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Prem Chand Yadav
Research Scholar, Bhagwant University, Ajmer, Rajasthan, India

DharmendraDubey
Supervisor, Bhagwant University, Ajmer, Rajasthan, India

Mohammad Gufran
Co-Supervisor, B.S.B.R.A. College Agricultural Engg. & Tech. Etawah, Uttar Pradesh, India

Rudra Pratap Singh
Faculty of Agriculture Sciences, Bhagwant University, Ajmer, Rajasthan, India

Corresponding Author:
Prem Chand Yadav
Research Scholar, Bhagwant University, Ajmer, Rajasthan, India

To study the development of hard pan with use of zero till ferti seed drill in deep loamy soil in Etawah district of Uttar Pradesh

Prem Chand Yadav, Dharmendra Dubey, Mohammad Gufran and Rudra Pratap Singh

Abstract
The present study explored the development of hard with use of zero till ferti seed dirll in deep loamy soil in Etawah district of Uttar Pradesh. Selection of the farmers for the experiment conducted for hard pan of soil was done from the group of farmers considered for impact study as the initial information was available during survey for impact analysis, the sowing date was planned as 15th November each year i.e. Rabi 2017, 2018 with zero till sowing in the plot and conventional tillage on other part of the plot for continuously two years with recommended dose of fertilizer as per soil testing in ZT and CT plots. Paddy crop with variety NDR-359 field in both ZT and CT was cultivated. Hard pan prediction model was developed which referred to predict the occurrence of hard pan in due course of time. Since the area under study does not come across with heavy machinery having more than 10 tons weight, the occurrence of hard pan comes at later stage in due course of time. However, precautions should be taken to avoid using heavy machines and also a planned movement of traction vehicle is suggested.

Keywords: bulk density, conventional tillage hard pan, seed drill, zero till

Introduction
Rice-wheat cropping system is very common in India. It contributes to over 70% of total food grain production in the country with an area of 12Mha under this cropping system. However, it is estimated that under rice and wheat crop separately, the area is 42.31 and 22.98Mha, respectively. This cropping system is also most predominating in Utter Pradesh, which occupies 65% of total cultivated area. Further wheat is most important crop of Utter Pradesh which alone about 35.5% of total area under this crop grown in country and producing more than one third of the total wheat. Thus, it is necessary that production of rice and wheat must keep pace with the growing population of our country. However, the factors such as degradation in natural resource shift in cropping pattern and energy constraints etc. are causing reduction in the productivity of these crops. In irrigated rice-wheat system; rice is mostly transplanted in puddle field. This causes delay in sowing which result in reduced crop yield to 30-40 kg per ha per day if crop is sown after 13th Nov. Delayed sowing of wheat is also due to late harvesting of rice, soil wetness, poor rice residue management, multiplicity of tillage operation, and no availability of power source and arrival of rain in the month of November. Therefore, the late sowing situation of wheat in rice-wheat cropping system to be very critical, where about 80% of the areas under wheat are sown late after harvesting of rice resulting into reduces productivity. This loss can be saved through early seeding of wheat by no-tillage technique. This technique advanced operation by 10-15 days and also reduces the cost of production by saving energy. Although this method of wheat seeding using zero till seed cum ferti drill is becoming very popular in Haryana and Punjab states but it not popular in U. P. particularly in central Uttar Pradesh.

As a result, in India, it is estimated that zero-tillage has increased incomes by US$97 per hectare, with households typically increasing their annual earnings by US$180-$340. The bulk of this is from reduced costs. Zero-tillage also has environmental benefits: reducing fossil fuel use and greenhouse gas emissions, improving both fertility and water-holding capacity of the soils, reducing rates of soil erosion, and encouraging rice-wheat farmers to leave crop residues on the soil surface rather than burning them.

Furthermore, reduced tillage has provided a “platform” for introducing other resource-conserving practices such as: sowing on raised beds; surface seeding in riverain areas; smallholders in the eastern IGP using laser levelling to improve irrigation efficiency; cropping diversification (introducing for example, pulses and vegetable crops); and supporting

conversion to full conservation agriculture by replacing puddled rice cropping with aerobic rice cultivation. Such practices will be crucial for the region, given that by 2050 climate-change induced heat and water stress in irrigated areas may reduce wheat yields by 12 percent and rice by 10 percent, while the unsustainable extraction of water for agriculture continues to drain aquifers.

The success of zero-tillage and the participatory approach through which it was promulgated, has helped overcome resistance to new practices among researchers, policymaker, and farmers. Support for zero-tillage has come from public-private partnerships and the facilitation of both national and international technology transfers, primarily through the RWC. State and local governments have come on board to promote and disseminate the technology, in some cases subsidizing seed drills to reduce the cost to farmers.

Adoption of zero-tillage is most widespread in India, where the RWC catalysed the public private partnerships instrumental to its development and dissemination. So far, adoption has centred on intensive, mechanized farms in the northwest states of Haryana and Punjab. Current efforts are targeting the eastern IGP, where agriculture is less mechanized and poverty more extreme.

Systems in India Socio-Economic and Policy Issues Introduction Rice-Wheat Cropping System (RWCS) gained prominence from the mid-1960s with the introduction of short-duration and high-yielding varieties of rice and wheat during mid-1960s. The rotation has spread in the most fertile regions and has covered about 10 million ha in the Indo-Gangetic plains (IGP) region of India. It is more popular in the non-traditional rice growing states of Punjab, Haryana and Uttar Pradesh, and less in traditional rice growing states of Bihar and West Bengal. The impressive performance of the system during the last three decades resulted in a quantum jump in the production of rice and wheat, which largely contributed in achieving the food self-sufficiency in India. The food grain production increased from about 90 million tonnes in 1964-65 to about 190 million tonnes in 1994-95, at an annual growth of little over 2.5 percent.

Material and Methods

Methodology for studying the development of hard pan by use of zero till machine-

For development of hard pan study with use of zero till seed drill in clay loam soil, methodology was adopted as below-

1. Plan of Study

1.1 Bulk Density Measurement

Since bulk density was the most important factor to study the hard pan development, the measurements were done for the site soils. The development of hard pan with use of zero till seed drill analysis of the fields at least three years, study was done by measuring bulk density for the deep loamy soil. It was assured that the farmers were using zero till machine for last three years in the fields (0.2 hectare size) and adjoining plots were continuously cultivated (CT) wheat under rice wheat system were selected for monitoring the changes in the bulk density and also infiltration rates as well as wheat crop yields.

In ZT field, the residues of paddy crop which was harvested by combine every year, was collected manually in order to have uniformity in the experiment. The wheat crop was sown with zero till machine. While in CT, also the residues of paddy were removed manually and seed bed preparation was done by one pass of disc harrow three pass of cultivator followed by planking. It was also the part of experiment that both fields of tillage i.e. ZT and CT. They were continuously puddled during *Kharif* season for past three years and the results were compared with the control plot i.e. the plot where zero till machine was not used and ultimately data was analysed. After selecting one farmer randomly where the experiments were to be conducted, the plots were selected for zero till used site. Each plot i.e. zero till and non-zero till (control plot), four plots of one sq. metre size was selected for bulk density samples in both CT and ZT plots. The samples were taken from surface (0 cm), 10 cm and 40 cms depth as a part of experiment in the month of May after wheat harvesting. Thus in total 24 samples were taken after each wheat harvest. Wheat crop was Malviya-234 during *Rabi* season of 2016-17 and 2017-18 to get yield in 2019 April.

1.2 Experimental Design for bulk density of the field soil under study

In order to achieve the stated objective, the experiment was planned as follow:

Selection of the farmers for the experiment conducted for hard pan of soil was done from the group of farmers considered for impact study as the initial information was available during survey for impact analysis. Since the experiment was to be conducted for only deep loamy soil with an additional parameter of the duration of use of zero till machine in their respective fields for at least three consecutive years, under this condition F1, F3, F8, F11, F14, F17 & F19 were fitted in. Out of that F14 was rejected on the basis of the soil i.e. slit clay loam. F8 was rejected on the basis, that he did not use ZT machine for three years continuously. However F1 was selected on random basis out of remaining. Further the farmers F1 was chosen for the experiment because of his good cooperation, acceptance for the experiments to be conducted in his fields and also being nearer to the office of Krishi Vigyan Kendra, Etawah as compared to other farmers under consideration. The details are in table 1.

Table 1: Soil Characteristics of Farmers fields with Clay loam soils under study for Hard Pan Development.

S. No.	Farmers	F1	F3	F11	F17
1	Soil	Clay loam	Clay loam	Clay loam	Clay loam
2	No. of years of ZT use	Four	Three	Three	Three
3	Bulk density CT	1.410	1.41	1.39	1.415
4	Av. Bulk density in ZT first year	1.440	1.47	1.50	1.484

The plots selected for the study has been designed and are shown in tab. 1. For CT and tab. 2 for ZT.

Tab 1: Experimental Plot Design Farmer F1-CT (Bulk Density) (Schematic not to Scale)

S. No.	Depth of Sample	Date of sample collection	Sample No.	Date of Sample collection	Sample No.	Date of Sample collection	Sample No.
		1st year		2nd Year		3rd Year	
1	Surface (top soil)	8.5.2012	$1C1_0$	15.5.2013	$1C1_0$	20.5.2014	$1C1_0$
2	10 cm	8.5.2012	$1C1_{10}$	15.5.2013	$1C1_{10}$	20.5.2014	$1C1_{10}$
3	20 cm	8.5.2012	$1C1_{20}$	15.5.2013	$1C1_{20}$	20.5.2014	$1C1_{20}$
4	40 cm	8.5.2012	$1C1_{40}$	15.5.2013	$1C1_{40}$	20.5.2014	1C140

Tab 2: Experimental Plot Design Farmer F1-ZT (Bulk Density) (Schematic not to Scale)

S.No.	Depth of Sample	Date of Sample collection	Sample No.	Date of Sample collection	Sample No.	Date of Sample collection	Sample No.
		1st year		2nd Year		3rd Year	
1	Surface (top soil)	12.6.2017	$1Z1_0$	18.6.2018	$1Z1_0$	20.6.2019	$1Z1_0$
2	10 cm	12.6.2017	$1Z1_{10}$	18.6.2018	$1Z1_{10}$	20.6.2019	$1Z1_{10}$
3	20 cm	12.6.2017	$1Z1_{20}$	18.6.2018	$1Z1_{20}$	20.6.2019	$1Z1_{20}$
4	40 cm	12.6.2017	$1Z1_{40}$	18.6.2018	$1Z1_{40}$	20.6.2019	$1Z1_{40}$

1.3 Experimental Design for measuring Infiltration Characteristics

The infiltration characteristics are dominantly related to the field compaction problems as discussed earlier. In fact as a limitation of the experiment only one site was so selected for the infiltration reading in starting the next year as proceeding and second year as the last one. The readings were planned in every fifteen minutes starting from 15th to 150th minutes thus to get an authentic result for effect of compaction on infiltration as a factor. This was to be done every year in summer when the soil was dry and almost constant moisture depletion exists within the soil. Initially, the filtration was taken into consideration so as to get other results such as infiltration rates, accumulated infiltration were planned to be calculated on the basis of the recordings. The site figures and experimental design has been detailed in Tab. 3 and Tab. 4 for CT and ZT respectively.

Tab 3: Experimental Plot Design Farmer F1-CT (Infiltration) (Schematic not to Scale)

S.No.	Depth of Sample	Date of Infiltration Readings	Date of Infiltration Readings	Date of Infiltration Readings
		1st Year	2nd Year	3rd Year
1	Surface (top soil)	10.5.2012	17.5.2013	22.5.2014

Tab 4: Experimental Plot Design Farmer F1-ZT (Infiltration) (Schematic not to Scale)

S.No.	Depth of Sample	Date of Infiltration Readings	Date of Infiltration Readings	Date of Infiltration Readings
		1st Year	2nd Year	3rd Year
1	Surface (top soil)	9.5.2012	16.5.2013	21.5.2014

1.4 Experimental Design for Wheat Yield Data as a Parameter for soil compaction

As mentioned earlier in the work plan, the sowing date was planned as 15th November each year i.e. Rabi 2017, 2018 with zero till sowing in the plot and conventional tillage on other part of the plot for continuously two years with recommended dose of fertilizer as per soil testing in ZT and CT plots. Paddy crop with variety NDR-359 field in both ZT and CT was cultivated. In CT plot wheat sowing was done as detailed in previous clause. It was planned that only wheat yield was to be considered for research finding purpose as a limitation of study and rest of all parameters in the cultivation method kept unchanged for consecutively two years i.e. Rabi 2017 and Rabi 2018 with same treatments in ZT and CT plots for paddy cultivation. The detail has been shown in Tab. 5 and 6 for CT and ZT.

Year of study-Rabi 2017 & Rabi 2018

Paddy residues removed manually
Seed bed preparation- one pass of disc harrow +three pass of cultivator followed by planking
Crop- Wheat, seed rate-40 kg/acre
Variety-Malviya-234
Tractor used-35 HP Escorts 335
Random movement of tractor with cultivator during Kharif
Random movement of combine during Kharif and Rabi

Tab 5: Experimental Plot Design Farmer F1-ZT (Infiltration) (Schematic not to Scale)

S.No.	Wheat Yield Experiment Parameters	1st Year	2nd Year
1	Date of Sowing	29.11.2017	05.12.2018
2	Combine weight – Weight with Cutter Bar as designated, Kg	8500	8500
3	Approx. Total weight of Tractor with fuel, lubricants, operator &zt M/c, Kg	2120	2120
4	Approx. Weight of Tractor trolley with grain bags, Kg	2500	2500

Year of study-Rabi 2017 & Rabi 2018

Zero till sowing by nine Tyne National Agro zero till seed cum ferti drill machine
Crop- Wheat, seed rate-40kg/acre
Variety-Malviya-234
Tractor used-35 HP Escorts 335
Random movement of tractor with cultivator during Kharif
Random movement of combine during Kharif and Rabi

Tab 6: Experimental Plot Design Farmer F1-ZT (Wheat Crop Yield) (Schematic not to Scale)

S.No.	Parameters in yield experiment	Year	Year
		1st Year	2nd Year
1	Date of Sowing	15.11.2017	15.11.2018
2	Depth wheel adjustment of Sowing	4 cm	4 cm
3	Combine weight- Weight with Cutter Bar (as designated) in Kg	8500kgs	8500kgs
4	Approx. Total Weight of Tractor with fuel and lubricants (with operator) and zt M/c in Kg	2120	2120
5	Approx. Weight of Tractor trolley with grain bags, Kg	2500	2500

Results and Discussion

The earlier studies revealed that with long term use of heavy equipments being used in the field for farm and other operations could cause development of hard pan below the soil surface. The possible effects reflected were increasing bulk density, reduced infiltration, and lower crop yield including other changes in the soil characteristics.

Development of a hard pan development prediction model

It is very important to know about the hard pan development and parameters selected can predict an early stage of hard pan in a farmer's field. Table 2 has fourteen considerations. In case, At least eight factors are positive, and then a detail hard pan development study can be preceded. In the case of present study, it is clear from table 4.20 that two farmers have score card of 9 or more than 9 i.e. F1 and F14. This means that both the farmers have chances of developing hard pan. Considering the limitation of the study, only one farmer was randomly chosen i.e. F1 for the detail study of the three parameters i.e. bulk density, hard pan and infiltration.

Table 2: Survey Questionnaire for Study on Effect of Hard Pan Development through Compaction in 2017

S.No	Symptoms	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20
1	No. of years since Farmer is using ZT	4	2	3	2	2	1	1	0	1	2	3	2	2	3	3	2	3	2	2	1
2	Is Nitrogen deficiency symptoms visible?	Slightly visible										Slightly visible				Slightly visible		Slightly visible			
3	Whether Yield is reducing?	Yes		Yes								Yes			Yes	Yes		Yes			
4	Potassium deficiency symptoms visible?					Slightly visible		Slightly visible							Slightly visible						
5	Are formation of large soil clods after tillage visible																				
6	Symptoms of Reduced infiltration	Slightly visible in 2014 rains		Seems more in 2014 rains											Slightly visible in 2014 rains						
7	New wet spots for a plow pan formation																				
8	Is fuel consumption for tillage more than in year 2012?	Seems more													Seems more						
9	Systematic traffic movement on field														Yes in 2013						
10	Is weight of tractor & equipment moving on fields> 2.5 ton?	Yes, used tractor trolley													Yes, used tractor trolly						
11	a. Tractor (upto 35hp)	Yes	Yes	Yes	Yes		Yes		Yes			Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	
	b. Tractor (>35hp)					Yes					Yes										
12	Owns zero till ferti seed drill	Yes	Yes	Yes	Yes							Yes			Yes	Yes		Yes			
13	Using Combine Harvester in 2014 for wheat harvesting	Yes	Yes						Yes		Yes				Yes						
	SCORE	9	3	5	2	2	1	1	2	0	2	5	1	1	10	5	5	5	1	1	0

Study of Bulk Density of the soil of F1

Bulk Density study at Surface (0cm)

The study revealed according to table 3 that the samples collected had shown bulk density of CT plots as 1.41, 1.421 and 1.423 gm/cm^3 at surface and for ZT plots as 1.440, 1.441, 1.442 gm/cm^3 in three years. This shows that there was an increase in bulk density to some extent in both i.e. ZT and CT cases i.e. 0.14 percent in ZT and 0.922 percent in CT. It means that compaction effect is more in CT at surface level. This phenomenon occurs due to compaction in wet soils is more and structure is disturbed by regular ploughing and harrowing where as in ZT soil structure is not disturbed and is pressed due to tractor and machinery movement for past three years.

Table 3: Bulk Density of F1 after one and two years of sowing wheat during study work in gm/cm^3 (0cm depth)

Sample No.	$1Z1_0$	$1C1_0$	$1Z2_0$	$1C2_0$	$1Z3_0$	$1C3_0$	$1Z4_0$	$1C4_0$	$1ZA_0$	$1CA_0$
	ZT	CT	ZT	CT	ZT	CT	ZT	CT	ZT	CT
Depth (cm)	0	0	0	0	0	0	0	0	0	0
First year 08.5.2017	1.435	1.416	1.445	1.408	1.437	1.401	1.443	1.415	1.440	1.410
Second year 15.5.2018	1.442	1.423	1.440	1.421	1.438	1.417	1.444	1.423	1.441	1.421
Third year 20.5.2019	1.439	1.427	1.440	1.419	1.444	1.425	1.445	1.421	1.442	1.423

Bulk Density study at depth (10cm)

The details are given in table 4 where it is clear that the bulk density has an increasing trend. The CT bulk density has increased from 1.449 to 1.454 gm/cm^3 and ZT as 1.463 gm/cm^3. The percentage increment in CT was 0.345 while in ZT it was 1.106 and this means bulk density increases in first 10 cms of depth in ZT condition and in CT since the soil is pulverized, the bulk density is not able to increase to recognizable extent.

Table 4: Bulk Density of F1 after one and two years of sowing wheat during study work (10 cm depth)

Sample No.	$1Z1_{10}$	$1C1_{10}$	$1Z2_{10}$	$1C2_{10}$	$1Z3_{10}$	$1C3_{10}$	$1Z4_{10}$	$1C4_{10}$	$1ZA_{10}$	$1CA_{10}$
	ZT	CT	ZT	CT	ZT	CT	ZT	CT	ZT	CT
Depth (cm)	10	10	10	10	10	10	10	10	10	10
First year 08.5.2017	1.449	1.452	1.442	1.450	1.451	1.443	1.446	1.451	1.447	1.449
Second year 15.5.2018	1.449	1.461	1.453	1.450	1.451	1.450	1.448	1.451	1.455	1.453
Third year 20.5.2019	1.461	1.457	1.467	1.451	1.464	1.455	1.460	1.453	1.463	1.454

Bulk Density study at depth (20cm)

It was revealed from the study of table 5 and 6 that CT bulk density is increased in 10-20 cm depth up to 8.63 percent in first year and increased up to 1.02 percent in three years depth wise (at 20 cm). While ZT bulk density is increased from 10-20 cm depth up to 6.36 percent in first year and increased up to 0.85 percent in three years depth wise (at 20 cm).

Table 5: Bulk Density of F1 after one and two years of sowing wheat during study work (20 cm depth)

Sample No.	$1Z1_{20}$	$1C1_{20}$	$1Z2_{20}$	$1C2_{20}$	$1Z3_{20}$	$1C3_{20}$	$1Z4_{20}$	$1C4_{20}$	$1ZA_{20}$	$1CA_{20}$
	ZT	CT	ZT	CT	ZT	CT	ZT	CT	ZT	CT
Depth (cm)	20	20	20	20	20	20	20	20	20	20
First year 08.5.2017	1.541	1.572	1.538	1.576	1.537	1.571	1.54	1.577	1.539	1.574
Second year 15.5.2018	1.544	1.582	1.543	1.583	1.539	1.579	1.538	1.580	1.541	1.581
Third year 20.5.2019	1.557	1.587	1.549	1.593	1.548	1.589	1.554	1.591	1.552	1.590

Bulk Density study at depth (40cm)

From the study of table 6 and 7 that CT bulk density is decreased in 20-40 cm depth up to 11.9 percent in first year and increased up to 0.76 percent in three years depth wise (at 40 cm). While ZT bulk density is decreased from 20-40cm depth up to 13.23 percent in first year and increased up to 1.6 percent in three years depth wise (at 40cm).

Table 6: Bulk Density of F1 after one and two years of sowing wheat during study work (40cm)

Sample No.	$1Z1_{40}$	$1C1_{40}$	$1Z2_{40}$	$1C2_{40}$	$1Z3_{40}$	$1C3_{40}$	$1Z4_{40}$	$1C4_{40}$	$1ZA_{40}$	$1CA_{40}$
	ZT	CT	ZT	CT	ZT	CT	ZT	CT	ZT	CT
Depth (cm)	40	40	40	40	40	40	40	40	40	40
First year 08.5.2017	1.454	1.458	1.457	1.453	1.451	1.452	1.450	1.457	1.453	1.455
Second year 15.5.2018	1.463	1.475	1.460	1.469	1.466	1.468	1.459	1.461	1.457	1.459
Third year 20.5.2019	1.473	1.479	1.475	1.476	1.470	1.473	1.477	1.480	1.459	1.466

Effect of Compaction on Infiltration Characteristics (ZT)

The infiltration rate and accumulated infiltration was measure in all three years and results were recorded. The details are shown in table 7, 8 and 9.

Table 7: Observation of infiltration in field of F1 ZT-2017

Time Elapsed in hrs.	Time Interval (hrs)	Infiltration (mm)	Acc. Inf. (mm)	Infiltration Ir. (mm/hr)
0.25	0.25	6	6	24
0.5	0.25	4.5	1.5	18
0.75	0.25	4	14.5	16
1.0	0.25	3.5	18	14
1.25	0.25	3	21	12
1.5	0.25	3	24	12
1.75	0.25	2.5	26.5	10
2.0	0.25	2	28	8
2.25	0.25	2	30	8
2.5	0.25	2	32	8

Table 8: Observations of infiltration in field of F1 ZT-2018

Time Elapsed in hrs.	Time Interval (hrs)	Infiltration (mm)	Acc. Inf. (mm)	Infiltration Ir. (mm/hr)
0.25	0.25	5.5	5.5	22
0.5	0.25	4	9.5	16
0.75	0.25	3.5	13	14
1.0	0.25	3.0	16	12
1.25	0.25	3.0	19	12
1.5	0.25	2.5	21.5	10
1.75	0.25	2.5	24	10
2.0	0.25	2	26	8
2.25	0.25	2	28	8
2.5	0.25	1.5	29.5	6

Table 9: Observations of infiltration in field of F1 ZT-2019

Time Elapsed in hrs.	Time Interval (hrs)	Infiltration (mm)	Acc. Inf. (mm)	Infiltration Ir. (mm/hr)
0.25	0.25	5.5	5.5	22
0.5	0.25	3.5	9.0	14
0.75	0.25	3	12	12
1.0	0.25	3	15	12
1.25	0.25	2.5	17.5	10
1.5	0.25	2.5	20	10
1.75	0.25	2	22	8
2.0	0.25	2	24	8
2.25	0.25	1.5	25.5	6
2.5	0.25	1.5	27	6

Looking at the tables it has been clear that accumulated infiltration has reduced from 32mm to 27mm in 2.5 hours in three years of study in case of ZT sowing when all other conditions did not vary. Whereas infiltration rate gone down from 24 to 8mm per hour in 2.0 hours in first year, from 22 mm to 6mm in 2.5 hours in second year and from 22mm to 6 mm in only 1.75 hours in third year. It means that average retardation of infiltration rate was 6.4 mm per hour in first year in average, 6.4mm per hour in the second year and 7.111 mm per hour in third year which shows slowing down of infiltration rate but in a very slow manner and shows the compaction affect.

Effect of Compaction on Infiltration Characteristics (CT)

It is clear from table 10, 11, and 12 that in case of CT, accumulated infiltration was 27mm in 2.5 hours with initial infiltration rate from 22mm to 6 mm per hour in first year. In second year accumulated infiltration was 24mm with infiltration rate came down from 20mm to 4 mm in 2.5 hours. While in third year, the accumulated infiltration was only 21 mm in 2.5 hours with infiltration rate coming down from 20 mm to 4mm in just 2.0 hours. It was also revealed that the infiltration rate retardation increased from 6.4 mm per hour to 8 mm per hour.

Table 10: Observation of infiltration in field of F1 CT-2017 (1stYr)

Time Elapsed in hrs.	Time Interval (hrs)	Infiltration (mm)	Acc. Inf. (mm)	Infiltration Ir. (mm/hr)
0.25	0.25	5.5	5.5	22
0.5	0.25	3.5	9	14
0.75	0.25	3	12	12
1.0	0.25	3	15	12
1.25	0.25	2.5	17.5	10
1.5	0.25	2.5	20	1
1.75	0.25	2	22	8
2.0	0.25	2	24	8
2.25	0.25	1.5	25.5	6
2.5	0.25	1.5	27	6

Table 11: Observation of infiltration in field of F1 CT – 2018 (2ndYr)

Time Elapsed in hrs.	Time Interval (hrs)	Infiltration (mm)	Acc. Inf. (mm)	Infiltration Ir. (mm/hr)
0.25	0.25	5	5	20
0.5	0.25	3.5	8.5	14
0.75	0.25	3	11.5	12
1.0	0.25	2.5	14	1
1.25	0.25	2	16	8
1.5	0.25	2	18	8
1.75	0.25	2	20	8
2.0	0.25	1.5	21.5	6
2.25	0.25	1.5	23	6
2.5	0.25	1	24	4

Table 12: Observation of infiltration in field of F1 CT-2019 (3rdYr)

Time Elapsed in hrs.	Time Interval (hrs)	Infiltration (mm)	Acc. Inf. (mm)	Infiltration Ir. (mm/hr)
0.25	0.25	5	5	20
0.5	0.25	3	8	12
0.75	0.25	2.5	10.5	10
1.0	0.25	2.5	13	1
1.25	0.25	2	15	8
1.5	0.25	1.5	16.5	8
1.75	0.25	1.5	18	6
2.0	0.25	1	19	4
2.25	0.25	1	20	4
2.5	0.25	1	21	4

Effect of Compaction on wheat yield (CT)

The experiment was done in selected plot of F1 for CT wheat and the yield data was recorded under similar conditions of all three years through out with parameters as seed rate as 60 kg/acre and irrigations options were common for all three years. The sowing time was also close and adjacent including the harvesting period. Under the condition yield data was calculated by harvesting one square metre area. The table 13 depicted that the yield was 28.22, 27.9 and 27.87 q/ha in first year, second year and third year. This showed that there is a decreasing trend.

Table 13: Experiment for yield for CT

S. No.	CT Experiment Plot of F1 Farmer		
	First Year 2017	**Second Year 2018**	**Third Year 2019**
Date of sowing	2nd December 2016	29th November 2017	28th November 2018
Date of harvesting	12th April 2017	15th April 2018	8th April 2019
Wheat Yield q/ha	28.22	27.90	27.87

Effect of Compaction on wheat yield (ZT)

The experiment was done in selected plot of F1 for ZT wheat and the yield data was recorded under similar conditions of all three years throughout with parameters as seed rate as 40 kg/acre and irrigations options were common for all three years. The sowing time was kept 15th November including the harvesting date almost close to get best result.

Table 14: Experiment for yield for ZT

S. No.	CT Experiment Plot of F1 Farmer		
	First Year 2017	**Second Year 2018**	**Third Year 2019**
Date of sowing	15th November 2016	15th November 2017	15th November 2018
Date of harvesting	12th April 2017	15th April 2018	8th April 2019
Wheat Yield q/ha	34.63	33.92	33.11

Under the condition, yield data was calculated by harvesting one square meter area. The table 14 depicted that the yield was 34.63, 33.92 and 33.11 q/ha in first year, second year and third year. This showed that there was decreasing trend. Again the trend indicated some compaction effect.

Summary and Conclusion

On the basis of the study and experiment done, the following findings could be inferred-

Hard pan prediction model was developed which referred to predict the occurrence of hard pan in due course of time. Since the area under study does not come across with heavy machinery having more than 10 tons weight, the occurrence of hard pan comes at later stage in due course of time. However, precautions should be taken to avoid using heavy machines and also a planned movement of traction vehicle is suggested.

Accumulated infiltration has reduced from 32mm to 27mm in 2.5 hours in three years of study in case of ZT sowing when all other conditions did not vary. Whereas infiltration rate gone down from 24 to 8mm per hour in 2.0 hours in first year, from 22mm to 6mm in 2.5 hours in second year and from 22mm to 6mm in only 1.75 hours in third year. It means that average retardation of infiltration rate was 6.4mm per hour in first year in average, 6.4mm per hour in the second year and 7.111mm per hour in third year which shows slowing down of infiltration rate but in a very slow manner and shows the compaction affect.

In case of CT, accumulated infiltration was 27mm in 2.5 hours with initial infiltration rate from 22 mm to 6mm per hour in first year. In second year accumulated infiltration was 24mm with infiltration rate came down from 20mm to 4 mm in 2.5 hours. While in third year, the accumulated infiltration was only 21mm in 2.5 hours with infiltration rate coming down from 20mm to 4mm in just 2.0 hours. It was also revealed that the infiltration rate retardation increased from 6.4 mm per hour to 8 mm per hour in three years.

The yield data was calculated harvesting one square metre area and it was revealed that the yield was 28.22, 27.9 and 27.87 q/ha in first year, second year and third year in case of CT. This showed that there was a decreasing trend. In case of ZT, the yield was 34.63, 33.92 and 33.11 q/ha in first year, second year and third year. This showed that there was a decreasing trend. Again the trend indicated some compaction effect.

To avoid compaction it was suggested that instead of using duals tires, tandem tires is advised if available. Thus the load is spread over more axles and soil pressure would be reduced without increasing the compacted area. On a four-wheel drive tractor, traction will improve because the rear tires run in a compacted track. Light weight equipment should be used and if required ballast from the tractors should be removed, using smaller tractors for light work and removing ballast when not needed would be good option.

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