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Effect of mechanized harvest of paddy on soil properties in Bhadra Command area of Davanagere District

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Abstract
A study was carried out in order to know the soil properties as influenced by mechanized harvest of paddy in Bhadra Command area of Davanagere distict, Karnataka during the year 2023-24 at College of Agriculture, KSNUAHS, Shivamogga. Under this investigation, 70 and 10 soil samples were collected randomly from mechanized and manual harvested fields, respectively under paddy cover of Davanagere and Channagiri taluks of Davanagere district. Soil samples were further processed and analyzed for physical and chemical properties. Soils had sandy clay loam, clay loam and clayey texture. Bulk density was recorded lower in soils under mechanized harvest system with mean of 1.28 Mg m^{-3}. Soil reaction varied from slightly acidic to slightly alkaline and EC was normal for soils under both harvest systems. Organic carbon, available N, P_2O_5 and K_2O contents were recorded higher in soils under mechanized harvest system ranging from 4.83 to 12.83 g kg^{-1}, 207.20 to 520.80, 16.23 to 68.99 and 112.45 to 661.78 kg ha^{-1} with mean of 8.41 g kg^{-1}, 350.73, 37.06 and 319.46 kg ha^{-1}, respectively. Available sulphur and micronutrients such as B, Fe, Mn, Cu and Zn contents recorded higher in soils under mechanized harvest system with mean of 12.42, 0.68, 30.29, 12.13, 2.62 and 1.30 mg kg^{-1}, respectively compared to the soils under manual harvest system which recorded the mean values of 12.30, 0.61, 24.02, 10.39, 1.74 and 0.82 mg kg^{-1} respectively.

Keywords: Soil properties, mechanized harvest, paddy, Bhadra Command area, Davanagere district

1. Introduction
Rice, scientifically known as *Oryza sativa* L. is an important staple food for almost 70 percent of the Asian population of approximately three billion people. It is considered the "king of cereals" and is one of the most important cereal crops worldwide. In the year 2022-23, it was grown in an area of 13.55 lakh hectares, yielding a total of 66.70 lakh tonnes, with an average yield of 5022 kg per hectare in Karnataka (Anon., 2023) [1]. It is grown in over 10 states in India, with distinct agro-climatic conditions. Uttar Pradesh, Punjab, Haryana, Bihar, Orissa, Karnataka, Telangana, Andhra Pradesh, Chhattisgarh, West Bengal and Tamil Nadu are the major states and contributors to rice production.

Agricultural productivity is significantly influenced by the management practices employed during crop cultivation. In the context of paddy farming, mechanization has become a prevalent practice in recent years to enhance efficiency and yield. The Bhadra Command Area, renowned for its extensive paddy cultivation, provides an ideal setting to explore these impacts due to its diverse soil types and varying agricultural practices.

The Bhadra River, a tributary of the Tungabhadra River in Karnataka, is associated with the Bhadra Command, which falls under the Bhadra Reservoir area. Covering 122,000 hectares, the Bhadra Command covers seven taluks across three districts *viz.*, Shivamogga, Chikkamagaluru, and Davanagere. Major growing crops in this region are rice (*Oryza sativa* L.), sugarcane (*Saccharum officinarum* L.) and arecanut (*Areca catechu* L.). The soils within the Bhadra Command under paddy cover exhibit diverse characteristics in terms of texture, chemical properties, and nutrient levels. They receive continuous input of paddy straw or stubbles due to mechanical harvesting and experience variations in fertilizer application.

Mechanized harvesting system has many benefits such as reduced labour costs, time saving method and also leaves behind large amount of paddy stubbles rich in nutrients especially potassium. When these stubbles are incorporated into the soils undergo decomposition and thereby serve as important source of organic matter. There is a need to understand how these practices influence the physical and chemical properties of soil and studies on this aspect are very limited.

2. Materials and Methods

The location of the study area was Davanagere and Channagiri taluks of Davanagere district, Karnataka which comes under Central Transition Zone of Karnataka (Agro-climatic zone No. 4) and lies between 13°5' and 14°50' N latitudes and 75°30' and 76°30' E longitudes (Fig 1). Major crops that are being cultivated in the region are paddy, sugarcane and areca nut. For the present study, seventy (70) and ten (10) surface composite soil samples (0-15 cm depth) were collected from mechanized and manual harvested paddy fields of farmers, respectively from different villages of both the taluks. The soil samples were brought to the laboratory, dried under shade, powdered using wooden pestle and mortar, passed through 2 mm sieve and preserved for analysis of physical and chemical parameters.

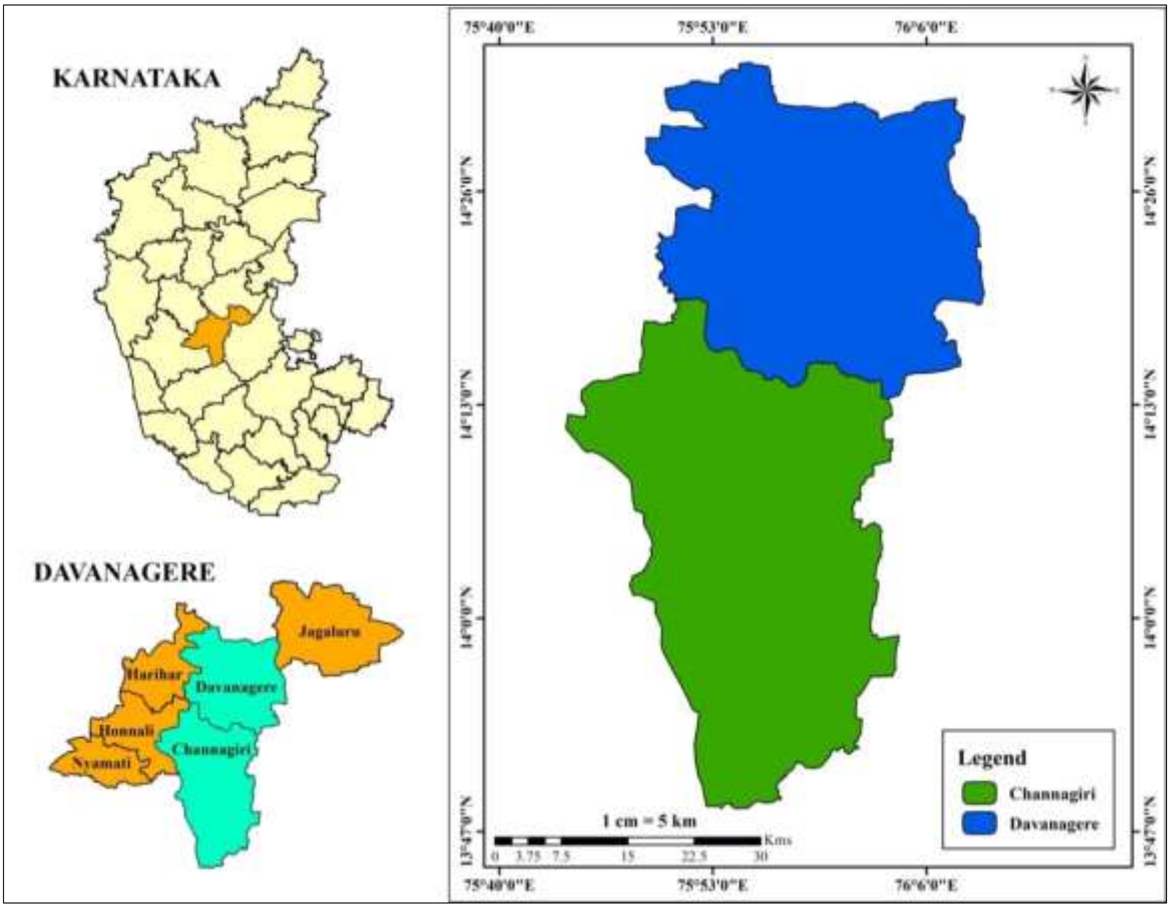

Fig 1: Map of Davanagere and Channagiri taluks of Davanagere District, Karnataka

Particle size distribution of soil samples was determined by International pipette method as described by Piper (1966) [13]. Bulk density was determined using core sampler method as described by Black (1965) [6] and was expressed in Mg m^{-3}. Soil pH was determined in 1: 2.5 soil to water suspension by dipping the combined electrode (glass electrode plus calomel electrode) of digital pH meter as outlined by Jackson (1973) [7]. The electrical conductivity (EC) of soils was measured in 1:2 soil to water extract using conductivity bridge (Jackson, 1973) [7]. The results of EC were expressed in terms of dS m^{-1} at 25 °C. Organic carbon in soil samples was determined by treating a known weight (0.50 g) of 0.2 mm sieved soil with known and excess quantity of chromic acid (Sulphuric acid and potassium dichromate) to oxidize the organic carbon present in the soil to carbon dioxide. After oxidation, the untreated potassium dichromate left in the contents was back titrated against standard ferrous ammonium sulphate using diphenylamine indicator (Walkely and Black, 1934) [20]. Available nitrogen in soil was determined by the alkaline potassium permanganate method as described by Subbaiah and Asija (1956) [17]. Available phosphorus in soil samples was extracted by Brays method for soils having pH less than 6.5 (0.03 N NH_4F + 0.025 N HCl) and Olsen's method for soils having pH more than 6.5 (0.5 M $NaHCO_3$) as described by Jackson (1973) [7]. The extract was treated with chloromolybdic acid and stannous chloride and the intensity of colour developed was measured by spectrophotometer at 660 nm. Available potassium was extracted from the soils using neutral N ammonium acetate and the concentration of potassium present in the extract was determined by the flame photometric method (Jackson, 1973) [7]. Exchangeable Ca and Mg of soils were determined by EDTA (Versenate) titration method after extracting the exchangeable Ca and Mg from soil using N N ammonium acetate (CH_3COONH_4) extractant as outlined by Jackson (1973) [7]. Available sulphur was extracted from soil using $CaCl_2$ (0.15%) as extractant and the concentration of sulphur in the extract was determined by turbidimetric method using spectrophotometer at 420 nm wavelength of light (Black, 1965) [6]. Available boron in soil was extracted with hot water and estimated colorimetrically by Azomethine-H using spectrophotometer at 420 nm (Berger and Troug, 1939) [4]. Available or DTPA extractable Fe, Mn, Cu and Zn of soil were extracted with DTPA extractant (0.005 M DTPA + 0.01 M $CaCl_2$ + 0.1 M TEA with pH 7.3) at 1:2 soil to extractant ratio as described by Lindsay and Norvell (1978) [10]. The concentration of micronutrients in the extract was determined by atomic absorption spectrophotometer using the appropriate hallow cathode lamps (Page *et al*., 1982) [12]. Finally, the results of soil analysis for different parameters were converted into mean and range values to draw better conclusion.

3. Results and Discussion

Soil physical properties

Table 1 depicts the physical properties of soils under mechanized and manual harvest systems of paddy and it was observed that the showed sandy clay loam, clay loam and clayey texture. These textural changes might be attributed to the parent material, physiography, clay's translocation, organic matter content and continuous soil puddling operations (Basavaraju *et al*., 2005) [2]. The bulk density value of soils under mechanized harvest system of paddy ranged from 1.12 to 1.41 Mg m^{-3} with mean of 1.28±0.06 Mg m^{-3}, while in the soils of manual harvest system of paddy ranged from 1.37 to 1.47 Mg m^{-3} with mean value of 1.42±0.03 Mg m^{-3}. The lower (normal) bulk density of soils under mechanized harvest system compared to manual harvest system might be attributed to more organic matter content of soil contributed from addition of more biomass through incorporation of stubbles into the soil. Moreover, soil bulk density is influenced by factors such as organic matter content, management practices, compaction, texture, porosity, soil fauna, etc. Similar results were reported by Walia *et al.* (2008) [19] and Bellakki *et al.* (1998) [3].

Table 1: Physical properties of soils under mechanized and manual harvest systems of paddy in Bhadra command area of Davanagere district

Harvest systems	Textural class	Bulk density (Mg m^{-3})	
		Range	Mean
Mechanized harvest system	Sandy clay loam, clay loam and clay	1.12 - 1.41	1.28±0.06
Manual harvest system	Sandy clay loam, clay loam and clay	1.37 - 1.47	1.42±0.03

Soil chemical properties

Chemical properties such as soil pH, EC, and organic carbon content in soils under mechanized and manual harvest systems of paddy in Bhadra command area are being depicted in Table 2. The pH of soils varied remarkably among the soils and the values ranged from 5.39 to 8.35 and 7.06 to 8.05 with mean of 6.67±0.72 and 7.68±0.35 in the soils under mechanized and manual harvest systems of paddy, respectively which indicated that soils were slightly acidic to slightly alkaline in nature. The variation in soil reaction may be attributed to variation in the rainfall pattern, nature of parent material, biomass content (Organic matter content) and texture of soils in Bhadra Command of Karnataka. Comparatively, lower pH value (Acidic range) was recorded in soils under mechanized harvest system than manual harvest system due to high biomass addition (root and stubbles) to soil which released more organic acids and CO_2 upon decomposition of stubbles when incorporated into the soils leads to lower soil pH. Similar results were reported by Bishworjit *et al*., 2013 [5].

The electrical conductivity of the soils ranged from 0.32 to 1.02 and 0.57 to 0.92 dS m^{-1} with mean value of 0.65±0.15 and 0.70±0.12 dS m^{-1} at 25 °C under mechanized and manual harvest systems of paddy respectively which indicated that these soils were normal with respect to soluble salts concentration. Kamla *et al*. (2017) [8] revealed that, the non-saline nature of the soils can be attributed to common flooding and the leaching process, wherein salts are washed from the surface layer and deposited at lower depths through percolating rainwater.

The organic carbon content ranged from 4.83 to 12.83 and 4.20 to 6.16 g kg^{-1} with mean of 8.41±1.91 and 4.87±0.60 g kg^{-1} in soils under mechanized and manual harvest system respectively. Higher organic carbon status in soils of mechanized harvest system may be due to management practices such as the in-situ addition of large portion of paddy stubbles to the soils through mechanical harvest served as major source of organic matter to the soil. Babhulkar *et al.* (2000) [22] reported similar findings that higher biomass production, which adds leaves and roots to soil leading to an increase in organic carbon status in soil.

Table 2: Chemical properties of soils under mechanized and manual harvest systems of paddy in Bhadra command area of Davanagere district

Properties	Mechanized harvest system		Manual harvest system	
	Range	Mean	Range	Mean
pH	5.39 - 8.35	6.67±0.72	7.06 - 8.05	7.68±0.35
EC (dS m^{-1} at 25 °C)	0.32 - 1.02	0.65±0.15	0.57 - 0.92	0.70±0.12
OC (g kg^{-1})	4.83 - 12.83	8.41±1.91	4.20 - 6.16	4.87±0.60

Available N, P_2O_5 and K_2O status

The available N, P_2O_5 and K_2O status in the soils under mechanized harvest system of paddy ranged from 207.20 to 520.80, 16.23 to 68.99 and 112.45 to 661.78 kg ha^{-1} with mean values of 350.73±68.87, 37.06±11.61 and 319.46±158.39 kg ha^{-1} respectively. Whereas the soils under manual harvest systems of paddy recorded varied but lower amounts of available N, P_2O_5 and K_2O and which ranged from 190.80 to 282.65, 21.56 to 41.77 and 88.36 to 162.45 kg ha^{-1} with mean of 243.65±32.23, 30.98±7.03 and 127.45±27.73 kg ha^{-1} respectively (Table 3). Higher available nitrogen content in the soils of mechanized harvest system might be due to higher biomass addition (root + stubbles) to soil thereby increased microbial activity which released organically bound nitrogen from stubble upon decomposition (Zhu *et al*., 2017) [17]. Higher available phosphorous content in soils under mechanized harvest system might be attributed to the phosphorus solubilizing microbes and organic acids released by the straw or stubble degrading microorganisms on high biomass addition to the soils. Lemanowicz (2011) [9] reported that these various organic acids have solubilized the phosphate bearing minerals and increased the rate of phosphate mineralization because of increased phosphatase enzyme activity which resulted in increased available phosphorous in soils. Higher available potassium in soils under mechanized harvest system as depicted in Fig. 2 might be due to the incorporation of more organic residues through paddy stubbles which are very rich source of potassium (1.79 to 2.98%). Moreover about 80-85% of total plant K remains in vegetative part at crop maturity which might have contributed to soil available potassium upon their addition and microbial decomposition (Singh *et al.*, 2005) [15].

Table 3: Available N, P_2O_5 and K_2O (kg ha^{-1}) status of soils under mechanized and manual harvest systems of paddy in Bhadra command area of Davanagere district

Properties	Mechanized harvest system		Manual harvest system	
	Range	Mean	Range	Mean
Available N	207.20 - 520.80	350.73±68.87	190.80 - 282.65	243.65±32.23
Available P_2O_5	16.23 - 68.99	37.06±11.61	21.56 - 41.77	30.98±7.03
Available K_2O	112.45 - 661.78	319.46±158.39	88.36 - 162.45	127.45±27.73

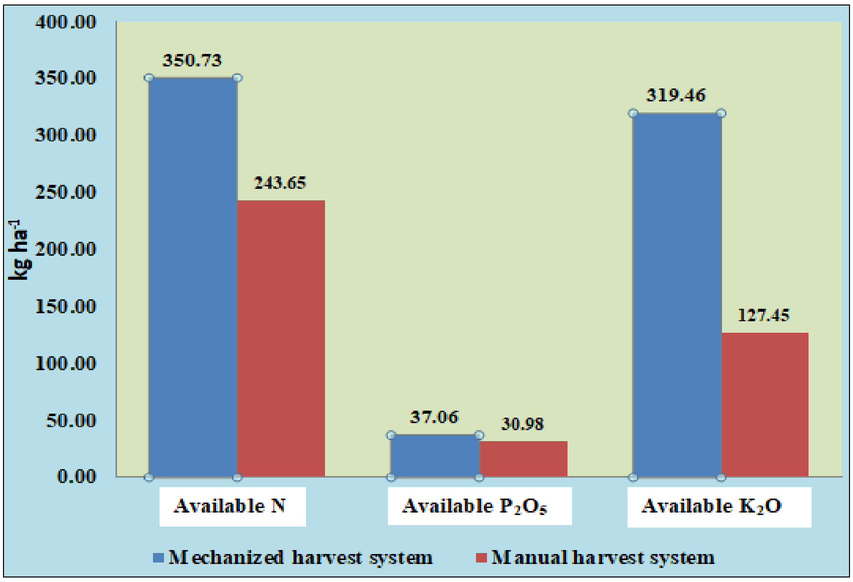

Fig 2: Available N, P_2O_5 and K_2O status in soils under mechanized and manual harvest systems of paddy in Bhadra command area of Davanagere district Available secondary nutrients

The exchangeable calcium and magnesium contents varied from 5.50 to 13.30 and 1.90 to 6.50 cmol (p^+) kg^{-1} with mean of 8.29±1.44 and 3.82±1.02 cmol (p^+) kg^{-1} respectively and available sulphur contents varied from 3.50 to 17.40 mg kg^{-1} with mean value 12.42±3.64 mg kg^{-1} in the soils under mechanized harvest system of paddy. Whereas in the soils under manual harvest system of paddy, exchangeable calcium and magnesium contents ranged from 8.00 to 11.70 and 3.10 to 7.10 cmol (p^+) kg^{-1} of soil with mean values of 9.54±1.15 and 4.86±1.29 cmol (p^+) kg^{-1} respectively and the available sulphur content ranged from 8.10 to 17.00 mg kg^{-1} with mean of 12.30±2.90 mg kg^{-1} (Table 4). The soils recorded higher exchangeable calcium content than magnesium. Thus, exchangeable calcium was found to be the dominant cation on the exchange complex of soil. Singh and Prasad (2020) [14] reported that calcium dominated the exchange complex in soils of semiarid regions due to the greater adsorption strength of calcium on soil compared to other cations. The higher available sulphur content in soils under mechanized harvest system might be due to the addition of sulphur through fertilizers, such as single superphosphate (farmers practice), sulphate bearing minerals, and higher organic matter content of soil contributed from paddy stubble incorporation. Similar results were reported by Manimalika *et al*. (2017) [11] and Singh and Prasad (2020) [14].

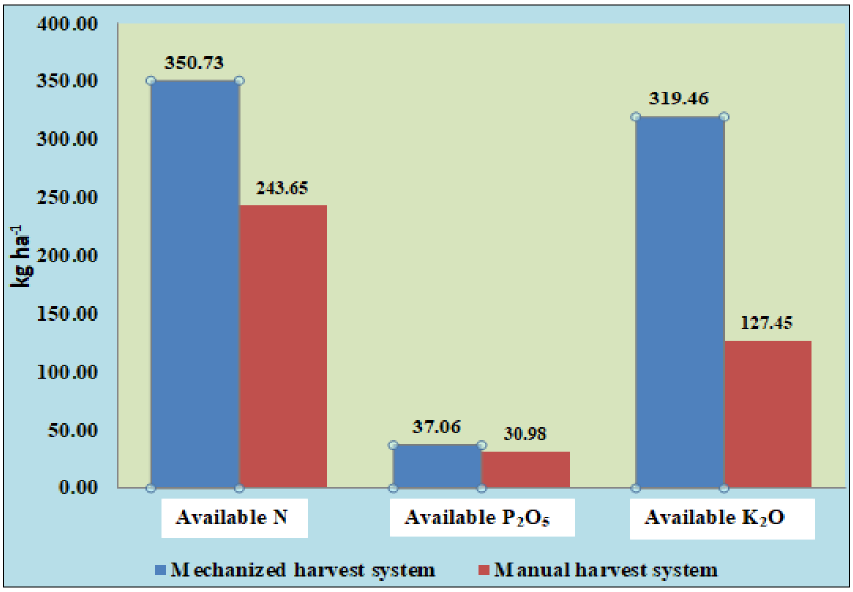

Fig 2: Available N, P_2O_5 and K_2O status in soils under mechanized and manual harvest systems of paddy in Bhadra command area of Davanagere district

Table 4: Available secondary nutrients status of soils under mechanized and manual harvest systems of paddy in Bhadra command area of Davanagere district

Properties	Mechanized harvest system		Manual harvest system	
	Range	Mean	Range	Mean
Exchangeable Ca (cmol (p^+) kg^{-1})	5.50 - 13.30	8.29±1.44	8.00 - 11.70	9.54±1.15
Exchangeable Mg (cmol (p^+) kg^{-1})	1.90 - 6.50	3.82±1.02	3.10 - 7.10	4.86±1.29
Available S (mg kg^{-1})	3.50 - 17.40	12.42±3.64	8.10 - 17.00	12.30±2.90

Available micronutrients

Available boron, iron, manganese, copper and zinc contents in the soils under mechanized harvest system ranged from 0.38 to 0.93, 20.97 to 39.25, 1.40 to 24.90, 1.11 to 3.81 and 0.42 to 2.67 mg kg^{-1} with mean values 0.68±0.12, 30.29±4.30, 12.13±5.28, 2.62±0.59 and 1.30±0.55 mg kg^{-1} respectively. Whereas the same mentioned micronutrients content ranged from 0.26 to 0.76, 18.23 to 29.18, 1.93 to 14.52, 0.81 to 2.45 and 0.12 to 1.12 mg kg^{-1} with mean values of 0.61±0.14, 24.02±3.69, 10.39±3.48, 1.74±0.58 and 0.82±0.30 mg kg^{-1} (Table 5). The higher available micronutrients content in soils of mechanized harvest system could be attributed to fact that about 50-80% of micronutrients taken up by rice crop remains in the vegetative part after maturity and same would be recycled through incorporated residue (Singh *et al.*, 2009) [16]. Moreover, added organic materials might have enhanced the microbial activity followed by decomposition in the soil and consequently the release of complex organic substances. These organic compounds are the chelating agents that could have prevented micronutrients from precipitation, fixation, oxidation and leaching and thus increased the availability. Similar results were reported by Vijayaprabhakar *et al*. (2017) [18].

Table 5: Available micronutrients (mg kg^{-1}) status of soils under mechanized and manual harvest systems of paddy in Bhadra command area of Davanagere district

Properties	Mechanized harvest system		Manual harvest system	
	Range	Mean	Range	Mean
Available B	0.38 - 0.93	0.68±0.12	0.26 - 0.76	0.61±0.14
Available Fe	20.97 - 39.25	30.29±4.30	18.23 - 29.18	24.02±3.69
Available Mn	1.40 - 24.90	12.13±5.28	1.93 - 14.52	10.39±3.48
Available Cu	1.11 - 3.81	2.62±0.59	0.81 - 2.45	1.74±0.58
Available Zn	0.42 - 2.67	1.30±0.55	0.12 - 1.12	0.82 0.30

4. Conclusion

The mechanized harvest system of paddy offers several benefits concerning soil properties. The higher levels of organic carbon, available macronutrients (such as nitrogen, phosphorus, potassium, and sulphur), and micronutrients (including boron, iron, manganese, copper, and zinc) in soils under this system suggest improved soil fertility. These enhanced nutrient levels can support better crop growth, higher yields, and overall soil health.

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