E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
www.agronomyjournals.com
2024; SP-7(9): 31-34
Received: 05-07-2024
Accepted: 14-08-2024

Pagala Sai Krishna Reddy
M.Sc. Graduate, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India

Vasanthi BG
Senior Scientist, AICRP for Dry Land Agriculture, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India

Mudalagiriyappa
Chief Scientist, AICRP for Dry Land Agriculture, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India

Devaraja
Senior Scientist, AICRP for Dry Land Agriculture, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India

Latha HS
Senior Scientist, AICRP for Dry Land Agriculture, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India

Corresponding Author:
Pagala Sai Krishna Reddy
M.Sc. Graduate, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India

Impact of conservation agriculture production system on soil biological properties

Pagala Sai Krishna Reddy, Vasanthi BG, Mudalagiriyappa, Devaraja K, Latha HS

DOI: https://doi.org/10.33545/2618060X.2024.v7.i9Sa.1418

Abstract
The research entitled "Effect of conservation production system on soil properties and carbon dynamics in rainfed condition" was conducted at AICRP for dryland agriculture, UAS, GKVK, and Bangalore during *Kharif* 2020. With three main plot treatments "Tillage practices" (M1-Conventional tillage, M2-Reduced tillage, M3-Zero tillage) and three sub plot treatments 'Cover crops' (C1-Control, C2-Field bean, C3-Horse gram) replicated thrice and laid out in split plot design. Higher organic carbon (0.43%) and available nitrogen (246.69 kg ha^{-1}) was in reduced tillage with horse gram as surface mulch (M2C3). Zero tillage with horse gram surface mulch (M3C3) provided favourable environment for increased microbial activity, with increased MBC (262.30 µg g^{-1}), MBN (30.54 µg g^{-1}) and dehydrogenase activity (54.72 µg TPFg^{-1} soil 24 h^{-1}). Overall, adoption of conservation agriculture; crop mulching and reduced tillage operations promotes the soil biological properties under rainfed condition.

Key words: Conventional tillage, reduced tillage, mulching

Introduction

Conservation agriculture (CA) system consists of no or minimal tillage and permanent soil cover, either with a live crop or with crop stubbles and diversified crop rotation that include legumes (FAO, 2019) [8]. An overall CA farming system is meant to ensure the sustainability of agriculture through conserving and protecting soil, water, and biological resources as much as possible with minimal external inputs, and it is associated with many benefits such as greater soil aggregation and water storage, improved soil quality, decreased erosion and in some instances higher yield and net farm income. This has led to the identification of conservation agriculture as a valuable tool to ensure future food production and to buffer agricultural productivity (FAO, 2019) [8].

Applying conservation agriculture essentially means altering literally generations of traditional farming practices and implement use. As such, the movement towards conservation agriculture-based technologies normally is comprised of a sequence of step-wise changes in cropping system management to improve productivity and sustainability. Reduced tillage systems in the United States have been shown to reduce soil erosion, reduce nutrient losses from the field, sequester carbon as a result of increasing organic matter, and increase crop yields. The widespread adoption of CA resulted in significant development of farmer profitability which is achieved through increased agricultural productivity and reduced input costs.

Soil tillage (soil surface management to alleviate soil related constraints to crop production) is a basic and an important input with short and long term effects on sustainability. It influences agriculture sustainability through its effects on soil properties, soil processes and crop growth. Appropriate tillage systems are soil and crop specific, and their adoption is governed by both bio-physical and socio-economic factors. In addition to increasing crop yields, tillage method facilitate soil and water conservation, improve root system development, maintain a favourable level of soil organic matter content and reduce soil degradation (Lal, 1991) [11].

The activity of dehydrogenase can be used as an excellent predictor of soil quality. As respiratory chain enzymes, dehydrogenases play an important role in the energy production of soil microbes (Boltan *et al.*, 2004) [5].

Phosphatase plays an important function in phosphorus cycle, including phospholipid breakdown. The addition of organic matter to the soil boosted the activity of the phosphatase enzyme (Singh *et al.*, 2007) [16]. Urease enzyme took part in the hydrolysis of urea to carbon dioxide and ammonia in soil, and it is a key part of the nitrogen cycle. The maximum urease enzyme activity was observed when NPK was combined with manure application (Bhatt *et al*., 2016) [4]. Nidaye and Dkhar (2000) [13] reported soil enzyme activity has the potential to help in manage the ecosystems for long-term viability. Abbasi and Khizar (2012) [1] reported that application of urea resulted in a drop in MBC, whereas the use of farmyard manure as a soil amendment resulted in an increase in MBC.

Crop residue and tillage affects the soil environment directly or indirectly, incorporation of crop residue into soil or retention on the surface through the adaptation of conservation agriculture practice has positive influence on physical, chemical and biological properties of soil. Hence, the present study was undertaken to assess the effect of different management practices on soil biological properties, the present investigation entitled “Effect of conservation production system on soil biological properties in rainfed condition” at AICRP on Dry Land Agriculture, UAS, GKVK.

Material and Methods

Experimental site and treatment details

The field experiment was carried out during *Kharif*-2020 at AICRP for Dry Land Agriculture, UAS, GKVK**,** Bengaluru-65. It is located in the Eastern Dry zone of Karnataka at 13º 05' N latitude and 77^0 34' E longitude with an altitude of 924 meters above Mean Sea Level (MSL). The total rainfall during 2020 at AICRP for Dryland Agriculture, GKVK, and Bengaluru was 1,182.2 mm with maximum rainfall during July (242.8 mm) and minimum during January and February (0.0 mm). The maximum and minimum temperature of 29.1 ºC and 18.2 ºC was observed during the cropping year. Relative humidity of 89.6 per cent was recorded during the cropping period.

The soils of Gandhi Krishi Vignana Kendra (GKVK) belongs to Vijayapura series which is a dominant soil series of Bengaluru plateau. The soils of experimental site at AICRP on Dry Land Agriculture Project represents the typical lateritic area of Bengaluru plateau. These soils are classified as fine, kaolinitic, isohyperthermic, Typic Kandiustalf as per USDA classification. These soils are deep, yellowish red, lateritic, red sandy clay loam with good drainage and are derived from granite-gneiss under subtropical semi-arid climate.

Cropping history of the experimental plot

In the experimental plot Inter cropping of finger millet (*Eleusine coracana* (L.) Gaertn) + Pigeon pea (*Cajanus cajan*) was grown during *Kharif* 2019 and left fallow during rabi and summer.

Table 1: Experimental details

Location	**AICRP for Dryland agriculture.**
Crop	Finger millet (*Eleusine coracana*), Pigeon pea (*Cajanus cajan*)
Cropping system	Inter cropping (8:2) Finger millet+Pigeonpea with conservation furrow
Variety	Finger millet-MR-1, Pigeon pea-BRG-5
Spacing	Finger millet (30cm × 10cm), Pigeon pea (60cm × 30cm)
Seed rate	Finger millet 12.5kg/ha, Pigeon pea 12-15kg/ha
No of treatments	**9**
No of replication	3
Number of plots	27
Design	Split plot design
Plot size	9.0 x 9.9 m
NPK	Finger millet (50:40:37.5 kg/ha), Pigeonpea (25:50:25 kg/ha)
FYM	Finger millet, Pigeon pea (15 t/ha)

Treatment details

A. Main Plot Treatments

M_1	Conventional tillage (1 tractor drawn ploughing + 2 harrowing + 1 intercultural operations).
M_2	Reduced tillage (1 harrowing + 1 intercultural operation + pre emergence herbicide).
M_3	Zero tillage (1 intercultural operation + pre emergence herbicide).

B. Sub Plot Treatments

C1	Control (no cover crops)
C2	Field bean (HA-4) leaving the residue after harvesting the green pods for vegetable
C3	Horse gram in-situ and mulching

Soil sampling, processing and analysis

Soil samples from experimental area were collected from 0-15 cm, after the harvest of the crop. The collected soil samples were kept in refrigerator and analysed for various biological properties adopting standard procedure. The biological properties included the Soil microbial biomass carbon (SMBC) and nitrogen (SMBN) was estimated by fumigation-extraction method as proposed by Carter (1991) [6] in which Ninhydrin-reactive N, as a measure of microbial biomass carbon released during soil fumigation by using ninhydrin reagent. The dehydrogenase activity in the soil was determined by the reduction of 2, 3, 5-triphenyl-tetrazolium chloride to 1, 3, 5-triphenylformazan (TPF) given by Casida *et al.* (1964) [7].

Statistical analysis

The observations recorded in these studies were analysed statistically for test of significance following the Fisher’s method of analysis of variance (ANOVA) as outlined by Gomez and Gomez (1984) [9]. Whenever F-test was significant for comparison amongst the treatments means an appropriate value of critical differences (CD) was worked out. Otherwise against CD values, abbreviation NS (Non-Significant) was indicated. All the data were analysed and the results are presented and discussed at a probability level of 0.05 per cent and correlation and regression study was done as given by Gomez and Gomez (1984) [9].

Results and Discussion

Impact of conservation agriculture production system on Soil biological properties

The results of the field experiment conducted to know the effect of conservation agriculture production system on soil biological properties *viz.* microbial biomass carbon, nitrogen and dehydrogenase enzyme activity are presented in Table 1.

Microbial Biomass Carbon (MBC)

The soil microbial biomass carbon reflects the soil ability to store and cycle nutrients (C, N, P and S) and has high turnover rate relative to the total soil organic matter. The rate of soil organic carbon input from plant biomass is generally considered the dominant factor controlling amount of soil microbial biomass carbon.

Different tillage practices significantly influenced MBC with higher microbial biomass carbon (223.57 µg g^{-1}) in zero tillage compared to conventional tillage (169.57 µg g^{-1}). Among different cover crops significantly higher microbial biomass carbon (227.73 µg g^{-1}), was observed in horse gram cover crop compared to control (152.30 µg g^{-1}). Tillage practices and cover crops showed non-significant interaction, with higher value (262.30 µg g^{-1}) in M_3C_3 (Zero tillage + Horsegram cover crop).

The influence of tillage practice on SMB-C and N seems to be mainly confined to the surface layers, with a stronger stratification when tillage is reduced (Alvear *et al.*, 2005 [2], Salinas-Garcia *et al.*, 2002) [15]. It is also reported that higher biomass carbon under zero tillage than the conventional tillage can be attributed to higher level of C substrates available for micro-organisms growth, better soil physical condition and higher water retention under zero tillage.

Table 2: Soil microbial carbon biomass, nitrogen and dehydrogenase activity parameters as influenced by conservation agriculture practices in finger millet+ pigeonpea intercropping (8:2)

Treatments	Microbial carbon biomass (µg g^{-1})	Microbial nitrogen biomass (µg g^{-1})	Dehydrogenase activity (µg TPF g^{-1z} soil 24 h^{-1})
Tillage practice			
M_1: Conventional tillage	169.57	19.74	25.68
M_2: Reduced tillage	195.86	22.80	43.61
M_3:Zero tillage	223.57	26.03	50.67
S.E.M. ±	5.10	0.06	0.74
CD (P=0.05)	20.01	0.23	2.89
Cover crop			
C_1: Control	152.30	17.73	32.76
C_2: Field bean	208.98	24.33	39.64
C_3: Horsegram	227.73	26.51	47.56
S.E.M. ±	13.95	0.21	1.82
CD (P=0.05)	42.97	0.66	5.62
Interaction			
M_1C_1	120.93	14.08	15.46
M_1C_2	192.84	22.45	23.10
M_1C_3	194.93	22.69	38.46
M_2C_1	137.17	15.97	39.43
M_2C_2	224.47	26.13	41.91
M_2C_3	225.96	26.30	49.48
M_3C_1	198.80	23.14	43.38
M_3C_2	209.62	24.40	53.92
M_3C_3	262.30	30.54	54.72
S.E.M. ±	24.16	0.37	3.16
CD (P=0.05)	NS	1.14	NS

Microbial Biomass Nitrogen (MBN)

Microbial biomass nitrogen responds to changes in soil management often before effects are measured in terms of organic C and N. The SMB plays an important role in physical stabilization of aggregates.

Different tillage practices significantly influenced MBN with higher microbial biomass nitrogen (26.03 µg g^{-1}) in zero tillage compared to conventional tillage (19.74 µg g^{-1}). Among different cover crops significantly higher microbial biomass nitrogen (26.51 µg g^{-1}), was observed in horse gram cover crop compared to control (17.73 µg g^{-1}). Tillage practices and cover crops showed significant interaction, with higher value (30.54 µg g^{-1}) in M_3C_3 (Zero tillage + Horsegram cover crop).

A study conducted on soybean-rapeseed crop rotation under CA for two years indicated that MBN content under CA treatments increased by 16.7 and 17.4 per cent for two and four years, respectively (Kumar *et al.*, 2016) [10]. However, Mbuthia *et al.* (2015) [12] reported an increase in MBN by 8.11 per cent under no tillage as compared to conventional tillage under long term study of 31 years.

Salinas-Garcia *et al.* (2002) [15] reported that SMB-N was significantly affected by tillage, but primarily at the soil surface (0-5 cm) it was 25-50% greater with zero tillage and minimum tillage than with disk ploughing to 30 cm. The results are in line with Spedding *et al.* (2004) [17] who found that residue management had more influence than tillage system on microbial characteristics, and higher SMB-C and N levels were found in plots with residue retention than with residue removal.

Dehydrogenase activity (DHA)

The enzyme activity in soil is considered as an index of microbial activity, which is influenced by nature, age of crop and addition of fertilizers and manures. The presence of microorganisms in soil depends on chemical composition, moisture, pH, and structure. The dehydrogenase activity is proposed as the best indicator of microbiological redox system, which is considered as good and adequate parameter of microbial oxidative action in soil.

Different tillage practices significantly influenced DHA with higher dehydrogenase activity (50.67 µg TPF g^{-1z} soil 24 h^{-1}) in zero tillage compared to conventional tillage (25.68 µg TPF g^{-1z} soil 24 h^{-1}). Among different cover crops significantly higher dehydrogenase activity (47.56 µg TPF g^{-1z} soil 24 h^{-1}), was observed in horse gram cover crop compared to control (32.76 µg TPF g^{-1z} soil 24 h^{-1}). Tillage practices and cover crops shown non-significant interaction, with higher value (54.72 µg TPF g^{-1z} soil 24 h^{-1}) in M_3C_3 (Zero tillage + Horsegram cover crop).

Bera *et al*. (2018) [3] evaluated the response of DHA to conservation agriculture practices under rice-wheat system in sandy loam soil of North Western India and reported that among wheat treatments, dehydrogenase was higher under ZTW+R than under ZTW-R and CTW-R at all growth stages of wheat. In the case of rice treatments (residual effects of rice establishment methods), the activity of all the soil enzymes were significantly higher after ZT-DSR compared with CT-DSR, DTR and the lowest after PTR.

Parihar *et al*. (2016) [14] study effect of CA on maize based rotations and reported that dehydrogenase activity (DHA) was significantly affected by tillage and crop rotations and their interactions. They also reported that maximum soil DHA was recorded under ZT plots, which was significantly higher than CT plots. Further, the DHA in 0-30 cm soil layer was 43.5 and 30.6 per cent higher in ZT and PB treatments compared to CT, respectively.

Conclusion

Different tillage practices significantly influenced MBC, MBN and DHA in zero tillage compared to conventional tillage. Among different cover crops significantly higher microbial biomass carbon was observed in horse gram cover crop compared to control. Conservation agriculture practice has positive influence on biological properties of soil. Adoption of proper crop residue management practices leads to improved soil quality and increase the production with the minimum adverse effect on environment. Residue management have greater influence on carbon sequestration, microbial activities, mineralization rate which in turn increases the microbial community.

References

1. Abbasi MK, Khizar A. Microbial biomass carbon and nitrogen transformations in a loam soil amended with organic-inorganic N sources and their effect on growth and N-uptake in maize. Ecol Engineering. 2012;39:123-132.
2. 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.
3. Bera T, Sharma S, Thind HS, Sidhu HS, Jat ML. Changes in soil biochemical indicators at different wheat growth stages under conservation-based sustainable intensification of rice-wheat system. J Integr Agric. 2018;17(8):1871-1880.
4. Bhatt B, Chandra R, Ram S, Pareek N. Long-term effects of fertilization and manuring on productivity and soil biological properties under rice (*Oryza sativa*) wheat (*Triticum aestivum*) sequence in Mollisols. Arch Agron Soil Sci. 2016;62(8):1109-1122.
5. Boltan K, Banik SK, Dey B. Dehydrogenase and phosphatase activities in rice field soils. Soil Biol Biochem. 2004;16(3):423-424.
6. Carter MR. Ninhydrin reactive-N released by the fumigation extraction method as a measure of microbial biomass under field conditions. Soil Biol Biochem. 1991;23:139-143.
7. Casida LE, Klein DA, Santaro T. Soil dehydrogenase activity. Soil Sci. 1964;96:371-376.
8. FAO. Conservation agriculture website; c2019. https://www.fao.org/home/en
9. Gomez KA, Gomez AA. Statistical procedures for agric. res. II ed. John Wiley & Sons, New York; c1984.
10. Kumar S, Garg AK, Aulakh MS. Effect of conservation agriculture practices on physical, chemical and biological attributes of soil health under soybean-rapeseed rotation. Agric Res J. 2015;5(2):145-161.
11. Lal R. Tillage and agricultural sustainability. Soil Till Res. 1991;20:133-146.
12. Mbuthia LW, Martínez AV, Debruyn J, Schaeffer S, Tyler D, Odoi E, *et al*. Long term tillage, cover crop, and fertilization effects on microbial community structure, activity: Implications for soil quality. Soil Biol Biochem. 2015;89:24-34.
13. Nidaye N, Dkhar MS. Impact of organic and inorganic fertilizers on microbial populations and enzymatic activities in paddy field soil. J Agron. 2000;9(3):102-110.
14. Parihar CM, Yadav MR, Jat SL, Singh AK, Kumar B, Pradhan S, *et al*. Long term effect of conservation agriculture in maize rotations on total organic carbon, physical and biological properties of a sandy loam soil in north-western Indo-Gangetic Plains. Soil Tillage Res. 2016;161:116-128.
15. Garcia SJR, Garcia VJD, Valdez GA, Mederos DP, Hernandez CF, Vargas TLM, *et al*. 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.
16. Singh M, Reddy SR, Singh VP, Rupa TR. Phosphorus availability to rice (*Oriza sativa* L.) wheat (*Triticum estivum* L.) in a Vertisols after eight years of inorganic and organic fertilizer additions. Bioresour Technol. 2007;98:1474-1481.
17. Spedding TA, Hamel C, Mehuys GR, Madramootoo CA. Soil microbial dynamics in maize-growing soil under different tillage and residue management systems. Soil Biol Biochem. 2004;36:499-512.