

# Evaluation of different districts of Tamil Nadu to mine out seasonal soil moisture stress based on moisture index for crop planning

S. Kokilavani <sup>1</sup>, S. Panneerselvam <sup>2</sup>, R. Nagarajan <sup>3</sup>, and T. N, Balasubramanian <sup>4</sup>.

Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore-641 003 Tamil Nadu, India

\*Corresponding author's E-mail: kokiacr@gmail.com

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## ABSTRACT

By utilizing the Southwest and Northeast monsoon seasonal rainfall data of 90 years (1911-2000) of 32 districts of Tamil Nadu leaving Chennai district, combo analyses (combined analysis) were made between moisture index values to find out the seasonal soil moisture stress status by using Thornthwaite and Mather (1955) moisture index. Paired t- test and correlation tools were used to evaluate the link between the two seasonal moisture stresses. The results on combo analysis made from moisture indices of both Southwest monsoon and Northeast monsoon of the same year, it was found from the paired t-test analysis that all the districts except Coimbatore did vary for their soil moisture status, while it was inferred from the results of correlation analysis that, all the districts did not vary for soil moisture stress except the district Perambalur. In respect of combo analysis made between the moisture indices of Northeast Monsoon of the previous year and the Southwest Monsoon of the succeeding year, the result from paired t- test revealed the similar findings that were observed for the combo analysis made between both Southwest monsoon and Northeast monsoon of the same year. In respect of correlation study except Tirunelveli district, the entire district did not vary significantly. Accordingly, crop plan agenda is suggested from the literature.

**Key words:** Southwest monsoon rainfall, Northeast monsoon rainfall, moisture index, crop plan, Paired t-test

The rain though it is the main source for crop production in the mother Earth, its availability to crop production is regulated by the concerned soil moisture storage capacity. Part of the rainwater that enters in to the soil profile alone meets the crop water requirement and hence it becomes the effective rainfall. Due to intra and inter-seasonal variability in rainfall amount and its distribution and soil types, soil moisture stress becomes a dominant dictating factor under dry land situation. This is seen in temporal and spatial dimensions across geographical locations of Tamil Nadu. Thornthwaite and Mather (1955) in their study on climate of arid zone reported that estimation of utilizable water from the soil under varying meteorological condition had already found practical application in the field of agriculture for determining the amount and time of supplemental irrigation needed. Northeast monsoon seasonal rainfall (Oct-Dec) is the lifeline monsoon for 32 districts of Tamil Nadu, while few five districts of Tamil Nadu alone (Salem, Dharmapuri, Krishnagiri,

The Nilgiris, and Kanyakumari) get benefitted (32 per cent of the annual mean rainfall) from Southwest monsoon season for crop production under dry land. The uni-model (southwest monsoon alone or northeast monsoon alone) and bi-model (both southwest monsoon and northeast monsoon) rainfall patterns that prevail over Tamil Nadu create variability in seasonal soil moisture storage under dry land between districts of Tamil Nadu and accordingly the crops productivity do vary greatly. Hence, to understand the soil moisture variability, study was undertaken in 31 districts of Tamil Nadu by employing moisture index values derived from Thornthwaite and Mather Model.

## MATERIALS AND METHODS

Ninety years (1911-2000) of both Southwest monsoon season (June -Sep) and Northeast monsoon (Oct-Dec) rainfall data in respect of 32 districts of Tamil Nadu were obtained from India Meteorological Department and used for analysis after excluding the rainfall data of urbanite Chennai

district. The potential evapo-transpiration data of 31 districts of Tamil Nadu except Chennai were collected from the published report of Rao *et al* (1971). The seasonal moisture index (Im) was computed based on the model of Thornthwaite and Mather (1955) as given below.

$$Im = (P - PE / PE) * 100$$

Where,

Im= Moisture index, P = Precipitation (mm), PE= Potential evapo-transpiration (mm).

Statistical procedure as given by Rangaswamy (1995) was used to analyze the data in terms of paired t-test and correlation test. For ninety years, year wise the moisture index was computed both for Southwest monsoon and Northeast monsoon seasonal rainfall individually for 31 districts of Tamil Nadu and used for Combo analysis by employing paired t-test and correlation test. Combo analysis (combined analysis) of 90 years seasonal moisture index of each district was done in two ways: The first one is, moisture indices of both Southwest and Northeast monsoon of the same year for each district of Tamil Nadu for 90 years. In the second type, the moisture index of the Northeast monsoon of the previous year with the Southwest monsoon moisture index of the succeeding year of each district. (For this purpose the moisture index of Northeast monsoon of the first year (1911) was combined with southwest monsoon of the second year (1912). At the terminal year cycle, the northeast monsoon season of 2000 was combined with southwest monsoon moisture index of 2001).

## RESULT AND DISCUSSION

The moisture index is an indicator of the supply of water in an area relative to the demand under prevailing climatic condition (Thornthwaite and Mather, 1955; Mather, 1978). Present results were derived from two statistical tools (paired t- test and correlation). The results on combo analysis made from moisture indices of both Southwest monsoon and Northeast monsoon of the same year, it was found from the paired t-test analysis that all the districts except Coimbatore did vary for their

soil moisture status between the two seasons studied. For example, in respect of Ariyalur district, the moisture index values were semi arid for Southwest monsoon and humid (B2) for Northeast monsoon (Table 1). Similarly, for Salem district, it was dry sub humid for Southwest monsoon and moist sub humid for Northeast monsoon. In respect of Virudhunagar district, it was arid for Southwest monsoon and moist sub humid for Northeast monsoon. Against this result, it was inferred from the results of correlation study that, all the districts did not vary for soil moisture stress except the district Perambalur. Considering the variation between two results obtained, under ground reality situation, the results obtained from correlation study might not happen. This can be supported by the fact that all the districts of Tamil Nadu are highly benefitted from Northeast monsoon seasonal rainfall (> 400 mm) against Tamil Nadu being the rain shadow region to the Southwest monsoon season except few districts. Veeraputhiran *et al.*, (2003) reported that NEM offers a higher rainfall with less variability aids for successful crop production with less risk against SWM where the rainfall was much below the crop requirement. Hence, there must be variability between seasonal moisture stresses of the same year that could be seen from the paired t-test. Under this context, scientifically, the results from the correlation studies should not be given proper weight for any crop planning process. In respect of combo analysis made between the moisture indices of Northeast Monsoon of the previous year and Southwest Monsoon of the succeeding year, the result from paired t- test revealed the similar findings that were observed for the combo analysis made between both Southwest monsoon and Northeast monsoon of the same year, thus confirming the variability in seasonal moisture stress between districts of Tamil Nadu. The result from correlation was away from the ground reality in the sense that except Tirunelveli, district the entire district did not vary significantly.

The result from the pair t-test on Southwest monsoon and Northeast monsoon of same year and Northeast monsoon of the previous year and Southwest monsoon of the succeeding year revealed similar trend thus conforming the superiority of this

statistical tools now used for this analysis. The suggested crop plan from the literature (Ramasamy et al., 2004) is presented for the districts of Tamil

Nadu in the Table 3 for the seasonal variability moisture stress observed in the present investigation.

**Table 1.** Combo seasonal analysis<sup>+</sup> of moisture index (Im) SWM and NEM of the same year

| S.No. | Districts        | SWM<br>(Im-Mean) | NWM<br>(Im-Mean) | Calculated t value | Correlation |
|-------|------------------|------------------|------------------|--------------------|-------------|
| 1     | Ariyalur         | -55.7            | 48.1             | 15.9*              | 0.165       |
| 2     | Coimbatore       | 19.3             | 10.7             | 1.2                | 0.023       |
| 3     | Cuddalore        | -34.4            | 105.4            | 17.3*              | -0.069      |
| 4     | Dharmapuri       | -45.6            | -5.5             | 9.6*               | -0.055      |
| 5     | Dindigul         | -52.0            | 33.6             | 17.9*              | -0.164      |
| 6     | Erode            | -52.0            | -4.8             | 9.1*               | 0.091       |
| 7     | Kanchepuram      | -47.1            | 106.7            | 18.6*              | -0.047      |
| 8     | Kanyakumari      | -4.9             | 29.6             | 5.7*               | -0.237*     |
| 9     | Karur            | -76.2            | -14.8            | 16.0*              | 0.071       |
| 10    | Krishnagiri      | -44.4            | -13.8            | 7.2*               | 0.182*      |
| 11    | Madurai          | -52.0            | 16.6             | 15.8*              | 0.020       |
| 12    | Nagapattinam     | -59.4            | 159.4            | 22.8*              | 0.008       |
| 13    | Namakkal         | -39.6            | -16.2            | 5.4*               | 0.028       |
| 14    | The Nilgiris     | 108.4            | 185.2            | 7.2*               | -0.241*     |
| 15    | Perambalur       | -61.9            | 22.9             | 14.5*              | 0.424*      |
| 16    | Pudukkottai      | -62.3            | 13.6             | 18.9*              | 0.023       |
| 17    | Ramanathapuram   | -86.1            | 50.4             | 25.6*              | -0.204*     |
| 18    | Salem            | -23.3            | -0.3             | 5.3*               | -0.011      |
| 19    | Sivagangai       | -65.9            | 21.9             | 18.9*              | 0.204*      |
| 20    | Thanjavur        | -62.1            | 59.3             | 20.1*              | -0.015      |
| 21    | Theni            | -68.2            | 6.3              | 17.7*              | -0.154      |
| 22    | Thiruchirappalli | -51.6            | 93.4             | 19.0*              | -0.107      |
| 23    | Thiruppur        | -65.0            | 100.8            | 14.8*              | 0.133       |
| 24    | Thiruvallur      | -92.4            | 2.5              | 19.2*              | -0.097      |
| 25    | Thiruvannamalai  | -66.0            | 8.0              | 9.4*               | 0.119       |
| 26    | Thiruvarur       | -81.2            | 30.6             | 22.0*              | -0.098      |
| 27    | Tuticorin        | -70.9            | -3.3             | 23.0*              | -0.168      |
| 28    | Tirunelveli      | -21.2            | 40.8             | 22.0*              | -0.128      |
| 29    | Vellore          | -26.5            | 14.3             | 7.9*               | 0.002       |
| 30    | Villupuram       | -25.5            | 60.0             | 12.8*              | 0.162       |
| 31    | Virudhunagar     | -80.0            | 23.7             | 20.9*              | -0.014      |

+For this analysis moisture index of both southwest and northeast monsoon of the same year were taken. SWM- Southwest monsoon season; NEM- Northeast monsoon season; Im – Moisture index; \*Significant at 5 % level; Table t value at 5 % =2.633; Correlation table value=0.175 at 5% level. Note: >(-66) to (-)100 : Arid (E); (-)66 to (-)33 : Semiarid (D); (-)33 to 0 : Dry Sub Humid (C1); 0 to 20 : Moist Sub Humid (C2); 20 to 40 : Humid (B1); 40 to 60 : Humid (B2); 60 to 80 : Humid (B3); 80 to 100 : Humid (B4) ; > 100 : Perhumid (A)

**Table 2.** Combo seasonal analysis<sup>+</sup> of moisture index (Im) of NEM previous year followed by SWM of the succeeding year

| S.No. | Districts        | SWM<br>(Im-Mean) | NWM<br>(Im-Mean) | Calculated t value | Correlation |
|-------|------------------|------------------|------------------|--------------------|-------------|
| 1     | Ariyalur         | -56.02           | 47.55            | 15.98*             | -0.003      |
| 2     | Coimbatore       | 19.16            | 10.73            | 1.21               | 0.200*      |
| 3     | Cuddalore        | -34.65           | 105.39           | 17.38*             | 0.058       |
| 4     | Dharmapuri       | -45.24           | -5.54            | 9.49*              | 0.014       |
| 5     | Dindigul         | -52.06           | 33.60            | 17.95*             | -0.164      |
| 6     | Erode            | -52.10           | -4.78            | 9.12*              | -0.144      |
| 7     | Kanchepuram      | -47.23           | 106.67           | 18.61*             | 0.116       |
| 8     | Kanyakumari      | -5.02            | 29.65            | 5.72*              | 0.160       |
| 9     | Karur            | -76.38           | -15.46           | 15.82*             | -0.150      |
| 10    | Krishnagiri      | -44.02           | -13.80           | 7.15*              | 0.171       |
| 11    | Madurai          | -52.09           | 16.57            | 15.79*             | -0.157      |
| 12    | Nagapattinam     | -59.39           | 159.37           | 22.79*             | 0.006       |
| 13    | Namakkal         | -39.54           | -16.19           | 5.43*              | 0.014       |
| 14    | The Nilgiris     | 107.27           | 185.19           | 7.31*              | 0.058       |
| 15    | Perambalur       | -62.16           | 23.19            | 15.20*             | 0.125       |
| 16    | Pudukkottai      | -62.23           | 13.57            | 18.85*             | 0.030       |
| 17    | Ramanathapuram   | -86.07           | 50.40            | 25.58*             | -0.148      |
| 18    | Salem            | -23.18           | -0.32            | 5.26*              | -0.004      |
| 19    | Sivagangai       | -65.94           | 21.92            | 18.91*             | -0.073      |
| 20    | Thanjavur        | -62.08           | 59.25            | 20.09*             | -0.024      |
| 21    | Theni            | -68.08           | 6.32             | 17.73*             | -0.120      |
| 22    | Thiruchirappalli | -66.10           | 7.99             | 18.97*             | -0.085      |
| 23    | Thiruppur        | -70.84           | -3.26            | 14.81*             | -0.033      |
| 24    | Thiruvallur      | -51.54           | 93.42            | 19.23*             | 0.059       |
| 25    | Thiruvannamalai  | -21.40           | 40.82            | 9.47*              | 0.102       |
| 26    | Thiruvarur       | -65.05           | 100.84           | 21.95*             | 0.035       |
| 27    | Tuticorin        | -92.41           | 2.54             | 23.05*             | -0.001      |
| 28    | Tirunelveli      | -81.23           | 30.56            | 22.01*             | 0.214*      |
| 29    | Vellore          | -26.44           | 14.30            | 7.93*              | 0.016       |
| 30    | Villupuram       | -25.92           | 60.01            | 12.87*             | 0.053       |
| 31    | Virudhunagar     | -80.01           | 23.69            | 20.94*             | -0.057      |

<sup>+</sup> For this analysis moisture index of NEM previous year followed by SWM of the succeeding year were taken.

SWM- Southwest monsoon season; NEM- Northeast monsoon season; Im – Moisture index; \*Significant at 5 % level; Table t value at 5 % =2.633; Correlation table value=0.175 at 5% level.

Note: >(-66) to (-)100 : Arid (E); (-)66 to (-)33 : Semiarid (D); (-)33 to 0 : Dry Sub Humid (C1); 0 to 20 : Moist Sub Humid (C2); 20 to 40 : Humid (B1); 40 to 60 : Humid (B2); 60 to 80 : Humid (B3); 80 to 100 : Humid (B4) ; > 100 : Perhumid (A)

**Table 3.** Alternate crops for different districts of Tamil Nadu

| Districts   | Moderate drought year   | Severe drought year  |
|---|---|--|
| Kancheepuram  |   |  |
| Rainfed areas : lateritic, red and black soils                                | Maize + pulses (July-Dec.) - pulses (Jan.-April)  | Horsegram / pearl millet / pulses / ragi / minor millet (Oct.-Jan.)  |
| Thiruvallur   |   |  |
| Rainfed areas : laterite and red soils  | Maize/sunflower/groundnut/pulses (Oct.-Jan.)<br>Tapioca + groundnut (June-Feb.)                       | Pearl millet / ragi / horsegram / sunflower / minor millets/pulses (Oct.-Jan.)   |
| Villupuram  |   |  |
| Rainfed areas : Laterite, Red and Black soils                                 | Maize (heavy soils)/sunflower + pulses (dewgram) /gingelly (Oct.-Jan.)                                | Pearl millet / horsegram / sunflower / minor millets /pulses (Oct.-Jan.)   |
| Thiruvannamalai   |   |  |
| Rainfed areas : Red, laterite and heavy clay soils                            | Maize (heavy soils) / sunflower + ragi/pulses (Oct.-Jan.)   | Pearl millet / horsegram / minor millets / pulses (Oct.-Jan.)  |
| Vellore   |   |  |
| Rainfed areas : Red and laterite soils  | Maize (heavy soils) / sunflower/ gingelly (Oct.-Jan.)   | Pearl millet / horsegram / sunflower / minor millets /pulses (Oct.-Jan.)   |
| Cuddalore   |   |  |
| Rainfed areas : Laterite and black soils                                      | Maize (heavy soil) / sunflower + dewgram/ sesame/varagu (Oct.-Jan.)                                   | Pearl millet / horsegram /sunflower / minor millets /pulses (Oct.-Jan.)  |
| Dharmapuri and Krishnagiri  |   |  |
| Rainfed areas : Red and black soils   | Groundnut spreading /sunflower/redgram/samai (June-Sep.)  | Samai / fodder /castor (July-Dec.)<br>Castor + pulses (July-Dec.)  |
| Salem   |   |  |
| Rainfed areas   | Spreading groundnut / sunflower / castor / redgram (June-Sep.) - horsegram (Oct.-Jan.)                | Sorghum/pearl millet/ragi/minor millets/pulses/fodder (May-Dec.)<br>Castor + pulses (July-Jan.)                                |
| Namakkal  |   |  |
| Rainfed areas : Red and black soils   | Tapioca (June-May)<br>Spreading groundnut + castor (May-Jan.) - horsegram (Oct.-Jan.) as an intercrop | Sorghum / pulses/pearl millet/fodder/minor millets (Oct.-Jan.)<br>Minor millet + pulses / castor / fodder / pulses (July-Dec.) |
| Erode   |   |  |
| Rainfed areas : Red and black soils   | Castor + groundnut (July-Feb.)<br>Pearl millet / sorghum/ pulses/gingelly (July-Oct.)                 | Sorghum / phillipesara (Sep.-Jan.)<br>Castor / redgram/ pulses (July-Feb.)<br>Fodder / minor millets (Oct.-Jan.)               |
| Coimbatore  |   |  |
| Rainfed areas : Red and black soils   | Sorghum / maize + pulses (Aug.-Jan.)  | Sorghum / pulses / bengalgram / horsegram / fodder/ minor millets (Oct.-Jan.)  |
| Karur   |   |  |
| Rainfed areas<br>Karur district except Kulithalai taluk : Red and black soils | Sorghum / maize + pulses (Aug.-Jan.) - fallow   | Sorghum / pearl millet / fodder / minor millet (Oct.-Jan.) - fallow<br>Horsegram / wheat (Nov.-Feb.) – fallow                  |
| Dindigul  |   |  |
| Rainfed areas   | Castor + pulses (July-Jan.)<br>Millet / pulses (July-Aug.) - fallow                                   | Sorghum / pearl millet / minor millets / pulses /sunflower / fodder (Oct.-Jan.) - fallow                                       |

**Table 3.** Conti...

| Theni  |  |   |
|--|--|---|
| Rainfed areas : Red and black soils  | Pearl millet / sorghum / maize / pulses (Aug.-Jan.)<br>Castor + pulses (July-Jan.)                 | Sorghum / pearl millet / fodder sorghum / minor millets (Oct.-Jan.)                       |
| Thanjavur, Thiruvarur & Nagapattinam (No specific crops for rainfed areas) |  |   |
| Trichirapalli  |  |   |
| Rainfed areas : Red, black and laterite soils                              | Sorghum/millets+pulses/gingelly/cucurbits (Oct-Feb)  | Fodder sorghum / minor millets/fodder/coriander (Oct.-Feb.)                               |
| Perambalur and Ariyalur  |  |   |
| Rainfed areas : Black, laterite and red soils                              | Cotton (Aug.-Feb.) – fallow<br>Gingelly (July-Oct.) - horsegram (Oct.-Feb.)                        | Fodder sorghum / minor millets / fodder / coriander(Oct.-Feb.)                            |
| Pudukottai   |  |   |
| Rainfed areas : Laterite and red soils                                     | Pulses (June-Sep.) - ragi (Oct.-Feb.)  | Fodder sorghum / fodder cowpea/castor / cucurbits (June-Jan.)                             |
| Madurai  |  |   |
| Rainfed areas : Red, black and laterite soils                              | Pearl millet + clusterbean / coriander / sunflower(Sept-Jan.)                                      | Millets + pulses (Sep.-Jan.)  |
| Ramanathapuram   |  |   |
| Rainfed areas : Red, black and laterite soils                              | Rice/ragi/cowpea/sesame/minor millets/sunflower /coriander(Sep.-Jan.)                              | Minor millets / coriander (Sep.-Jan.)   |
| Virudhunagar   |  |   |
| Rainfed areas : Red, black and laterite soils                              | Pearl millet + cluster bean / minor millets / chillies /coriander/ gingelly/ sunflower (Sep.-Jan.) | Minor millets / pearl millet / cowpea (Sep.-Jan.)   |
| Sivagangai   |  |   |
| Rainfed areas : Black and laterite soils                                   | Groundnut + pulses (Sep.-Jan.)   | Varagu / Sorghum + redgram / pearl millet / cowpea(Sep.-Jan.)                             |
| Tirunelveli  |  |   |
| Rainfed areas : Red and black soils  | Coriander / pulses / clusterbean / lab lab / bhendi /minor millets (Sep.-Jan.)                     | Cowpea / water melon (Sep.-Jan.)  |
| Thoothukudi  |  |   |
| Rainfed areas : Red, black and sandy soils                                 | Sunflower / pearl millet / clusterbean / lab lab /bhendi (Sep.-Jan.)                               | Minor millets / pearl millet / cowpea / coriander(Sep.-Jan.)                              |
| Kanyakumari  |  |   |
| Rainfed areas : Laterite and red soils                                     | Millets + pulses (Oct.-Jan.)<br>Groundnut (June-Sep.) - fallow                                     | Minor millets / fodder / pulses (Oct.-Jan.)<br>Castor (Sep.-Feb.)<br>Gingelly (Sep.-Dec.) |

## CONCLUSION

Among the two statistical tool used, considering the validation done and observed results on ground reality, out of paired t-test and correlation, the results from paired t test study alone could be taken for consideration for any crop planning process.

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