International Journal of Plant & Soil Science

Volume 35, Issue 19, Page 1192-1203, 2023; Article no.IJPSS.105148
ISSN: 2320-7035

Influence of Different Residue Retention and Nutrient Levels on Crop Productivity of Soybean (*Glycine max* L.) under Conservation Agriculture

Bharti Parmar [a*], A. K. Vishwakarma [b], Varsha Gupta [a], Pramod Jha [b], A. K. Biswas [b], K. M. Hati [b], Ganesh Malgaya [a], Anil Nagwanshi [b], Shubham Singh [a] and Rupesh Yadav [b]

[a] *Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh (474002), India.*
[b] *ICAR-Indian Institute of Soil Science, Berasia Road, NabiBagh Bhopal, Madhya Pradesh (462038), India.*

Authors' contributions

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

Article Information

DOI: 10.9734/IJPSS/2023/v35i193658

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/105148

Original Research Article

Received: 12/06/2023
Accepted: 18/08/2023
Published: 01/09/2023

ABSTRACT

During the kharif season of 2020-22, a field experiment with soybean in a soybean-wheat cropping system was conducted at the ICAR-Indian Institute of Soil Science, Bhopal, (M.P.) to assess the effect of different levels of crop residue retention treatments and nutrient doses on growth parameters, physiological indices, yield attributes, yield and profitability of soybean. The experiment was laid out with Factorial Randomized Block Design (FRBD) comprised of 16

**Corresponding author: E-mail: parmarbharti1223@gmail.com;*

combinations of 4 residue level (0%, 30%, 60% and 90%) and 4 nutrient doses (N_1-RDF (120:60:40 kg N, P_2O_5 and K_2O ha^{-1}), N_2-75% N+100% P_2O_5 and K_2O ha^{-1}, N_3-75% P_2O_5+100% N and K_2O ha^{-1}, N_4-75% K_2O+100% N and P_2O_5 ha^{-1}) with 3 replication under ongoing CRP-CA (Consortium Research Platform on Conservation Agriculture). The result showed that growth parameters, physiological indices as well as yield, yield attributes and profitability were significantly higher in 90% than other crop reside retention treatment. The higher (90%) crop residue retention resulted in 16% higher grain yield, 16.88% stover yield and 17.55% higher profitability then without residue treatment. Among different nutrient doses 100% RDF showed significantly higher growth and better physiological indices at all the growth stages. Significantly higher seed (1226 kg ha^{-1}) and stover (2274 kg ha^{-1}) yields were recorded with 100% RDF with any other management practices.

Keywords: Soybean; nutrient; residue; yield; conservation agriculture.

1. INTRODUCTION

"Maintaining water and soil quality, soil organic matter (SOM), recycling and storing nutrients, efficient use of natural resources and controlling soil degradation are all ways to ensure food and nutritional security for an ever-growing population under climate change. The world population has increased significantly during the last ten years and is expected to reach over 9.5 billion by 2050" [1]. However, in recent years, "the global emphasis has shifted away from increasing prospective yield levels and towards environmental issues, soil health, lowering production costs, and reducing reliance on plant protection methods" [2]. CA is gaining popularity around the world as one of the potential resource conserving technologies that not only aids in the management of crop residues, soil health and associated problems, but also aids in resource conservation, crop productivity improvement, soil erosion reduction and carbon sequestration. CA is defined as "a resource-saving agricultural crop production concept that aims to generate acceptable earnings as well as high and sustained production levels while also conserving the environment" [3]. It is largely concerned with soil, water and agricultural resource management in order to promote economically, environmentally and socially viable agricultural output [4]. Conservation agriculture practices are gradually gaining traction as an alternative to conventional agricultural practices for controlling difficulties caused by conventional tillage practices, hence lowering overall output costs [5]. "Traditional intensive agriculture practices were successful in meeting production targets in the second half of the twentieth century, but they also resulted in severe deterioration of natural resources, putting the agricultural production potential of these resources in jeopardy for future generations" [6]. "In India, about 92 million tonnes (Mt) of crop residue are burned each year, resulting in significant emissions of particulate matter, air pollution and smog" [6]. According to [7] every year, "the country produces more than 683 Mt of crop residue, with a surplus of 178 Mt. One of the most essential components of CA is the retention of crop residues on the soil surface, which is critical to its performance and improvement in agricultural yield, soil characteristics, and environmental services. As a result, regulating the residue is crucial for the long-term health and stability of the system. Tillage practices and crop residue retention as mulch have significant impact on soil moisture regime, improvement in soil biota, soil organic carbon and nutrient recycling" [8], nutrient availability. nutrient use efficiency [9] and improve crop productivity [10,11]. "Long-term soil health is improved by optimising zero tillage (ZT) based on residue management. Intensive tillage practices frequently result in soil health degradation due to soil structure degradation, surface crusting, compaction, depletion of soil organic carbon (SOC), and a detrimental impact on soil microbial diversity and activity" [12,13]. "Improved soil health is a crucial component for adaptation and mitigation against adverse effects of climate change on crop production" [14]. "The increase in SOC and aggregate stability following CA adoption is critical for regulating water and gas flow, nitrogen cycling, and overall soil behavior. CA use has been shown to improve soil fertility and nutrient availability. As a result, N, P and K generally rise in the surface under CA treatment compared to CT treatment" [15]. "A sufficient and well-balanced supply of plant nutrients is critical for promoting soil health. Improving the availability of less nutrients in the soil is becoming increasingly important in this regard. Crop rotation, which involves the cultivation of different crops with different rooting habits, nutrient requirements and leaf litter deposition, can be efficient, which helps to regulate soil nutrient supply" [16]. "Crop residue is important to nutrient cycling and soil fertility, removal of crop residue will cause the depletion of soil nutrition which would decrease crop productivity and increase land degradation" [17] depending on the type of residue produced and its nutrient composition, it was estimated that residue included 18 to 62 kg Mg^{-1} of agronomically significant nutrient, which would be comparable to 83% of global fertiliser consumption in 2001. Crop residue use boosts OM, conserves soil water and encourages biological activity [18], promotes soil aggregation, improves nutrient cycling and reduces temperature swings. Crop residues are well known for their beneficial effects on soil quality and soil degradation; however, these effects vary depending on the type and quantity of crop residues sprayed, as well as the soil composition. "Optimising the retention rate of soybean residues can speed the beneficial interaction of black soil complexes with residues, which may play an important role in increasing soil carbon and thereby minimising land degradation. Permanent soil cover with agricultural wastes is predicted to offer the majority of the benefits of conservation agriculture. Surface crop residues play an important role for crop growth through their benefits on soil-related structural components and processes in the agro-ecosystem, referred to in this study as agro-ecological functions" [18].

"Soybean (*Glycine max* L.) is the world's largest legume crop in terms of overall production; it is native to East Asia and is widely produced for its edible bean, which has several uses. In India, soybean crops have a short maturity time ranging from 90 to 105 days. 90% of the soybean crop is grown in three states: Madhya Pradesh, Maharashtra and Rajasthan" [19]. "Soybean is an important leguminous oilseed crop in India, yielding approximately 13.5 t crop residue per year" [20]. "Soybean residue has a high nutritional recycling ability and contains around 41.4% C, 2.8% N, 0.5% P, and 1.3% K [21]. Improved soil carbon and thus soil fertility after carefully decomposing the waste" [22]. The low C:N ratio expedited mineralization and made nutrient release easier [23]. As a result, the residue can be used to improve soil quality while minimising soil degradation. According to the Soybean Processors Association of India, the area under soybean has increased to 11.64 million hectares (Mha) in 2020 from 10.76 Mha a year before. "The crop is in good condition in Madhya Pradesh, Maharashtra, and Rajasthan, which account for more than 90% of overall production in the country. Meeting food demands without further damaging the environment will be a critical problem for agriculture in the next decades. Increasing smallholder agricultural productivity and economic returns in a sustainable manner is a critical challenge to accomplishing global poverty reduction and environmental management goals" [24].

The present study was conducted with hypothesis that long term residue retention in soil as a part of CA practices may improve crop productivity and reduce fertilizer availability under higher (90%) crop residue retention. The information will help to highlight the role of CA practice on residue retention in Vertisols of central India which in turn would govern K supply to the crop for sustained crop growth, balanced nutrition and soil health.

2. MATERIALS AND METHODS

2.1 Soil and Climate

During the rainy season 2021-2022, a field experiment with soybean crop under CA systems was conducted at the ICAR-Indian Institute of Soil Science, Bhopal Research Farm in Vertisols of Central India. The experimental site is at latitude 23 18'28.26" N, longitude 77 24'26.00" E, and elevation 485 m above mean sea level. The soil of the experimental site was an Isohyperthermic, Typichaplustert and deep heavy clay in texture (47.4% clay, 30.5% silt, 22.1% sand), slightly alkaline (pH 7.73) in reaction having a bulk density 1.41 Mg m^{-3}, electrical conductivity (EC) 0.22 dS m^{-1}, soil organic carbon (SOC)%, available N 296 kg ha^{-1}, P 30 kg ha^{-1} and K 697 kg ha^{-1}, respectively. The decadal average rainfall in the experimental farm is 1146 mm, more than 80% of which occurs from June to September and potential evapotranspiration of 1400 mm. The climate in the experimental site is humid subtropical, with warm and humid monsoons during mid of June to end of September.

2.2 Conservation Agriculture Practices

Sowing was done with the help of 'happy seeder' at the onset of monsoon under no till system. Soybean and wheat crop residue (0%, 30%, 60% and 90%). A recommended dose of fertilizer (RDF) is 25 kg N, 60 kg P_2O5, and 20 kg K_2O $ha^{-1}$and 25 % reduced doses of N, P and K were applied as per treatments through single super phosphate, muriate of potash and urea respectively was maintained uniformly in all the plots. Variety RVS-2001-4 of soybean was planted in the experimental field at a row spacing of 27.5 cm during the last week of June. Pre-emergence application of herbicides was done immediately after sowing followed by post-emergence treatment was applied as per scheduled interval. The recommended package of agronomic practices and need based plant protection measures were adopted.

2.3 Treatment Details and Experimental Set-Up

The experiment was carried out in a factorial randomized block design (FRBD) comprising of sixteen treatments and three replications (gross plot size = 7 m x 6 m = 42 m^2). Observations on plant growth, yield attributes, yield at different growth stages were recorded as per standard protocols. Observations were recorded with the help of a quadrant 0.25 m^2 placed randomly at four places in each plot. The growth, yield attributes and yields were recorded from net plot area. The experiment was laid out in Factorial Randomized Block Design (FRBD) comprised of 16 combinations of 4 residue level (0%, 30%, 60% and 90%) and 4 nutrient doses (N_1-RDF (25:60:20 kg N, $P_2O_5$and K_2O ha^{-1}), N_2-75% N+100% P_2O_5 and K_2O ha^{-1}, N_3-75% P_2O_5+100% N and K_2O ha^{-1}, N_4-75% K_2O+100% N and P_2O_5 ha^{-1}) with 3 replications.

2.4 Collection and Analysis of Plant Samples

"Random samples of soybean plant samples from quadrats were drawn from each treatment at the time of harvesting, the samples were air-dried, and kept in an oven at 65˚C until constant weight was obtained. The sample was powdered with the help of a grinder and these samples were used for the determination of nutrient content" [25]. Wet oxidation technique as described by Jackson [25] was adopted for determination of total C content in the samples. Total nitrogen in the crop residues were determined by micro Kjeldhal method after digesting in concentrated sulphuric acid [26]. P and K were determined by digesting the samples in a mixture of HNO_3 and $HClO_4$ (9:4) as suggested by Singh et al. 2005. The total P was determined by Vanado Molybdate Yellow Colour Method as described by Jackson 1973 whereas total K was determined by using flame photometer technique Jackson 1973 in plant samples.

2.5 Statistical Analysis

Standard method of "Analysis of variance" was used for analyzing the data. Standard error of the means (S.E.m+) was worked out for each factor and interactions. The least significant difference test was used to interpret the treatment effect at the 5% level of significance ($p < .05$). The data were suitably illustrated with graphs at appropriate place.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes and Physiological Indices

Growth parameters of soybean *viz*. plant height, dry matter accumulation, leaf area index was influenced significantly by different levels of crop residue retention and nutrient doses. Maximum plant height (59.14 cm), leaf area (895.63), DMA (23.11 g) at maturity were recorded with higher level of crop residue (90%) retention and were found significantly superior over rest of the treatments. Whereas, no residue retention treatment recorded significantly lower values of plant height (45.93 cm), leaf area (646.30), DMA (16.04 g). Similarly, CGR (6.55 and 16.00), RGR (0.011 and 0.012) and AGR (0.180 and 0.440) at 30-60 and 60-90 DAS respectively were also found numerically superior at 30-60 DAS and 60-90 DAS under 90% crop residue retention treatment. This improvement in growth parameters of soybean in without residue treatment was ascribed to higher soil moisture conservation and improved soil physical conditions as residue conserved soil moisture and improved the micro environment of soil thus created conductive environment for plant growth and development [8]. Similar result obtained by [27] they revealed that the growth parameters of soybean were significantly improved with zero tillage & residue retention. Maximum plant height, LAI and dry matter accumulation (DMA) were observed with ZT+SWR (zero tillage + soybean wheat residue). This may be attributed to the fact that higher level of crop residue retention resulted in significant improvement in soil health, better moisture retention and the improved soil microenvironment under zero tillage techniques. The maximum dry matter accumulation under zero tillage with higher level of residue retention may be a result of the soil's moderated temperature, favourable soil moisture, and better soil biota due to the sustained supply of nutrients from residue mineralization [6].

Soybean growth parameters were influenced significantly by different nutrient doses. The highest plant height (54.99), DMA (19.25) and leaf area index (2.93) were retained maximum with N_1 (100% RDF) which were significantly higher than N_3 (75% P_2O_5+100% N and K_2O) and N_2 (75% N+100% $P_2O_5$and K_2O). DMA and leaf area index were retained at par with N_4 (75% K_2O+100% N and P_2O_5. shows that application of recommended dose of fertilizer gives additional advantage over reduction of 25% in nutrient dose of application as well as reduction of 25% K gives similar result as RDF. Nitrogen influenced the total photosynthesis of plants through its effect on the leaf area and increased nutrient application may have promoted vegetative development, causing plants to produce grater biomass [28] These results are in conformity with [29], who stated that the development of leaf area is a result of and an increase in LAI are caused by the availability of sufficient amounts of nutrients, notably nitrogen, during the crop's active growth stages. This may be due to a surface layer of mulch enriched with organic plant residues and nutrients, and altering the dynamics of the organic matter of the soil and the cycling and flows of nutrients [30]. The various physiological indices were not significantly influenced by nutrient doses except the CGR (4.76), RGR (0.009) and AGR (0.131) at 30-60 DAS, favourable synthesis of components that promote growth in the plant system due to greater nutrient availability, which led to an increase in the number of leaves per unit area and an increase in leaf area [31]. The increase in growth attributes with higher nitrogen dose was owing to a greater number of leaves and their better growth under adequate [32]. The significant effect of nutrient doses may be attributed to the fact that there is significant improvement in soil properties and nutrient recycling as a result. Interactive effect of residue levels and nutrient doses on leaf area, CGR and AGR at 30-60 DAS found to be significant (Table 1).

3.2 Yield Attributes

The different levels of crop residue retention treatments and nutrient doses had significant effect on yield attributes of soybean except on seeds pod^{-1} and HI (Table 2). Significantly maximum number of pods plant^{-1} (43.49) and weight of pods plant^{-1} (14.23 g) were found with 90% crop residue which were superior over rest of the treatments. Minimum number of pods plant^{-1} (34.04) and weight of pods plant^{-1} (9.21 g) were found with no residue retention. This is because crop residue can boost crop yield attributes [33,34]. Among the different doses of nutrient, the maximum number of pods plant^{-1} (39.51) and weight of pods plant^{-1} (12.46 g) were found with 100% RDF which were significantly superior over rest of the treatments. This is because proper NPK nutrition is important for improving the grain weight through improved photosynthetic activities and better assimilates translocation [35].

Minimum number of pods plant^{-1} (38.00) and weight of pods plant^{-1} (11.50 g) were found with the treatment where 25% less N applied. Interaction effect of residue levels and nutrient doses on pods plant^{-1} and seed index were found to be significant (Table 2). Maximum number of pods plant^{-1} and seed index were obtained under higher level of residue retention with RDF which was significantly higher as compare to lower levels of nutrients and residue retention treatment.

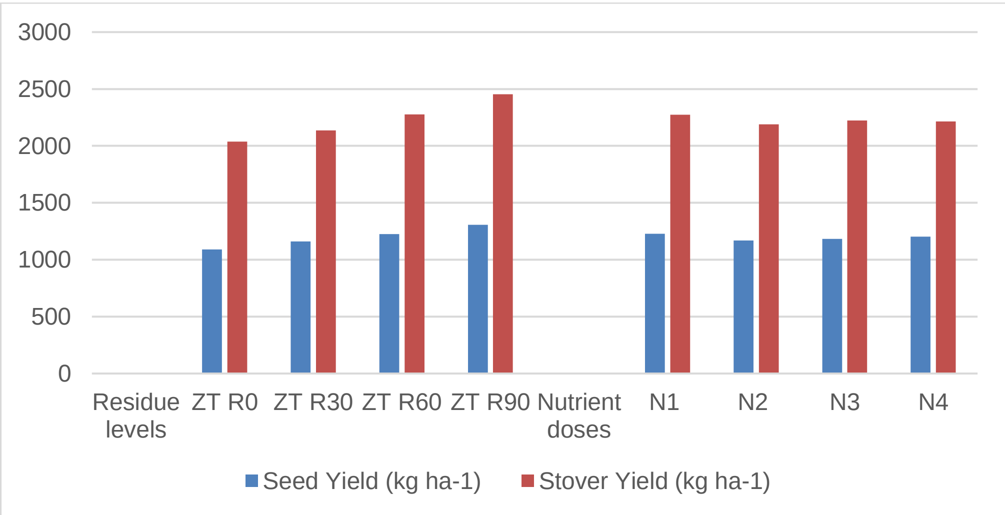
3.3 Yield and Profitability

The different levels of crop residue retention treatments and nutrient doses had significant effect on yield of soybean except harvest index (HI) (Table 3). Significantly maximum seed yield (1306 kg ha $^{-1}$), straw yield (2452 kg ha^{-1}) and biological yield (3759 kg ha^{-1}) were recorded maximum with 90% crop residue retention. This may be because of crop residues viewed as a valuable renewable resource that has to be properly managed in order to preserve soil quality and increase crop output [36].

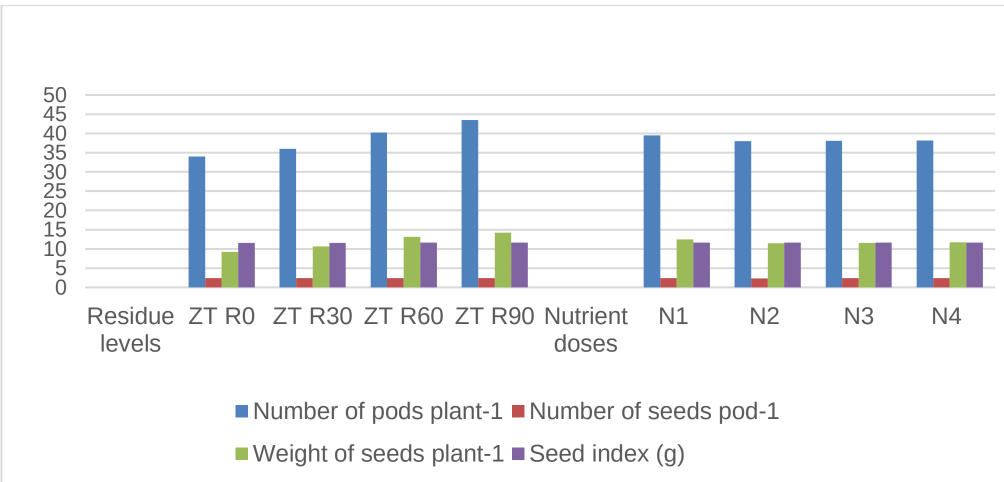
Seed yield was recorded with the overall improvement of crop growth reflected into better source-sink relationship which in turn enhanced the yield attribute. Effect of residue retention treatments on HI ranged between 34.75-35.98 and found no significant effect. Different nutrient doses on seed, straw and biological yield were found significant effects. Maximum yields were found under (1226 kg ha^{-1}), recorded with the treatment receiving under 100% RDF which was at par with N_4 -75% K_2O+100% N and P_2O_5 and maximum straw (2274 kg ha^{-1}) and biological yield (3501 kg ha^{-1}) obtain with 100% RDF which were at par with N_4-75% K_2O+100% N and P_2O_5 (2214 and 3417 kg ha $^{-1}$ respectively) and N_3-75% P_2O_5+100% N and K_2O (2223 and 3407 kg ha^{-1} respectively). Higher N level might have enhanced the manufacturing and storage of photosynthates which attributed to higher yield parameters. This may be because of improvements in soil fertility in CA reductions in pests/diseases as a consequence of including legumes have been observed to contribute to yield gains [37-40].

Minimum seed (1167 kg ha^{-1}), straw (2190 kg ha^{-1}) and biological yield (3358 kg ha^{-1}) resulted with N_2 (75% N+100% P_2O_5 and K_2O). Harvest index (HI) of soybean found non-significant with residue level and nutrient doses range between (34.77-35.20%). There was discernible impact on yield from the interaction between residue levels and nutrient doses except on HI (Table 3). Maximum yields found under higher residue retention with RDF which was significantly higher as compared to lower levels of nutrients and residue retention treatments.

Economic analysis revealed that significantly highest net returns were obtained in 90% crop residue and closely followed by 60% crop residue retention. This might be owing to higher seed and stover yield under 90% crop residue retention treatments. Treatment involving the lowest residue retention gave the lowest net returns. In case of different nutrient doses highest net return (₹49723) were recorded with the treatment with 100% RDF followed by 25% less N applied (₹49269). Lowest net returns were obtained with 25% less phosphorus from RDF treatment. There are several reports showing saving in nutrients, labour and production cost and higher net economics return in CA compared with conventional tillage (CT) system this is because of reduction in cost of production, reduction in incidence of weeds, water and nutrients savings, increased yield, Crop diversification, resource improvement and environmental benefits [41].



Graph 1. Effect of Residue levels and nutrient doses on yield of soybean crop



Graph 2. Effect of Residue levels and nutrient doses on yield parameters of soybean crop

Table 1. Effect of Residue levels and nutrient doses on growth parameters and physiological indices in soybean crop (pooled mean data of 2 years)

Treatment	Growth parameters at physiological maturity			Crop growth rate (g g^{-1} day^{-1})		Relative growth rate (Mg g^{-1} day^{-1})		Absolute growth rate (g day^{-1})	
	Plant height (cm)	DMA (g $plant^{-1}$)	Leaf area index (cm^2)	30-60 DAS	60-90 DAS	30-60 DAS	60-90 DAS	30-60 DAS	60-90 DAS
A. Residue levels									
ZT R_0	45.93	16.04	2.35	2.86	11.26	0.006	0.013	0.079	0.310
ZT R_{30}	52.27	17.15	2.41	3.74	11.56	0.008	0.012	0.103	0.317
ZT R_{60}	56.07	19.01	3.11	4.83	12.83	0.009	0.012	0.133	0.353
ZT R_{90}	59.14	23.11	3.26	6.55	16.00	0.011	0.012	0.180	0.440
SE(m)	0.24	0.1487	0.0126	0.0556	0.1812	0.0001	0.0001	0.0015	0.0050
CD (P=0.05)	0.69	0.430	0.036	0.161	0.523	0.0004	0.0004	0.004	0.014
B. Nutrient doses									
N_1 (100% RDF)	54.99	19.25	2.928	4.76	13.19	0.009	0.012	0.131	0.363
N_2 (75% N+100% P_2O_5 and K_2O)	51.59	18.56	2.773	4.29	12.73	0.008	0.012	0.118	0.350
N_3 (75% P_2O_5+100% N and K_2O)	52.88	18.63	2.835	4.45	12.73	0.009	0.012	0.122	0.350
N_4 (75% K_2O+100% N and P_2O_5)	53.94	18.88	2.895	4.47	12.97	0.009	0.012	0.123	0.357
SE(m)	0.24	0.1487	0.0126	0.0556	0.1812	0.0001	0.0001	0.0015	0.0050
CD (P=0.05)	0.69	0.430	0.036	0.161	NS	0.0004	NS	0.004	NS
Interaction									
SE(m)	0.48	0.2974	0.0251	0.1113	0.3624	0.0003	0.0003	0.0031	0.0100
CD (P=0.05)	NS	NS	0.073	0.321	NS	NS	NS	0.009	NS
Grand mean.	53.35	18.83	2.86	4.49	12.91	0.009	0.012	0.124	0.355

Table 2. Effect of Residue levels and nutrient doses on yield parameters of wheat crop

Treatment	Number of pods plant^{-1}	Number of seeds pod^{-1}	Weight of seeds plant^{-1}	Seed index (g)
A. Residue levels				
ZT R_0	34.04	2.37	9.21	11.53
ZT R_{30}	36.01	2.38	10.65	11.59
ZT R_{60}	40.22	2.39	13.13	11.66
ZT R_{90}	43.49	2.39	14.23	11.67
SE(m)	0.1396	0.0128	0.0899	0.0586
CD (P=0.05)	0.403	NS	0.260	NS
B. Nutrient doses				
N_1 (100% RDF)	39.51	2.39	12.46	11.63
N_2 (75%N+100%P_2O_5 and K_2O)	38.00	2.36	11.50	11.61
N_3 (75% P_2O_5+100%N and K_2O)	38.11	2.39	11.58	11.60
N_4 (75% K_2O+100%N and P_2O_5)	38.14	2.39	11.69	11.61
SE(m)	0.1396	0.0128	0.0899	0.0586
CD (P=0.05)	0.403	NS	0.260	NS
Interaction				
SE(m)	0.2792	0.0256	0.1798	0.1172
CD (P=0.05)	0.806	NS	0.519	NS
Grand mean	38.44	2.38	11.81	11.61

Table 3. Effect of Residue levels and nutrient doses on yield of soybean crop

Treatment	Seed Yield (kg ha^{-1})	Stover Yield (kg ha^{-1})	Net profit (₹ ha^{-1})	B: C	Harvest Index (%)
A. Residue levels					
ZT R_0	1088.90	2038.90	44393	2.78	34.81
ZT R_{30}	1161.81	2135.04	47680	2.91	35.24
ZT R_{60}	1224.23	2276.25	50244	3.01	34.98
ZT R_{90}	1306.35	2452.73	53841	3.15	34.75
SE(m)	5.6068	9.6200	340.701	0.0138	0.1333
CD (P=0.05)	16.193	27.785	984.017	0.040	NS
B. Nutrient doses					
N_1 (100% RDF)	1226.69	2274.69	49723	2.89	35.03
N_2 (75% N+100% P_2O_5 and K_2O)	1167.98	2190.06	49263	3.13	34.78
N_3 (75% P_2O_5+100% N and K_2O)	1183.75	2223.25	48327	2.93	34.77
N_4 (75% K_2O+100% N and P_2O_5)	1202.88	2214.92	48845	2.90	35.20
SE(m)	5.6068	9.6200	340.701	0.0138	0.1333
CD (P=0.05)	16.193	27.785	984.017	0.040	NS
Interaction					
SE(m)	11.2135	19.2401	681.403	0.0275	0.2665
CD (P=0.05)	32.387	55.569	1968.03	0.079	NS
Grand mean	1195.32	2225.73	49040	2.96	34.94

Similarly, as net returns higher B:C (3.15) with 90% crop residue retention closely followed by 60% and 30% crop residue. Among different nutrient doses highest (3.13) B:C were recorded with N_2 (75% N+100% P_2O_5 and K_2O) followed by N_3 (75% P_2O_5+100% N and K_2O) and N_4 (75% K_2O+100% N and P_2O_5) and the lowest B:C ratio comes under 100% RDF. Similar results were obtained by [42], according to him the maximum net returns and B:C ratio were recorded in the SW system with zero tillage. Interaction effect between crop residue retention and nutrient doses had significant effect on net profit and B:C ratio. Thus, it concluded that 90% residue retention treatments and 100% RDF had significantly higher net returns followed by 90% and N_4 treatment combinations.

4. CONCLUSION

Based on one year experimentation, it is concluded that adoption of conservation agricultural practices along with higher level of crop residue retention (90%) and reduced rate of fertilizer application (-25%) can be obtained to get the higher production and productivity under soybean - wheat cropping system.

ACKNOWLEDGEMENT

I am very much grateful to Director of ICAR-Indian Institute of Soil Science, Bhopal and Head, Division of Soil Chemistry and Fertility for allowing me to work under the programme CRP on CA. I would like to thank the staffs of IISS Bhopal for their support.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Paravar A, Piri R, Balouchi H, Ma Y. Microbial seed coating: an attractive tool for sustainable agriculture. Biotechnology Reports. 2023;00781.
2. Vishwakarma AK, Meena BP, Das HP, Jha P, Biswas AK, Bharati K, et al. Impact of sequential herbicides application on crop productivity, weed and nutrient dynamics in soybean under conservation agriculture in Vertisols of Central India. PloS one. 2023;18(1):e0279434.
3. FAO. What is Conservation Agriculture in: Conservation Agriculture website of FAO; 2008.
Available:http://www.fao.org/ag/ca/1a.html.
4. Jat RA, Wani SP, Sahrwat KL. Conservation Agriculture in the semi–arid tropics: prospects and problems. Advance Agronomy. 2012;117:191–273.
5. Rani K, Datta A, Jat HS, Choudhary M, Sharma PC, Jat ML. Assessing the availability of potassium and its quantity-intensity relations under long term conservation agriculture based cereal systems in North-West India. Soil and Tillage Research. 2023;228:105644.
6. Kumar N, Kamboj BR, Thakral SK, Singh M. Growth Parameters and Productivity of Wheat as Influenced by Crop Establishment Methods and Different Seed Rate. International Journal of Pure and Applied Bioscience. 2017;5(4):2134-2140.
7. Dutta AA, Patra K, Hazra K, Nath CP, Kumar N, Rakshit A. A state-of-the-art review in crop residue burning in India: Previous knowledge, present circumstances and future strategies. Environmental Challenges. 2022;100581.
8. Choudhary M, Rana KS, Rana DS, Bana RS. Tillage and crop residue effects in rainfed pearl millet in conjunction with sulphur fertilization under pearl millet–Indian mustard cropping system. Indian Journal of Agronomy. 2016;61(1):15–19.
9. Choudhary RL, Behera UK, Singh HV, Meena MD, Dotaniya ML. Jat RS. Energetics and nitrogen-use efficiency of kharif maize in conservation agriculture-based maize (*Zeamays*)–wheat (*Triticum aestivum*) sequence. International Journal of Chemical Studies. 2020;8(2):1252-1258.
10. Alam MK, Salahin N, Islam S, Begum RA, Hasanuzzaman M, Islam MS, Rahman MM. Patterns of change in soil organic matter, physical properties and crop productivity under tillage practices and cropping systems in Bangladesh. Journal of Agriculture Science. 2017;155:216–238.
11. Choudhary M, Datta A, Jat HS, Yadav AK, Gathala MK, Sapkota TB, Das AK, Sharma PC, Jat ML, Singh R, Ladha JK. Changes in soil biology under conservation agriculture based sustainable intensification of cereal systems in Indo-Gangetic Plains. Geoderma. 2018;313: 193-204.
12. Allen DE, Singh BP, Dalal RC. Soil health indicators under climate change: a review

of current knowledge. Soil health and climate change. 2011;25-45.

13. Bhan S, Behra UK. Conservation Agriculture in India - Problems, Prospects and Policy Issues. International Soil and Water Conservation Research. 2014;2(4): 1-12.
14. Kumawat A, Vishwakarma AK, Wanjari RH, Sharma NK, Yadav D, Kumar D, Biswas AK. Impact of levels of residue retention on soil properties under conservation agriculture in Vertisols of central India. Archives of Agronomy and Soil Science. 2022;68(3):368-382.
15. Kumar V, Naresh RK, Kumar S, Kumar S, Kumar S, Singh SP, Mahajan NC. Tillage, crop residue and nitrogen levels on dynamics of soil labile organic carbon fractions, productivity and grain quality of wheat crop in Typic Ustochrept soil. Journal of Pharmacognosy and Phytochemistry. 2018;7:598–609.
16. Ramteke PR, Patle PN, Navnage NP. Efficient management of crop residue for optimum soil physical properties and their manipulations. Journal of Pharmacognosy and Phytochemistry. 2018;7:2919–2922.
17. Blanco H Canqui, Lal R. Crop residue removal impacts on soil productivity and environmental quality. Critical Reviews in Plant Sciences. 2009;28:139–16.
18. Xu Y, Nie L, Buresh RJ, Huang J, Cui K, Xu B, Gong W, Peng S. Agronomic performance of late-season rice under different tillage, straw and nitrogen management. Field Crops Research. 2010; 115:79–84.
19. Mtyobile M, Muzangwa L, Mnkeni PNS. Tillage and crop rotation effects on soil carbon and selected soil physical properties in a Haplic Cambisol in Eastern Cape, South Africa. Soil and Water Research. 2019;15(1):47-54.
20. Das TK, Saharawat YS, Bhattacharyya R, Sudhishri S, Bandyopadhyay KK, Sharma AR, Jat ML. Conservation agriculture effects on crop and water productivity, profitability and soil organic carbon accumulation under a maize-wheat cropping system in the North-western Indo-Gangetic Plains. Field Crops Research. 2018;215:222–231.
21. Angus JF, Grace PR. Nitrogen balance in Australia and nitrogen use efficiency on Australian farms. Soil Research. 2017;55: 435-450.
22. Yadav D, Vishwakarma AK, Sharma NK. Sustaining the properties of black soil in Central India through crop residue management in a conservation-agriculture-based soybean–wheat system. Land Degradation and Development. 2021;32: 2906–2921.
23. Dong S, Ma Z, Wang L, Yan C, Liu L, Gong Z, Cui G. Decomposition and nutrient release characteristics of incorporated soybean and maize straw in Northeast China. Ekoloji Dergisi. 2019;28: 2119–2129.
24. FAO. Food and Agriculture Organization of the United Nations; 2012. Available:http://www.fao.org/ag/ca/6c.html
25. Jackson ML. Soil chemical analysis, New Delhi: Asian Publication House. 1958;173–195. Available:https://doi.org/10.1002/jpln.19590850311
26. Chapman HD, Pratt PF. Methods of analysis for soils, plants and waters. Division of Agric. Sci., Berkeley, Univ. California, USA. 1961;150–152.
27. Ronanki S, Behera UK. Effect of Tillage, Crop Residues and Nitrogen Management Practices on Growth Performance and Soil Microbial Parameters in Wheat. International Journal of Current Microbiology and Applied Science. 2018; 7(01):845-858.
28. Fazily T, Thakral SK, Dhaka AK. Effect of Integrated Nutrient Management on Growth, Yield Attributes and Yield of Wheat. International Journal of Advances in Agricultural Science and Technology. 2021;8(1):106-118.
29. Patel GG, Sadhu AC, Patel HK, Shan SN, Lakum YC. Effect of organic and inorganic fertilizers in comparison with humic acid on growth and yield of wheat (*Triticum aestivum* L.). International Journal of Agriculture Sciences. 2018;10:6524-6527.
30. Séguy L, Bouzinac S, Husson S. Direct-seeded Tropical Soil Systems with Permanent Soil Cover: Learning from Brazilian Experience. In: Biological Approaches to Sustainable Soil Systems (Uphoff, N. et al., Eds.), CRC Press, Taylor & Francis Group. 2006;323-342.
31. Alam MS. Growth and yield potentials of wheat as affected by management practices. African Journal of Agricultural Research. 2013;8(47):6068-6072.
32. Singh Y, Sidhu HS. Management of cereal crop residues for sustainable rice-wheat

production system in the Indo-gangetic plains of India. Proc. Indian Natl. Sci. Acad. 2014;80:95–114.

33. De Aquino GS, Medina CDC. Productivity and biometric and physiological indices of sugarcane grown under different amounts of straw. Pesqui. Agropecu. Brasil. 2014;49:173–180.
34. Aquino GSD, Medina CDC, Porteira AL Junior, Santos LO, Cunha ACB, Kussaba DAO, Santos JHD Júnior, Almeida LF, Santiago AD. Root system and productivity of sugarcane ratoon associated to different quantities of straw. Pesquisa Agropecuária Brasileira. 2015;50*:*1150-1159.
35. Mengel K, Barker AV, Pilbeam DJ. Handbook of plant nutrition. CRC: Taylor & Francis Boca Raton, FL*,* USA. 2007;91-120.
36. Meena BP, Biswas AK, Singh M, Das H, Chaudhary RS, Singh AB, Shirale AO, Patra AK. Energy budgeting and carbon footprint in long-term integrated nutrient management modules in a cereal-legume (*Zeamays–Cicer arietinum*) cropping system. Journal of Cleaner Production. 2021;314:127900.
37. Rusinamhodzi L, Corbeels M, Van Wijk MT, Rufino MC, Nyamangara J, Giller KE. A meta-analysis of long-term effects of conservation agriculture on maize grain yield under rain-fed conditions. Agronomy Sustainable Development. 2011; 31: 657.
38. Ngwira AR, Aune JB, Mkwinda S. On farm evaluation of yield and economic benefit of short-term maize legume intercropping systems under conservation agriculture in Malawi. Field Crops Research*.* 2012; 132*:*149–157.
39. Nyagumbo I, Mkuhlani S, Pisa C, Kamalongo D. Dias and M. Mekuria, M. Maize yield effects of conservation agriculture-based maize– D. legume cropping systems in contrasting agro-ecologies of Malawi and Mozambique. Nutrient Cycling in Agroecosystems. 2016; 105:275-290.
40. Quemada M, Daughtry CST. Spectral indices to improve crop residue cover estimation under varying moisture conditions. Remote Sens. 2016;8:article # 660.
41. Bhan S, Behera UK. Conservation agriculture in India – Problems, prospects and policy issues. International Soil and Water Conservation Research. 2014;2(4): 1-12.
42. Karunakaran V, Behera UK. Tillage and residue management for improving productivity and resource-use efficiency in Soybean (*Glycine max*)–wheat (*Triticum aestivum*) cropping system. Experimental Agriculture*.* 2016;52(4):617–634.

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