattern for last ten years. Soybean and pigeon pea intercrop was grown in kharif seoson and in summer chickpea was grown for last ten years. The present investigation was conducted in *kharif* 2018-19 with soybean as a test crop. The initial soil sample have been collected from every farmes and analyzed the various soil properties.

Table 1: Experimental details

Sr. No	Site	Treatment	Cropping Pattern	
			2018-19 Kharif	Management Practices
1	Site 1 (Yogesh Hage)	T_1	-Soybean + Pigeon pea	-No ploughing since 15 years - Harrowing -Crop residues incorporated in soil
2	Site 2 (Babulal Charawane)	T_2	-Soybean + Pigeon pea	- No ploughing since 8 years -Harrowing -Crop residues incorporated in soil
3	Site 3 (Sakari Yawatkar)	T_3	-Soybean + Pigeon pea	-No ploughing since 4years -Harrowing -Crop residues incorporated in soil
4	Site 4 (Purshottam Lande)	T_4	-Soybean + Pigeon pea	-Regular ploughing each year
5	Site 5 (Ramdas Kakad)	T_5	-Soybean + Pigeon pea	-No ploughing since 12 years -Harrowing -Crop residues incorporated in soil
6	Site 6 (Sanjay Bhawane)	T_6	-Soybean + Pigeon pea	-No ploughing since 10 years -Harrowing -Crop residues incorporated in soil
7	Site 7 (Ramrao Wannere)	T_7	-Soybean + Pigeon pea	-No ploughing since 6 years -Harrowing -Crop residues incorporated in soil
8	Site 8 (Sanjay Dhore)	T_8	-Soybean + Pigeon pea	- No ploughing since 1 year - Crop residues incorporated in soil
9	Site 9 (Ganesh Nanote)	T_9	-Soybean + Pigeon pea	- No ploughing since 3 year - Crop residues incorporated in soil
10	Site 10 (Najakrao Nanote)	T_{10}	-Soybean + Pigeon pea	- No ploughing since 2 year - Crop residues incorporated in soil

Each sample has been treated as one replication and three samples have been taken from each site. Thus 10 treatments with 3 replications has been studied using RBD design.

Location, duration and season of experiment

The experiment on “Effect of continuous adoption of conservation agriculture management practices on soil health in Vertisol” carried out on the Farmers field of Barshi takali tehsil, Akola during *kharif* 2018-19.

Climate and weather conditions

Akola is situated in sub-tropical region between 22^0 42’ N latitude and 77^0 02’ E longitudes. The altitude of the place is 304.42 m above mean sea level. The climate of Akola is semi-arid and characterized by three distinct season *viz.*, hot and dry summer from March to May, warm humid rainy season from June to October and mild cold winter from November to February. Average annual precipitation on the basis of last fifteen years is 515.8 mm. Monthly weather data recorded at Agro-meteorology Observatory, Dr. PDKV, Akola during 2018-19 along with corresponding normal are presented in Table 1. Weather situation during 2018-19 and the crop season has been described briefly in following sections.

Rainfall

Month wise rainfall distribution at Akola during June 2018 to March 2019 is presented in Table 1. The month wise data along with normal on various other weather parameters recorded at Agro-meteorology Observatory, Dr. PDKV, Akola during 2018-19 is also presented in Table 1. Rainfall during Kharif 2018 (June- September) amounted 830.1 mm which was 127% of the corresponding normal rainfall (656.2 mm). Monthly rainfall during June, July, August and September amounted to 291.6, 261.9, 212.2 and 64.4 mm which was 104, 130, 112 and 52 per cent of the monthly normal (1981-2010), respectively. During post monsoon period (October- December) rain events recorded were during 20 November amounting to 4.5 mm. Remaining post monsoon months (November to December) and winter months (January and February) did not receive any rain day event affecting rainfed *rabi* crops. Further rainless weather continued across March month also. Total rainy days during June to September were 41 as against the normal of 34 days.

Air Temperature

The average maximum high temperature of 43.7 ^{0}C was recorded in May 2018 while, average minimum low temperature of 10.5 ^{0}C was recorded in Janury 2019. By and large, the temperature deviation showed mostly above normal trend with very few occasions below normal deviation across the season, which affected growth and development of soybean crop.

Relative Humidity

The higher relative humidity of 88% was observed in July 2018 and the lower relative humidity of 33% was observed in April 2018. Higher humidity range across most part of the monsoon season was due to rainy/cloudy monsoon atmosphere. Overall actual evening relative humidity more or less followed the trend of morning relative humidity.

Pan Evaporation

The higher pan evaporation of 14.9 mm was recorded in May 2018 while, the lower pan evaporation of 4.3 mm was recorded in December 2018.

Bright sunshine hours

The higher bright sunshine of 9.1 hrs was recorded in April 2018 while, lower bright sunshine of 2.0 hrs was recorded in July and August 2018.

During the major part of post-monsoon and winter months BSH values were above normal (+0.6 to +1.2 hrs), excepting marginally below normal values during 45 MW (1.2 hrs). By and large, lower than normal bright sunshine hours might have interfered with the potential photosynthetic activity of crop plants. Also it might have facilitated availability of soil moisture for comparatively longer period of time.

Wind speed

Wind speed was lower than normal through- out the *kharif* as well as *rabi* growing season. Except during 26 MW (+2.2 km/hr) of monsoon phase, It remained markedly lower than normal across the *kharif* as well as *rabi* growing season. Lower wind speed keeps the rate of evaporation lower benefiting *kharif* and *rabi* crops.

Soil

The soil of experimental site was Vertisol belonging to fine, smectitic, hyperthermic, Typic Haplusterts. It was calcareous in nature and moderately alkaline in reaction. The fertility status of the soil indicates that the soil was moderate in organic carbon, available nitrogen and phosphorus and very high in available potassium.

Cropping history of the experimental plot

The field experiment was conducted on farmer's field in three villages of Barshi takali tehsil. All the farmers have been following no tillage practices for last few years except one farmer who have been regularly following conventional agricultural practices. All the farmers have been following same cropping pattern for last ten years. Soybean and pigeon pea intercrop was grown in *kharif* seoson and in summer chickpea was grown for last ten years. The present investigation was conducted in *kharif* 2018-19 with soybean as a test crop. The initial soil sample have been collected from every farmer and analyzed the various soil properties.

Statistical analysis

Experimental data were analysed by adopting standard statistical methods of analysis of variance as given by Gomez and Gomez (1984). The field experiment was conducted in Farmer's field of three villages *viz.*, Sukali, Alanda and Nimbhara under Barshi takali tehsil. The performances of ten treatments on different conservation management practices were separately analysed by using RBD.

Methods adopted

Collection and processing of soil samples

The treatment wise initial surface soil samples (0-20 cm) before sowing in *kharif* (2018-19) from experimental site and after harvest of *kharif* were collected. Soil samples were air dried in shade and stored in polythene bags for further analysis. The air dried samples were carefully and gently ground with the wooden pestle to break soil lumps (clods) and passed through sieve of 2 mm diameter. The sieved samples were mixed thoroughly and stored in polythene bags, properly labelled and preserved for subsequent analysis. Soil samples for biological parameters was collected during peak growth stages or grand growth stages of crop and immediately analysed.

Soil analysis

Soil chemical properties

Soil reaction (pH)

Hydrogen ion activity expressed as pH was measured with pH meter using 1:2.5 soil-water suspension (Jackson, 1973) [11].

Electrical conductivity

The clear supernatant extract obtained from soil-water suspension used for pH was utilized for the EC measurement using a conductivity bridge (Jackson, 1973) [11].

Organic carbon

Walkley and Black method as described by Jackson, 1973 [11] was used to determine organic carbon content of soil.

Calcium carbonate content ($CaCO_3$)

Rapid titration method as directed by Piper (1966) [20] was used to determine the calcium carbonate content of soil.

Available nutrients

Nitrogen

Available nitrogen was determined by alkaline permanganate method using microprocessor based automatic distillation system (Subbiah and Asija, 1956) [26].

Phosphorus

Available phosphorus was determined by Olsen's method using 0.5 M sodium bi-carbonate as an extractant using UV based double beam spectrophotometer (Watanabe and Olsen, 1965) [28].

Potassium

Available potassium was determined by neutral normal ammonium acetate method using flame photometer (Knudsen and Peterson, 1982) [15].

Available Sulphur

Available sulphur was determined by Morgan's reagent as extractant (Turbidimetric method) using UV based double beam spectrophotometer (Chesnin and Yien, 1950) [4].

Yield of soybean

Yield of soybean was picked from net plots in all the replications and yield per plot and yield per hectare was calculated.

Table 2: Monthly Weather data for the year 2018-2019 recorded at Meteorological Observatory, Department of Agronomy, Dr PDKV., Akola

Actual 2018-19 Normal 1981-2010																			
Month	**T MAX (ºC)**		**T MIN (ºC)**		**BSH (hrs)**		**Ws (km/hr)**		**RHI (%)**		**RHII (%)**		**Evap (mm)**		**RF (mm)**		**CRF (mm)**		**Rainy Days**
2018	**N**	**A**	**N**	**A**	**N**	**A**	**N**	**A**	**N**	**A**	**N**	**A**	**N**	**A**	**N**	**A**		**N**	**A**
January	29.8	30.2	11.8	10.9	8.2	7.9	4.2	1.2	70	63	29	21	4.4	5.8	10.7	0.0	0.0	0.9	0
February	32.6	33.1	13.7	15.8	8.8	7.1	4.9	2.2	57	55	22	22	6.3	7.2	7.4	0.7	0.7	0.6	0

March	37.0	37.4	18.2	20.3	8.9	7.2	6.0	3.0	45	38	18	15	9.1	9.0	15.2	3.4	4.1	1.1	1
April	41.0	41.8	23.5	25.4	9.4	9.1	8.0	3.9	38	33	15	12	12.7	11.7	2.6	0.3	4.4	0.4	0
May	42.3	43.7	27.5	30.3	9.4	8.6	12.8	7.5	46	37	19	15	15.6	14.9	12.4	0.5	4.9	1.2	0
June	37.5	36.6	25.9	25.2	6.7	5.4	13.5	11.2	69	74	41	43	10.7	9.8	142.6	291.6	296.5	6.8	13
July	32.1	30.0	23.9	23.9	4.0	2.0	10.6	6.4	83	88	61	70	5.3	4.4	200.7	261.9	558.4	10.8	18
August	30.4	29.6	23.1	23.7	3.7	2.0	9.9	8.5	87	86	68	69	4.1	4.5	189.7	212.2	770.6	9.9	8
September	32.1	32.1	22.5	23.0	6.0	5.9	6.8	3.9	85	84	57	52	4.6	4.7	123.2	64.4	835.0	6.5	2
October	33.4	35.0	18.6	18.8	7.9	8.7	3.7	0.7	78	73	39	30	4.9	5.2	53.9	0.0	835.0	2.9	0
November	31.5	33.2	14.2	16.4	8.2	8.1	3.4	0.6	72	73	32	29	4.5	4.8	18.8	4.5	839.5	1.1	1
December	29.6	28.5	11.1	12.0	8.1	7.0	3.4	1.1	71	73	29	33	4.0	4.3	11.5	0.0	839.5	1.6	0
2019																			
January	29.8	28.4	11.8	10.5	8.2	7.6	4.2	1.2	70	69	29	27	4.4	4.9	10.7	0.0	0.0	0.9	0.0
February	32.6	32.2	13.7	15.6	8.8	8.2	4.9	3.0	57	53	22	22	6.3	6.4	7.4	1.9	1.9	0.6	0.0
March	37.0	36.7	18.2	16.9	8.9	8.9	6.0	2.6	45	44	18	20	9.1	7.9	15.2	0.0	1.9	1.1	0.0

Table 3: Initial physical and chemical properties of soil

Treatments	Physical properties of soil				Chemical properties of soil							
	BD	MWD	HC	Soil moisture	pH	EC	OC	$CaCO_3$	Available nutrients (kg ha^{-1})			S
	(Mg m^{-3})	(mm)	(cm h^{-1})	(%)	(1:2.5)	(dS m^{-1})	(g kg^{-1})	(%)	N	P	K	(mg kg^{-1})
Site 1 (15 years)	1.34	0.71	0.67	13.07	7.95	0.34	6.70	7.70	221.27	20.30	416.15	10.69
Site 2 (8 years)	1.41	0.67	0.69	12.53	8.13	0.31	6.67	7.90	198.47	17.73	407.87	10.87
Site 3 (4 years)	1.48	0.68	0.67	12.08	8.25	0.24	6.27	8.10	190.07	12.16	400.50	10.00
Site 4 (Regular ploughing)	1.50	0.63	0.71	11.34	8.39	0.26	5.03	8.35	172.70	9.61	365.77	8.38
Site 5 (12 years)	1.38	0.70	0.66	11.73	8.00	0.32	6.90	7.78	206.17	18.35	408.57	10.14
Site 6 (10 years)	1.37	0.67	0.66	11.56	8.00	0.31	6.87	7.87	203.32	17.82	409.27	10.90
Site 7 (6 years)	1.35	0.69	0.66	11.46	8.20	0.25	6.47	8.13	196.32	14.14	407.33	10.00
Site 8 (3 years)	1.48	0.66	0.70	11.88	8.26	0.25	5.80	8.20	176.75	10.81	367.37	9.96
Site 9 (1 years)	1.47	0.67	0.71	10.64	8.29	0.23	6.30	8.17	186.99	11.50	391.10	9.97
Site 10 (2 years)	1.48	0.67	0.71	10.81	8.28	0.25	6.03	8.23	188.39	10.04	381.53	10.02

Results and Discussion

Chemical properties of soil

Soil pH

Data pertaining to soil pH under different treatments are presented in table 4. The effect of conservation agriculture practices and incorporation of crop residues on soil pH was non-significant. The pH influenced by different treatments varied from 7.77 to 8.41. The lower pH (7.77) was recorded in T_1 where conservation agriculture was followed for last 15 years, followed by 8.02 in T_5, where ploughing was not made since last 12 years. The higher soil pH was also recorded in T_4 (8.41) where regular ploughing was followed by farmer. The decrease in soil pH might be due to long term use of organic manures, crop residues incorporation and long term conservation agriculture practices. The organic manures and crop residues contain large amount of organic nitrogen such as protein and amino acids, which mineralizes to nitrate in soil producing protons during nitrification and hence acidifying the soil. Singh *et al.* (2014) [24] reported decrease in pH of soil under farmyard manure, which might be due to the activation of Al^{3+} and continuous release of basic cation upon its decomposition and gravitational movement of those cations into lower horizons of soil. The similar result also noted by Guled *et al.* (2002) who has reported that application of organic manures and incorporation of crop residues decreases the pH of soil. These results are also in conformity with Mandal *et al.* (2007) [17]. The identical result was observed by Rathod *et al.* (2003) [21] that the pH of the soil was reduced significantly by application of FYM at 5 tons per ha.

Soil EC

The data on electrical conductivity influenced by long term conservation agriculture management practices is presented in table 4. The effect of conservation practices and incorporation of crop residues on electrical conductivity of soil was non-significant. The electrical conductivity as influenced by different treatments varied from 0.24 to 0.35 dSm^{-1}. The numerically higher electrical conductivity was observed in T_1 (0.35 dSm^{-1}) where the farmer have been practicing conservation tillage since last 15 years followed by T_5 (0.32 dSm^{-1}) where no ploughing was practicing since last 12 years and the lower value of electrical conductivity was observed in T_4 (0.24 dSm^{-1}) where regular ploughing was followed. These results are in accordance with the findings of Guled *et al.* (2002), who stated that no tillage has more electrical conductivity than conventional tillage system.

Organic carbon

The results on organic carbon content in soil after harvest of soybean is presented in table 4. The organic carbon in soil was significantly influenced due to the effect long term no ploughing practice. The organic carbon status under various treatments were assessed and presented in table 7. The organic carbon varied from 5.07 to 7.8 g kg^{-1}. Significantly higher value of organic carbon was observed in T_1 (7.8 g kg^{-1}) where conservation agriculture practice was followed since last 15 years followed by T_5 (7.67 g kg^{-1}) where the same practice was followed for last 12 years. While lower value of organic carbon was registered with T_4 (5.07 g kg^{-1}) were regular ploughing was practiced each year. The enrichment of soil organic carbon where conservation agriculture management practices was followed since last many years might be due to accumulation of biomass in soil and favorable biological environment. Similar results were noted by Wagh *et al.* (2016) [27] who stated slightly higher values of organic carbon in conservation tillage as compared to conventional tillage. These results are in accordance with Novak *et al.* (2009) [19] who reported that conservation tillage increases the soil organic carbon as compared to disc tillage system. Sainju *et al.* (2009) [22] also noted that no tillage increases organic carbon in soil as compared to tilled plot. Lal and Jacinth

(2009) [16] reported that organic C concentration in the 0-5 cm soil depth were significantly greater under no tillage (16.3 g kg^{-1}) compared to conventional tillage (8.8 g kg^{-1}). Similar results recorded by Sonune *et al*. (2012) [25], and stated that, that higher organic carbon under minimum tillage as compared to the conventional tillage in Vertisols.

Calcium carbonate

The presence of calcium carbonate affects the physical and chemical characteristics of soil. High concentration may not severely restrict water movement but it prevents root penetrations. The calcium carbonate content in the soil as influenced by various treatments is presented in table 4. The effect of long term conservation agriculture management practices on calcium carbonate content was found to be non-significant. In the present study, the investigation showed calcium carbonate range varied from 7.63 to 8.25%. The lowest value of calcium carbonate was noted in T_1 (7.63%) where conservation agriculture management practices were followed since last 15 years. Marginal value of calcium carbonate was noted in T_5 (7.71%) where conservation agriculture management practices were followed since last 12 years and highest value of calcium carbonate was noted in T_4 (8.25%) where conventional agriculture practices was followed each year. The results are in accordance with the findings of Bellakki and Badanur (1997) [1] and Nehra and Hooda (2002) [18], Katkar (2008) [12] reported slight reduction in calcium carbonate content of Vertisol with organic manure in combination with inorganic fertilizer.

Table 4: Effect of conservation agriculture management practices on soil chemical properties under soybean

Treatments	pH (1:2.5)	EC (dS m^{-1})	Organic carbon (g kg^{-1})	Calcium carbonate (%)
T1: Site 1 (15 years)	7.77	0.35	7.80	7.63
T2: Site 2 (8 years)	8.09	0.32	7.33	7.82
T3: Site 3 (4 years)	8.18	0.25	6.50	8.05
T4: Site 4 (Regular ploughing)	8.41	0.24	5.07	8.25
T5: Site 5 (12 years)	8.02	0.32	7.67	7.71
T6: Site 6 (10 years)	8.05	0.29	7.47	7.83
T7: Site 7 (6 years)	8.16	0.24	7.33	8.00
T8: Site 8 (1 years)	8.18	0.26	5.83	8.20
T9: Site 9 (3 years)	8.26	0.23	6.53	8.12
T10: Site 10 (2 years)	8.21	0.24	6.20	8.20
SE (m) ±	0.11	0.03	0.32	0.12
CD at 5%	NS	NS	0.94	NS

Soil Fertility

Available nitrogen

Data pertaining to available nitrogen as influenced by different treatments is presented in table 5. The data in respect of available nitrogen as influenced by long term conservation agriculture management practices was found significant. Available nitrogen recorded significantly highest in T_1 (225.38 kg ha^{-1}) where conservation agriculture was introduced since last 15 years followed by T_5 (209.51 kg ha^{-1}) where the same practice was followed for last 12 years, and followed by rest of treatments. The lower value of available nitrogen was found in T_4 (177.10 kg ha^{-1}) where regular ploughing was adopted each year. The higher availability of nitrogen was recorded by Khiani and More (1984) [14], due to adoption of harrowing against ploughing in Vertisol due to enhanced decomposition process and mineralization of the nutrients in the soil. Further, the decreasing trend in available nitrogen was noticed as the soil depth increases. Improved nitrogen status after harvest of crop was due to addition of biomass which was stayed large period under conservation tillage. Nitrogen (N) is generally considered to be a major limiting factor (low soil N status) and is usually applied in sufficient amounts to meet the crop needs. Mineralization-immobilization processes in soil affect the availability of N to the crop. High C/N ratios and lignin contents cause slow mineralization of soybean crop residues. Irrigated Vertisols of Australia observed lower soil mineral N content at planting with stubble retained compared to the stubble removed plots. Dick (1983) [5] reported greater amount of nitrogen under no-tilled surface (0-30 cm) soil compared to minimum and conventional tillage. Khiani and More (1984) [14] observed through a long term experiment that available nitrogen was higher due to harrowing (85.4 kg ha^{-1}) than ploughing (81.1 kg ha^{-1}) in Vertisol. The results are in accordance with the findings of Bharambe *et al*. (1999) [2], Bharambe *et al*. (2002) [3] and Halemani *et al.* (2004) reported higher available nitrogen under minimum tillage as compare to conventional tillage.

Available phosphorous

Data pertaining to available phosphorous as influenced by different treatments are presented in table 5. On perusal of data indicated that available phosphorus in different treatments varied from 10.43 to 23.81 kg ha^{-1}. The higher value of phosphorus was found in T_1 (23.81 kg ha^{-1}) where the farmer has been following no ploughing practices since last 15 years followed by T_5 (21.84 kg ha^{-1}) where no ploughing was practiced since last 12 years. The lower value of phosphorus was noticed in T_4 (10.43 kg ha^{-1}) where regular ploughing was followed each year. Conservation tillage involves minimum surface tillage, leaving crop residue to accumulate at the soil surface and increase in organic matter ultimately enhance availability of nutrient like phosphorus. Similar observation was also recorded by Dick (1983) [5]. Gaikwad and Khupse (1976) [7] observed that available P was higher due to harrowing than ploughing in black soil. Sonune *et al*., (2012) [25] also observed higher available P in black cotton soils and minimum tillage compared to conventional tillage. Significant variation was observed in available phosphorus due to the tillage practices. This implies that high organic carbon in soil due to conservation tillage reduces phosphorus fixation due to release of various organic acids as a results of which more phosphorus becomes readily available to plant roots in the soil. Khakural *et al.* (1992) [13] observed higher available phosphorus due to no-till (16.6 and 41.7 kg ha^{-1}) than a mould board plough (12.2 and 29.5 kg ha^{-1}), chisel plough (8.8 and 37.5 kg ha^{-1}) and ridge till (14.7 and 38.9 kg ha^{-1}) in beadle and worthing soil respectively.

Available potassium
Data in respect of available potassium as influenced by different treatments are presented in table 5. In the present investigation available potassium was found profoundly well in respect of different treatments. The available potassium was varied from 367.89 to 419.7 kg ha^{-1}. The higher value was noticed in T_1 (419.7 kg ha^{-1}) where ploughing was not practiced since last 15 years, followed by T_5 (414 kg ha^{-1}) where same management were practicing since last 12 years. The lower value of potassium was noticed in T_4 (367.89 kg ha^{-1}) where the farmer has been following regular ploughing each year. The higher values might be due to conservation tillage, conserve organic carbon in soil and increase availability nutrient like potassium. Similar observation recorded by Gaikwad and Khuspe (1978) [6] in Vertisol and reported that available potassium was higher with harrowing against ploughing in black soil. Similar results were also observed by Sonune *et al.* (2012) [25]. The increase in available potassium might be due to the fact that available soil moisture would have helped in hastening the decomposition process and mineralization of the nutrients in the soil. The results corroborates with the findings reported by Bharambe *et al*. (2002) [3] and Halemani *et al.* (2004) [9, 10].

Available sulphur
Data pertaining to available sulphur as influenced by different treatments are presented in table 5. On close examination of data, it is noticed that, the effect of conservation agriculture management practices on available sulphur was found to be significant. Significantly higher available sulphur was registered in T_1 (12.00 g kg^{-1}) where conservation agriculture management practices was practiced since last 15 years followed by T_5 (11.12 g kg^{-1}) where the same management was practiced since last 12 years. The lower value of sulphur was observed in T_4 (8.26 g kg^{-1}) where regular ploughing was practiced each year. The increased availability of sulphur might be due to enhanced decomposition process and mineralization of the organic manures under conservation tillage. Improvement in available sulphur status under crop residues and green manuring also due to its ameliorative influence on improvement of physical and chemical properties which alters the availability of native sulphur in the soil. The results corroborates with the findings reported by Bharambe *et al*. (2002) [3] and Halemani *et al.* (2004) [9, 10].

Table 5: Effect of conservation agriculture management practices on available nutrients (NPK and Sulphur) under soybean

Treatments	Available nutrients (kg ha^{-1})			Available sulphur (mg kg^{-1})
	N	P	K	
T1: Site 1 (15 years)	225.38	23.81	419.70	12.00
T2: Site 2 (8 years)	204.99	20.72	412.90	11.08
T3: Site 3 (4 years)	193.50	14.82	406.83	11.10
T4: Site 4 (Regular ploughing)	177.10	10.43	367.89	8.26
T5: Site 5 (12 years)	209.51	21.84	414.00	11.12
T6: Site 6 (10 years)	207.00	19.88	413.17	11.06
T7: Site 7 (6 years)	200.10	17.53	410.30	10.59
T8: Site 8 (1 years)	177.08	11.20	369.47	9.90
T9: Site 9 (3 years)	191.01	13.78	395.97	10.07
T10: Site 10 (2 years)	190.30	11.84	382.03	10.12
SE (m) ±	7.26	2.11	10.70	0.62
CD at 5%	21.56	6.26	31.80	1.83

Yield of soybean
The data pertaining to grain and straw yield of soybean presented in table 6. The yield of soybean as influenced by conservation agriculture management practices was significant. Highest grain yield (24.50 q ha^{-1}) was obtained under T_4 where conventional agricultural practices was followed each year followed by T_{10} (23.67 q ha^{-1}), and T_9 (23.37 q ha^{-1}), where conservation management practices was adopted just one and two years back respectively. Similarly numerically lower grain and straw yield was calculated in T_1, T_5, T_6, and T_7, where conservation agriculture management practices was adopted for last 15, 12, 10 and 6 years, respectively. Generally, increased grain and straw yield to be obtained from conservation agriculture as compare to conventional agriculture as soil fertility achieved through long term conservation agriculture management practices. But the lower trend of crop yield is most, might be due to hardness of black cotton soil, poor hydraulic conductivity and poor soil aeration under conservation agriculture practices. However the yields obtained under conservation agriculture practices are very close to yields obtained in conventional agriculture systems. Singh *et al.* (2005) [23] carried out a field experiment during three winter seasons at Patna, to find out effect of tillage practices. They concluded that highest soybean grain yield of 36.6 q ha^{-1} was obtained in zero tillage, followed by conventional tillage (34.1 q ha^{-1}) and bed planting (31.5 q ha^{-1}).

Table 6: Effect of conservation agriculture management practices on yield of soybean

Treatments	Soybean yield (q ha^{-1})	
	Grain yield	Straw yield
T1: Site 1 (15 years)	22.90	25.37
T2: Site 2 (8 years)	21.00	24.17
T3: Site 3 (4 years)	23.23	26.37
T4: Site 4 (Regular ploughing)	24.50	28.20
T5: Site 5 (12 years)	22.50	24.40
T6: Site 6 (10 years)	22.00	26.10
T7: Site 7 (6 years)	21.00	23.97
T8: Site 8 (1 years)	23.03	26.80
T9: Site 9 (3 years)	23.37	26.27
T10: Site 10 (2 years)	23.67	27.17
SE (m) ±	0.70	0.82
CD at 5%	2.09	2.43
CV	5.36	5.47

Conclusion
Based on the investigation, the residual fertility of soil in respect of available N,P,K and sulphur were enhanced under conservation agricultural practices. Significantly increasing trend of soil fertility status investigated in T_1 compare to other treatments, while, the highest grain and straw yield of soybean was registered with regular ploughing.

Hence, it is concluded that the consistent adoption of conservation agricultural practices supported well to enhance the soil health parameters and also noted significant change in yield of soybean. Therefore, adoption of conservation agriculture practices is advisable for long term sustainability of soil in rainfed agricultural system.

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