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A simple approach in assessing the impact of weather on rice yield in two rice growing seasons at Pattambi, Kerala

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सार – पट्टंबी में खरीफ और रबी के मौसम के दौरान क्रमशः वर्षा और सिंचाई की स्थितियों से रेतीली दुमट मृदा में बोई गई धान की जया की किस्म की अच्छी उपज का अध्ययन किया गया है। यह विश्लेषण समीकरण को विकसित करने के लिए एक सरल बहुसमाश्रयण तकनीक के आधार पर किया गया था और फिर एक समय में एक घटक के परिवर्तनशील रूप पर विचार करते हुए अन्य घटकों को अपरिवर्तनीय माना गया। इस अध्ययन में खरीफ और रबी के मौसम में मौसम प्राचलों के विभिन्न प्रकारों से जया की किस्म की उपज अनुक्रिया को ज्ञात किया गया है।

धान की बुआई के इन दोनों मौसमों में जब जल की आवश्यकता की पूर्ति पूर्णतया वर्षा से होती है अथवा जब रबी के मौसम में सिंचाई वाली स्थितियों से बुआई की जाती है, उपज के साथ वर्षा का संबंध नकारात्मक पाया गया है। खरीफ में बहुत अधिक वर्षा अथवा रबी में मौसम में अपेक्षाकृत अधिक वर्षा हानिकारक पाई गई है जिसके परिणामस्वरूप दोनों मौसमों में धान की उपज कम हुई है। दोनो मौसमों के माध्य 29° सें. और लगभग 22° सें. के अधिकतम और न्यूनतम तापमान उत्तम फसल के लिए आदर्श प्रतीत होते हैं। रबी के मौसम के दौरान सूर्य की तेज़ धूप के और अधिक घंटों (≥ 700 घंटे) के प्रभावस्वरूप धान की उपज में बढ़ोतरी होती है जबकि खरीफ के दौरान जब धान पर 300 से 500 घंटों की तेज़ धूप पड़ती है तो उपज एक समान होती है।

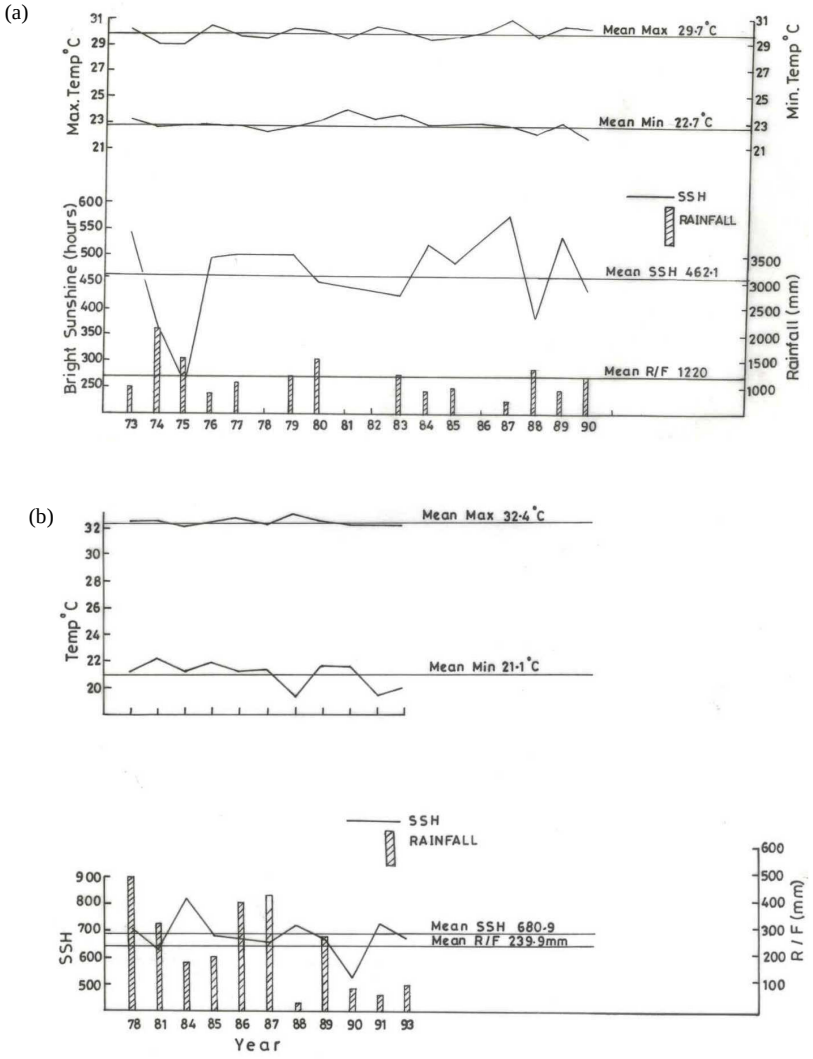
ABSTRACT. .A study was conducted with high yielding Jaya variety of rice grown during kharif and rabi seasons in sandy loam soil under rainfed and irrigated condition respectively at Pattambi. The analysis was based on a simple multiple regression technique for developing, the equation and then considering one element at a time as variable when other elements were considered constant. The study enables determination of response of Jaya variety yield to different ranges of weather parameters in kharif and rabi seasons.

Rainfall was found to be negatively correlated with yield in both the rice growing seasons when water requirement is fully met from rainfall or when it is grown under irrigated condition in rabi season. Very high rainfall in kharif or relatively high rainfall in rabi season were found detrimental causing reduction in rice yield in both\ the seasons. For both the seasons mean maximum and minimum temperature of 29° C and about 22° C appear ideal for optimum yield. More hours of bright Sunshine (≥700 hours) during rabi season favoured higher rice yield where as yield remained more or less constant when the kharif rice experienced bright sunshine in the range of 300 to 500 hours.

Key words – Simple multiple regression technique, Photoinsensitive Jaya variety, Diurnal temperature.

1. Introduction

Though rice can be grown all throughout the year in India, yet it is mostly cultivated during the kharif season. It is generally believed that rice yield varies due to variations in weather mainly due to variable rainfall. The extent to which the crops weather requirements are met varies widely in Indian regions and that gives rise to a wide variety of cropping practices and systems. Rice is the natural choice in monsoon areas where mean precipitation in this season exceeds 100 cm. However, the monsoon seasons overcast skies and relatively low maximum temperature (25° C) and high minimum temperature (20° C) in the vegetative and flowering phases in the region of India are not conducive to optimum net assimilation of photosynthate and nutrient absorption (Sreenivasan and Banerjee, 1978). Because of variation in meteorological parameters in different crop growing seasons, the yield of rice varies considerably in the region. In this study an attempt has been made to assess the impact of weather on rice yield at Pattambi, Kerala during the two rice growing



Figs. 1(a&b). Average maximum and minimum temperature total rainfall and total bright sunshine hours during (a) kharif and (b) rabi rice growing season

seasons *viz*., kharif (June -September) and rabi (October-January). For this study the weather experienced by the crop during the growth phases from transplanting to harvest have been considered. The rice yield data and weather for 12 years for Jaya variety from 1974 to 1990 for kharif season and 11 years from 1978, 1981, 1984 to 1991 and 1993 for rabi season are considered.

2. Climate and crop seasons at Pattambi

Pattambi (10° 48′ N, 76° 12′ E) is located 25 m.a.s.l., in Palghat district of Kerala. The district has a tropical climate with an oppressive hot season and plentiful and fairly assured seasonal rainfall in the kharif season. The average annual rainfall in the district is 2396.6 mm. March is the hottest month with the mean daily maximum temperature at 37.4° C and the mean daily minimum temperature at 24.5°C. The air is highly humid throughout the year, the relative humidity being generally over 70% (Climate of Kerala state – IMD, 1986).

The kharif season is the period when paddy transplanting commences in the 3rd / 4th week of June or 1st week of July and harvesting starts in mid September onwards. On the other hand transplanting commences in the 2nd / 3rd week of October and harvesting begins in January in rabi season. Kharif rice is transplanted after the heavy rains of June or early July. It receives average rainfall of 1220 mm during the crop-growing season. The crop experiences an average maximum temperature of 29.7° C and minimum temperature of 22.7° C. A mean total bright sunshine hour is 462 hours during the growing period of the crop [Fig. 1(a)].

TABLE 1(a)

Estimated yield of Jaya for different weather parameters for kharif season

Year	Max. temp. (°C) X_1	Estimated yield (kg/ha)	Min. temp. (°C) X_2	Estimated yield (kg/ha)	Total rainfall (mm) X_3	Estimated yield (kg/ha)	Total bright sunshine (hours) X_4	Estimated yield (kg/ha)
1974	29.0	1872.4	22.6	1526.9	2191.9	–1492.4	359.9	1611.0
1975	28.9	1909.9	22.6	1526.9	1580.8	438.3	262.0	1640.4
1976	30.3	1397.9	22.8	1580.3	901.5	2585.3	496.0	1570.2
1977	29.5	1689.9	22.8	1580.3	1105.0	1942.2	502.0	1568.4
1979	30.1	1470.9	22.8	1580.3	1242.1	1509.0	499.8	1569.1
1980	29.9	1543.9	23.1	1660.5	1507.3	671.0	451.6	1583.5
1983	29.9	1543.9	23.5	1767.5	1254.4	1470.1	423.5	1591.9
1984	29.3	1762.9	22.8	1580.3	918.7	2531.0	522.6	1562.2
1985	29.5	1689.9	22.9	1607.1	1022.8	2202.0	486.1	1573.2
1987	30.8	1215.4	22.8	1580.3	759.6	3033.7	574.4	1546.7
1989	30.0	1507.4	22.9	1607.1	937.8	2470.6	534.3	1558.7
1990	30.1	1470.9	21.7	1286.3	1212.7	1601.9	433.3	1589.0

The rabi rice is transplanted after the withdrawal of south-west monsoon under irrigated conditions. This season receives a meagre amount of rainfall (average rainfall = 239.9 mm) during the crop-growing season. The crop experiences an average minimum temperature of 21.0° C and maximum temperature of 32.4° C. A mean total sunshine hour is 680.9 hours during the growing period [Fig. 1 (b)].

3. General methodology

To study the impact of weather on rice yield at two distinctly different rice-growing seasons, multiple linear regression technique was applied. Multiple regression equations have been developed for both the crop seasons, using predominant Meteorological parameters such as maximum and minimum temperatures, total rainfall and total sunshine hours. The regression equations thus obtained are given below for kharif and rabi seasons respectively.

$$Y = 10355.2 - 365.0\, X_1 + 267.3\, X_2 - 3.16 X_3 - 0.3\, X_4 \quad (1)$$

M.C.C. = 0.78, Significant at 1 % level.

$$Y = -12.21 - 2.89\, X_1 + 5.51 X_2 - 0.0207\, X_3 + 0.034\, X_4 \quad (2)$$

M.C.C. = 0.84, Significant at 1% level.

Where, Y is the estimated yield in kg/ha for Eqn. (1) and in q/ha for Eqn.(2)

X_1 – Mean maximum temperature (°C)

X_2 - Mean minimum temperature (°C)

X_3 - Total rainfall (mm) in the growing seasons.

X_4 - Total sunshine hours in the growing seasons.

The estimated yield for each meteorological parameters have been computed for both the seasons and presented in Tables l(a&b). In estimating the yield it is assumed that only one meteorological parameter is influencing the yield and the other meteorological parameter remain constant. The yields for different years have been computed varying only one meteorological parameter and taking mean values of other meteorological parameters for kharif and rabi seasons.

4. Results and discussion

An attempt has been made in this study to find out the relative importance of each of the weather elements on yield both for kharif and rabi seasons for the same variety Jaya. The study revealed that both maximum and minimum temperatures have played the most important role towards rice yield at Pattambi. Jaya variety takes about 130-135 days for maturity. This variety is though photoinsensitive but sensitive to temperature and has performed well under higher number of bright sunshine hours in rabi seasons. The average maximum temperature during the crop-growing season at Pattambi for kharif season was 29.8° C and for rabi season was 32.4° C. But the average diurnal ranges of temperature were respectively 7.0 and 11.3° C during kharif and rabi rice growing seasons. This higher diurnal range of temperature in rabi season has provided favourable conditions for efficient conversion of solar energy in to photosynthesis and net gain of photosynthate.

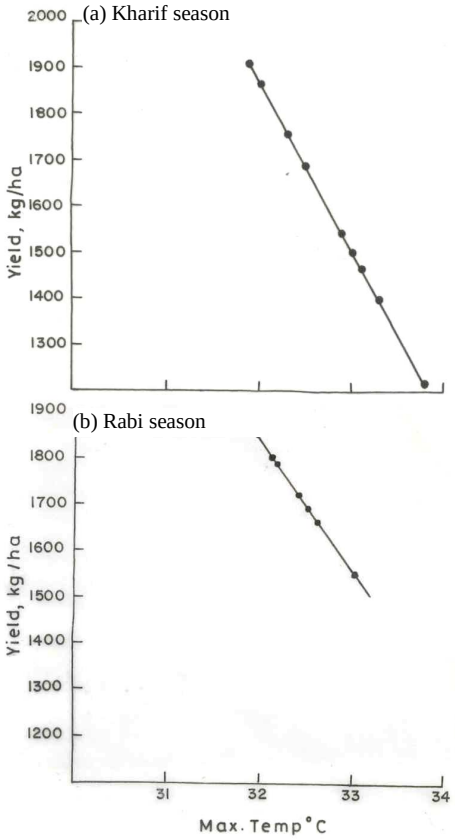
TABLE 1(b)

Estimated yield of Jaya for different weather parameters for kharif season

Year	Max. temp. (°C) X_1	Estimated Yield (kg/ha)	Min. temp. (°C) X_2	Estimated Yield (kg/ha)	Total rainfall (mm) X_3	Estimated yield (kg/ha)	Total bright sunshine (hours) X_4	Estimated yield (kg/ha)
1978	32.5	1701	21.8	3103	579.4	1794	714.7	2833
1981	32.5	1701	22.2	3324	320.4	2499	630.0	2544
1984	32.1	1806	21.2	2773	176.6	2899	823.2	3203
1985	32.4	1730	21.9	3158	198.7	2829	677.6	2706
1986	32.6	1672	21.3	2828	408.4	2259	671.3	2685
1987	32.2	1788	21.4	2883	427.2	2208	654.5	2627
1988	33.0	1556	19.2	1671	32.8	3281	718.9	2847
1989	32.4	1730	21.7	3048	258.5	26.67	681.8	2721
1990	32.1	1806	21.6	2993	77.7	3159	515.9	2155
1991	32.1	1806	19.5	1835	63.5	3197	725.9	2871
1993	32.1	1806	20.0	2111	96.1	3109	676.9	2701

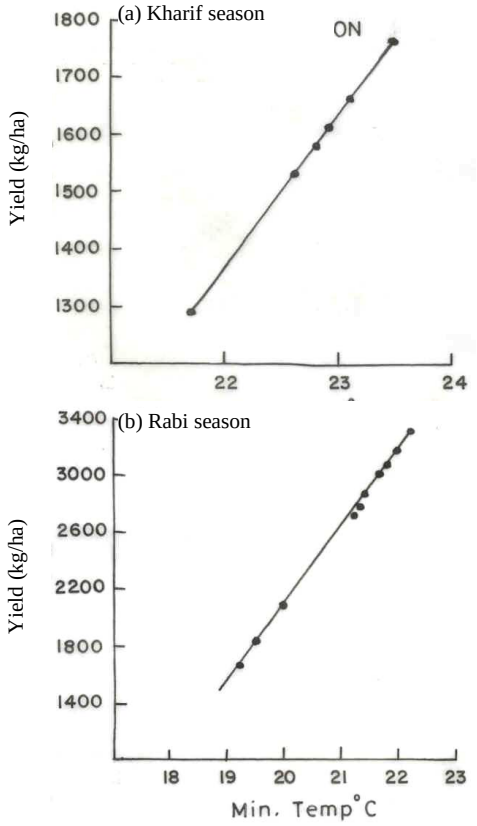
Fig. 2 (a) shows that during kharif season, optimum yield was reached when maximum temperature was around 28.9° C. The yield showed a decreasing trend with increase in maximum temperature. Fig. 2 (b) shows that for rabi rice optimum yield was reached for a maximum temperature of about 32.1° C, and a subsequent rise in maximum temperature had adverse impact even within a narrow range of maximum temperature variation of 32.0 to 33.0° C on yield particularly after 32.5° C when sharp decline in yield took place. Temperature influences both growth duration and growth pattern of the rice plant. Extreme high temperatures are a critical factor in rice production because they induce spikelet sterility (Oldeman *et al*., 1986).

On the contrary a rise in minimum temperature helped better yield for both kharif and rabi rice. Fig. 3 (a) shows that for kharif season, minimum temperature of about 23.5° C appears to be ideal for optimum yield. Yield increased gradually with the increase in minimum temperature. Increase; in yield was observed when minimum temperature increased above 21.6 to 23.5° C. For the kharif rice-growing season the minimum temperature ranged between 21.7 to 23.5° C and the maximum temperature ranged from 28.9 to 30.8° C. Whereas in rabi season, rice crop experienced a minimum temperature range of about 19.0 to 22.0° C and maximum temperature range of 32.2 to 33.0° C. Fig. 3 (b) shows that in rabi season optimum yield at Pattambi was observed when the crop experience average minimum temperature of about 22.0° C.

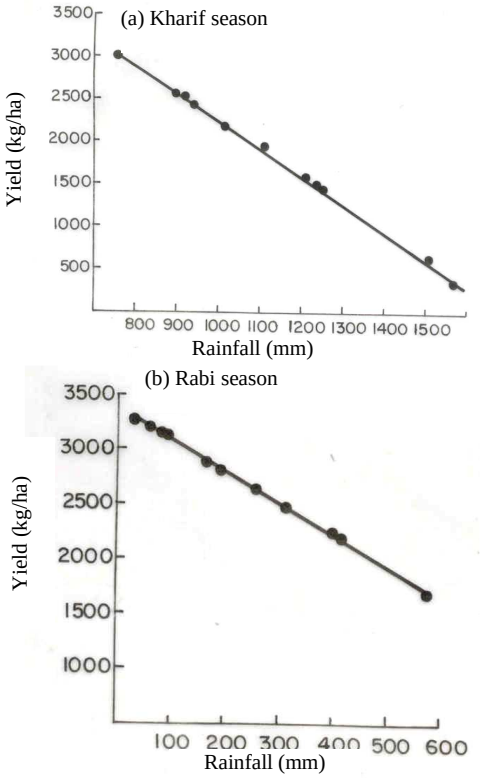


Figs. 2(a&b). Relationship between maximum temperature and rice yield during (a) kharif season and (b) rabi season at Pattambi, Kerala

Osada (1964) also showed that the optimum temperature range for a better yield is from 25 to 35° C. A high diurnal difference leads to a more efficient conversion and use of solar energy in the photosynthesis process, leading to a higher net photosynthesis (Frere, 1986). Our results confirm the Osada (1964) findings and also establish that rabi rice growing seasons is more suitable for higher rice yield due to higher diurnal



Figs. 3(a&b). Relationship between minimum temperature and rice yield during (a) kharif season and (b) rabi season at Pattambi, Kerala



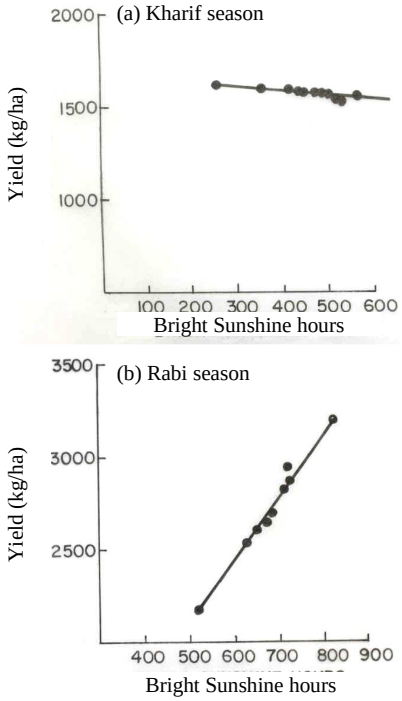
Figs. 4(a&b). Relationship between rainfall and rice yield during (a) kharif season and (b) rabi season at Pattambi, Kerala

variation in temperature (11.3° C) and higher bright sunshine hours.

On an average the crop experienced higher rainfall in the range of 940 to 2192 mm during the growing period. Jaya being short duration high yielding variety requires much less seasonal rainfall for its growth and maturity compared to that of long duration varieties. An amount of about 800-900 mm [Fig. 4 (a)] appears adequate to ensure proper growth (Samui and Choudhari, 1994). As coastal regions of Kerala receives heavy rainfall in most of the time in kharif season flooding in the rice field, is common phenomena which cause water logging and runoff at most of the growth stages. These conditions might have caused reduction in yield in association with damages due to pests and diseases attack due to favourable hot and humid weather conditions.

On the contrary rabi rice at Pattambi is cultivated under irrigated conditions. The crop experienced rainfall in the range of 35 to 570 mm in rabi season for the years considered in this study. Fig. 4 (b) also shows that, yield decreased even with an increase of rainfall in this narrow range at Pattambi. Because of uncertainty of rainfall and meager amount receives during rabi season, the farmer grow rice only under irrigated condition. During rabi season the crop is irrigated at a regular interval for maintaining standing water level. The amount and distribution of rainfall is so meagre and erratic that farmers do not consider this rainfall as resources in planning the management practices. Thus this meagre amount of rainfall associated with more humidity and more cloudy days provided congenial conditions for infestations of pests and diseases in the rabi rice causing the low yield. Dubey and Ronghe (1986) also found that minimum temperature of 17-18° C in November increased the incidence of pest infestation. Reduced precipitation also results in increased solar radiation, where water is not limiting factor due to irrigation. The increase in solar radiation during the rice-growing season when rainfall was less also resulted in increased yields (IRRI 1986).

In kharif season, the crop received a total hours of sunshine in the range of 262 to 574 hours only during the crop growing period. Total sunshine hours of about 400 hrs were found to be ideal for optimum yield [Fig. 5 (a)] under Pattambi condition. Yield remains more or less constant even though total sunshine hours increased above 550 hours. The rabi rice received total sunshine hours in the range of 515 to 820 hours during its growth period.



Figs. 5(a&b). Relationship between bright sunshine hours and rice yield during (a) kharif season, (b) rabi season at Pattambi, Kerala

Higher sunshine hours of about 800 hours in the rabi rice growing season was found favourable for higher yields [Fig.5 (b)]. In rabi season higher duration of bright sunshine hours was received compared to that of kharif season. In general yield increased with the increase in sunshine hours in rabi season. Higher solar radiation particularly during reproductive and ripening stages is found conducive for higher yields (Sastry, 1976).

5. Conclusions

(*i*) Higher diurnal temperature ranges play the most important role towards higher rice productions. Higher diurnal ranges (11.3° C) during rabi rice growing season is found optimum for higher rice yield compared to kharif season when diurnal range is much less.

(*ii*) Under irrigated condition during rabi season, cloud free days with higher amount of bright sunshine favours rice growth and yield. 800 hours of bright sunshine appears adequate to ensure higher yield of Jaya in rabi season. An amount of about 900 mm seasonal rainfall appears adequate for proper growth and yield in kharif season.

(*iii*) Photoinsensitive Jaya has potential to produce very high yield of about 4100 kg/ha in rabi rice growing season under Pattambi condition.

(*iv*) This simple analysis technique has brought out clearly that photoinsensitive rice varieties are preferably to be grown in rabi season under irrigated condition using suitable water management practices. Shifting of rice growing season from June- September to August-November would be preferable so as to achieve potential yield by exploiting the better thermal, radiation and soil water regimes during October-November .

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