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ESTABLISHMENT OF A RICE TILLER NUMBER PREDICTION MODEL USING SOIL COMPACTION AND DAYS AFTER TRANSPLANTING

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ABSTRACT
Soil compaction has a real effect on rice growth in the Mekong Delta. The correlation between soil compaction and rice growth (tiller number and plant height) in a paddy field in An Giang province was evaluated in the 2020 Winter-Spring and Summer-Autumn crops using the Pearson's correlation test. The research results show that soil compaction 0-20 cm from the soil surface has a positive correlation with rice tiller number, while the effect on plant height is non-significant. Therefore, a prediction model for rice tiller numbers is constructed using the Curve Fitting application in Matlab software. The obtained prediction models can effectively predict the number of rice tillers from the value of the 0-20 cm soil layer compaction at times under 40 DAT in the two studied crops. This study provides the optimal value of soil compaction (about 229.8 and 337.6 kPa in these crops), which can aid in the utilization of soil tillage for paddy rice cultivation by farmers.

Contribution/Originality: This paper may be the first to apply Matlab software to construct a prediction model for rice tiller numbers using days after transplanting of rice and soil compaction. The most suitable soil compaction value for the tillering of rice was determined, which will directly benefit farmers.

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1. INTRODUCTION

Rice is Vietnam's main food source and export item. In 2020, Vietnam's rice export was 6.25 million tons, a decrease of about 1.9% compared to 2019. The Ministry of Agriculture and Rural Development forecasted that Vietnam's rice export would be 6.5 million tons in 2021. Rice production is concentrated in the plains; the Mekong Delta produces 50% of the country's rice (Do, 2021). Rice cultivation plays an important role in ensuring the country's food security as well as for export. The cultivation of rice in the Mekong Delta is grouped into three growing seasons (Winter–Spring, Summer–Autumn, and Autumn–Winter). Environmental factors (soil, water, fertilizer, light, etc.) and farming techniques affect the growth and yield of rice (Alvarez-Herrera, Pinzón-Gómez, & Vélez, 2017; Chen, Yang, Ding, Jiang, & Sun, 2021; Chozin & Sudjatmiko, 2015; Kamara, Kamara, & Kamara, 2015; Sasaki, Ando, & Kakuda, 2002; Timotiwu & Dewi, 2014). Of these, tillage to adjust the compaction of topsoil was considered in the current study.

Compaction, which is a physical property of soil, is related to soil bulk density (Thomas et al., 2020) and thereby the growth and yield of rice (Pinheiro, Stone, & Barrigossi, 2016). Soil compaction can be reduced through tillage measures, biochar application, and crop rotation. Tillage is a useful method for improving the physical conditions of paddy soil and the growth and yield of rice. The maximum tiller number and plant height in conventional tillage transplanting have been shown to be higher than that in no-tillage transplanting (Badshah, Naimei, Zou, Ibrahim, & Wang, 2014).

In recent years, the relationships between biochar or fertilizer application, soil properties, and rice growth have been of interest to researchers. Based on the straw management of paddy fields, a recent study by Saothongnoi, Amkha, Inubushi, and Smakgahn (2014) pointed out that soil without rice straw ash or rice straw incorporation has a relation to rice tiller number. A suitable rate of rice straw biochar application to the soil results in increasing plant height and rice tiller number (Kamara et al., 2015). Similarly, Chen et al. (2021) and Paiman and Effendy (2020) reported that the application of biochar to paddy soil has a significant effect on leaf area, plant height, tiller number, and rice yield. A study by Sasaki et al. (2002) in Tsurlloka city, Japan, in 1998 and 1999, showed that the amount of ammonium nitrogen (NH_4^+-N) in a paddy soil layer of 0–10 cm significantly affects the tiller number 20 days after transplanting. According to Khan and Qasim (2007), zinc (Zn) fertilizer content significantly affects plant height, tiller number, spikelet number, 1000-paddy weight, straw yield, and paddy yield of IRRI-6 rice. In particular, the application of 10 kg Zn per hectare is an optimum value for the growth and yield components, as demonstrated with the Least Significant Difference test method. A study by Anggria, Husnain, Sato, and Masunaga (2017) also indicated that the rice height at 36 days after transplanting is significantly affected by the rates of silicon (Si) and phosphorus (P) in the soil. The main stem, early-emerging tillers, and late-emerging tillers of rice are affected by the rate of nitrogen (N) fertilizer application (Wang et al., 2017). According to the results of Alvarez-Herrera et al. (2017), the double sigmoid logistic model is suitable for estimating rice height according to days after emergence and the maximum value of the rice height in time. The level of N and Si in the soil has a significant effect on the tiller number of rice. The rate of N supply significantly affects the grain yield of rice when planted at high and low densities. The rice tiller number increases with an increasing rate of N supply up to a suitable value based on plant density (Tian et al., 2017). The level of Si and manganese (Mn) supply in soil positively impacts the productive tiller number of rice (Timotiwu & Dewi, 2014). The growth and yield of rice planted in swamp soil with water levels ranging from 0 to 20 cm above the soil surface was observed by Chozin and Sudjatmiko (2015). Here, the tiller number, productive tiller number, and grain number per panicle positively affect the grain yield of rice.

Furthermore, a recent study reported that productive tillers per hill increased under increasing seeding spacing for two different soil fertility levels (Wang et al., 2014). However, the rice tiller number is negatively correlated with soil electrical conductivity (Purnomo, Hashidoko, Hasegawa, & Osaki, 2018). Kumar, Quick, Barrios, Cruz, and Dingkuhn (2017) pointed out that an atmospheric CO_2 of 780 ppmv provides good conditions for producing the maximum rice tiller number. Huang et al. (2013) observed that early season and high plant density positively impact the tiller number of black rice. Here, the tiller number was higher in the early season than in the late season, and the maximum tiller number was higher under locally recommended plant density and N rate than under the combination of a reduced plant density and an increased N rate in the early season; however, this pattern was reversed in the late season. The sigmoid logistic model, which was constructed to estimate the rice tiller number according to the maximum value of the rice height in time and days after transplanting was fitted to curves using DPS software. The linear of a multi-polynomial model of tiller number was constructed under the circumference of bunched tillers at 50 and 70 days after seeding (Abu Bakar, Rahman, Teoh, Abdullah, & Ismail, 2018), alternatively, water level from the soil surface and days after transplanting using Table Curve 3D v4.0 software (Hasanah, Setiawan, Arif, & Widodo, 2017). In addition, rice tiller number models have been plotted against thermal time from seedling emergence, the number of leaves on main stem (Martinez-Eixarch, Del Mar Català, Tomàs, Pla, & Zhu, 2015), and area growth rate (Tao et al., 2006) using linear or non-linear regression.

In this study, the relationship between soil compaction and rice growth is observed and studied. Besides that, a polynomial function is created as a prediction model in which days after transplanting of rice and soil compaction are used as input variables to estimate the rice tiller number.

2. MATERIALS AND METHODS

2.1. Experiment

The experiment was conducted from December 2019 to April 2020 (2020 Winter-Spring crop, named WS-crop) and from April to July 2020 (2020 Summer-Autumn crop, named SA-crop) in the same paddy field with an area of 200 x 24 m at Dinh Thanh Agricultural Research Center (10°18'45"N; 105°19'08"E; 1 m), Dinh Thanh Commune, Thoai Son District, An Giang Province.

The variety of experimental rice *(Oryza sativa L.)* was OM18. It was transplanted by machine with a hill and row spacing of 30 x 15 cm.

2.2. Soil Sampling Selection and Compaction Measurements

For each crop, the experimental design was completely randomized (Alvarez-Herrera et al., 2017; Kamara et al., 2015; Paiman & Effendy, 2020; Saothongnoi et al., 2014) with 120 marked samples. To prepare the land for rice cultivation, the paddy field was flooded, plowed, flattened, and drained. The FieldScout SC 900 soil compaction meter was used to measure the soil average compaction data at an interval of 5 cm soil depth from 5–40 cm for all samples (Pinheiro et al., 2016).

The soil compaction of depth 0–20 cm (SC0–20) was averaged from the soil compaction of the depths of 5, 10, 15, and 20 cm, named SC5, SC10, SC15, and SC20, respectively, and rounded to the nearest tens (Table 4 and Table 5).

2.3. Rice Growth Measurements

Rice growth, including rice height and rice tiller number, was measured by sampling from 120 selected points in the WS-crop and the SA-crop and was recorded at 8, 25, 39, and 7, 24, 38 days after transplanting (DAT), named height8D, tillers8D, height25D, tillers25D, height39D, tillers39D, and height7D, tillers7D, height24D, tillers24D, height38D, tillers38D, respectively. The tiller number per square meter was calculated using the average recorded actual rice tiller number (including main stems) of four representative plants at each point (Chen et al., 2021) (Table 1). The plant height was measured from the ground to the tip of the highest leaves (Anggria et al., 2017) and rice tillers with at least three leaves were counted.

2.4. Data Analyses

Data were pre-processed using Microsoft Excel 2016 (Nielsen, 2016). The Pearson correlation coefficient test method (Ghosh & Devi, 2019) was used to compare the means and standard deviations of the compaction of the soil layers and evaluate the correlation between soil compaction and rice growth using SPSS software (Field, 2009).

2.5. Application of Regression Models

The non-linear regression method was used to construct the prediction model of rice tiller number for the collected data by using the Curve Fitting application in Matlab software (Zielesny, 2011). Rice tiller numbers from other collected data sets were used to add the DAT variable to the model. The mathematical model is a function that varies with the SC0–20 of the following form:

$$y = f(x,t) \quad (1)$$

where y is rice tiller number (/ m^2), x is the SC0–20 (kPa), and t is the DAT (day).

3. RESULTS AND DISCUSSION

3.1. Statistical Analyses of Soil Compaction and Rice Growth

The results of the statistical analyses of soil compaction are shown in Figure 1. The compaction value increases slightly in the lower 5–10 and 30–40 cm and increases rapidly in the 10–30 cm layer. This finding is similar to the result of the study by Pinheiro et al. (2016), where soil compaction with/without subsoiling was shown to increase from 2.755–3.46/3.674–4.108 kPa due to increasing soil depth (0–40 cm).

The means and standard deviations of rice growth in the WS-crop and the SA-crop are shown in the left and right half of Table 1, respectively. The mean values of the tiller number and the rice height in the three data collections of the WS/SA-crop all increased along with the DAT; specifically, these were 125.55/123, 348.15/299.4, 482.4/436.05, and 21.54/21.3, 48.65/59.33, 64.95/74.68, respectively. There was also an insignificant difference between the mean values of the WS-crop and SA-crop. The standard deviation of the tiller number was very high; however, for the rice height, it was low.

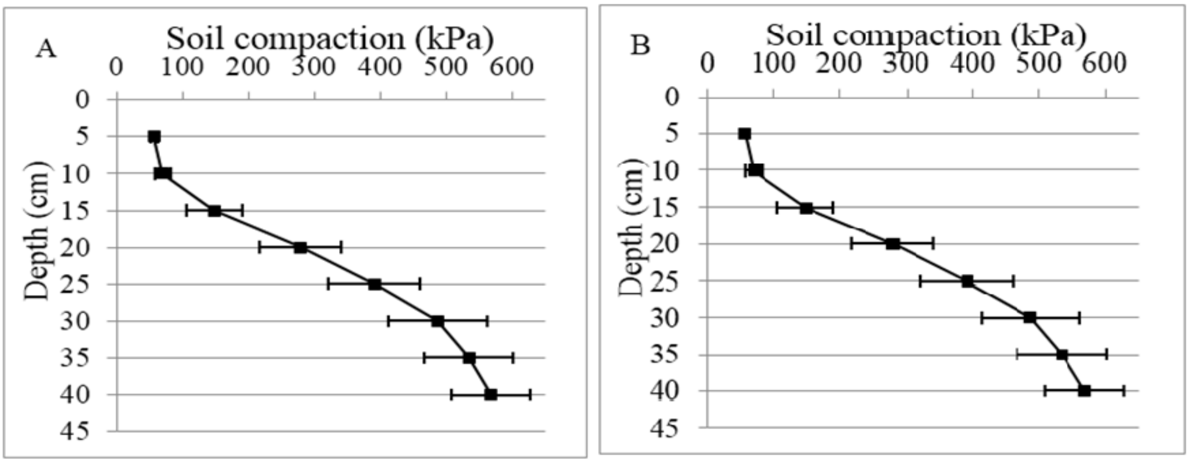

Figure 1. Soil compaction in the WS-crop (A) and the SA-crop (B).

Table 1. The means and standard deviations of rice growth in the WS-crop and SA-crop.

WS-Crop	Mean	Std. Deviation	SA-crop	Mean	Std. Deviation
Tillers8D (/m^2)	125.55	60.11	Tillers7D (/m^2)	123	48.91
Tillers25D (/m^2)	348.15	125.61	Tillers24D (/m^2)	299.4	119.08
Tillers39D (/m^2)	482.4	173.38	Tillers38D (/m^2)	436.05	114.12
Height8D (cm)	21.54	2.62	Height7D (cm)	21.3	3.65
Height25D (cm)	48.65	4.4	Height24D (cm)	59.33	6.31
Height39D (cm)	64.95	4.75	Height38D (cm)	74.68	8.5

3.2. The Effect of Soil Compaction on Rice Growth

The degree of association between the collected data of the WS-crop and the SA-crop was analyzed using the Pearson correlation coefficient test, as shown in Table 2 and Table 3.

Table 2 illustrates that at a 1% significance level, there are significant positive correlations between the SC15, SC20, SC25, SC0–20, and the tillers25D/tillers39D with correlation coefficients of 0.248/0.371, 0.282/0.405, 0.254/0.268, 0.288/0.431 (the highest correlation coefficients), as well as a positive correlation between SC10, SC30 and the tillers39D. A significant negative correlation with correlation coefficients of 0.287, 0.28, and 0.286 was found between SC20, SC25, SC0–20, and the height8D. Meanwhile, none of the soil compaction values correlate with tillers8D, height25D, and height39D.

As can be seen in Table 3, the compaction of the soil layers at 10, 15, 20, and 0–20 cm were positively correlated with tillers24D and tillers38D at a 1% significance level with correlation coefficients of 0.281, 0.333, 0.333, 0.377 and 0.247, 0.271, 0.269, 0.306, respectively. There was a negative correlation at a 1% significance level with low coefficients (0.276/0.257) between the soil compaction of the soil layers 10/0–20 cm and the height38D.

Table 2. The correlation between soil compaction and rice growth in the WS-crop (n=120).

Item	Tillers8D (/m²)	Tillers25D (/m²)	Tillers39D (/m²)	Height8D (cm)	Height25D (cm)	Height39D (cm)
SC5 (kPa)	0.038	0.165	0.179*	-0.137	-0.004	-0.096
SC10 (kPa)	0.095	0.136	0.248**	-0.172	-0.069	-0.060
SC15 (kPa)	0.045	0.248**	0.371**	-0.231*	-0.051	-0.092
SC20 (kPa)	0.074	0.282**	0.405**	-0.287**	-0.126	-0.108
SC25 (kPa)	0.063	0.254**	0.268**	-0.280**	-0.057	-0.165
SC30 (kPa)	0.061	0.190*	0.263**	-0.203*	0.024	-0.048
SC35 (kPa)	0.027	0.139	0.152	-0.110	0.056	-0.064
SC40 (kPa)	0.050	0.119	0.118	-0.146	0.050	-0.072
SC0–20 (kPa)	0.075	0.288**	0.431**	-0.286**	-0.099	-0.108

Note: *,**. Correlation is significant at the 0.05, 0.01 level (2-tailed).

Table 3. The correlation between soil compaction and rice growth in the SA-crop (n=120).

Item	Tillers7D (/m²)	Tillers24D (/m²)	Tillers38D (/m²)	Height7D (cm)	Height24D (cm)	Height38D (cm)
SC5 (kPa)	0.067	0.065	0.033	0.033	-0.042	-0.078
SC10 (kPa)	-0.040	0.281**	0.247**	0.111	-0.136	-0.276**
SC15 (kPa)	-0.075	0.333**	0.271**	0.088	-0.189*	-0.206*
SC20 (kPa)	-0.040	0.333**	0.269**	0.012	-0.132	-0.202*
SC25 (kPa)	-0.026	0.202*	0.196*	0.065	-0.047	-0.105
SC30 (kPa)	-0.015	0.111	0.144	0.056	-0.046	-0.074
SC35 (kPa)	-0.027	0.057	0.097	-0.021	-0.059	-0.076
SC40 (kPa)	-0.038	0.094	0.136	-0.055	-0.072	-0.097
SC0–20 (kPa)	-0.061	0.377**	0.306**	0.064	-0.178	-0.257**

Note: *,**. Correlation is significant at the 0.05, 0.01 level (2-tailed).

Table 4. Statistical analyses of average rice growth according to SC0–20 in the WS-crop.

Sample number (percentage (%))	Compaction of 0–20 cm soil layer (kPa)	Tillers 8D (/m²)	Tillers 25D (/m²)	Tillers 39D (/m²)	Height8D (cm)	Height25D (cm)	Height39D (cm)
1 (0.83)	60	72	288	324	19.5	41	60
8 (6.67)	70	92.25	292.5	416.25	22.12	48.62	68.25
11 (9.17)	80	140.73	345.27	427.09	24.09	52.55	66.45
10 (8.33)	90	127.8	351	451.8	22.95	49.05	67
11 (9.17)	100	160.36	279.82	384.55	21.59	49.41	61.55
10 (8.33)	110	97.2	282.6	399.6	20.75	46.5	65.3
3 (2.5)	120	114	324	426	23	52.67	64.67
7 (5.83)	130	110.57	303.43	385.71	21.43	46.86	63.43
9 (7.5)	140	126	346	452	21.89	47.72	66.78
7 (5.83)	150	102.86	360	506.57	20.57	46.64	63.43
8 (6.67)	160	137.25	357.75	519.75	21.75	47.88	65.38
5 (4.17)	170	129.6	370.8	579.6	21.7	49	64
7 (5.83)	180	144	416.57	637.71	18.64	48.5	64.29
5 (4.17)	190	104.4	374.4	478.8	20.6	51.4	65.4
3 (2.5)	200	126	432	672	21.33	49.83	62.67
5 (4.17)	210	108	525.6	658.8	20.8	48.9	64
2 (1.67)	220	162	432	594	18.75	46.25	59
2 (1.67)	240	180	333	585	21	47	69.5
3 (2.5)	250	138	432	606	20.83	49.67	66.33
2 (1.67)	260	180	351	621	19.25	43	64
1 (0.83)	280	72	252	558	25	50	62

3.3. Establishment of Prediction Models for the Number of Rice Tillers

The compaction of the soil layer is selected as the input parameter for the mathematical models to predict the number of rice tillers. Rounded to the nearest tens of SC0–20, the statistical analyses of rice growth according to SC0–20 in the WS-crop and the SA-crop are shown in Table 4 and Table 5, respectively. It can be seen that the values of rice tiller number and plant height significantly and insignificantly differed among the 120 samples for each crop. The values of tillers8D/tillers7D, tillers25D/tillers24D, and tillers39D/tillers38D ranged between 72/99 and 180/156, 252/234 and 525.6/486, and 324/356.4 and 672/558 tillers/m². The height8D/height7D, height25D/height24D, and height39D/height38D values ranged from 18.64/17.28 to 25/24.98, 41/51.5 to 52.67/64, and 59/61 to 69.5/89.67 cm. In general, as soil compaction increased, the rice tiller number increased, at the cost of a slight decrease in plant height.

Table 5. Statistical analyses of average rice growth according to SC0–20 in the SA-crop.

Sample number (percentage (%))	Compaction of 0–20 cm soil layer (kPa)	Tillers 7D (/m²)	Tillers 24D (/m²)	Tillers 38D (/m²)	Height7D (cm)	Height24D (cm)	Height38D (cm)
6 (5)	90	150	252	408	17.28	58.67	72.5
3 (2.5)	100	156	306	426	22.9	63.67	78
3 (2.5)	110	126	258	450	21.5	60.33	76.33
4 (3.33)	120	112.5	234	369	22.25	60.75	75.5
3 (2.5)	130	126	240	408	23.23	64	89.67
3 (2.5)	140	162	288	450	20.77	61	78.33
12 (10)	150	102	259.5	397.5	20.22	60.33	76.25
4 (3.33)	160	108	247.5	409.5	21.48	63	79
12 (10)	170	123	271.5	408	22.18	58.58	74.17
3 (2.5)	180	102	270	360	19.17	57.67	70.67
11 (9.17)	190	134.18	279.82	418.91	22.12	60.09	76.91
5 (4.17)	200	100.8	241.2	356.4	24.98	55.2	70.4
8 (6.67)	210	119.25	274.5	407.25	20.42	60.62	76.88
3 (2.5)	220	162	312	486	22.43	60	76
3 (2.5)	230	132	312	456	21.6	61.33	75
8 (6.67)	240	112.5	342	470.25	21.54	62	78.5
11 (9.17)	250	116.18	348.55	479.45	20.28	55	70.82
6 (5)	260	123	375	504	21.67	57	69.5
3 (2.5)	270	156	372	516	23.17	62	73.67
3 (2.5)	280	132	432	558	21.47	59.33	72.67
2 (1.67)	300	99	378	504	19.6	51.5	67
1 (0.83)	320	126	486	558	21.2	58	65
1 (0.83)	340	108	450	558	19.8	56	61
2 (1.67)	360	117	378	468	21.05	57.5	67.5

According to the results shown in Table 2 and Table 3, the SC0–20 had a strong correlation with the number of rice tillers in the two crops' third data collection point. Traditional mathematical models were utilized to evaluate the suitability of the prediction models for the number of rice tillers in the WS-crop and the SA-crop at the third data collection point, as shown in Equation 2 and Equation 4. Non-linear regression methods were used (Zhang & Ordóñez, 2012) with the application of the Curve Fitting Tool in Matlab software (Zielesny, 2011). The coefficients of the model were determined using the Levenberg-Marquardt optimization algorithm. The coefficients of the rice tiller number prediction models are presented in Table 6. The correlation coefficient (R^2) and the Mean Absolute Error (RMSE) values of the y_{WS} and y_{SA} established models for two crops were 0.9751, 14.59 and 0.9666, 9.084, respectively. It can be noted that the R^2 values were high and the RMSE values were low, indicating a good fit for the two y_{WS}, y_{SA} models. Data collected at the first and second data collection points (8/7 and 25/24 DAT) were used to build the part of the model that changes according to the DAT, as shown in Equation 3 and Equation 5.

$$y_{WSt3} = a_1x^3 + b_1x^2 + c_1x + d_1 \quad (2)$$

$$y_{WS} = (a_1x^3 + b_1x^2 + c_1x + d_1)(0.987-(0.000987(39-t)))^{(39-t)} \quad (3)$$

$$y_{SAt3} = a_2x^3 + b_2x^2 + c_2x + d_2 \quad (4)$$

$$y_{SA} = (a_2x^3 + b_2x^2 + c_2x + d_2)(0.987-(0.000987(38-t)))^{(38-t)} \quad (5)$$

Where y_{WSt3}, y_{WS} and y_{SAt3}, y_{SA} are the number of rice tillers (tillers / m²) in the WS-crop and the SA-crop at the third data collection point (39/38 DAT), any time of data collection; *a*, *b*, *c*, and *d* are the coefficients of functions; *x* is the SC0–20 (kPa); and *t* is the DAT (day).

Table 6. Regression results of the rice tiller number prediction models at the third data collection point.

Model	a	b	c	d	R²	RMSE
y_{WS}	-0.000261	0.1291	-18.01	1166	0.9751	14.59
y_{SA}	-3.715e-05	0.02665	-5.291	716.8	0.9666	9.084

Having established the prediction models, the estimated values of the number of rice tillers in the WS-crop and the SA-crop are shown in Figure 2 and Figure 3. These values tend to increase according to a polynomial pattern with the increase in measured SC0–20 for the two crops. Namely, after slowly decreasing, the number of rice tillers in the WS-crop and the SA-crop steadily increased in the case of the SC0–20 in the range from 100 to 230 and 150 to 340 kPa; after reaching the peak, it rapidly or slightly declined for the WS-crop or SA-crop, respectively. Meanwhile, high or low compaction of the 0–20 cm soil layer had a negative effect on the tillering of rice.

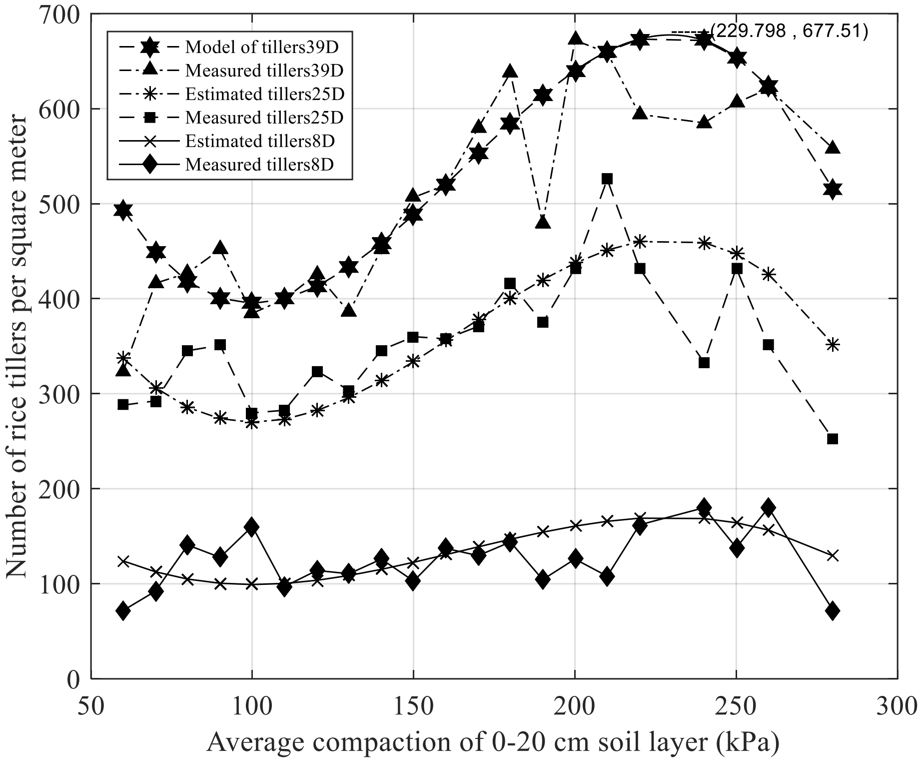

Figure 2. The rice tiller number in the WS-crop.

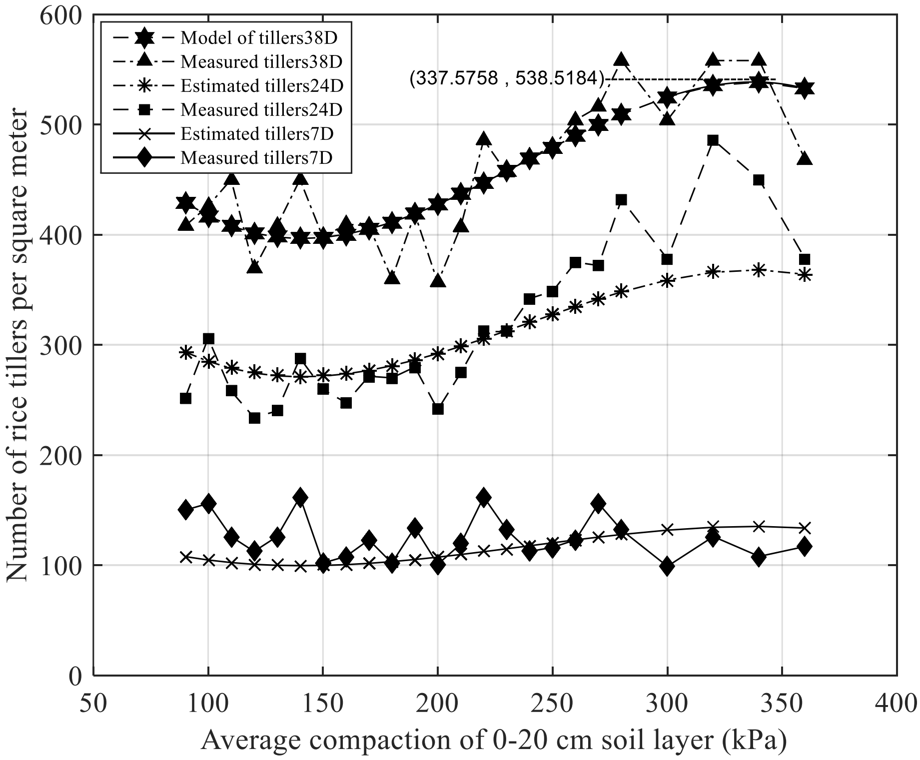

Figure 3. The rice tiller number in the SA-crop.

The graphs of the number of rice tillers at the three data collection points are similar for both the WS-crop and the SA-crop. This was the basis for including a date-variable component into each model Equation 2 and Equation 4, resulting in Equation 3 and Equation 5. It means that the number of rice tillers at previous times is equal to the number of rice tillers at 39/38 DAT multiplied by the value of this component. The value of this component is a factor that varies and gradually increases from 0.25111 to 1 during the period from 8/7 to 39/38 DAT. The results of calculating the rice tiller numbers using the models of this study, which were consistent with the results of some of the above-mentioned studies, were a gradual increase in numbers during the vegetative phase of rice. The number of rice tillers increased rapidly at the tillering stage until it reached a peak between 35 and 42 DAT, after which it decreased slightly and remained stable after the late tillering stage (Chen et al., 2021; Wang et al., 2014).

The polynomial models were best fitted to the relationship between soil compaction and rice tiller numbers and showed significant direct relationships in both the WS-crop and the SA-crop (R^2 equal to 0.9751 and 0.9666), as shown in Table 6. The RMSE and Mean Absolute Error (MAE) values of the differences between all expected and predicted values using prediction models Equation 3 and Equation 5 are presented in Table 7. The MAE of the y_{WS} and y_{SA} models at 8/7 and 25/24 DAT were 23.7164/17.1676 and 31.9711/23.5617 (19.21/12.87 and 9.07/7.81% of the mean of the actual rice tiller numbers), respectively. In addition, Table 6 and Table 7 show that the RMSE value between the estimated and measured rice tiller numbers in the WS-crop/SA-crop at 8/7, 25/24, and 39/38 DAT was 30.7289/23.3672, 42.8667/30.4656, and 14.59/9.084. These results illustrate that the values of the regression models were a good fit with the measured rice tiller data at the selected time of model building (39/38 DAT), while at previous times (25/24 and 8/7 DAT), the model's compatibility with the true values gradually decreased. Therefore, the y_{WS} and y_{SA} polynomial models were reliable.

Table 7. The RMSE and MAE values of rice tiller number prediction models at the first and second data collection points.

Model	RMSE	MAE	MAE / actual rice tiller number average (%)
y_{WSt1}	30.7289	23.7164	19.21
y_{WSt2}	42.8667	31.9711	9.07
y_{SAt1}	23.3672	17.1676	12.87
y_{SAt2}	30.4656	23.5617	7.81

Across Equation 3 and Equation 5, the highest rice tiller numbers of the WS-crop and SA-crop are about 678 and 539 tillers under 229.8 and 337.6 kPa of the SC0–20 values. It can be seen that the SC0–20 value of the WS-crop was lower than that of the SA-crop, whereas the highest rice tiller number of the WS-crop was higher than that of the SA-crop. This can be explained by the fact that the lowland was flooded with silt from major rivers about 2 months before the WS-crop, while this was not the case for the SA-crop. It can be seen that a soil compaction value about 70% higher than the mean is the most suitable for the tillering of rice.

4. CONCLUSIONS

The soil compaction SC0–20 was positively and closely correlated with rice tiller number; however, it did not greatly affect the height of rice. The rice tiller number prediction models were established using polynomial regression methods for the WS-crop and SA-crop of 2020. They proved to be reliable and suitable models for predicting rice tiller numbers based on the SC0–20 from the surface and for times under 40 DAT. Rice tillered well when the SC0–20 was about 239.8 and 337.6 kPa.

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