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Effect of Different Levels of Residue Retention on Soil Physico-Chemical and Biological Properties at different Stages of Soybean Crop after Harvest under Conservation Agriculture

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ABSTRACT: Adopting conservation agriculture with crop residue retention can enhance crop productivity, soil health and overall sustainability of soybean-wheat cropping system. Benefits of CA with crop residue application vary from location to location depending on management practices, agro-climatic condition and type of soil. However the effect of different levels of residue retention on soil properties and crop productivity in black soil of M.P. in soybean cropping system under conservation agriculture practices need to be studied. Keeping the above facts in view, a study was conducted during 2018-19 at ICAR- IISS, Bhopal and under this a experiment was carried out in randomized block design with four residue levels as treatments and six replications under soybean cropping system. So, the finding of the study indicate that Retention of 90% residue level in treatment T4 recorded significantly higher soil moisture content on dry weight and volume at 0-5 cm and 5-10 cm. With increase in levels of residues in soil after harvest of soybean crops OC of the soils under different treatments increased significantly. The highest SOC was recorded under treatment T4 (1.13%). Retention of different levels of residue significantly increased the soil available N, P & K status after harvest of soybean crops. Different residues level had significant effect on DHA. DHA, which indicates the microbial activity, was found to be increased with increasing levels of crop residues retention after harvest soybean crop.

Keywords: Soil, Residue, Retention, Under, Level, Soybean, Crop.

INTRODUCTION

Conservation Agriculture (CA) is a modern crop management technology being practiced over 155 m ha globally (FAO, 2015) and Vertisols in India occupy a total area of 70.3 m ha, constituting 22% of the total geographical area of the country of which 30.2% are in Madhya Pradesh (central India) (Kushwah *et al*., 2016). Improving soil health and conserving resources along with sustaining and improving crop yield is a challenging task in black soil. In this regard, conservation agriculture could be one of the potential practices for conserving soil and water, apart from other soil health benefits in black soil (Salem *et al*., 2015).

Conservation agriculture can be an important component for the overall strategy towards enhancing productivity, improving environmental quality and preserving natural resources for food security and poverty alleviation. Tillage is one of the fundamental operations in agriculture because of its significant influence on soil properties, clearing weeds, environment and crop growth. Since continuous tillage strongly influence the soil properties which results in degradation of soil and loss of soil OC, it is important to adopt appropriate tillage practices to avoid degradation of soil structure, maintain crop yield as well as ecosystem stability (Karunakaran and Behera 2015). For instance, soil organic carbon (SOC) generally seems to slightly increase if residues are returned to the soil, particularly in the long term (Chenu *et al*., 2014; Autret *et al*., 2016; Merante *et al*., 2017). However, the actual quantification of straw incorporation effect on soil organic carbon stocks shows conflicting results, as synthetized by Poeplau *et al*. (2015), with studies reporting SOC losses, SOC stabilization or even non-significant or negligible impact. The effect of tillage on SOC content is less clear. While some studies show an increase of SOC with reduced or no-tillage (Arrouays *et al*., 2002; Smith, 2008; Garcia-Franco *et al*., 2015).

MATERIALS AND METHODS

A. Experimental site and Treatment

The field experiment was laid out at the research farm of Indian institute of Soil Science (ICAR), Bhopal, (M.P.) under Conservation Agriculture in Soybean - Wheat cropping system in Vertisols. The experiment was laid out in randomized block design with four treatments, replicated six times.

B. Soil

The soil of the experimental site belongs to the Vertisols (fine clay, montmorillonite, Typic Haplustert). Soil varies from neutral to alkaline in soil reaction. The soil was categorized as low in available N and medium in OC and high in P and high in K content. Soil is having good water holding capacity and moderate to slow internal drainage.

The details are as below treatments

Treatment	(Residue levels)
T_1	0 % Residue
T_2	30% Residue of the preceding
T_3	60% Residue of the preceding
T_4	90% Residue of the preceding

(Wheat residues were applied by harvesting at 30%, 60% and 90% on plant height basis while soybean residues were applied on weight basis)

C. Protocols and methodology adopted for soil analysis

Soil properties	Parameter	Method to be employed
Physical properties	Bulk Density Soil Temperature Soil Moisture	Blake and Hartge (1986) Digital Thermometer. Piper (1950)
Chemical properties	Oxidizable Carbon Available Nitrogen Available Phosphorus Available Potassium	Walkley and Black (1934); Jackson (1976) Alkaline permanganate method (Subbiah and Asija 1956) Olsen's method (Olsen *et al*., 1954). Neutral normal ammonium acetate method (Jackson, 1973)
Biological properties	Labile carbon Dehydrogenase Activity (DHA)	Weil *et al.* (2003) Casida *et al.* (1964)

D. Statistical analysis

The relevant data were tabulated in systematic manner and analysed statistically by Fisher's Method. The calculated "F" value was compared with tabulated "F" value at 5 per cent level of significance. Critical difference (C.D.) or least significant difference at 5 per cent level of Confidence was calculated to judge the difference (LSD) between the treatment means. The skeleton of analysis of variance and formula for standard error of mean (SEm ±), critical difference (C.D.) and Coefficient of variation (C.V.) are given below (Cochran and Cox 1957).

RESULT AND DISCUSSION

Soil physical properties. Retention of crop residues after harvesting is considered to be an effective anti-erosion measure. Crop residues act as mulches to conserve soil moisture and improve soil structure, increase organic matter content in the soil, reduce evaporation. Retention of different levels of crop residues has significant impact on various physical, chemical and biological properties of soil. The results obtained under different levels of residue retention on soil properties under conservation agriculture are presented under different headings below.

Soil moisture. Data on soil moisture status is presented in the Table 1 and Fig. 1 which revealed that retention of 90% residue level in treatment T4 in the field recorded maximum soil moisture content on dry weight, volume and depth basis at 0-5 and 5-10 cm (21.42%, 21.63%) which was significantly higher than treatment T3 and treatment T2 residue level and the lowest soil moisture was recorded under treatment T1 (17.02%, 17.70%). This significant increase in soil moisture with increasing residue level may be correlated with improvement in soil physical properties like soil structure, increase in soil organic matter and thus soil porosity and finally water retention capacity. Retention of crop residue on soil surface alters soil hydrothermal characteristics and regulates soil temperature thus preserve soil moisture.

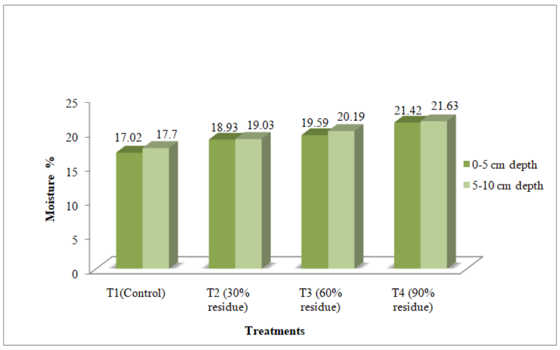

Fig. 1. Effect of different residue levels retention on soil moisture % 90 DAS of Soybean crop.

Soil bulk density. Soil bulk density is an indicator of soil compaction and soil health. It affects infiltration, rooting depth, restrictions, soil moisture, soil porosity, plant availability nutrient and soil microorganism activity, which influences key soil processes and productivity. Data pertaining to bulk density at 0-5, 5-10 cm depth are presented in the Table 1 and Fig. 2 revealed that there were no differences observed under different levels of residue retention treatments.

However, treatment T4 90% residue recorded lower bulk density at both depths 0-5 and 5-10 cm (1.38 g cm^{-3}, 1.39g cm^{-3}) as compared to treatment T3 and treatment T2 and highest BD was recorded under control without residues. The fact behind decrease in BD due to increasing level of residue over no residue is because of improvement in soil organic matter and soil structure over time. Adoption of CA practices with crop residue retention on soil is expected to bring progressive reduction in soil compaction and higher aggregate stability over time.

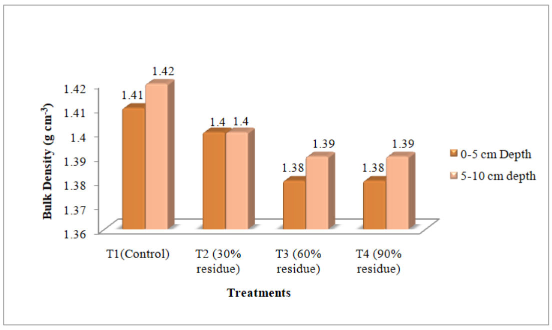

Fig. 2. Effect of different residue levels retention on soil bulk density after harvest of Soybean crop.

Table 1: Effect of different residue level retention on soil moisture and BD different stages of Soybean crop.

Treatments	Moisture		Bulk Density (g cm^{-3})	
	0-5 cm depth	5-10 cm depth	0-5 cm Depth	5-10 cm depth
T_1(Control)	17.02	17.70	1.41	1.42
T_2(30% residue)	18.93	19.03	1.40	1.40
T_3(60% residue)	19.59	20.19	1.38	1.39
T_4(90% residue)	21.42	21.63	1.38	1.39
SEm±	0.31	0.37	0.008	0.006
CD (P=0.05)	0.94	1.12	NS	NS

Table 2: Effect of different residue level retention on temperature different stages of Soybean crop.

Soil Temperature (°C)				
Treatments	**0-5 cm depth at morning**	**5-10 cm depth at morning**	**0-5 cm depth at afternoon**	**5-10 cm depth at afternoon**
T_1(Control)	25.55	25.87	32.43	29.10
T_2(30% residue)	25.45	25.70	30.75	28.25
T_3(60% residue)	25.30	25.50	30.40	27.80
T_4(90% residue)	25.05	25.17	29.47	27.43
SEm±	0.04	0.12	0.166	0.103
CD (P=0.05)	0.11	0.35	0.499	0.310

Soil temperature. Soil temperatures under different levels of residue retention on the soil surface under conservation tillage systems can decrease the rate of change in soil temperature because surface residue increases the reflection of incident solar radiation. Data presented in Table 2 and Fig. 3 revealed that there is significant impact of different level of residue in soil temperature at both depths 0-5 and 5-10 cm during morning time (25.05°C and 25.17°C) and at afternoon (29.47°C and 27.43 °C) which was significantly lower as compared to treatment T3 and Treatment T2 residue levels and the maximum soil temperature was recorded under treatment T1 control at morning time (25.55°C and 25.87°C) and at afternoon (32.43°C and 29.10°C).

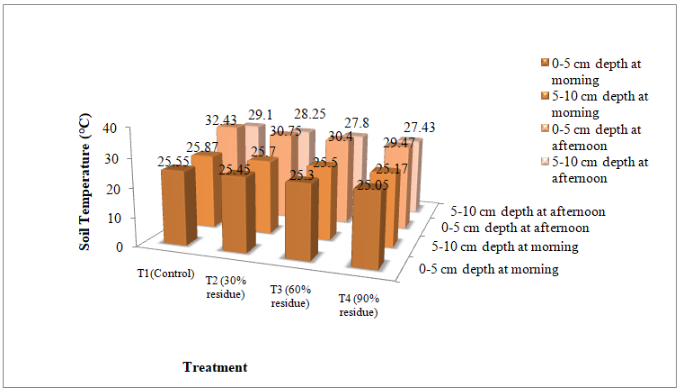

Fig. 3. Effect of different residue levels retention on soil temperature different stages of Soybean crop.

Soil chemical studies

Soil pH. Residue retention under conservation agricultural practices is one of the important constituents for enhancing soil quality/health and productivity. Results presented in Table 3 and Fig. 4 indicated that with the increase in levels of residues in soil after harvest of soybean, pH of the soil decreased significantly. The maximum soil pH was noticed under treatment T1 (7.94), followed by treatments T2 (7.89) and T3 (7.84) whereas, the minimum was registered under treatment T4 (7.81). Results indicated that with increase in the level of residues in soil, the carbon content of the soil increased, which might be responsible for lowering down the pH of the soil.

Electrical conductivity (EC). A perusal of data presented in Table 3 and Fig. 5 indicates that with increase in levels of residues retention in soil there is no influence on EC of soil after harvest of soybean.

Soil organic carbon (SOC). Data on soil organic carbon (SOC) presented in Table 3 and Fig. 6 indicates that with increasing the levels of residues in soil after harvest of soybean, OC of the soils under different treatments increased significantly. The highest SOC was recorded under treatment T4 (1.13%) closely followed by treatment T3 (1.12%) and both these treatments were found to be significantly higher than treatment T2 (0.98%) and T1 (0.98%), whereas treatment T1 and T2 statistically at par with each other. The high residue levels in soils increased the residual biomass in soil, which might be responsible for higher OC content.

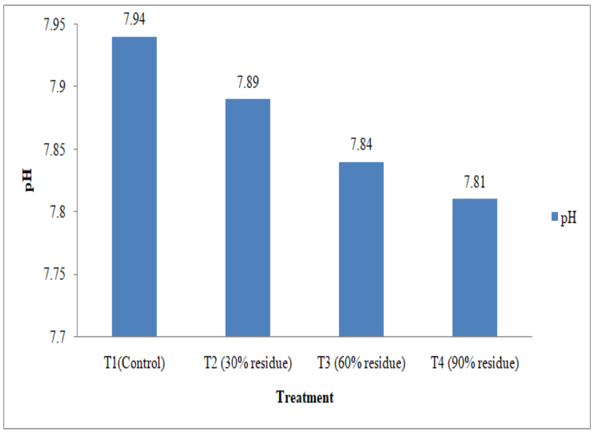

Fig. 4. Effect of different residue levels retention on soil pH after harvest of soybean crop.

Table 3: Effect of different residue level retention under conservation agriculture on soil chemical properties after harvest of soybean.

Treatments	pH	EC (ds m^{-1})	OC (%)	Av- N (kg ha^{-1})	Av- P (kg ha^{-1})	Av- K (kg ha^{-1})
T$_1$ (Control)	7.94	0.24	0.98	217.43	19.16	509.79
T$_2$ (30% residue)	7.89	0.24	0.98	221.61	19.39	596.03
T$_3$ (60% residue)	7.84	0.26	1.12	228.93	20.90	699.63
T$_4$ (90% residue)	7.81	0.26	1.13	252.97	21.14	796.32
SEm±	0.01	0.01	0.02	3.49	2.67	8.16
CD (P=0.05)	0.03	NS	0.07	10.52	NS	24.60

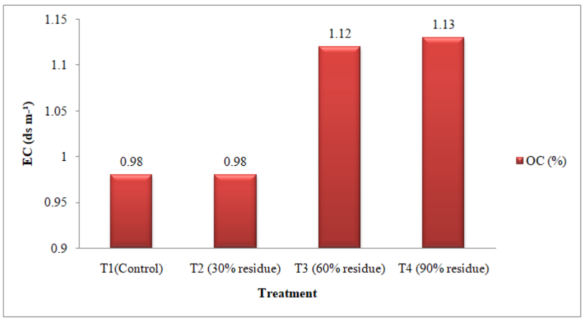

Fig. 5. Effect of different residue levels retention on soil EC after harvest of soybean crop.

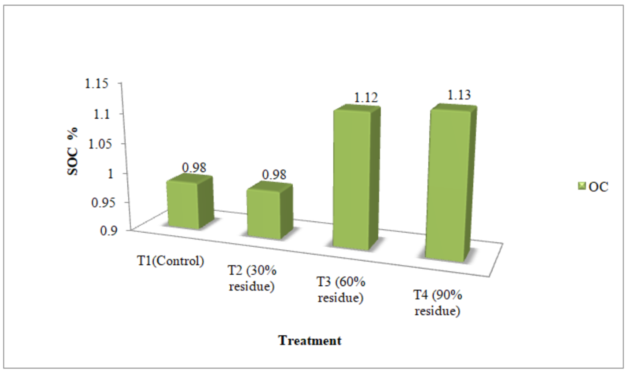

Fig. 6. Effect of different residue levels retention on SOC after harvest of soybean crop.

Available N. Soil available N is one of the most essential elements for plant growth and yield. Data presented in Table 3 and Fig. 7 revealed that retention of different levels of residue significantly affected soil available N status after harvest of soybean. The available N of soils increased significantly under treatment T4 (252.97 kg ha^{-1}) which was significantly superior over treatment T3 (228 kg ha^{-1}) and T2 (221.61 kg ha^{-1}) and treatment T1 (217.43 kgha^{-1}). The high residual biomass and high OC content in soils might be responsible for increasing the levels of available N in soil.

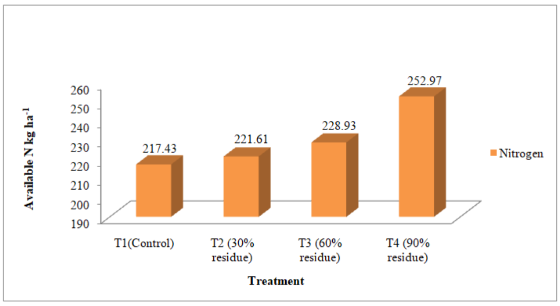

Fig. 7. Effect of different residue levels retention on soil available Nitrogen after harvest of soybean crop.

Available P. Soil available P is one of most essential factor for plant growth and yield. Data presented in Table 3 and Fig. 8 revealed that retention of different levels of residue did not affect the soil available P status after harvest of soybean crop. Maximum available P was found treatment T4 (21.14kg ha^{-1})

whereas, the minimum available P was observed under Treatment T1 (19.16 kg ha^{-1}). Retention of different levels of residue did not significantly affect the soil available P status after harvest of crops. Soil available P under treatments increased slightly with increasing levels of residue retention, albeit statistically not significant.

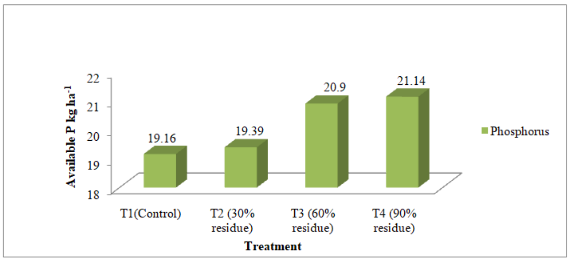

Fig. 8. Effect of different residue levels retention on soil available Phosphorus after harvest of soybean crop.

Available K. Soil available K is another important factor for plant growth and yield. Data presented in Table 3 and Fig. 9 revealed that application of different levels of residue significantly affected the soil available K status after harvest of soybean. The available K of soils was found to be significantly higher under treatment T4 (796.32 kg ha^{-1}) and the minimum available K was observed under Treatment T1 (509.79 kg ha^{-1}). Treatment T4 was significantly superior over all other treatments T3 (699.6 kg ha^{-1}) and T2 (596 kg ha^{-1}). The available K was found to be significantly affected with increased levels of residues.

Soil biological properties

Dehydrogenase Activity (DHA). Mean dehydrogenase activity (DHA) values for treatment T4, T3, T2, and T1 control were 48.27µgTPF 24 hr^{-1} g^{-1}soil,44.73 µg TPF 24 hr^{-1} g^{-1} soil, 42.45 µg TPF 24 hr^{-1}g^{-1} soil and 42.05 µg TPF 24 hr^{-1} g^{-1} soil respectively Table 11 and Fig. 18). Different residues level had significant effect on DHA. DHA, which indicates the microbial activity, was found to be increased with increasing levels of crop residues retention after harvest soybean crop. Different residue levels had significant effect on DHA. DHA, which indicates the microbial activity, was found to be higher with increasing levels of crop residues retention after harvest of soybean crop.

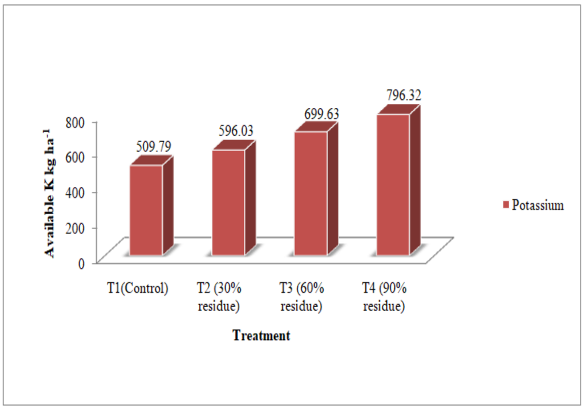

Fig. 9. Effect of different residue levels retention on soil available Potassium after harvest of soybean crop.

Soil biological properties

Dehydrogenase Activity (DHA). Mean dehydrogenase activity (DHA) values for treatment T4, T3, T2, and T1 control were 48.27µgTPF 24 hr^{-1} g^{-1}soil,44.73 µg TPF 24 hr^{-1} g^{-1} soil, 42.45 µg TPF 24 hr^{-1}g^{-1} soil and 42.05 µg TPF 24 hr^{-1} g^{-1} soil respectively Table 11 and Fig. 18). Different residues level had significant effect on DHA. DHA, which indicates the microbial activity, was found to be increased with increasing levels of crop residues retention after harvest soybean crop. Different residue levels had significant effect on DHA. DHA, which indicates the microbial activity, was found to be higher with increasing levels of crop residues retention after harvest of soybean crop.

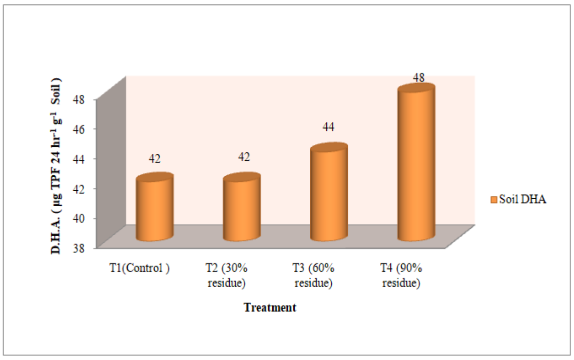

Fig. 10. Effect of different residue level retention on soil dehydrogenase activity after harvest of soybean crop.

Table 4: Effect of different residue level retention under conservation agriculture on labile carbon and dehydrogenase activity of soil after harvest of soybean

Treatments	Soil Dehydrogenase Activity (µg TPF 24 hr^{-1} g^{-1} Soil)	Labile Carbon Soil mg C kg^{-1}Soil
T$_1$(Control)	42	505
T$_2$(30% residue)	42	534
T$_3$(60% residue)	44	549
T$_4$(90% residue)	48	562
SEm±	1.18	19.96
CD (P=0.05)	3.57	NS

Labile Soil Carbon. The result showed that the accumulation of permanganate oxidizable soil carbon content was higher in surface soil. Data presented in the Table 4 and Fig. 11 revealed that retention of 90% residue level in treatment T4 recorded the maximum permanganate oxidizable soil carbon content (562.20mg C kg^{-1}) which was statistically on par with treatments T3 (549.40mg C kg^{-1}), T2 (534.26 mg C kg^{-1}) and treatment T1 (505.30 mg C kg^{-1}).

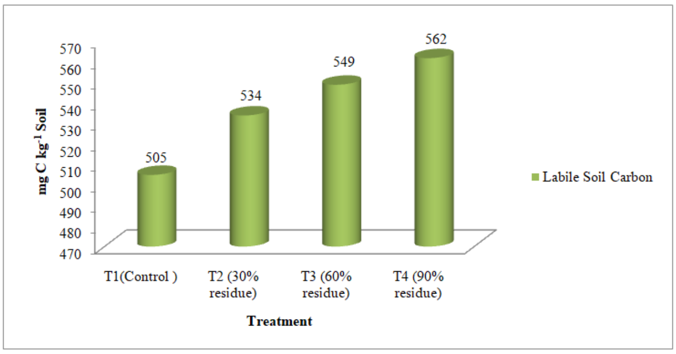

Fig. 11. Effect of different residue level retention on labile soil carbon after harvest of soybean crop.

Table 5: Effect of different residue level retention on nutrient content (%) in soybean straw after harvest.

Nutrient content (%) in Soybean straw			
Treatments	**N %**	**P %**	**K %**
T_1(Control)	2.54	0.25	1.70
T_2 (30% residue)	2.57	0.25	1.70
T_3 (60% residue)	2.89	0.27	1.85
T_4 (90% residue)	2.90	0.30	1.96
SEm±	0.12	0.019	0.05
CD (P=0.05)	NS	NS	0.15

Nutrient content

Nitrogen content (%). The data presented Table 5 revealed that the application of treatment T4 (90% residue) recorded the highest N-content in straw (2.90%), which was found to be non-significant whereas, the lowest N-content (2.54%) was recorded under Treatment T1(0%residue). The differences among different residues levels could not attain the level of significance.

Phosphorus content (%). The data presented Table 5 revealed that there are non-significant differences among different treatments in terms of phosphorus content in straw. Treatment, T4 (90% residue) recorded the highest P-content (0.30%), which was found to be on par with all other treatments, the lowest P-content (0.25%) was recorded under Treatment T1(0% residue) in case of soybean crop.

Potassium content (%). The data on K-content in straw are presented Table 5 the data revealed that a significant effect of different levels of residue retention on K-content of straw was observed. The highest K-content was recorded under the treatment T4(1.96%), which was found at par with treatment T3(1.85%) and significantly superior over all other treatments. The minimum K-content was observed in absolute treatment T2(1.70%) and control Treatment T_1 (1.70%).

A perusal of data presented in Table 6 indicated that maximum quantity of residues were retained under treatment T4 (90% residue retention) in case of soybean (26.51 q/ha), T3 (60% residue) 17.32 q/ha and under treatment T2 (30% residue) 7.99 q/ha.

Table 6: Quantity of Residue recycled under different treatments.

Residue level	**Soybean(q/ha)**
T_1(Control)	0
T_2 (30% residue)	7.99
T_3 (60% residue)	17.32
T_4 (90% residue)	26.51

Table 7: Quantity of Nutrient recycled under different treatments.

Residue level	**Nutrient recycled through soybean residues (kg ha^{-1})**		
	N	**P**	**K**
T_1(Control)	0.0	0	0
T_2 (30% residue)	20.5	2.00	13.58
T_3 (60% residue)	50.1	4.68	32.05
T_4 (90% residue)	76.9	7.95	51.96

Table 8: Effect of different residue level retention on nutrient content (%) in soybean seeds after harvest.

Treatment	**Nutrient content (%) in Soybean seeds**		
	N %	**P%**	**K%**
T_1(Control)	4.21	0.25	1.21
T_2 (30% residue)	4.65	0.27	1.29
T_3 (60% residue)	5.11	0.30	1.41
T_4 (90% residue)	5.25	0.32	1.45

Data presented in Table 7 revealed that maximum quantity of nutrients recycled was maximum under treatment T4 (90% residue retention) in case of soybean (76.9, 7.95 & 51.96 kg NPK/ha).

Data presented in the Table 8 revealed that highest quantity of nutrient content (%) was recorded under the treatment T4 (90% residue) in soybean seeds (5.25, 0.32 & 1.45NPK %). The lowest quantity of nutrient content (%) was recorded under treatment T1 (Control) (4.21, 0.25 & 1.21 NPK %).

Table 9: Effect of different residue level retention on nutrient uptake by soybean seed.

Treatment	**Seed yield kg ha^{-1}**	**Nutrient uptake by soybean seed**		
		N kg ha^{-1}	**P kg ha^{-1}**	**K kg ha^{-1}**
T_1 (Control)	1542.59	64.94	3.86	18.67
T_2 (30% residue)	1745.83	81.18	4.71	22.52
T_3 (60% residue)	1915.28	97.87	5.75	27.01
T_4 (90% residue)	1965.28	103.18	6.29	28.50

A perusal of data presented in Table 9 indicated that highest nutrient uptake by soybean seed was observed under treatment T_4 (103.18, 6.29 & 28.5) NPK kg ha^{-1}. Lowest nutrient uptake by soybean seed was observed under treatment T1 (64.94, 3.86 & 18.67) NPK kg ha^{-1}. Because there was no organic matter available under Treatment T1. So becomes minimum value of T1.

Table 10: Effect of different residue level retention under conservation agriculture on yield attributes or yield attributing character of soybean.

Treatment	No. of seed pod^{-1}	Pods $plant^{-1}$	Seed index	No. of seed $plant^{-1}$	Seed yield kg ha^{-1}	Straw yield kg ha^{-1}	HI (%)
T_1 (Control	2.56	35.44	9.13	59.56	1542.59	2364.81	39.48
T_2 (30% residue)	2.56	37.67	9.57	71.56	1745.83	2662.04	39.61
T_3 (60% residue)	2.72	40.89	10.24	80.94	1915.28	2887.04	39.88
T_4 (90% residue)	2.72	43.22	10.35	84.17	1965.28	2945.83	40.02
SEm±	0.04	1.68	0.10	2.49	38.79	40.03	0.69
CD (P=0.05)	0.12	5.08	0.30	7.50	116.91	120.66	NS

Seed index. The seed index was calculated after threshing and sun drying of soybean seeds. The data was statistically analysed and presented in the Table 10. It is evident that seed index was significantly influenced by treatments comprising of different residue levels as compared to without residue. The maximum seed index was recorded in treatment T4-90% residue (10.35), which was on par with treatment T3 - 60% residue (10.24) and these treatments were significantly superior over treatments T2 - 30% residue (9.57) and T1 – control (9.13).

Number of seeds. The numbers of seeds/plant of soybean have been presented in Table 5 after statistically analysis. It is clear from the results that number of seed per plant was significantly higher under the treatment T4 - 90% residue (84.17) which was on par with treatment T3 - 60% residue (80.94). And these treatments were significantly superior over treatments T2 - 30% residue (71.56) and T1 - control (59.56).

Seed yield. The seed yield of crop has been calculated and after statistical analysis it was presented in Table 5. As per the data recorded it is evident that the seed yield was significantly influenced by different residue level as compared to control. Among all treatments the maximum seed yield was recorded in treatment T4-90% residue (1965.28kg ha^{-1}) which was on par with treatment T3 - 60% residue (1915.28 kg ha^{-1}) and these treatments were significantly superior over treatments T2 - 30% residue (1746 kg ha^{-1}) and T1 - control (1543 kg ha^{-1}).

Straw yield. The straw yield of crop have been calculated and presented in Table 5. The different levels of residue significantly influenced the straw yield kg ha^{-1}. The maximum straw yield was recorded in treatment T4-90% residue (2946 kg ha^{-1}) which was on par with treatment T3 - 60% residue (2887) and these treatments were significantly superior over treatments T2 - 30% residue (2662) and T1 - control (2365 kg ha^{-1}).

Harvest Index. The harvest index was computed by using the data of seed yield and biological yield. After statistical analysis the results were presented in the Table 5. The data clearly shows that harvest index was found to be higher in the treatments comprising of different residue levels as compared to control but statistically they are non- significant to each other. The highest harvest index was recorded in treatment T4-90% residue (40.02%) followed by treatment T3 - 60% residue (39.88), T2 - 30% residue (39.61) and T1 - control (39.48).

CONCLUSIONS

The present study clearly showed that residue retention along with no tillage under conservation agriculture in Soybean-Wheat system improve physical chemical and biological properties of a deep black soil of central India and there by contributed positively in affecting growth parameter, yield attributing characters and productivity of both Soybean and Wheat crops.

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Conflict of Interest. None.

REFERENCES

Arrouays, D., Balesdent, J., Germon, J. C., Jayet, P. A., Chenu, C., Houot, S. and Soussana, J. F. (2002). Mitigation of the greenhouse effect-Increasing carbon stocks in French agricultural soils? Scientific Assessment Unit for Expertise. Synthesis of an Assessment Report by the French Institute for Agricultural Research (INRA) on request of the French Ministry for Ecology and Sustainable Development.

Autret, B., Mary, B., Chenu, C., Balabane, M., Girardin, C., Bertrand, M. and Beaudoin, N. (2016). Alternative arable cropping systems: A key to increase soil organic carbon storage? Results from a 16 year field experiment. *Agriculture, Ecosystems & Environment*, *232*, 150-164.

Blake, G. R. and Hartge, K. H. (1986). Bulk density. In: Klute, A., Ed., Methods of Soil Analysis, Part 1—Physical and Mineralogical Methods, 2nd Edition, Agronomy Monograph 9, American Society of Agronomy—*Soil Science Society of America, Madison*, 363-382.

Casida, L. E., Klein, D. A. J. and Santoro, T. (1964). Soil dehydrogenase activity. *Soil Sci.*, *98*, 371-376.

Cochran, W. G., & Cox, G. M. (1957). Some methods for the study of response surfaces. *Experimental designs*, 335-375.

Chenu, C., Klumpp, K., Bispo, A., Angers, D., Colnenne, C. and Metay, A. (2014). Stocker du carbonedans les sols agricoles: évaluation de leviersd'action pour la France.

FAO (2015). AQUASTAT Main Database - Food and Agriculture Organization of the United Nations (FAO).

Garcia-Franco, N., Albaladejo, J., Almagro, M. and Martínez-Mena, M. (2015). Beneficial effects of reduced tillage and green manure on soil aggregation and stabilization of organic carbon in a Mediterranean agroecosystem. *Soil and Tillage Research*, *153*, 66-75.

Jackson, M. L. (1973). Soil Chemical Analysis, *Prentice Hall of India Pvt. Ltd*., New Delhi, 498.

Jackson, M. L. (1976). *Soil Chemical Analysis*. Prentice Hall India, New Delhi.

Karunakaran, V. and Behera, U. K. (2016). Tillage and residue management for improving productivity and resource-use efficiency in Soybean (*Glycine max*)—Wheat (*Triticum aestivum*) cropping system. *Experimental Agriculture*, *52*(4), 617-634.

Kushwah, S. S., Reddy, D., Damodar Somasundaram, J., Srivastava, S. and Khamparia, R. S. (2016). Crop Residue Retention and Nutrient Management Practices on Stratification of Phosphorus and Soil Organic Carbon in the Soybean–Wheat System in Vertisols of Central India, *Communications in Soil Science and Plant Analysis*, *47*(21), 2387-2395.

Merante, P., Dibari, C., Ferrise, R., Sánchez, B., Iglesias, A., Lesschen, J. P. and Bindi, M. (2017). Adopting soil organic carbon management practices in soils of varying quality: Implications and perspectives in Europe. *Soil and Tillage Research*, *165*, 95-106.

Olsen, S. R., Cole, C. V., Watanabe, F. S. and Dean, L. A. (1954). Estimating of available phosphorus in soil by extraction with sodium bicarbonate *USDA* Circular., 939.

Piper, C. S. (1950). Soil and plant analysis. *The University of Adelaide, Australia*, 286-287.

Poeplau, C., Kätterer, T., Bolinder, M. A., Börjesson, G., Berti, A. and Lugato, E. (2015). Low stabilization of aboveground crop residue carbon in sandy soils of Swedish long-term experiments. *Geoderma*, *237*, 246-255.

Smith, P. (2008). Land use change and soil organic carbon dynamics. *Nutrient Cycling in Agroecosystems*, *81*(2), 169-178.

Subbiah, B. V. and Asija, G. L. (1956). A rapid procedure for the determination of available nitrogen in soils. *Curr. Sci.*, *25*, 259–260.

Walkley, A. and Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil science*, *37*(1), 29-38.

Weil, R. R., Islam, K. R., Stine, M. A., Gruver, J. B. and Samson-Liebig, S. E. (2003). Estimating active carbon for soil quality assessment: A simplified method for laboratory and field use. *America J. Altern. Agric.*, *18*, 3–17.

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