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Quantification of Seasonal Rainfall Variability Effect on Pearl Millet Yield Over Madurai District of Tamil Nadu

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Dryland agriculture is entirely reliant on the monsoonal rainfall for its crop sensation. Pearl millet crop cultivation in a rainfed region like Madurai district Tamil Nadu became remunerative task, where the major rainfall contribution is from North-East monsoon. The influence of seasonal rainfall variability on pearl millet was quantified through correlating the inter-seasonal rainfall deviation with pearl millet productivity using the 30 years (1990-2019) rainfall and simulated pearl millet productivity data. Results indicated that pearl millet productivity had the relationship with seasonal rainfall by 46 percent. The research revealed that pearl millet crop yield dropped in nine out of 12 dry rainfall years and excess rainfall years also reduced the yield of pearl millet crop. It may well be implicit from the results that low and high rainfall years adversely affect the yield of pearl millet crop.

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Keywords: Rainfall Variability; pearl millet; Crop simulation model.

1. INTRODUCTION

Weather conditions contribute almost 60 percent share over the exposed Indian agriculture, predominantly rainfall during South-West monsoon being a game changer in India [1] and North-east monsoon for Tamil Nadu. The near century is likely to create a vulnerable monsoon behaviour that negatively impact crop productivity [2]. Drylands of Asian countries are in the verge to face the challenge of drought to a greater extent [3]. Drought can directly affect crop production and indirectly influence the nutrient stress on pearl millet crop. Pearl millet crop can withstand the water stress, butshows negative effect on growth parameters and eventually grain yield [4]. Farmers in southern zone of Tamil Nadu tend to choose crop based on seasonal temperature and precipitation.

The present study id carried out in Agricultural college and Research institute, Madurai. Madurai is one of the district in the Southern Agro Climate Zone of Tamil Nadu is bound by the district of Sivagangai on the East, Theni on the west, Virudhunagar on the South and Dindugal on the North. It is situated between 9º30'and 10º30' North latitudes and 77º30' and 78º30' East longitudes with the altitude of 147 m above sea level. The district has 7 taluks and 13 blocks with a total geographical area of 3, 74,173 ha majoring Red loam and black soils. The district has varied climate with maximum temperature of 41ºC, minimum temperature of 23ºC and 841 mm rainfall [5]. Millets are the predominant crop of Madurai district covering 1247 ha area which is 7.23 percent of the crop sown area in 2018-2019, producing 4613 tones and attaining the productivity of 1156 kg/ha. This research article presents the impact of seasonal rainfall variability on pearl millet productivity over Madurai district.

2. MATERIALS AND METHODS

2.1 Weather Data

The district level daily weather data obtained from IMD was been used through Weatherman tool in DSSAT [6] for the crop simulation. The seasonal rainfall was calculated for the major pearl millet growing season in the Madurai district (September to February)

2.2 Crop Yield Simulations

The experimental data was collected from field trial conducted at Agricultural College and Research Institute, Madurai. The calibrated genetic coefficient for CO (Cu) 10 [7] pearl millet was used in DSSAT model simulation [8] for 30 years (1990- 2019) to simulate the yield and assessed the impact of climate variability on pearl millet productivity.

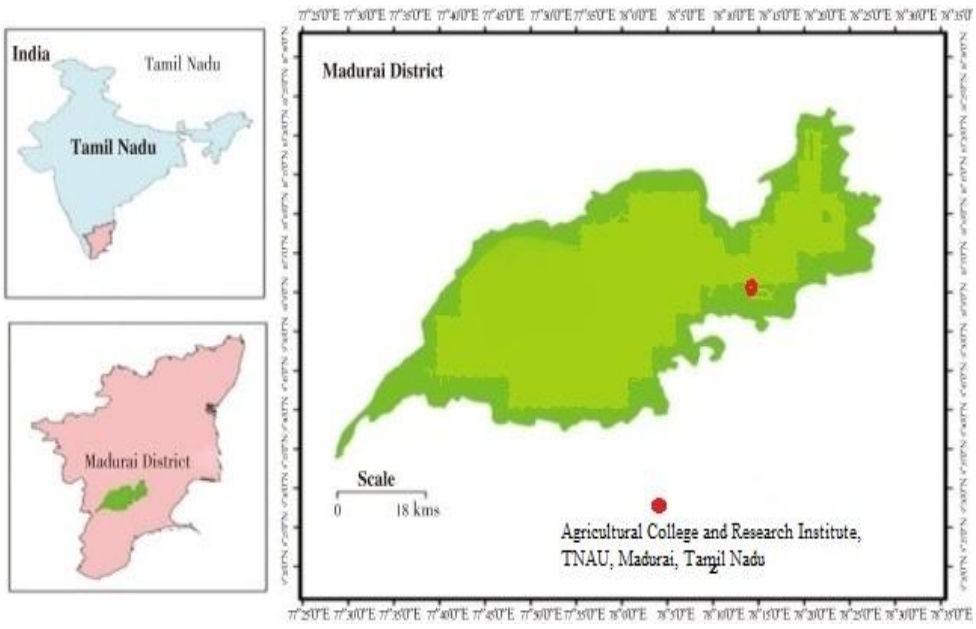

Fig. 1. Location map of Madurai district

2.3 Rainfall Deviation

Deviation percentage of actual rainfall from the long term mean rainfall was calculated using 30 years (1990-2019) weather data. The years were classified as Excess (above 19% value), Normal (+19% to -19% range) and Deficit (below - 19% value) based on IMD classification by calculating the actual rainfall and normal rainfall then correlated with the pearl millet productivity for understanding the influence of varied weather conditions on pearl millet productivity.

3. RESULTS AND DISCUSSION

The results on crop simulation and rainfall deviation are presented in Table 1. The results revealed that out of 12 dry years 1995, 1996, 2001, 2002, 2003 and 2004 have resulted in yield drop which is evident from Fig 2. It could be noted that 40 percent of the dry years have affected the yield negatively. Rainfall deviations of -10.05, and 18.18 percent in1994 and 2006 respectively had also reduced the yield in spite of being the normal rainfall years. The distribution of rainfall could be emphasized to take into consideration when normal rainfall years had behaved in the negative terms. The wet years also resulted positive yield when compared to the normal years which happened in case of 1993, 1998, 2005, 2011, 2015 and 2015. The highest simulated yield was observed in 2011 with excess rainfall (75.00) and lowest was observed in 2003 with scanty rainfall (-69.31) It is interesting to observe that excess rainfall by 82.43 percent in 1995 resulted in second lowest yield next to 2002 during which the least was observed among the 30 years. The trend line equation $y = 0.9296x + 1290.9$ indicated that rainfall had a positive effect on yield to a certain extent. The present study clearly indicates that rainfall deviation towards the negative side effects the yield and positive rainfall deviation would be beneficial to yield of pearl millet unless

Table 1. Simulated pearl millet yield and seasonal rainfall deviation of Madurai district (1990-2019)

Year	Simulated yield	Rainfall deviation	Rainfall classification
1990	1639	-1.50	Normal
1991	989	-50.10	Dry
1992	2552	17.01	Normal
1993	2102	64.63	Excess
1994	485	-10.05	Normal
1995	397	-82.43	Dry
1996	1377	-26.76	Dry
1997	1536	-31.45	Dry
1998	2279	55.21	Excess
1999	1764	2.15	Normal
2000	2002	-47.85	Dry
2001	508	-65.05	Dry
2002	434	-51.94	Dry
2003	418	-69.31	Dry
2004	576	-22.66	Dry
2005	2485	80.13	Excess
2006	1157	18.18	Normal
2007	1595	59.20	Excess
2008	1916	9.77	Normal
2009	2241	1.82	Normal
2010	2352	133.22	Excess
2011	2708	75.00	Excess
2012	1957	8.53	Normal
2013	1435	2.89	Normal
2014	2333	43.71	Excess
2015	2139	49.24	Excess
2016	1042	-56.33	Dry
2017	2035	-45.27	Dry
2018	1059	-59.96	Dry

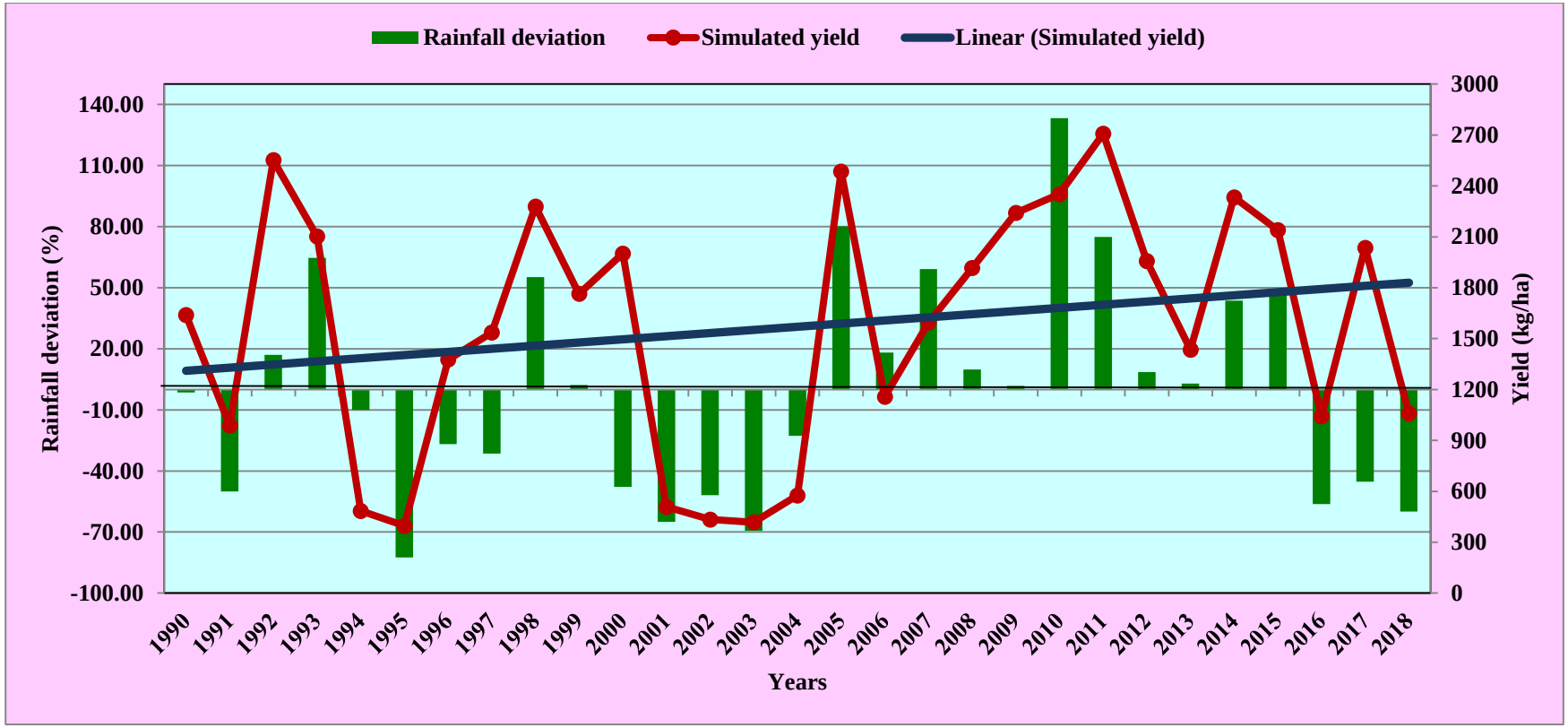

Fig. 1. Effect of Seasonal Rainfall Variability on pearl millet Yield over Madurai District of Tamil Nadu

there is excess rainfall that could completely damage the crop [9]. The r square value of 0.47 between yield and seasonal rainfall revealed that rainfall influenced the yield by 47.7 percent and certain other factors are deciding pearl millet productivity in Madurai district. Under the current climate conditions the pearl millet yield is about 2231 kg ha^{-1} which will sustain the economic viability of the farmers [10]. In the future climate projections under RCP 4.5 and RCP 8.5 the productivity of pearl millet is declined by 2.39%, 4.12% and 7.32% in near, mid and end end century slices [11]. To sustain the current yield in forth coming climate conditions the crop should be sown in early stages of monsoon with 25% extra dose of fertilizers. The farmers has to plan the crop and cultivation practices based on the weather forecasting to obtain the good yields.

4. CONCLUSION

From the above results and discussion, It could be concluded that the inter-seasonal rainfall variability proves to be an influential factor in the yield component of pearl millet crop over Madurai district of Tamil Nadu. Moreover the yield drop during normal years and good yield in Dry years indicate that further exploration is necessary in the rainfall distribution pattern and several other factors to be included in yield estimation in future.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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