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The Effect of Weather Parameters on Yield Performance of Some Aromatic Rice Cultivars (*Oryza sativa* L.) of Manipur

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ABSTRACT

Background: The primary objective of the study was to find out the effect of Weather parameters on the *Chakhao* production. Reports postulated that crop productivity is impacted by agricultural practises rather than climate. However, yield is very much dependent on environmental and cultural conditions which are less studied and not yet defined. Since *Chakhao* is traditionally a low yielding crop of Manipur. Despite of being their great values in nutrition, medicinally and economically, the farmers of Manipur neglect the cultivation of the black scented rice in large scale due its low yield. Thus, the current study was taken to have a better understanding of the growth and yield with effect to weather parameters of the three *Chakhao* cultivars *viz.* Poireiton, Amubi, Angouba.

Methods: The present investigation was conducted to study the effect of various weather parameters on growth and yield of black scented and aromatic rice cultivars of Manipur. During this study, three local rice cultivars of Manipur was cultivated in *kharif* crop season (June -July to November-December) during the year 2019, 2020 and 2021 at PDDUIAS, Research farm of Utlou, Manipur. The experimental field is located at 24°43′78″N Latitude, 93°51′60″E Longitude and the elevation or altitude of 2513 feet above mean sea level. During these experiments different major growth stages were recorded, while all other input parameters were kept constant. For this study the spacing adopted was 25 cm × 25 cm. After harvesting, the agro-morphological characters compared to analyse the effect of weather parameters were Temperature, Relative Humidity, Rainfall and Wind speed for the period of 3 years *i.e.*, 2019, 2020, 2021.

Result: It was observed that the rice variety Chakhao Angouba resulted the highest yield followed by Chakhao Poireiton and Chakhao Amubi. The correlation between weather parameters and agro-morphological growth and yield related parameters were estimated by Pearson correlation coefficient and degree of dependencies of these agro-morphological parameters on weather parameters were analysed by using linear regression analysis. All the yield attributing characters *i.e.,* number of panicles per plant, number of grains per panicle and 1000 grain weight (g) were taken but they do not showed significant correlation except average rainfall and the number of leaves.

Key words: Chakhao Amubi, Chakhao Angouba, Chakhao Poireiton, Correlation, Crop-weather relations, Growth parameter, Yield, Variety.

INTRODUCTION

Manipur's specialty glutinous rice, known as *Chakhao* or aromatic rice, recently received protection under India's geographical indication law. *Chakhao*, which translates to "delicious rice" in Manipuri comprises a number of lesser-known landraces with either pigmented (black, amubi) or non-pigmented (white, angouba) rice kernels. Commonly, *Chakhao* cultivar is a type of Manipur rice with purple pericarp colour (other than white and red) and is usually known as "Black rice". This type of the rice species belongs to *Oryza sativa* L. (Abdel *et al.,* 2006). Rice (*Oryza sativa L.*) is very sensitive to growing conditions and it requires specific climatic circumstances. We must thus determine the relationships between the magnitude of yield changes and the environmental factors that affect the crop growth season. Thus, the primary objective of the study was to find out the effect of Weather parameters on the *Chakhao* production. Crop productivity is reportedly impacted by agricultural practises rather than climate (Dela Cruz and Khush, 2002). However, yield is very much dependent on environmental and cultural conditions which are less studied and not yet defined. Since *Chakhao* is traditionally a low yielding crop. Despite of being their great values in nutrition, medicinally and economically, the farmers of Manipur neglect the cultivation of the black scented rice due its low yield. Thus, the current study was taken to have a better

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understanding of the growth and yield with effect to weather parameters of the three *Chakhao* cultivars (Poireiton, Amubi, Angouba). As well as the present study would let understand the growth and yield of the concerned rice cultivars, which would make easier the exploration of black scented and aromatic rice cultivars and furthermore, the inclusion of the black scented rice in the crop improvement program. Therefore, a study to understand the influence of weather parameters on *Chakhao* cultivars production is very useful not only to the farmers (technology adopters) but also to the scientists (technology generators). The agricultural extension workers can also improve the rate of diffusion of technology through timely advice.

MATERIALS AND METHODS

A study was conducted to evaluate the effect of weather parameters on growth and yield of black scented rice (*Oryza sativa* L.) and scented rice cultivars of Manipur during kharif, 2019, 2020 and 2021 at the School of Agriculture, Pandit Dayal Upadhyay Institute of Agricultural Sciences, Utlou, Bishnupur District Manipur (India).The size of the experimental field is 0.125 ha., 130 ft. in length and 41 ft. in breadth. Accordingly crop plantation harvest was done during June to December. The study comprised of 3 cultivars of chakhao poireiton, chakhao angouba and chakhao amubi in randomized block design (RBD) model. The following growth characters of the rice plants were recorded plant height (in cm), number of tillers per hill, number of leaves per plant. The primary data on the weather parameters for the period 2019, 2020, 2021 (3 years) were collected from the Automatic weather station of Agricultural Research Station, PDDUIAS, Utlou, Bishnupur District.The data was subjected for statistical analysis and coefficient of correlation (r) by using Pearson's coefficient and linear regression analysis. Yield and yield attributes are considered as dependent variables and growth and agro meteorological indices are considered as independent variables.

The weekly weather variable and the average temperature, average rainfall, average relative humidity, average wind speed for the year 2019, 2020, are presented in the Table 1-3, Fig 1-4 respectively.

RESULTS AND DISCUSSION

(i) Correlation studies

The correlation analysis with weather parameters and growth parameters with yield for Amubi indicate that there is a non-significant relation between the mat 5% level of significance except for the weather parameter *i.e.* average temperature with number of leaves with correlation coefficient value (r) of 0.9868 Regression analysis with average temp. (Independent variable) and no of leaves (dependent variable) indicates R^2 value of 0.993 implying that the average temperature accounts for nearly 96% of variation. (Fig 1) average relative humidity and no. of tillers value of (r) of 0.9501 regression analysis indicating R^2 value of 90.27% of variation (Fig 2) average rainfall and no. of tillers value of (r) of 0.9976 regression analysis indicating R^2 value of 99.5% of variation. (Fig 3), Average wind speed and plant height with correlation coefficient value (r) value of 0.9830 Regression analysis with average temp. (Independent variable) and no of leaves (dependent variable) indicates R2 value of 96.63% of variation (Fig 4) Average wind speed and 1000 Grain Weight value of (r) of

Table 1: Weekly weather variable for July to December, 2019, PDDUIAS, Utlou, Research Farm, Automatic Weather Station.

No. of week	Avg. max. temp. (°C)	Avg. min. temp (°C)	Avg. rh-i (%)	Avg.rh- ii (%)	Avg.ws (km/h)	Avg.rf (mm)
1	30.9	21.6	98	61	5.92	7.08
2	31.8	22.6	96	64	5.24	8
3	32.9	21.9	96	56	5.18	2.02
4	31.1	22	98	62	4.56	0.88
5	30.7	21.5	99	62	4.62	0.62
6	32.1	22.3	97	57	6.13	1.02
7	29.9	22.1	99	73	4.12	11.57
8	31.3	20.9	98	60	3.95	4.51
9	31	20.2	98	63	3.9	7.71
10	29.1	20.3	98	59	3.58	4.48
11	29	20.3	98	59	3.65	1.51
12	30.2	18.5	98	56	3.11	0.28
13	29.6	17.8	99	55	3.72	1.22
14	28.9	18.7	99	53	2.79	7.1
15	28.3	14.4	98	53	1.86	0
16	27.2	13.3	99	47	2.75	3.4
17	26.2	10.2	98	38	2.94	0
18	24	9.3	99	53	2.78	0.02

0.9981 regression analysis indicating R^2 value of 99.64% of variation (Fig 5).

ii) Regression analysis

The regression analysis between weather parameters and growth parameters including yield for three cultivars of aromatic rice *viz*. Chakhao Amubi, Chakhao Angouba and Chakhao Poireiton are presented below under the following heads.

Average temperature and no. of leaves (Fig 5)

It shows that the correlation analysis between Average temperature and number leaves resulted with a correlation coefficient of 0.993 (Table; 4, 5 and 6) showing a strong positive correlation between them but the study does not provide enough evidence to show that there is statistically significance at 5% level. The result show R-square of 96.3%

Table 2: Weekly weather variables for July to December 2020, PDDUIAS, Utlou, Research Farm, Automatic Weather Station.

No. of week	Avg. max. temp. (°C)	Avg. min. temp (°C)	Avg. RH-I (%)	Avg. RH-II (%)	Avg. WS (km/h)	Avg. RF (mm)
1	31.4	22.3	97	74	2.53	5.61
2	32.7	24.1	96	66	2.53	7
3	30.1	22.7	98	75	2.1	13.42
4	29.5	21.6	98	73	1.96	1.25
5	30.4	22.3	97	70	1.84	0.6
6	31.1	21.2	98	66	2.18	3
7	30.9	22.3	97	74	1.75	2.45
8	31.9	21.5	97	64	2.76	0.45
9	29.4	22	98	76	2.18	15.6
10	30	22.4	97	71	1.76	1.51
11	31.2	21.1	98	65	1.33	3.94
12	31.2	20.2	97	53	1.26	2.74
13	27.4	20	99	80	1.97	9.17
14	27.9	12.4	98	56	1.89	0
15	27.4	12.4	97	56	1.2	0
16	24.4	9.7	97	54	1.85	0
17	25.6	9.6	97	50	0.91	0
18	24.3	8.2	97	44	1.2	0

Table 3: Weekly weather variables for July to December 2021, PDDUIAS, Utlou, Research Farm, Automatic Weather Station.

No. of week	Avg. max. temp. (°C)	Avg. min. temp (°C)	Avg. RH-I (%)	Avg. RH-II (%)	Avg. WS (km/h)	Avg. RF (mm)
1	29.5	22.1	99	77	3	8.71
2	30.4	22.4	98	70	4.09	1.31
3	29.5	29.5	97	72	2.3	0.22
4	28.6	21.8	99	75	2.74	3.54
5	30.4	22.5	98	74	2.29	1.6
6	30.9	22.2	98	77	2.71	0.37
7	30.3	21.4	96	78	3.3	0.25
8	30.3	21.5	99	71	2.6	5.14
9	30.1	21.2	99	70	14.14	1.91
10	30.6	21.6	98	68	2.12	0.02
11	31.6	20.8	99	67	2.01	0.14
12	32.7	20.5	98	58	2.55	0
13	30.1	15.2	99	62	2.24	6.57
14	28.2	16.7	99	67	2.01	0.53
15	27.7	14.6	97	71	2.08	0
16	27.4	13.7	99	72	2.52	0.6
17	26	10.2	98	66	2.11	0
18	24.8	9.9	98	67	1.82	0.02

variation and R value of 0.993 meaning average temperature explains R-value of chakhao Amubi number of leaves with regression equation:

$$Y = a + b \times X \text{ (Average temperature)}$$

$$Y = 4.7292 + 79.282 \text{ X } 23.29$$

$$Y = 1,851.20$$

Average relative humidity and no. of tillers (Fig 6)

The correlation analysis between average Relative Humidity and no. of tillers resulted with a correlation co-efficient of -0.950 (Table; 4,5 and 6) showing negative correlation between them. The result show R- square of 90.27% and R-value of 0.9501 indicating that the Relative Humidity accounts for only 90.27% with no. of tillers in chakhao Amubi yield. R-value x 100% of chakhao Amubi plant height with regression equation:

$$Y = a+b \text{ x } X \text{ (Average Relative Humidity)}$$

$$Y = 0.4667+48.464 \text{ x } 83.74$$

$$Y = 4,097.45$$

Average rainfall and no. of tillers (Fig 7)

The correlation analysis between average rainfall and no. of tillers resulted with a correlation co-efficient of -0.998 (Table; 4,5 and 6) showing negative correlation between them. The result show R-square of 99.5% and R-value of 0.9976 indicating that average Rainfall accounts for 99.5% with tillers in Chakhao Amubi yield. R-value $\times$ 100% of Average rainfall and no. of tillers with regression equation:

$$Y = a + b \times X \text{ (Average Relative Humidity)}$$

$$Y = 1267+17.596 \times 7.89$$

$$Y = 10135.46$$

Average windspeed and plant height (Fig 8)

The correlation analysis between average windspeed and plant height resulted with correlation coefficient of -0.279 (Table 4,5 and 6) showing negative correlation between them. The result show R- square of 99.28% and R-value of 0.9962 indicating that Average windspeed and plant height accounts for only 99.28% variation in chakhao Amubi yield.

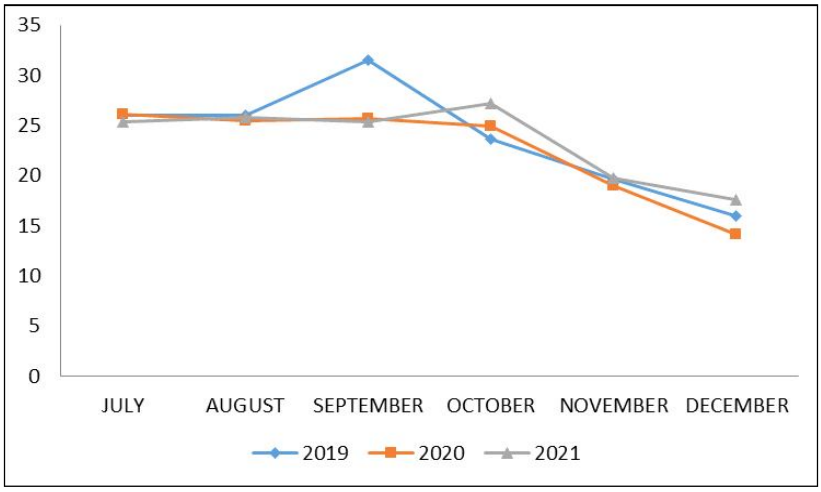

Fig 1: Average temperature for the year 2019, 2020 and 2021.

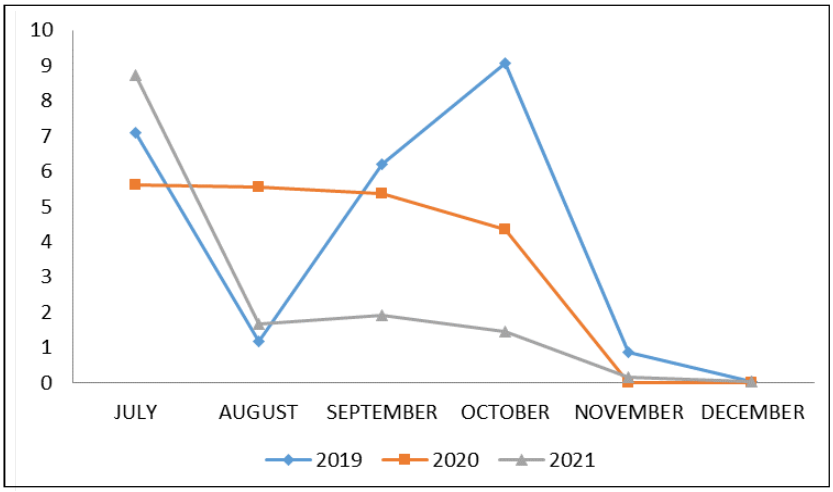

Fig 2: Average rainfall for the year 2019, 2020 and 2021.

R-value X 100% of average windspeed and plant height with regression equation:

$$Y = a+b \times X \text{ (Average relative humidity)}$$

$$Y = 6.3171+137.1 \times 2.71$$

$$Y = 377.58$$

Average windspeed and 1000 grain weight (Fig 9)

The correlation analysis between average windspeed and 1000 grain weight resulted with a correlation co-efficient of -0.780 (Table; 4,5 and 6) showing negative correlation between them. The result show R-square of 99.64% and R-value of 0.9981 indicating the average wind speed and 1000 grain weight accounts for 99.64% variation with 1000 grain weight in chakhao Angouba yield.

The effect of weather parameters on growth and yieldof *Chakhao* Poireiton and *Chakhao* Amubi and *Chakhao* Agouba. Association of grains per panicle with meteorological factors from the simple correlation coefficient it was evident that the relative humidity and

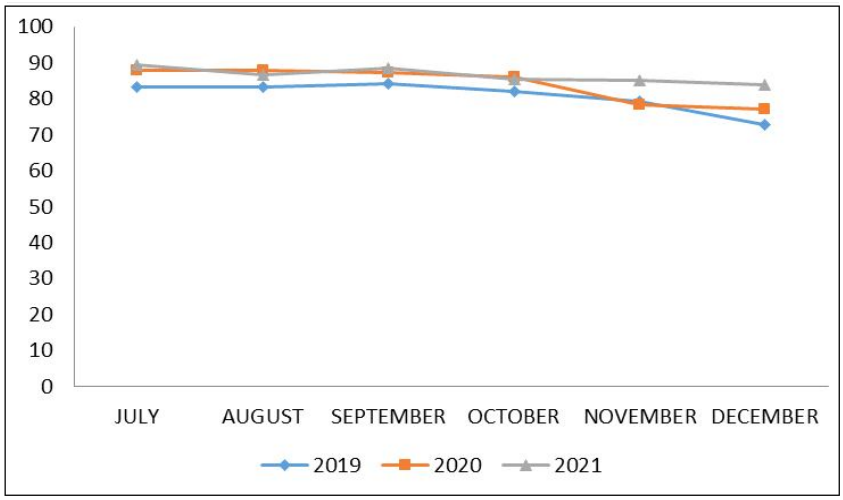

Fig 3: Average relative humidity for the year 2019, 2020 and 2021.

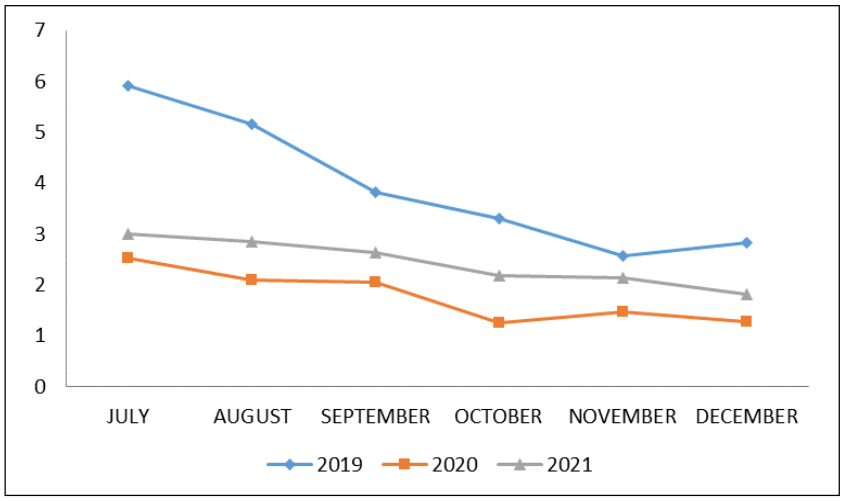

Fig 4: Average windspeed for the year 2019, 2020 and 2021.

Table 4: Pearson correlation coefficient for weather parameters and growth and yeild for chakhaoamubi.

Weather parameters	P. H	No. Til	No. L	L. Pan	No. Pan	Tgw	Yield
Avg. Temp. (°C)	-0.996	0.240	0.993	0.264	-0.264	-0.442	-0.473
Avg. RF. (Mm)	-0.72	-0.998	-0.414	0.691	0.691	0.512	0.482
Avg. RH. (%)	0.472	-0.950	-0.040	0.972	0.972	0.512	0.482
Avg. WS (Km/Hr)	-0.279	0.789	-0.299	0.480	0.480	-0.780	-0.948

*Significant at 5%.

All are non-significant as there is no significantly positive correlated with the R value of nearly 1.00.

average temperature is the main factor that had high significant positive association with *chakhao* grain number/panicle during reproductive as well as ripening stage. Close association between spikelet production and solar radiation during three weeks before and four weeks after heading. Lower grain number under shaded conditions can be attributed to the degeneration of spikelets induced by low solar radiation (Matsushima, 1966). Results obtained from the present investigation also corroborate the findings of several other workers (Matsushima, 1957); (Togari and Kashiwakura, 1958); (Wada, 1969); (Murty and Venkateswarlu, 1975); (Sahu and Murty 1976); (Yoshida and Parao 1976). A negative association of relative humidity and rainfall with grain number/panicle was apparent during both reproductive and ripening stages. However, partial correlation coefficients (Table; 4,5 and 6) indicate that relative humidity, rainfall and maximum temperature also have no direct influence on grains/panicle. From the foregoing discussion it is evident that under high temperature the number of grains/ panicle is not affected. This may be due to the formation of higher number of spikelets/panicle or no degeneration of more number of spikelets or both (Matsushima, 1966). Stansel *et al*. (1965) reported that the crop shaded during the ripening period had a low percentage of filled grains not because of increased sterility but because of increased partially filled grains.

Table 5: Pearson correaltion coefficient of weather parameters and growth and yeild for chakhao Angouba.

Weather parameters	P.H	No. Til	No. L	L. Pan	No. Pan	TGW	Yield
Avgtemp	-0.138	-0.999	-0.807	0.247	-0.264	-0.682	-0.138
Avg RF	0.138	0.100	0.635	-0.564	0.564	-0.682	-0.892
Avg RH	0.771	-0.751	-0.259	0.205	0.205	0,266	-0.082
Avg WS	-0.279	-0.931	-0.977	-0.233	0.233	-0.780	-0.948

*Significant at 5%.

All are non-significant only average temp.and no of tillers is significantly positive correlated with the r value of nearly 1.00.

Table 6: Pearsonco-rrelationco-efficient of weather parameters and growth and yeild parameters for chakhao Poireiton.

Weather parameters	P. H	No. Til	No. L	L. Pan	No. Pan	TGW	Yield
Avg. Temp (°C)	0.801	0.976	0.968	-0.839	0.999*	-0.976	-0.917
Avg. RF (Mm)	-0.533	0.866	0.882	0.531	-0.36	0.262	0.441
Avg. RH (%)	-0.138	0.866	0.882	0.999*	-0.117	-0.304	-0.117
Avg. WS (Km/H)	-0.279	-0.866	-0.882	-0.929	0.990	-0.996	-0.960

*Significant at 5%.

All are non significant only average temp. And length of panicle is significantly positive correlated with the r value of nearly 1.00.

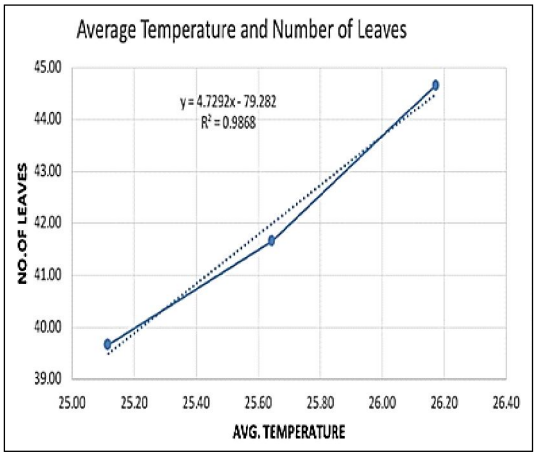

Fig 5: Simple linear regression analysis of average temperature and number of leaves.

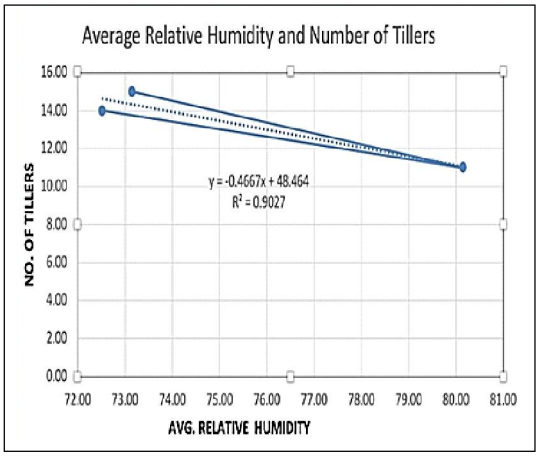

Fig 6: Simple linear regression analysis of average relative humidity and number of tillers.

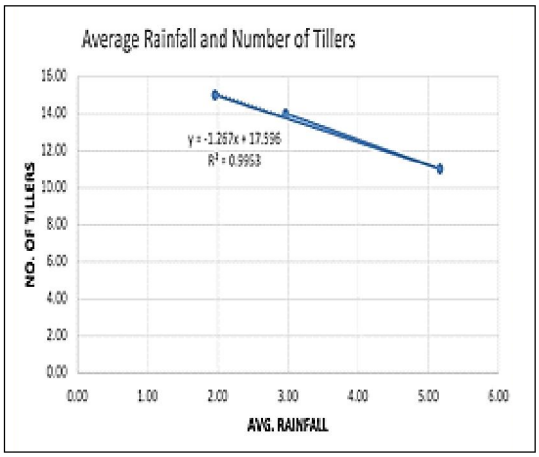

Fig 7: Simple linear regression analysis of average rainfall and number of tillers.

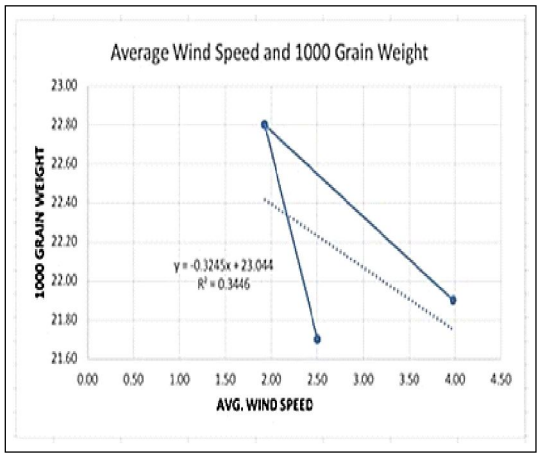

Fig 9: Simple linear regression analysis of average wind speed and 1000 grain weight.

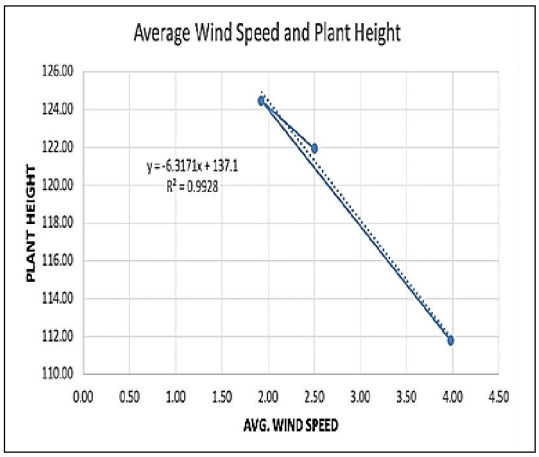

Fig 8: Simple linear regression analysis of average wind speed and plant height.

CONCLUSION

In this study, the relationship between meteorological parameters and field crop performance is examined. The weather-related uncertainties during the various biological phases of crop production, such as rainfall, temperature and humidity, lead to poor farm decision-making. In order to cultivate crops, particularly chakhao cultivars, effective techniques must be adopted and the study of meteorological characteristics should seek to quantify these uncertainties. The nutritional value and nutraceutical benefits of coloured Chakhao cultivars, particularly the black ones, have reignited attention and are being used in food applications. Manipur provides a diverse range of locally adapted, high-quality, non-basmati landraces, but more research and study are needed to fully comprehend these cultivars' growth and development. It requires thorough investigation and more focus from researchers to understand its impact on meteorological factors for production and increased yield of Chakhao needs to be properly investigated and specifically there is ample scope to study on yield of chakhao as influence by several weather factors so that yield potential could be predicted by following suitable statistical procedure.

Based on the experimental findings it was concluded that, growth and yield parameters as well as total grain yield was more in Chakhao Angouba. The maximum temperature, which is an important weather parameter has no impact on rice yield, however, wind speed, minimum temperature, rainfall, RH max and RH min also showed no effect on grain yield of rice under *kharif*, 2019, 2020 and 2021 planting of the three variety of *Chakhao* Angouba, Poireiton and Amuba in Manipur. The non-significant relation of growth parameters including yield with important weather parameter might be due to the preliminary studies we have conducted i.e., for only for three years. Therefore, further studies are needed taking into account the data for another two to three year for the conclusive analysis.

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Conflict of interest: None

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