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Impact of Crop Diversification on Soil Physical properties and Maize Grain Equivalent Yield in a Typic Hapludalf of Himachal Pradesh

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ABSTRACT: The present experiment was started in the year 2019 in the month of October and continued till November 2021 covering two seasons of *rabi* and *kharif*. The field experiment was conducted with ten intensive crop sequences in Randomized block design (RBD) with three replications at the experimental farm of Agronomy, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur under the network of All India Coordinated Research Project on integrated farming system since 2018. The experiment comprised of ten treatments *viz*., maize-wheat, maize-wheat + gobhi sarson, dhaincha-cabbage-french bean, sunhemp-vegetable pea-french bean, maize + soybean-chickpea + linseed, rice-wheat + gram, hybrid sorghum + hybrid bajra-oats + sarson (hybrid), hybrid sorghum + hybrid bajra-ryegrass + berseem, babycorn-broccoli-french bean and maize-turnip-tomato. The soil of the experimental area falls in the order of Alfisols with Paleudalf as the great group as per the Udic Moisture Regime. During *rabi* and *kharif* season the crop varieties were applied with the recommended dose of N, P_2O_5 and K_2O (kg ha^{-1}). Among physical soil properties, the highest bulk density value was recorded in the hybrid sorghum + hybrid bajra-oats + sarson and sunhemp-vegetable pea-french bean, whereas the properties *viz*., porosity, water holding capacity and water stable aggregates recorded the highest values in the dhaincha-cabbage-french bean. The diversification of conventional maize-wheat cropping systems with legumes improved the physical properties of soil. Maize-turnip-tomato has obtained highest maize grain equivalent yield followed by babycorn-broccoli-french bean and the lowest values was observed in maize-wheat.

Keywords: Fodders, green manures, legumes, physical properties, yield.

INTRODUCTION

Indian agriculture is the source of income for majority of farmers and it plays an indispensable role in shaping the financial stability of the farmers as well as the overall prosperity of the country. In the last few decades, intensive cultivation practices involving the use of heavy machinery, extensive soil manipulation, and agrochemicals were indeed commonly employed in agriculture to increase productivity and ensure food safety. The outcomes were breath taking but, their long term sequel proved negative impact on ecological balance by limiting the productivity of land which affects the sustainability of crop production.

Crop diversification has emerged as a promising strategy to address the challenges faced by agricultural systems The agriculture predominantly relies on maize-wheat cropping system, which serves as a staple food for both humans and livestock. However, cereal-cereal cropping system can affect the physical properties of soil including bulk density (BD), porosity, water holding capacity (WHC) and water stable aggregates (WSA) which play a vital role in determining soil health and fertility. In agroecosystems, functional crop mixtures comprise a combination of any of the four main categories: C_3 plants (such as wheat), C_4 grasses (such as maize), legumes that fix nitrogen from the atmosphere, and non-leguminous plants (Vukicevich *et al.*, 2016). This is because plants with different growth habits tend to thrive together in a community, benefiting from their diverse needs in terms of timing, spatial niche, and soil nutrient availability (Roscher *et al.*, 2013).

The growing of legumes such as peas, beans, have a unique ability to fix nitrogen from the atmosphere through a symbiotic relationship with nitrogen-fixing bacteria in their root nodules. Legumes, with their deep-rooting systems, can improve soil structure by enhancing aggregation and reducing soil compaction. The extensive root systems of legumes help create channels and pores in the soil, allowing for better air and water movement, and promoting drainage. In addition, green manuring increases soil organic matter, available nitrogen and reduces N losses through leaching and soil erosion. The benefits of green manure in cropping system are dynamic as they improve physical properties of soil (Javanmard, 2015; Naidu *et al.*, 2022). The traditional crop rotation systems, involves different crops such as cereals, legumes, and oilseeds to enhance soil health and break pest cycles. Fodder-based crop rotation takes this concept further by incorporating specific fodder crops into the rotation cycle. These crops, which may include grasses, legumes, and forage crops, offer numerous benefits to both the soil and the livestock. This study aims to assess the effects of crop diversification on soil physical properties and maize grain equivalent yield (MGEY) in a Typic Hapludalf of Himachal Pradesh. By elucidating the diversification of cereal-cereal based cropping system will help us to understand the potential benefits on soil physical properties and crop productivity.

MATERIAL AND METHOD

A two-year field experiment was from the *rabi* 2019 to *kharif* 2021 at the Experimental Farm of the Department of Agronomy, Forages and Grassland Management, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya, Palampur, as part of the All India Coordinated Research Project on integrated farming systems. The soil in the area falls under the “Typic Hapludalf” and “Alfisol” taxonomic groups, exhibiting a silty clay loam texture and acidic pH.

A. Soil sampling

The soil sample (0-15 cm) of the experimental field from each plot was collected after the completion of each cropping cycle in 2020 and 2021. The soil samples were examined for determining different soil physical properties by following certain standard procedures given in Table 1.

Table 1: Standard procedures for the analysis of soil samples.

Parameter	Method employed	Reference
Bulk density	Core sampler	Singh (1980)
Water holding capacity	Keen’s moisture box	Piper (1950)
Porosity	Empirical	Gupta and Dhakshinamoorthy (1980)
Water stable aggregates	Wet sieving	Yoder (1936)

The ten combinations of cropping systems were examined during *kharif, rabi* and summer seasons i.e maize-wheat, maize-wheat + gobhi sarson, dhaincha-cabbage-french bean, sunhemp-vegetable pea- french bean, maize + soybean-chickpea + linseed, rice-wheat + gram, hybrid sorghum + hybrid bajra-oats + sarson (hybrid), hybrid sorghum + hybrid bajra-ryegrass + berseem, babycorn-broccoli-french bean and maize-turnip-tomato, which were replicated thrice with randomized block design (RBD). Yields were recorded at the end of each season and maize grain equivalent yield (MGEY) was computed at the end of each cropping cycle and further the system yield was obtained by adding MGEY of component crops.

B. Statistical analysis

The data collected were statistically analysed using the randomized block design technique for analysis of variance in order to interpret the findings using accepted practices as outlined by Gomez and Gomez (1984).

RESULT AND DISCUSSION

A. Effect of crop diversification on bulk density (Mg m^{-3}) of soil

The data pertaining to the effect of cropping systems on bulk density of soil after the harvest of each cropping cycle (2019-20 and 2020-21) have been presented in table 2. The bulk density of soil after the completion of first cropping cycle (2019-20), ranged from 1.22 to 1.37 Mg m^{-3}. The higher value of bulk density (1.37 Mg m^{-3}) in hybrid sorghum + bajra-oats + sarson might be due to low organic matter content in the soil under this system. The cropping sequences including legumes and green manure crops *i.e* dhaincha-cabbage-french bean (1.22), sunhemp-vegetable pea- french bean (1.23 Mg m^{-3}), maize + soybean-chickpea + linseed (1.28 Mg m^{-3}) and rice-wheat + gram (1.32 Mg m^{-3}) reported lower values of bulk density as compared to cereal-cereal in rotation which might be due to the higher amount of added biomass from leguminous crops made soil loose, porous, and less squeezed (Rahman *et al.*, 2007). During second year after the harvest of crops in 2020-21, soil reported lowest bulk density in dhaincha-cabbage-french bean (1.21 Mg m^{-3}) which was statistically alike with sunhemp-vegetable pea-french bean (1.23 Mg m^{-3}). The site was under rice based cropping system before 2018-19 cropping cycle. Crop diversity is one of the most important managements that can influence BD (Rorick and Kladivko 2017). The reduction in bulk density in plots where green manures were grown and incorporated was likely related to greater aggregate stability and greater residue accumulation compared to cereal based cropping systems (Kazula *et al.*, 2017). Differences in weather conditions between 2020 and 2021 (Fig. 2) may result in differences in the response of BD to the cropping systems in these two years. Similar results were reported by Feng *et al.* (2011); Shrestha *et al.* (2013); Feng *et al.* (2020).

Table 2: Effect of crop diversification on bulk density (Mg m^{-3}) and porosity (%) of soil.

Cropping sequence	Bulk density		Porosity	
	2019-20	2020-21	2019-20	2020-21
Maize-Wheat	1.33	1.31	47.1	49.1
Maize-Gobhisarson + Toria	1.30	1.33	46.1	47.1
Dhaincha- Cabbage-French bean	1.22	1.21	51.2	51.6
Sunhemp-Vegetable pea-French bean	1.24	1.23	49.6	50.7
Maize + Soyabean-Chickpea + Linseed	1.28	1.29	47.2	47.7
Rice-Wheat + Gram	1.32	1.32	49.0	50.9
Hybrid Sorgum + Hybrid Bajra-Oats + Sarson	1.37	1.35	44.1	46.2
Hybrid Sorghum + Hybrid Bajra-Ryegrass + Barseem	1.36	1.35	45.8	47.1
Babycorn-Broccoli-French bean	1.29	1.28	48.7	50.8
Maize-Turnip-Tomato	1.27	1.26	49.5	49.8
CD (P=0.05)	0.05	0.04	2.4	2.3

B. Effect of crop diversification on porosity (%) of soil

The data pertaining to the effect of cropping systems on porosity of soil after harvest of each cropping cycle (2019-20 and 2020-21) have been presented in table 2. The porosity of soil after the completion of first cropping cycle (2019-20), ranged from 44.1 to 51.2 %. There was an increase of 16 and 12 % in dhaincha-cabbage-french bean and sunhemp-vegetable pea-french bean over the lowest value in hybrid sorghum + bajra-oats + sarson. The cropping systems involving cereals in maize-turnip-tomato, rice-wheat + gram, maize + soybean-chickpea + linseed and maize-wheat was statistically at par with each other. Similarly, during second year after the harvest of crops in 2020-21, dhaincha-cabbage-french bean reported highest porosity of 51.60 % which was statistically alike with all cropping systems except hybrid soghum + hybrid bajra-ryegrass + barseem and hybrids sorghum + bajra-oats + sarson. Earthworms are attracted to nitrogen rich legume wastes. The treatments including legumes and green manure crops i.e dhaincha- cabbage-french bean, sunhemp-vegetable pea-french bean, maize + soybean-chickpea + linseed and rice-wheat + gram observed highest porosity as compared to cereal-cereal in rotation which might be attributed to higher organic carbon in surface soils (Dhaliwal *et al.*, 2019). The greater extent of added biomass from leguminous crops and green manures made soil porous, increase macro pores, promote aggregate stability, and increase in microbial population and activity which makes the soil more voluminous (Bandyopadhyay *et al.*, 2011). Root channels and earthworm tunnels promote soil porosity, allowing air and water to percolate deep into the soil (Ananda *et al*., 2022). The addition of FYM promotes total porosity of the soil as the microbial decomposition products of organic matter such as polysaccharides and bacterial gums are known to act as soil particle binding agents. These binding agents may decrease the bulk density of the soil by improving soil aggregation and hence increase the porosity.

C. Effect of crop diversification on water holding capacity (%) of soil

Measurement of water holding capacity of soils is helpful for evaluating the pore volume of soil related to movement of water, nutrient and salts and the capacity of soils to hold water. The data pertaining to the effect of cropping systems on water holding capacity of soil after harvest of each cropping cycle (2019-20 and 2020-21) have been presented in Table 3. The porosity of soil after the completion of first cropping cycle (2019-20), ranged from 41.8 % in hybrid sorghum + hybrid bajra-ryegrass + barseem to 49.7 % in dhaincha-cabbage-french bean. The treatments including legumes and green manure crops i.e dhaincha- cabbage-french bean (49.7 %), sunhemp-vegetable pea-french bean (46.7 %), maize + soybean-chickpea + linseed (45.4 %) and rice-wheat + gram (46.7 %) observed the highest porosity as compared to cereal-cereal in rotation which might be attributed to higher organic carbon in surface soils (Dhaliwal *et al.*, 2019). The lowest water holding capacity in hybrid sorghum + hybrid bajra-ryegrass + barseem was found to be statistically at par with hybrid sorghum + hybrid bajra-oats + sarson. Similarly, during second year after the harvest of crops in 2020-21, dhaincha-cabbage-french bean reported highest porosity of 48.6 % and maize-gobhisarson + toria registered lowest value of 44.5 %. Root channels and earthworm tunnels promote soil porosity, allowing air and water to percolate deep into the soil (Ananda *et al.*, 2022). Cereal-legume cropping system stored amount of organic matter in to soil, by decomposition of organic matter, polysaccharides, fulvic acid, and humic acid are produced which bind soil particles, improve water stable aggregates, and consequently increase WHC of soil (Sihag *et al.*, 2023).

Table 3: Effect of crop diversification on water holding capacity (%) and water stable aggregates (%) of soil.

Cropping sequence	Water holding capacity		Water stable aggregates	
	2019-20	2020-21	2019-20	2020-21
Maize-Wheat	44.6	47.3	88.6	91.6
Maize-Gobhisarson + Toria	43.7	44.5	83.5	87.5
Dhaincha- Cabbage-French bean	49.7	48.7	94.5	97.5
Sunhemp-Vegetable pea-French bean	46.7	48.1	92.7	96.3
Maize + Soyabean-Chickpea + Linseed	45.4	45.2	86.3	89.7
Rice-Wheat + Gram	46.8	47.6	91.0	95.2
Hybrid Sorgum + Hybrid Bajra-Oats + Sarson	42.3	44.5	81.2	84.6
Hybrid Sorghum + Hybrid Bajra-Ryegrass + Barseem	41.8	44.8	83.1	86.2
Babycorn-Broccoli-French bean	45.2	48.2	88.4	92.4
Maize-Turnip-Tomato	46.6	48.3	90.6	94.9
CD (P=0.05)	1.6	1.2	3.1	2.6

D. Effect of crop diversification on water stable aggregates (%) of soil

The data pertaining to the effect of cropping systems on water stable aggregates of soil after harvest of each cropping cycle (2019-20 and 2020-21) have been presented in table 3. The water stable aggregates of soil after the completion of first cropping cycle (2019-20) ranged from 94.5 to 81.2 %. The higher water stable aggregates in dhaincha-cabbage-french bean was statistically at par with sunhemp-vegetable pea-french bean. The intercropping of legumes in maize + soybean-chickpea + linseed and rice-wheat + gram reported higher values of bulk density as compared to cereal-cereal in rotation. There was increase in water stable aggregates in comparison to that of initial value in all the crop sequences. The highest increase in waster stable aggregates under dhaincha- cabbage-french bean was 16 % than hybrid sorghum +hybrid bajra-oats + sarson. Similarly, after the harvest of crops in 2020-21, water stable aggregates ranged from 97.5 % in dhaincha-cabbage-french bean to 84.6 % in hybrid sorghum + hybrid bajra-oats + sarson. The cropping system comprising of legumes in sunhemp-vegetable pea-french bean, maize + soybean-chickpea + linseed registered 96.3 and 95.2 % water stable aggregates. The lowest value in hybrid sorghum + hybrid bajra-oats + sarson was also found to be statistically comparable with hybrid sorghum + hybrid bajra-ryegrass + barseem. The stabilization of aggregates with the application of FYM and inorganic fertilizers to each crop, improves the physical condition of soil, may be caused by an increase in organic carbon content (Tripathi *et al.*, 2014; Hazra *et al.*, 2019).

E. Effect of crop diversification on maize grain equivalent yield (q ha^{-1})

To facilitate the comparison among different crop sequences tested, MGEY obtained from these were converted into their maize equivalents (Table 4). Maize-turnip-tomato recorded 337 q ha^{-1} MGEY, being significantly higher among all crop systems in 2019-20. Higher yield and better price of maize, turnip and tomato played an important role in improving MGEY. The next cropping system in the order was babycorn-broccoli-french bean with MGEY of 268 q ha^{-1} which was found to be statistically at par with hybrid sorghum + hybrid bajra-oats + sarson with MGEY of 243.4 q ha^{-1}. There was 3.86 times increase in MGEY in maize-turnip-tomato over maize-wheat.

Table 4: Effect of crop diversification on Maize grain equivalent yield (MGEY).

Cropping sequence	Maize grain equivalent yield	
	2019-20	2020-21
Maize-Wheat	87.3	76.2
Maize-Gobhisarson + Toria	87.4	97.7
Dhaincha- Cabbage-French bean	197.7	189.9
Sunhemp-Vegetable pea-French bean	187.4	143.3
Maize + Soyabean-Chickpea + Linseed	110.0	104.5
Rice-Wheat + Gram	101.3	80.3
Hybrid Sorgum + Hybrid Bajra-Oats + Sarson	243.4	212.4
Hybrid Sorghum + Hybrid Bajra-Ryegrass + Barseem	232.7	207.2
Babycorn-Broccoli-French bean	268.0	230.1
Maize-Turnip-Tomato	337.0	289.7
CD (P=0.05)	33.3	24.3

The lowest MGEY was registered with the maize-wheat (87.3 q ha^{-1}) cropping system which was statistically alike with maize-gobhisarson + toria (87.4 q ha^{-1}) maize + soybean-chickpea + linseed (110 q ha^{-1}) and rice-wheat + gram (101.3 q ha^{-1}). Similarly, during the 2020-21 system productivity was significantly higher in the rotation including cereal and vegetables i.e., maize-turnip-tomato to the extent of 34.5 % more than dhaincha- cabbage-french bean. The next best cropping system was baby corn-broccoli-french bean with MGEY of 230.1 q ha^{-1} which was statistically alike with hybrid sorghum + hybrid bajra-oats + sarson

(212.4 q ha^{-1}), and hybrid sorghum + hybrid bajra-ryegrass + barseem (207.2 q ha^{-1}). The cereal-cereal crop rotation in maize-wheat system recorded 3.80 times increase in MGEY under the sequence maize-turnip-tomato over maize-wheat. The systems where legumes were either intercropped with cereals or grown in rotation with cereals in maize + soybean-chickpea + linseed (104.5 q ha^{-1}) and rice-wheat + gram (80.3 q ha^{-1}) also recorded better MGEY as compared to the conventional maize-wheat (76.2 q ha^{-1}) cropping system. The increase in MGEY was mainly due to additional yield advantage of intercropping and vegetable crops in rotation as well as higher market price of grain legumes and vegetable crops as compared to that of maize-wheat. The system productivity was higher through the inclusion of green manure crops and vegetables owing to high nitrogen fixation and its availability (Singh *et al.*, 2021). Maize-wheat also registered lower MGEY comparable to maize-gobhisarson + toria, maize + soybean-chickpea + linseed and rice-wheat + gram in both years. Despite the higher economic yield of maize-wheat, it could not give higher MGEY due to lower market price as compared to other cropping systems. Ananda *at al.* (2022) also reported that inclusion of different crops in rotation with legumes boost the yields of succeeding crops by improving physical, chemical and biological properties of soil. Similar results were reported by Rana *et al.* (2011); Lal (2017); Bhargavi *et al.* (2019).

CONCLUSIONS

From the results it is concluded that cropping systems incorporating legumes and green manure crops had positive impacts on soil bulk density, porosity, water holding capacity, and water stable aggregates. These systems exhibited lower bulk density and higher porosity, which can improve soil structure and enhance water movement and nutrient availability. Additionally, the inclusion of legumes and green manure crops promoted the formation of water stable aggregates, indicating improved soil stability. Furthermore, the crop sequences that included vegetables and legumes demonstrated higher maize grain equivalent yields compared to cereal-cereal rotations. Overall, these findings highlight the importance of crop diversification in maintaining soil health and increasing crop productivity.

FUTURE SCOPE

There is a great chance to increase farmers' income while also ensuring sustainability. It is important to conduct additional research on the creation of location-specific cropping systems that can be integrated into farming practices. Given that climate change poses a significant challenge for the farming community, it is crucial to address it by implementing diversification among cropping systems.

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Conflict of Interest. None.

REFERENCES

Ananda, M. R., Vaiahnav, S., Naide, P. R., Aruna, N. V. and Vishwanath (2022). Long-term benefits of legume-based cropping systems on soil health and productivity: an overview. *International Journal of Environment and Climate Change*, *12*, 299-315.

Bandyopadhyay, P. K., Saha, S. and Mallick, S. (2011). Comparison of soil physical properties between a permanent fallow and a long-term rice–wheat cropping with inorganic and organic inputs in the humid subtropics of eastern India. *Communications in Soil Science and Plant Analysis*, *42*, 435-449.

Bhargavi, B., Behera, U. K., Rana, K. S., Singh, R., Prasad, S., Pandey, R. N. and Singh, G. (2019). Crop diversification with high-value crops for higher productivity and profitability under irrigated ecosystem. *Indian Journal of Agronomy*, *64*(4), 440-444.

Dhaliwal, S. S., Naresh, R. K., Mandal, A., Walia, M. K., Gupta R. K. and Singh, R. (2019). Effect of manures and fertilizers on soil physical properties, build-up of macro and micronutrients and uptake in soil under different cropping systems. *Journal of Plant Nutrition*, *42*, 2873-2900.

Feng, G., Sharratt, B. and Young, F. (2011). Influence of long-term tillage and crop rotations on soil hydraulic properties in the US Pacific Northwest. *Journal of Soil and Water Conservation*, *66,* 233-241.

Feng, H., Abagandura, G. O., Senturklu, S., Landblom, D. G., Lai, L., Ringwall, K. and Kumar, S. (2020). Soil quality indicators as influenced by 5-year diversified and monoculture cropping systems. *The Journal of Agricultural Science*, 1-12.

Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedures for Agricultural Research. John Wiley and Sons, New York p 680.

Gupta, R. P. and Dhakshinamoorthy, C. (1980). Procedures for Physical Analysis of Soils and collection of Agrometerological Data. Division of Agricultural Physics, Indian Agricultural Research Institute, New Delhi.

Hazra, K. K., Nath, C. P., Singh, U., Praharaj, C. S., Kumar, N., Singh, S. S. and Singh, N. P. (2019). Diversification of maize-wheat cropping system with legumes and integrated nutrient management increases soil aggregation and carbon sequestration. *Geoderma*, *353*, 308-319.

Javanmard, A. (2015). Improvement of Soil Physicochemical Characteristics Using Legume Crops. *Biological Forum – An International Journal*, *17,* 869-874.

Kazula, M. J., Lauer, J. G. and Arriaga, F. J. (2017). Crop rotation effect on selected physical and chemical properties of Wisconsin soils. *Journal of Soil and Water Conservation*, *72*, 553-563.

Lal, R. (2017). Improving soil health and human protein nutrition by pulses-based cropping systems. *Advances in Agronomy*, *145*, 167-204.

Naidu, C. B., Bindu, G. M., Reddy, M. M. and Devi, M. D. (2022). Soil physicochemical properties as influenced by fertilisation of green manure crops grown during RABI. *Biological Forum – An International Journal*, *14*, 833-837.

Piper, C. D. (1950). Soil and Plant Analysis. Inc. Sci. Pub. INC, New York

Rahman, M. N., Rahman, M. M., Islam, M. B., Begum, R. A. and Mondol, A. T. M. A. I. (2007). Effect of tillage practices on soil properties and moisture conservation under Maize-GM-T. Aman cropping sequence. Annual Research Report, Soil Science Division, Bangladesh Agricultural Research Institute, Gazipur.

Rana, S. S., Sharma, H. L., Subehia, S. K., Negi, S. C. and Sharma, S. K. (2011). Promising cropping systems for mid hill agro climatic conditions of Himachal Pradesh. *Himachal Journal of Agricultural Research*, *37*, 138-148.

Rorick, J. and Kladivko, E. (2017). Cereal rye cover crop effects on soil carbon and physical properties in southeastern Indiana. *Journal of Soil and Water Conservation*, *72*, 260-265.

Roscher, C., Schumacher, J., Lipowsky, A., Gubsch, M., Weigelt, A., Pompe, Kolle, O., Buchmann, N., Schmid, B. and Schulze, E.D. (2013). A functional trait-based approach to understand community assembly and diversity–productivity relationships over 7 years in experimental grasslands. *Perspectives in Plant Ecology, Evolution and Systematics*, *15*(3), 139-149.

Shrestha, B. M., McConkey, B. G. and Smith, W. N. (2013). Effects of crop rotation, crop type and tillage on soil organic carbon in a semiarid climate. *Canadian Journal of Soil Science*, *93*, 137-146.

Sihag, S., Gopinath, K. A., Sheoran, S., Meena, S. R., Srinivasarao, C., Bedwal, S., Jangir, C., Mrunalini. K., Jat, R. and Praharaj, C. S. (2023). Pulse-based cropping systems for soil health restoration, resources conservation, and nutritional and environmental security in rainfed agroecosystems. *Frontiers in Microbiology*, *13*, 1041124.

Singh, R., Babu, S., Avasthe, R. K., Meena, R. S., Yadav, G. S., Das, A., Mohapatra, K. P., Rathore, S. S., Kumar, A. and Singh, C. (2021). Conservation tillage and organic nutrients management improve soil properties, productivity, and economics of the maize–vegetable pea system in the Eastern Himalayas. *Land Degradation and Development*.

Singh, R. A. (1980). Soil Physical Analysis. Kalyani Publishers, Ludhiana, India.

Tripathi, R., Nayaka, A. K., Bhattacharyya, P., Shukla, A. K., Shahid, M., Raja, R., Panda, B. B., Mohanty, S., Kumar, A. and Thilagama, V. K. (2014). Soil aggregation and distribution of carbon and nitrogen in different fractions after 41 years long-term fertilizer experiment in tropical rice–rice system. *Geoderma*, *213*, 280-286.

Vukicevich, E., Lowery, T., Bowen, P., Úrbez-Torres, J. R. and Hart, M. (2016). Cover crops to increase soil microbial diversity and mitigate decline in perennial agriculture: a review. *Agronomy for Sustainable Development*, *36*(3), 48.

Yoder, R. E. (1936). A direct method of aggregate analysis and study of the physical nature of erosion losses. *Journal of American Society of Agronomy*, *28*, 337-351.

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