

## **Role of Conservation Agriculture for Sustaining Soil Quality and Improving Crop Productivity- A Review**

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*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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### **ABSTRACT**

Intensive agriculture and excessive use of external inputs are leading to degradation of soil and water resources and negatively affecting agricultural production. This review article aims to determine the role of conservation agriculture for sustaining soil quality and improving crop productivity. Conservation Agriculture (CA) practices cause prominent changes in physical, chemical and biological properties of soil compared to conventional agricultural practices. The improved biophysico-chemical qualities of soil in turn, affect the ecosystem services and sustainability of crop production system through counterbalancing the climate variability with the help of increasing sink for carbon sequestration within the soil. There was significant interaction of tillage and cropping system on mineral nitrogen measured at the beginning of the cropping system. Mineral N contents were higher with manual tillage and no tillage systems compared with conventional tillage in the soybean maize rotation system. Conservation agriculture also helps in improving the crop production in a sustainable way hence there is an intense need of conservation agriculture which will not only meet the present and future demand of ever increasing population, but also seize degradation of environmental quality.

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## **1. INTRODUCTION**

Global agriculture is facing numerous challenges and adversely affecting food and nutritional security. Intensive agriculture and excessive use of external inputs are leading to degradation of soil and water resources and negatively affecting agricultural production. In the Indian context, the production system is facing serious challenge of soil and water degradation, rising production cost and increasing uncertainty in the form of: (i) declining organic matter and organic carbon in the soil; (ii) practicing intensive agriculture by adopting extensive tillage, imbalance of nutrients, and residue burning to catch up next crop [1]. To conserve soil and water resources and overcome the agrarian challenges, the role of conservation agriculture is well recognized by most of the developed countries and many developing countries. Conservation agriculture has been identified as one of the technological options to meet the global challenges of increasing food production and conserving soil, water and environment, thereby improves food and nutritional security and alleviates poverty [2]. The main aim of conservation agriculture is to allow farmers to make more sustainable use of their resources in ways that improve their incomes and welfare, and lead to acquire the knowledge and skills to operate systems that save labor, promote soil water retention, improve soil fertility and crop yields [3]. Zero tillage systems typically save energy (e.g., tractor fuel, animal tillage, human labor), stop or revert soil and land degradation (soil organic matter decline, soil structural breakdown, soil erosion) and lead to more efficient use of water and other inputs. When the crop residues are retained on the soil surface in combination with no-tillage, it initiates processes that lead to improved soil quality and overall resource enrichment [4]. Permanent raised beds permit the maintenance of a permanent soil cover on the bed for greater rainwater capture and conservation [5,6]. Wheat yields with CA practices are either equal or even better than those obtained with conventional practices because of timely planting of wheat, efficient use of fertilizers and weed control. In addition, CA is fuel and energy efficient [7]. Conservational agriculture system showed significantly higher total bacterial count in rhizospheric soil of main crops viz. paddy, maize and soybean over conventional agriculture system [8].

## **2. PRINCIPLES OF CONSERVATION AGRICULTURE**

### **2.1 Conservation Agriculture is based on Three Main Principles**

#### **2.1.1 Minimum soil disturbance**

This principle recommends for minimal or little soil disturbance where the soil is either not ploughed or ploughed to minimum extent. Continuous tillage practices destroy the soil structure, ultimately forming a hard pan that prevents water infiltration and proper crop root development. Instead of ploughing and harrowing, the soil could be sub-soiled using a sub-soiler and then ripped using a ripper to make furrows for seed placement. On the other hand, direct planting could be done using a hand operated jab planter, animal or tractor drawn direct planter. We can also plant through the soil cover by using equipments viz., dibbler, the hand hoe, jab planter, animal drawn direct seeder, and tractor drawn zero-till or direct planter. These equipments can be used to plant with minimal disturbance of the soil [9].

#### **2.1.2 Crop rotation**

It is the practice of growing two or more different type of crops on the same piece of land in sequence. Farmers should plant several crops in rotation instead of planting a single crop in a season or year. Crop rotations should include legumes, deep-rooted crops and high-residue crops. Leguminous crops fix nitrogen into the soil and their biomass adds nitrogen through decomposition. Crop rotation also help in control of various weeds, pests and diseases. Cultivation of the same crop season after season may encourage certain weeds, insects and diseases to thrive. Planting crops in rotation breaks their life cycle and prevents them from multiplying.

#### **2.1.3 Providing soil cover**

The main aim of providing soil cover is to maintain a protective layer above the soil surface. This can be done by inclusion of cover crops and spreading of dead vegetative material, mainly from crop residue. Providing soil cover protects the soil from being eroded by surface run off and high speed winds. It also improves water infiltration rate of the soil and at the same time reduces soil moisture losses due to evaporation.

### 3. IMPACT OF CONSERVATION AGRICULTURE ON SOIL QUALITY

Conservation agriculture (CA) practices cause prominent changes in physical, chemical and biological properties of soil compared to conventional agricultural practices. The improved bio-physico-chemical qualities of soil in turn, affect the ecosystem services and sustainability of crop production system through counterbalancing the climate variability with the help of increasing sink for carbon sequestration within the soil. It has been found that conservation agriculture improves soil physical qualities by favouring soil aggregation, soil hydraulic conductivity, bulk density (BD), compared to conventional tillage. The combined effect of zero tillage (ZT) and crop residue retention increases chemical quality by improving the soil organic carbon (SOC) storage and macro and micro nutrient dynamics. Long term adoption of conservation agriculture and residue management has a significant impact on soil fauna and flora communities under diversified crop rotations.

#### 3.1 Impact on Physical Properties

##### 3.1.1 Soil aggregation

Lynch and Elliott [10] found that formation of stable aggregates increased by straw incorporation through increase in microbial cells, microbial products and decomposition products released during the death of the microorganisms. Soil organic carbon in turn is protected within aggregates for decomposition.

Naresh et al. [11] studied the effect of residue retention on water stability of soil aggregates and porosity under wheat maize cropping system. The various treatments included, no till residue removed, no till 50% residue retained, no till 100% residue retained, permanent beds with residue removed, permanent beds with 50% residue retained, permanent with 100% residue retained, and conventional practices, and they found that percentage of water stable aggregates as well as porosity was highest in the treatment of permanent raised beds with 100% residue retained (Table 1).

##### 3.1.2 Porosity

Li et al. [12] and Xu and Yao [13] noted a significant increase in porosity and formation of large micro aggregates and decrease in bulk density in paddy soils after rice straw incorporation. Bellakki et al. [14] and Bhagat et al. [15] also concluded that there was significant increase in the porosity of fine textured soils after the application of rice and lantana residues.

##### 3.1.3 Infiltration rate

Naresh et al. [16] studied the effect of zero tillage and conventional tillage with and without soil cover and concluded that the infiltration rate and total infiltration were significantly higher with zero tillage with residue retention than with conventional tillage. Although infiltration rate was considerably higher in conventional tillage than zero tillage without residue retention as studied by Govaerts et al. [17].

**Table 1. Effect of residue retained on water stability of aggregates, clod breaking strength and soil organic carbon (%) in a silty loam soil under Maize-wheat cropping system After 3 years (Naresh et al., 2012)**

Crop establishment	Water stable aggregates > 0.25 mm (%)	Aggregate porosity (%)	Clod breaking strength (kpa)	Soil organic carbon (%)
No- till residue removed	66.7	39.6	418.7	0.54
No till 50% residue retained	72.9	40.2	367.5	0.58
No –till 100% residue retained	79.0	41.3	332.9	0.61
Permanent beds residue removed	80.3	40.8	289.7	0.55
Permanent beds+50% residue retained	81.9	42.7	235.6	0.59
Permanent beds+100% residue retained	82.8	43.2	204.8	0.63
Conventional practices	59.1	36.2	423.8	0.52
C D at 5%	5.3	1.74	95.3	0.53

### 3.1.4 Bulk density and compaction

Bellakki et al. [14], Meelu et al. [18], Singh et al. [19], and walia et al. [20], concluded that bulk density as well as compaction of soils under rice-rice and rice- wheat cropping systems decreased after incorporation of crop residues into paddy soil.

Meenakshi [21] studied the effect of different methods of planting and nitrogen levels on bulk density of wheat and concluded that the initial values of bulk density at 0- 15 cm soil depth were lower than that recorded at harvest under all the methods of planting except rotavator. The corresponding values at 15-30 cm depth were higher except zero tillage and happy seeder. At a soil depth of 30 – 45 cm the values were higher than initial bulk density under all the methods of planting at harvest. There was decrease in initial bulk density from 0- 15 cm to 30- 45 cm but in case of bulk density recorded at harvest, under happy seeder, rotavator and conventional tillage was increased upto 15 – 30 cm and corresponding values at 30 – 45 cm were decreased in case of zero tillage and happy seeder. At a soil depth of 0- 15 cm and 15- 30 cm the bulk density was same in zero tillage but increased at harvest at 30- 45 cm soil depth (Table 2).

### 3.1.5 Impact on chemical properties

Conservation agriculture practices influence various soil quality parameters to a great extent. The various soil quality parameters that are influenced by conservation agriculture practices include organic carbon, Nutrient levels, P.H, cation exchange capacity, etc.

### 3.1.6 Soil organic carbon

Soil organic carbon is a primary indicator of soil quality [22].

### 3.1.7 Soil organic carbon as influenced by tillage practices

Govaerts et al. [17] studied the influence of different conservation agriculture practices (reduced tillage, crop residue retention and crop rotation) on soil organic carbon. They studied the effect of these practices in 78 cases and concluded that out of 78 cases soil organic carbon was higher in 40 cases compared to conventional tillage, it was lower in 7 of 78 cases

and in 31 of the cases there was almost no significant difference.

### 3.1.8 Soil organic carbon as influenced by residue retention

Crop residues re the precursors of organic carbon in soil and there is increase in the soil organic carbon concentration in soil on returning more crop residues to the soil (Dolan et al. [23], Wilhelm et al. [24], Paustian et al. [25] and Rasmussen and Parton [26]). Blanco-Canqui [27] studied the long term (10 year) effect of three different levels of straw mulch (0, 8 16, Mg ha<sup>-1</sup> on a dry matter basis) when applied annually under zero tillage on a Aeric epiaqualf in central Ohi. From this study they concluded that soil organic carbon increased as level of straw was increased. At a soil depth of 0-50cm soil organic carbon was 82.5 Mg ha<sup>-1</sup> in the unmulched soil, 94.1 Mg ha<sup>-1</sup> with 8 Mg ha<sup>-1</sup> mulch and 104.9 Mgh<sup>-1</sup> with 16 Mg ha<sup>-1</sup> mulch.

### 3.1.9 Soil organic carbon as influenced by crop rotation

Soil organic is influenced by altering crop rotations as it causes the change in quantity and quality of organic matter input [17]. The mechanism of capturing carbon in stable and long term forms might be different for different crop species [28].

### 3.1.10 Nutrient availability

Tillage, crop rotation and residue management have a profound effect on nutrient distribution and transformation in soils [29,30], usually related to the effects of conservation agriculture on soil organic carbon contents. The distorted nutrient availability under zero tillage as compared to conventional tillage may be due to surface placement of crop residues in comparison with incorporation of crop residues with tillage [31]. The density of crop roots is generally greater near the soil surface under zero tillage compared to conventional tillage. This may be common under zero tillage as in the study of Mackay et al. [32] a much greater proportion of nutrients was taken up from near the soil surface under zero tillage than under tilled culture, illustrated by significantly higher p uptake from the 0-7.5 cm soil layer under zero tillage than under conventional tillage.

**Table 2. Effect of methods of planting and levels of nitrogen on bulk density of wheat (Meenakshi, 2010)**

Planting Method	Bulk density (g cm <sup>-3</sup> )		
	0-15 cm	15-30 cm	30-45 cm
Happy seeder	1.40	1.45	1.52
Zero tillage	1.44	1.44	1.55
Rotavator	1.53	1.59	1.56
Conventional tillage	1.46	1.62	1.49
Initial bulk density	1.47	1.46	1.44

**Table 3. Soil organic carbon, total nitrogen and mineral nitrogen averaged across soil layers, as affected by tillage and cropping system**

Tillage system	Cropping system			
	Sole maize	SB-MZ	SB/MZ	Mean
<b>Organic carbon(gkg<sup>-1</sup>)</b>				
CT	3.42	4.26	4.82	4.17
MT	4.14	5.29	4.52	4.65
NT	5.40	5.39	5.20	5.33
Mean	4.32	4.98	4.85	
<b>Total nitrogen (gkg<sup>-1</sup>)</b>				
CT	0.37	0.41	0.43	0.40
MT	0.54	0.62	0.64	0.60
NT	0.59	0.71	0.66	0.65
Mean	0.50	0.58	0.58	
<b>Mineral nitrogen(mgkg<sup>-1</sup>)</b>				
CT	20.3	26.6	24.0	23.6
MT	40.5	33.8	32.2	35.5
NT	35.1	51.1	47.4	44.5
Mean	31.9	37.2	35.5	

CT, conventional tillage; MT, manual tillage; NT, no tillage; CMZ, continuous maize; SB-MZ, soybean maize rotation; SB/MZ, soybean/maize intercrop. Means within a column followed by similar upper case letters are not significantly different

Naab et al. [33] conducted an experiment to study the effect of soil organic carbon, total nitrogen and mineral nitrogen averaged across soil layers, as affected by tillage and cropping system and they concluded that within the tillage systems conventional tillage with sole cropping of maize decreased soil organic carbon with soybean- maize with annual rotation and soybean/maize intercropping (Table 3). Higher soil organic carbon content was found in manual tillage (MT) with soybean – maize (SM) rotation compared to continuous sole cropping or intercropping. It was also observed in the study that within cropping systems there is higher soil organic carbon in manual tillage or no tillage with continuous sole cropping with no difference between tillage systems with soybean maize annual rotation. No tillage soybean/maize intercropping maintained higher soil organic carbon compared with conventional tillage. There was significant interaction of tillage and cropping

system on mineral nitrogen measured at the beginning of the cropping system. Mineral N contents were higher with manual tillage and no tillage systems compared with conventional tillage in the soybean maize rotation system. Tillage system did not influence mineral nitrogen content in the sole and intercropping systems. Within tillage systems mineral nitrogen content were higher with soybean- maize rotation and intercropping and sole maize cropping (Table 3).

### 3.1.11 Cation exchange capacity

Duiker and Beegle [34] revealed that the high organic matter contents at the soil surface, commonly observed under conservation agriculture can increase the cation exchange capacity of the top soil. However at a 0-15 cm soil depth the cation exchange capacity was not significantly different between tillage systems in the same study. This was confirmed by Govaerts

et al. [6] who did not find an effect of tillage practices and crop on cation exchange capacity. However Govaerts et al. [6] concluded that cation exchange capacity in the 0-5 cm soil layer due to retention of crop residues on permanent raised beds compared to soil from which the residues were removed, but there was no difference in 5-29 cm layer.

### 3.1.12 Salinity/sodicity

Govaerts et al. [6] states that under rainfed conditions permanent raised bed planting reduces soil sodicity. They observed that Na concentration to be 2.64 and 1.80 times lower in 0-50cm and 5-20 cm layer, respectively in permanent raised beds compared to conventionally tilled raised beds. Furthermore, there was increase in Na concentration with decreasing amounts of residue retained on the permanent raised beds.

## 4. IMPACT OF CONSERVATION AGRICULTURE ON BIOLOGICAL SOIL QUALITY

Changes in number of soil flora and fauna are induced by changes in tillage, residue management and rotation practices [35]. Soil organisms respond to tillage induced changes in the soil physical/chemical environment and they, in turn, have an impact on soil physical/chemical conditions i.e. soil structure, nutrient cycling and organic matter decomposition. Interactions among different organisms can have either beneficial or harmful effects on crops [36]. Maintaining soil microbial biomass and micro flora activity is fundamental for sustainable agriculture management [37]. Soil management affects soil microorganisms and soil microbial processes through alterations in the quantity and quality of plant residues entering the soil, their seasonal and spatial distribution, the ratio between above and below ground inputs and changes in nutrient inputs [38].

### 4.1 Soil Microbial Biomass

The soil microbial biomass reflects the soils ability to store and cycle nutrients (C, N, P, S) and organic matter and has a high turnover rate relative to the total soil organic matter [39,40]. Due to its dynamic character, soil microbial biomass responds to changes in soil management often before effects are measured in terms of carbon and nitrogen [41].

The influence of tillage practice on soil microbial biomass carbon and nitrogen seems to be mainly confined to the surface layers, with a stronger stratification when tillage reduced [42,43]. Alvear et al. [42] found higher soil microbial biomass carbon and nitrogen in the 0-20 cm layer under zero tillage than under conventional tillage in an ultisol from southern Chile and attributed this to the higher levels of carbon substrates available for microorganism growth, better soil physical conditions and higher water retention under zero tillage.

### 4.2 Enzyme Activity

Soil enzymes play an important role in catalyzing the reactions necessary for organic matter decomposition and nutrient cycling. Enzymes are involved in various activities like energy transfer, environment quality and crop productivity [44,45]. Soil enzymes are diversely affected by various management practice such as tillage, residue management and crop rotation [45] and in this way may alter the plant nutrients. According to Green et al. [46] zero tillage management increases stratification of enzyme activities in the soil profile, probably because of similar vertical distribution of organic residues and microbial activity. Management practices like crop rotation and residue management also effect soil enzyme activity. Angers et al. [47] concluded from their studies that 15% larger alkaline phosphatase activity in a barley- red clover rotation than in continuous barley on a clay soil in Quebec.

### 4.3 Earthworms

The positive effects of earthworms are not only mediated by the abundance but also by the functional diversity and activity have been found to increase under conservation agriculture [35,48]. Earthworms support decomposition and incorporation of straw into the soil and the presence of sufficient population of earthworms are essential to maintain soil structure. Earthworm activity and their population is influenced intensity of tillage. Constantini et al. [49] reported that among different tillage systems including zero tillage, reduced tillage and conventional tillage, zero tillage proved to be more efficient system at the soil surface depth (0-5cm). Mc Garry et al. [50] reported increased beneficial fauna with zero tillage. Radford et al., (1995) also revealed that earthworm population was four fold more in zero tillage compared to conventional tillage.

## 5. IMPACT OF CONSERVATION AGRICULTURE ON CROP PRODUCTIVITY

Land quality and land degradation affect agricultural productivity but quantifying these relationships has been difficult [51]. Increase in food production for the ever increasing will have to come from increase in productivity of the existing land rather than agricultural expansion, the restoration of degraded soils as well as improvement in soil quality is very important to achieve this goal. One of the important possible ways is by adopting conservation agriculture (zero tillage, crop residue management, crop rotations, etc.).

Govaerts et al. [5] studied the effect of tillage, crop rotation and crop residue management on average wheat and maize yield in maize-wheat cropping system. The various treatments used in the study include continuous maize or wheat cultivation, zero tillage, crop rotation of maize and wheat and retaining or removal of residue in the field [52]. From this study they concluded that mean yield of both maize and wheat ( $5285 \text{ kg ha}^{-1}$  and  $5591 \text{ kg ha}^{-1}$  respectively) was highest in the treatment of rotation of maize and wheat with zero tillage and residue kept in the field (Table 4).

Rice –wheat is a highly opted, highly profitable and surely the most important cropping system of northwestern region of India and is known to be crucial for food security and livelihood in Indian subcontinent. But the current system of burning the rice straw, which at present is to the extent of about 80% causes the pollution of the environment and health hazards [53] Punjab agriculture university developed a machine called happy seeder for sowing wheat in the combine harvest paddy fields without any straw burning and or removal of paddy straw. The loose straw

was evenly distributed in the field prior to sowing wheat with happy seeder. Singh et al. [54] conducted 10 on farm trials in each district of Jalandhar, Kapurthala, Patiala, and Fatehgarh sahib to study the influence of sowing methods including Rotavator, Happy seeder and farmer practice on grain yield and straw yield of wheat. From the findings of this study they concluded that happy seeder sown wheat gave the comparable grain yield and straw yield as wheat sown with farmers' practice and rotavator (Table 5).

Tolk et al. [55] conducted an experiment to study the effect of mulch level on grain yield in maize, and they concluded that mulches applied on soil increased grain yield in maize significantly as compared to bare soil. Maximum grain yield was observed in  $M_2$  (mulch @  $14 \text{ Mg ha}^{-1}$ ) ( $10.5 \text{ Mg ha}^{-1}$ ), followed by  $M_1$  (mulch @  $7 \text{ Mg ha}^{-1}$ ) ( $9.4 \text{ Mg ha}^{-1}$ ) and minimum in  $M_0$  (mulch @  $0 \text{ Mg ha}^{-1}$ ) ( $8.6 \text{ Mg ha}^{-1}$ ). Similarly Parvez et al. [56] carried out a study to see the effect of mulching on grain yield in maize and concluded that mulch significantly increased the grain yield in maize. Maximum grain yield was observed in  $M_2$  i.e. mulching @  $14 \text{ Mg ha}^{-1}$  ( $10.5 \text{ Mg ha}^{-1}$ ), followed by  $M_1$  i.e. mulching @  $7 \text{ Mg ha}^{-1}$  ( $9.4 \text{ Mg ha}^{-1}$ ) and minimum in  $M_0$  or control ( $8.6 \text{ Mg ha}^{-1}$ ).

Mohammad et al. [11] conducted field experiments during 2004-2009 to study the impact of crop rotation on wheat crop productivity. The different crop rotations used in the study include wheat- fallow –wheat, wheat-summer legume-wheat, and wheat- summer cereal-wheat. From this study they observed that wheat grain yield was significantly higher in wheat-summer legume-wheat and wheat-fallow-wheat as compared to wheat – summer cereal-wheat rotation. Maximum average wheat grain yield was recorded in wheat-summer legume-wheat rotation compared to other rotations (Table 6).

**Table 4. Effect of tillage, crop rotation and crop residue management of average wheat and maize yield (Govaerts et al., 2005)**

Management practice	Maize (mean) (kg ha <sup>-1</sup> )	Wheat (mean) (kg ha <sup>-1</sup> )
Continuous M or W, ZT, K	4628	5471
Continuous M or W, ZT, R	2600	4464
Rotation MW, ZT, K	5285	5591
Rotation MW, ZT, R	4339	3518
Continuous M or W, CT, K	3569	3985
Continuous M or W, CT, R	3570	4414
Rotation MW, CT, K	4406	5082
Rotation MW, CT, R	4063	4646

*W, wheat; M, maize; K, residue kept in the field; R, residue is removed; CT, conventional tillage; ZT, zero tillage*

**Table 5. Effect of rotavator, happy seeder and farmers' practice on wheat grain yield**

Treatment	Wheat grain yield (qha <sup>-1</sup> )			
	Jhalandar	Kapurthala	Patiala	Fatehgarh sahib
Rotavator	41.19	46.79	44.52	47.88
Happy seeder	43.63	47.76	49.53	51.13
Farmer practice	42.47	46.91	46.02	50.86
CD( $\rho=0.05$ )	NS	0.65	1.36	2.06

**Table 6. Effect of crop rotation on the grain yield of wheat in dry area (rainfed) of north-west Pakistan**

Treatments	2005-06	2006-07	2007-08	2008-09	Average
<b>Grain yield( kg ha<sup>-1</sup>)</b>					
Wheat-fallow-wheat	1937.5	2700.4	1407.8	1469.4	1878.8
wheat-summer legume-wheat	1920.5	2872.8	1522.2	1386.1	1925.4
wheat-summer cereal-wheat	1696.5	2622.8	1263.9	1225.5	1702.05

## 6. CONCLUSION

Conservation agriculture plays an important role in maintaining soil physical, chemical and biological characteristics and thus ensuring the aim of sustaining soil quality. Conservation agriculture also helps in improving the crop production in a sustainable way hence there is an intense need of conservation agriculture which will not only meet the present and future demand of ever increasing population, but also seize degradation of environmental quality.

As it is a new paradigm for agricultural research there is a scope of development and improvement in the concept of conservation agriculture.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

- Lalani B, Dorward P, Holloway G, Wauters E. Smallholder farmers' motivations for using conservation agriculture and the roles of yield, labour and soil fertility in decision making. *Agricultural Systems*. 2016;146:80-90.
- Farooq M, Siddique KH. Conservation agriculture: Concepts, brief history, and impacts on agricultural systems. In *Conservation Agriculture*, Springer, Cham. 2015;3-17.
- Calegaria, Hargrove WL, Rheinheimer DS, Ralisch R, Tessier D, Tourdonnet S, Guimaraes MF. Impact of long term no-tillage and cropping system management on soil organic carbon in an oxisol, a model for sustainability. *Agronomy Journal*. 2008;100:1013-1019.
- Gathala MK, Kumar V, Sharma PC, Saharawat YS, Jat HS, Singh M, Kumar A, Jat ML, Humphreys E, Sharma DK, Sharma S, Ladha JK. Optimizing intensive cereal based cropping systems addressing current and future drivers of agricultural change in the northwestern Indo-Gangetic Plains of India. *Agriculture, Ecosystems and Environment*. 2013;177:85-97.
- Govaerts B, Sayre KD, Deckers J. Stable high yields with zero tillage and permanent bed planting, *Field Crop. Res*. 2005;94:33-42.
- Govaerts B, Sayre KD, Lichter K, Dendooven L, Deckers J. Influence of permanent raised bed planting and residue management on physical and chemical soil quality in rain fed maize/wheat systems. *Plant Soil*. 2007;291:39-54.
- Jat RK, Sapkota TB, Singh RJ, Jat ML, Kumar M, Gupta RK. Seven years of conservation agriculture in a rice-wheat rotation of Eastern Gangetic Plains of South Asia. *Yield trends and economic profitability*. *Field Crop Research*. 2014; 164:199-210.
- Dongre K, Sachidanand B, Porte SS. Assessment of different microbial population in the rhizosphere of main kharif crop under conventional and conservation agriculture system. *International Journal of Current Microbiology and Applied Sciences*. 2017;6(9):813-819.
- Sommer, R, Thierfelder C, Tittonell P, Hove L, Mureithi J, Mkomwa S. Fertilizer



- use should not be a fourth principle to define conservation agriculture: Response to the opinion paper of Vanlauwe et al. A fourth principle is required to define conservation agriculture in sub-Saharan Africa: the appropriate use of fertilizer to enhance crop productivity'. *Field Crops Res.* 2014;169:145-148.
10. Lynch JM, Elliott LF. Minimizing the potential phytotoxicity of wheat straw by microbial degradation, *Soil Biol. Biochem.* 1983;15:221–222.
  11. Mohammad W, Shah SM, Shehzadi S, Shah SA. Effect of tillage, rotation and crop residues on wheat crop productivity, fertilizer nitrogen and water use efficiency and soil organic carbon status in dry area (rainfed) of North-West Pakistan. *Journal of Soil Science and Plant Nutrition.* 2012; 12(4):715-727.
  12. Naresh RK, Singh SP, Chauhan Pankaj. Influence of conservation agriculture: Permanent raised bed planting and residue management on soil quality and crop productivity in maize-wheat in western Uttar Pradesh. *Int. J. Life Sci. Bt & Pharm. Res.* 2011;1(4):27-34.
  13. Xu XY, Yao XL. Effect of organic matter on the physical properties of two paddy soils. *Soils (Turang).* 1988;20:69–174.
  14. Bellakki MA, Badanur VP, Setty RA. Effect of long-term integrated nutrient management on some important properties of a Vertisol. *J. Indian Soc. Soil Sci.* 1998; 46:176–180.
  15. Bhagat RM, Bhardwaj AK, Sharma PK. Long-term effect of residue management on soil physical properties, water use and yield of rice in north-western India. *J. Indian Soc. Soil Sci.* 2003;51:111–117.
  16. Naresh RK, Gupta Raj K, Prakash Satya, Kumar Ashok, Singh Madhvendra, Misra AK. Permanent beds and rice-residue management for rice–wheat systems in the North West India. *International Journal of Agricultural Sciences.* 2011;7(2):429-439.
  17. Govaerts B, Sayre KD, Goudeseune B, De Corte P, Lichter K, Dendooven L, Deckers J. Conservation agriculture as a sustainable option for the central Mexican highlands. *Soil Till. Res.* 2009;103:222-230.
  18. Meelu OP, Yadvinder-Singh, Bijay-Singh, Khera TS, Kumar K. Crop residues recycling and green manuring for soil and crop productivity improvement in rice-wheat cropping system. In *Temperate Rice-Achievements and Potentials* (Humphreys E, Murray EA, Clampett WS, Lewin LQ, Eds.), NSW Agriculture, GrIYth, NSW, Australia. 1994;2:605–613.
  19. Singh Y, Singh D, Tripathi RP. Crop residue management in rice-wheat cropping system. In 'Abstracts of Poster Sessions. 2<sup>nd</sup> International Crop Science Congress, 43. National Academy of Agricultural Sciences, New Delhi, India; 1996.
  20. Walia SS, Brar SS, Kler DS. Effect of management of crop residues on soil properties in rice-wheat cropping system. *Environ. Ecol.* 1995;13:503–507.
  21. Meenakhi. Influence of paddy residue and nitrogen management on the productivity of wheat (*Triticum aestivum* L.). M.Sc. Thesis, Punjab Agricultural University, Ludhiana, Punjab, India; 2010.
  22. Reeves DW. The role of soil organic matter in maintaining soil quality in continuous cropping systems. *Soil Till. Res.* 1997;43: 131.
  23. Dolan MS, Clapp CE, Allmaras RR, Baker JM, Molina JAE. Soil organic carbon and nitrogen in a Minnesota soil as related to tillage, residue and nitrogen management. *Soil Till. Res.* 2006;89:221-231.
  24. Wilhelm WW, Johnson JMF, Hatfield JL, Voorhees WB, Linden DR. Crop and soil productivity response to corn residue removal: A literature review. *Agri. J.* 2004; 96:1-17.
  25. Paustian K, Andren O, Janzen HH, Lal R, Smith P, Tian G, Tiessen H, Van Noordwijk M, Wooster PL. Agricultural soils as a sink to mitigate CO<sub>2</sub> emissions. *Soil Use Manage.* 1997;13:230-244.
  26. Rasmussen PE, Parton WJ. Long-term effects of residue management in wheat-Fallow .1. Inputs, yield, and soil organic-matter. *Soil Sci. Soc. Am. J.* 1994;58:523-530.
  27. Blanco-Canqui H, Lal R. Mechanisms of carbon sequestration in soil aggregates. *Crit. Rev. Plant Sci.* 2004;23:481-504.
  28. Gal A, Vyn TJ, Micheli E, Klavivko EJ, McFee WW. Soil carbon and nitrogen accumulation with long-term no-till versus moldboard plowing overestimated with tilled-zone sampling depths. *Soil Till. Res.* 2007;96:42-51.
  29. Galantini JA, Landriscini MR, Iglesias JO, Miglierina AM, Rosell RA. The effects of crop rotation and fertilization on wheat productivity in the Pampean semiarid region of Argentina 2. Nutrient balance,

- yield and grain quality. *Soil Till. Res.* 2000; 53:137-144.
30. Etana A, Hakansson I, Zagal E, Bucas, S. Effects of tillage depth on organic carbon content and physical properties in five Swedish soils. *Soil Till. Res.* 1999;52:129-139.
  31. Ismail I, Blevins RL, Frye WW. Long-term no-tillage effects on soil properties and continuous corn yields. *Soil Sci. Soc. Am. J.* 1994;58:193-198.
  32. Mackay AD, Kladivko EJ, Barber SA, Griffith DR. Phosphorus and potassium uptake by corn in conservation tillage systems. *Soil Sci. Soc. Am. J.* 1987;51: 970-974.
  33. Naab JB, Mahama GY, Yahaya I, Prasad PVV, Conservation agriculture improves soil quality, crop yield, and incomes of smallholder farmers in North Western Ghana. *Frontiers in Plant Science.* 2017;8: 996.
  34. Duiker SW, Beegle DB. Soil fertility distributions in long-term no-till, chisel/disk and moldboard plow/disk systems. *Soil Till. Res.* 2006;88:30-41.
  35. Andersen A. Plant protection in spring cereal production with reduced tillage. II. Pests and beneficial insects. *Crop Prot.* 1999;18:651-657.
  36. Kladivko EJ. Tillage systems and soil ecology. *Soil Till. Res.* 2001;61:61-76.
  37. Insam, H. Developments in soil microbiology since the mid 1960s. *Geoderma.* 2001;100:389-402.
  38. Kandeler E, Tscherko D, Spiegel H. Long-term monitoring of microbial biomass, N mineralisation and enzyme activities of a Chernozem under different tillage management. *Biol. Fert. Soils.* 1995;28: 343-351.
  39. Dick RP. A review - long-term effects of agricultural systems on soil biochemical and microbial parameters. *Agr. Ecosyst. Environ.* 1992;40:25-36.
  40. Carter MR., Gregorich EG, Angers DA, Beare MH, Sparling GP, Wardle DA, Voroney RP. Interpretation of microbial biomass measurements for soil quality assessment in humid temperate regions. *Can J. Soil Sci.* 1999;79:507-520.
  41. Powelson DS, Jenkinson DS. A comparison of the organic-matter, biomass, adenosine triphosphate and mineralizable nitrogen contents of ploughed and direct-drilled soils. *J. Agr. Sci.* 1981;97:713-721.
  42. Alvear M, Rosas A, Rouanet JL, Borie F. Effects of three soil tillage systems on some biological activities in an Ultisol from southern Chile. *Soil Till. Res.* 2005;82:195-202.
  43. Salinas-García, JR, Velázquez-García JD, Gallardo-Valdez A, Díaz-Mederos P, Caballero-Hernández F, Tapia-Vargas LM, Rosales-Robles E. Tillage effects on microbial biomass and nutrient distribution in soils under rain-fed corn production in central-western Mexico. *Soil Till. Res.* 2002;66:143-152.
  44. Dick RP. Soil enzyme activities as indicators of soil quality. In defining soil quality for a sustainable environment, Ed. Doran JW, Coleman DC, Bezdicek DF, Stewart BA. 1994;107-124.
  45. Tabatabai MA. Soil enzymes. In *Methods of soil analysis: Microbiological and biochemical properties*, Ed. Weaver RW, Angle JS, Bottomley P, Bezdicek D, Smith S, Tabatabai A, Wollum AG, Madison WI: Soil Science Society of America. 1994; 775-827.
  46. Green VS, Stott DE, Cruz JC, Curi N. Tillage impacts on soil biological activity and aggregation in a Brazilian Cerrado Oxisol. *Soil Till. Res.* 2007;92:114-121.
  47. Andersen A. Plant protection in spring cereal production with reduced tillage. II. Pests and beneficial insects. *Crop Prot.* 1999;18:651-657.
  48. Chan KY. An overview of some tillage impacts on earthworm population abundance and diversity - implications for functioning in soils. *Soil Till. Res.* 2001;57: 179-191.
  49. Constantini A, Cosentino D, Segat A. Influence of tillage systems on biological properties of a Typic Argiudoll soil under continuous maize in central Argentina. *Soil Till. Res.* 1996;38?:265271.
  50. Mc Garry D, Bridge BJ, Radford BJ. Contrasting soil physical properties after zero and traditional tillage of an alluvial soil in the semi-arid subtropics. *Soil Till. Res.* 2000;53:105115.
  51. Weibe KD, Agricultural Productivity, and Food Security. 823, USDA-ERS. *Agricultural Economic Report*; 2003.
  52. Li HZ, Han HR, Wu ZC, Yang JC, Ge LM. A study on the efficacy of organic manures

- in improvement of paddy soil fertility. J. Soil Sci., China. 1986;17:252–258.
53. Kalkat GS. Punjab Agriculture-The Way Forward. J. Res. Punjab Agric. Univ. 2012; 49(3):124-128.
54. Singh A, Kang JS, Kaur M. Planting of wheat with happy seeder and rotavator in rice stubbles. Indo-American Journal of Agricultural and Veterinary Sciences. 2016; 1(2).
55. Tolk JA, Hawell TA, Evett SR. Effect of mulch, irrigation and soil type on water use and yield of maize. Soil and Tillage Research. 1999;50:137-147.
56. Parvez MA, Iqbal M, Shahzad K, Hassan, AU. Effect of mulch on soil physical properties and N, P, K concentration in maize (*Zea mays*) shoots under two tillage systems. International Journal of Agriculture & Biology. 2009;11:119-124.

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