MAUSAM, **64**, 3 (July 2013), 489-500

551.553.21 : 551.502.4 (540.63,540.65)

Northeast monsoon rainfall and agricultural production in Tamil Nadu and Andhra Pradesh : II - Dry and wet spell and its impact on cropping pattern

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(*Received 12 July 2011, Modified 15 December 2011*)

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सार – इस पृथ्वी पर कृषि समेत प्राणियों की पानी की आवश्यकता को पूरा करने के लिए केवल वर्षा ही जल का मुख्य स्रोत है। मॉनसून की वर्षा के अनिश्चित और परिवर्तनशील रहने के कारण शुष्क भूमि में की जाने वाली खेती से कृषि का उत्पादन अनिश्चित हो जाता है। भारत के शुष्क, अर्धशुष्क और शुष्क उपआर्द्र क्षेत्रों में अंतर और अंतरा मौसमी सूखे का होना असामान्य नही है जिसके कारण नमी प्रतिबल बहुत अधिक हो जाता है। सामान्यतः तमिलनाडु और आंध्र प्रदेश के शुष्क भूमि वाले क्षेत्रों में कृषि के लिए मुख्य कठिन कारक नमी की कमी है। चूँकि फसल उत्पादन में जलवायु से होने वाले जोखिम अधिक हैं अतः फसल योजना और कृषि व्यापार के लिए आर्द्र और शुष्क दौरों की परिणामी घटनाओं और संभावनाओं की जानकारी का उपयोग किया जा सकता है। इस प्रकार कृषि उत्पादन में वृद्धि का एक तरीका कृषि की बढ़ोतरी के लिए जलवायविक सूचना का सही सामंजस्य हो सकता है।

इस अध्ययन में तमिलनाडु और आंध्र प्रदेश के विभिन्न जिलों में शुष्क और आर्द्र दौर की आरम्भिक और प्रतिबंधी संभावनाओं का पता लगाया गया है। ≥10 और ≥30 मि.मी. वर्षा की साप्ताहिक संभावना की प्रति सप्ताह वर्षा की सहायता से गणना की गई है। 10 और 30 मि.मी. वर्षा की आरम्भिक संभाव्यता का उपयोग फसल पैटर्न का निर्धारण करने और भूमि की तैयारी, रोपण क्यारी की तैयारी, बुवाई, दूसरी जगह रोपण, सिंचाई की योजना बनाना, खादों का उपयोग आदि कार्यों को करने के लिए किया गया है।

इस अध्ययन से पता चला है कि फसलों और किस्मों का चयन उक्त क्षेत्र में दक्षिण पश्चिम/उत्तर पूर्व मॉनसून के आरंभ होने के साथ शुष्क और आर्द्र दौर के विश्लेषण के माध्यम से किया जा सकता है। जब मॉनसून के दौरान वर्षा देर से आरंभ होती है तब उस क्षेत्र की फसल के बढ़वार की अवधि निस्संदेह कम होगी। आंध्र प्रदेश के अधिक वर्षा वाले उत्तर पूर्व के क्षेत्रों में अधिक पानी की खपत करने वाली फसलें जैसे कि धान और कपास का चयन किया जा सकता है। इसी प्रकार कम वर्षा वाले दक्षिण पश्चिम के क्षेत्रों में कम पानी खपत करने वाली फसलें जैसे दालें, तिलहन और ज्वार, बाजरा आदि को लगाने की सलाह दी जाती है। जब शुष्क दौर की स्थितियाँ लम्बे समय तक देखी जाएँ तब सूखे की स्थिति को झेल जाने वाली फसलें जैसे मूँगफली और कम अवधि वाली फसलों को लगाने का सुझाव दिया जाता है। ऐसा करने से उस क्षेत्र की वर्षा की जलवायु के तत्वों को समझने की आवश्यकता को बल मिलता है। इस अध्ययन से यह निष्कर्ष भी निकलता है कि मॉनसून के आगे बढ़ने ओर पिछले कुछ सप्ताहों की वर्षा के वितरण के आधार पर फसलों और उनकी किस्मों का चयन भविष्य में होने वाली वर्षा की संभावना को ध्यान में रखते हुए किया जाना चाहिए।

ABSTRACT. Rainfall is the only major source that meets the water needs of living beings on earth including agriculture. Due to uncertainty and variability of monsoon rainfall, the agricultural production in dry land agriculture is uncertain. It is not uncommon to experience both inter and intra-seasonal drought in the arid, semi-arid and dry sub humid regions of India causing severe moisture stress. In general, moisture is the major limiting factor for agriculture in the dry land regions of Tamil Nadu and Andhra Pradesh. As climate triggered risks are high for crop production, the knowledge of sequential occurrence and likelihood of wet and dry spells can be used for crop planning and agricultural operations. Thus proper blending of climatic information for the benefit of agriculture could be one of the ways to increase the production.

In the present study the initial and conditional probabilities of dry and wet spells over different districts of Tamil Nadu and Andhra Pradesh are worked out. The weekly probability of rainfall with ≥10 and ≥30 mm rainfall per week has been calculated. The initial probability of getting 10 and 30 mm rainfall has been used for fixing the cropping pattern and preparation of land, nursery bed preparation, sowing, transplanting, scheduling of irrigation, application of fertilizers, etc.

The study reveals that crops and varieties could be selected through the analysis of dry and wet spell durations with the onset and advance of southwest / northeast monsoon in the given region. When the rainfall commences late during the

monsoon, growing period in the region is surely reduced. In Andhra Pradesh, high water requiring crops like paddy and cotton could be selected for the stations in northeast region receiving high rainfall whereas low-water requring crops like pulses, oilseeds and millets are advised for the stations in southwest region receiving poor rainfall. When prolonged dry spell conditions are observed, drought-tolerant crops like groundnut and short duration crops are suggested. This emphasizes the need for understanding rainfall climatology of the region. The study also concludes that depending on the advancement of monsoon and distribution of rainfall for the past few weeks, crops and varieties needs to be selected, taking due consideration of probability of getting wet weeks in future.

Key words – Rainfall variability, Initial and conditional probability, Crop planning.

1. Introduction

Meeting the challenges for realization of a sustainable agricultural production would require a management re-orientation, re-channelization of available resources and creation of favourable environment regime and increasing application of modern technologies. Among the various meteorological parameters, rainfall plays a significant role in determining the sowing time for crops. The distribution of annual, seasonal, monthly rainfall in space and time plays a crucial role in determining the management of water resources while the weekly rainfall analysis proves beneficial in planning of crops (Singh *et al*., 2007 and Singh *et al*., 2008).

A long range forecast of rainfall for a country is a useful tool for management in a variety of fields. However, agriculturists need forecast for smaller regions and for shorter periods. However, short range weather forecast (48 hrs) may not always provide sufficient lead time to take effective decisions in agricultural management. Further, there are some weather sensitive agricultural operations like pre-sowing, seed bed preparations, transplanting nursery plants, application of fertilizers or pesticides, etc. which require specific rainfall conditions for their most successful and economic completion. It is thus always advantageous to make use of historical weather data for minimizing the risk of adverse weather and take full advantage of prevailing weather conditions. The presentation of rainfall data in the form of simple averages cannot be utilized in certain specific operations. The quantity of rainfall received over a period of time at a particular place provides a general picture regarding its sufficiency to meet crop growth needs. The specific agricultural operations need additional information like persistency in receiving specific amount of rainfall during a particular time interval. In such situations, an analysis of past data in the form of probabilities and knowledge of dry and wet spells has a special significance. Among few sites receiving the same amount of rainfall during crop growth season, a crop will thrive better at the site having continuous rainfall with a few intermittent dry spells than at the site where dry spells are prolonged and wet spells are of a shorter duration (Gore, 2001). A farmer, at the beginning of the main rainy season is interested to know whether the rain spell occurring at that time will be sustained to help sprouting of the seeds, if sown. He will also like to know whether during the initial growth phases, *i.e*., emergence and early part of tillering, the prolonged dry spell is likely to persist or not. This is because in such eventuality he will have to take recourse to resowing with additional economic burden of purchasing new seeds, reploughing of soil, etc. Alternately a long and severe drought spell after an initial favourable rainfall situation, may force him to go for a shorter duration crop or take recourse to fodder crops. Such decisions perforce emerge from the conditional probabilistic rainfall analysis.

2. Data and methodology

The daily rainfall data of 55 years from 1951 to 2005 from India Meteorological Department were used for the weekly analysis of rainfall. Rainfall probability analysis was done by using initial and conditional probability. The districts of Tamil Nadu taken into consideration were Coimbatore, Cuddalore, Ramanathapuram, Thanjavur and Vellore while the districts Ananthapur, Cuddapah, East Godavari, Kurnool, Prakasm in Andhra Pradesh were chosen in this case study.

2.1. *Initial probability*

In initial probability, the probability of a particular week whether being dry or wet is worked out. The formulas used in this method are :

$$P(W) = \frac{F(W)}{F(W) + F(D)} \times 100$$

$$P(D) = \frac{F(D)}{F(W) + F(D)} \times 100$$

where,

$P(W)$ = Probability of the week being wet (%)
$P(D)$ = Probability of the week being dry (%)
$F(W)$ = Frequency of wet weeks in the data set
$F(D)$ = Frequency of dry weeks in the data set

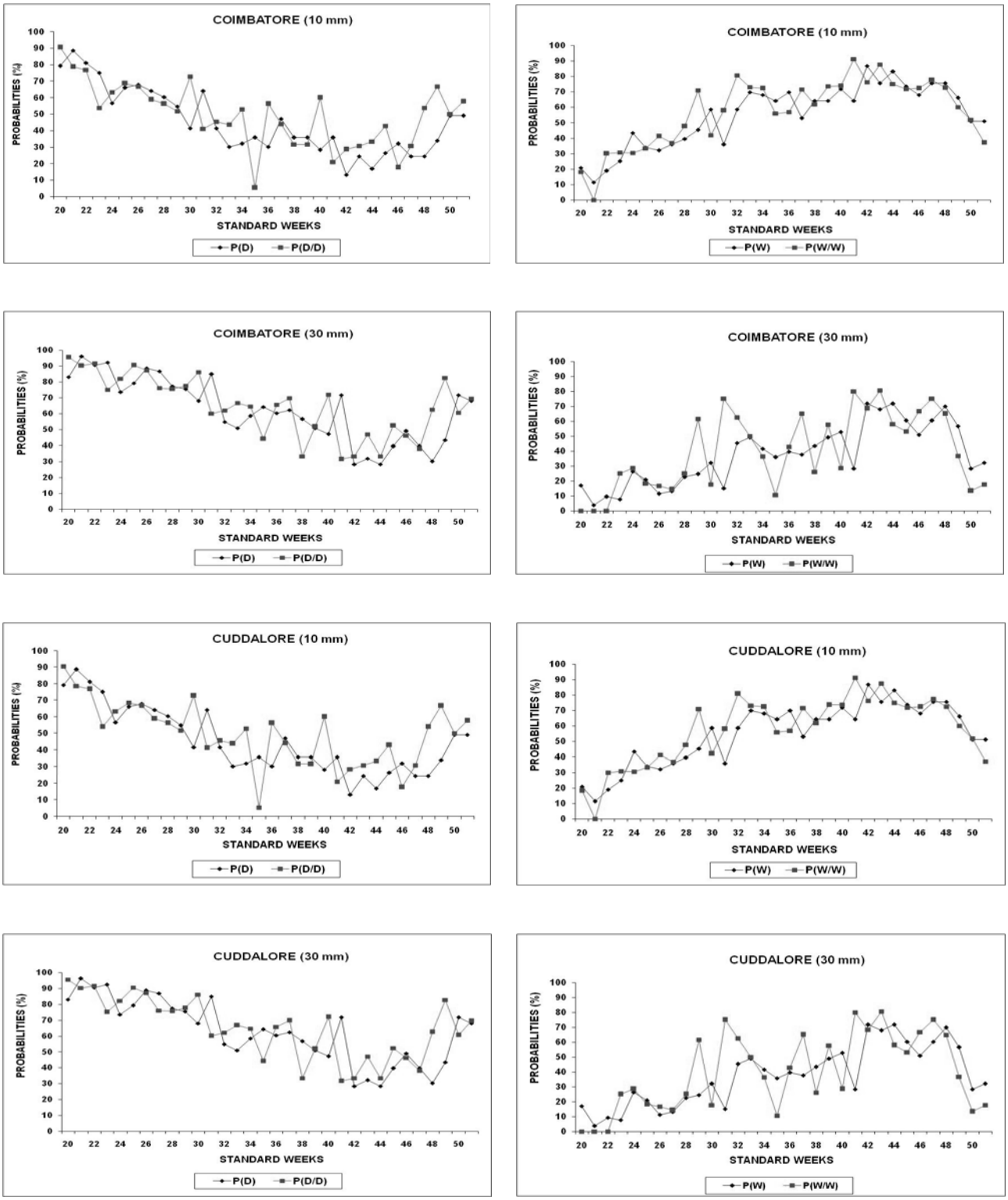


Fig. 1 (a). Probabilities P(D), P(W), P(D/D) and P(W/W) in Coimbatore and Cuddalore districts of Tamil Nadu

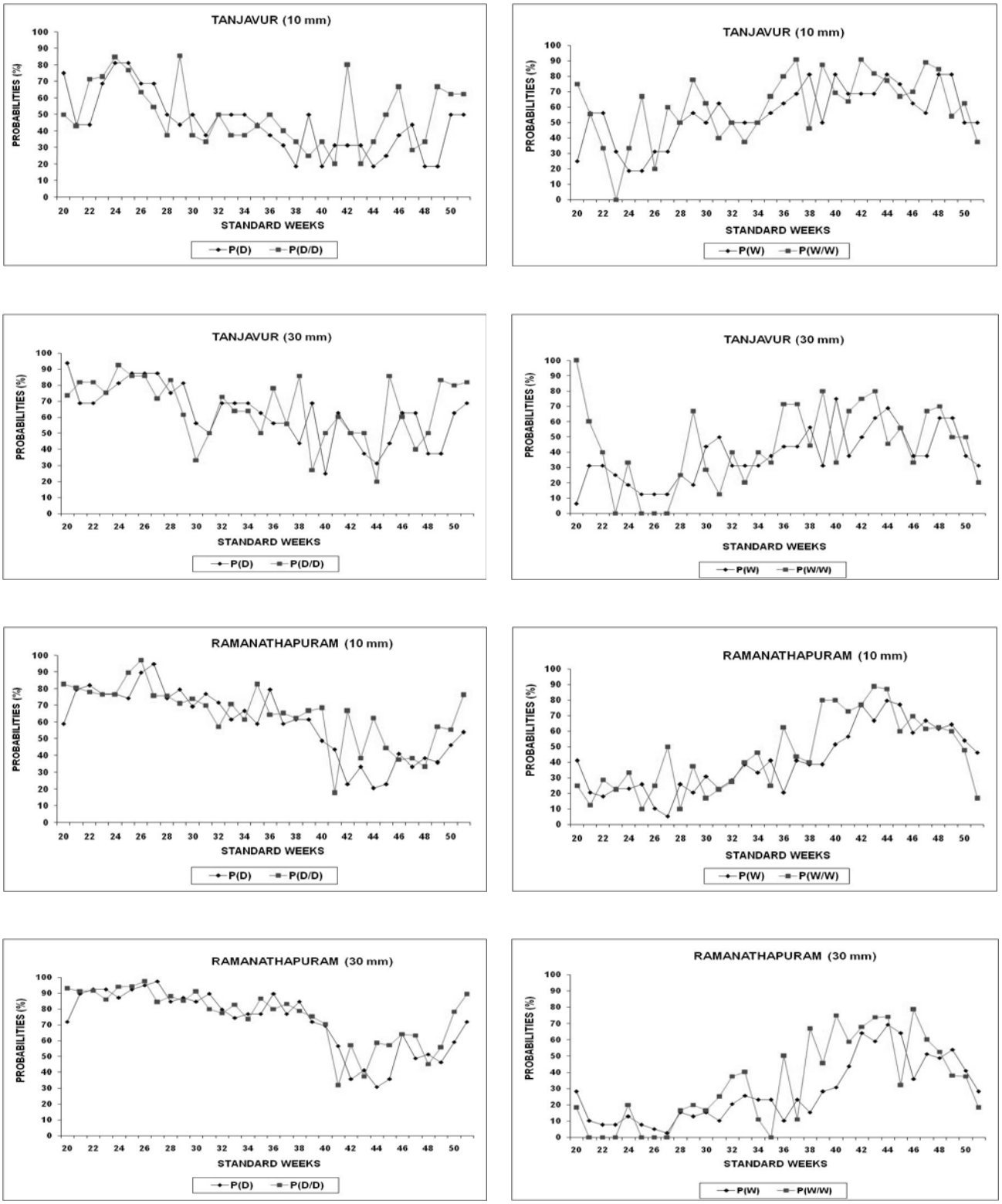


Fig. 1 (b). Probabilities P(D), P(W), P(D/D) and P(W/W) in Tanjavur and Ramanathapuram districts of Tamil Nadu

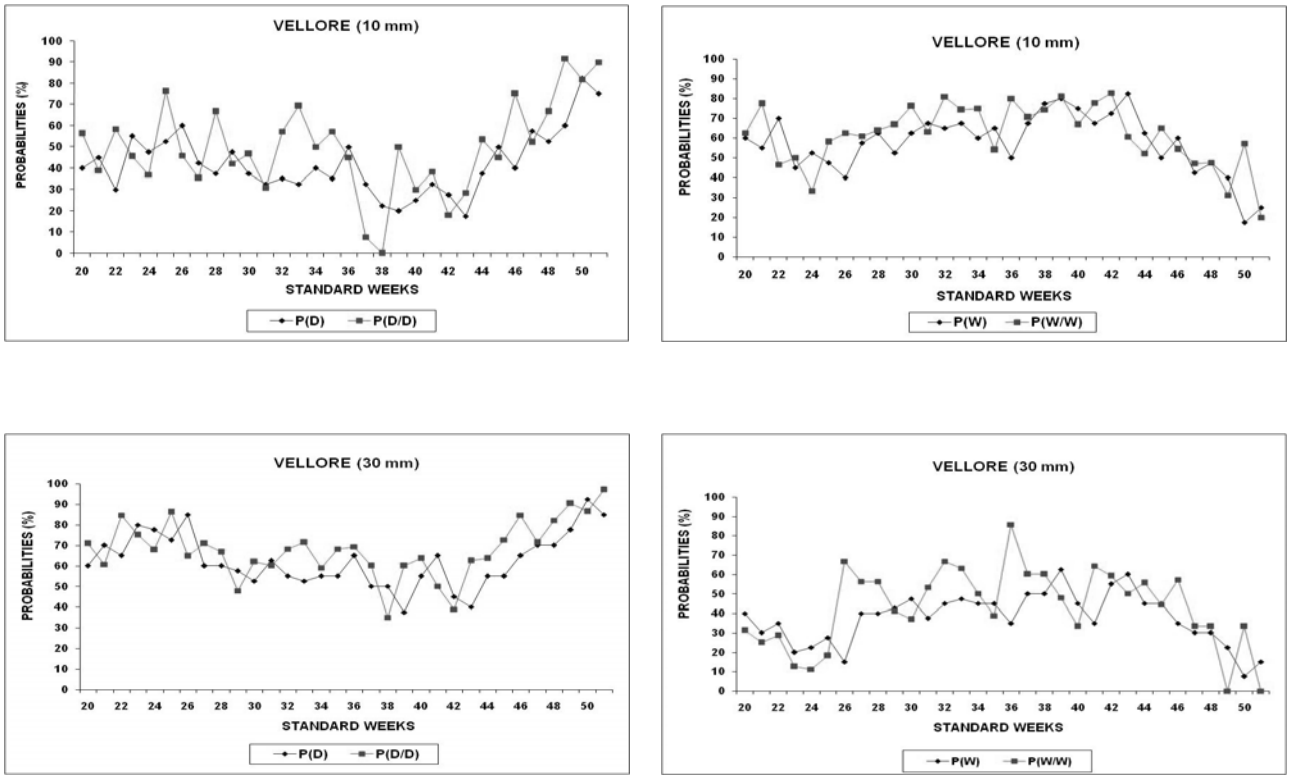


Fig. 1 (c). Probabilities P(D), P(W), P(D/D) and P(W/W) in Vellore district of Tamil Nadu

For the present study, a weekly rainfall of ≥ 30 mm was taken as wet week and < 30 mm was taken as dry week. A second criterion of weekly rainfall of ≥ 10 mm was taken as wet week and < 10 mm was taken as dry week has also been worked out to find out the chances for minimum rainfall in a week for planning of agricultural operations after sowing.

2.2. *Conditional probability*

The conditional probability of dry week preceded by a dry week or wet week preceded by wet week are computed by using following formula.

$$P(D_2 / D_1) = \frac{F(D_2 D_1)}{F(D_1)}$$

$$P(W_2 / W_1) = \frac{F(W_2 W_1)}{F(W_1)}$$

(Subscript to W and D indicates the no. of week)

Where,

$P(D_2 / D_1)$ = Probability of second week being dry with the preceding week dry

$P(W_2 / W_1)$ = Probability of second week being wet with the preceding week wet

$F(D_2 / D_1)$ = Frequencies of dry week preceded by dry week

$F(W_2 / W_1)$ = Frequencies of wet week preceded by wet week

Both initial and conditional probability for each week was computed from the weekly rainfall data over 55 years (1951-2005).

3. Results and discussion

Analysis of probability of dry and wet spell in the two states indicates a wide variation with respect to

rainfall and associated crop selection. While probability of 30 mm rainfall is useful in fixing the date of sowing, probability of 10 mm rainfall will be useful in identifying the chances of minimum support for crop growth with respect to water needs (Veeraputhiran *et al*., 2003).

3.1. *Tamil Nadu*

In Tamil Nadu all the districts considered, receive substantial rainfall during northeast monsoon season (October-December) though some of the districts in the western region receive significant rainfall during southwest monsoon also. Out of selected stations in Tamil Nadu, part of Cuddalore district is also benefited from southwest monsoon. Any deviation in the normal rainfall either during southwest monsoon season or during northeast monsoon season in a year would impact cropping greatly and also the water availability would be always under stake, in all the three fragile sources of irrigation, *viz*., tank, canals and wells in Tamil Nadu. Year to year variation in the rainfall and recent scenarios of alternating floods and droughts in this region envisages, the need for proper planning for judicious cropping strategies.

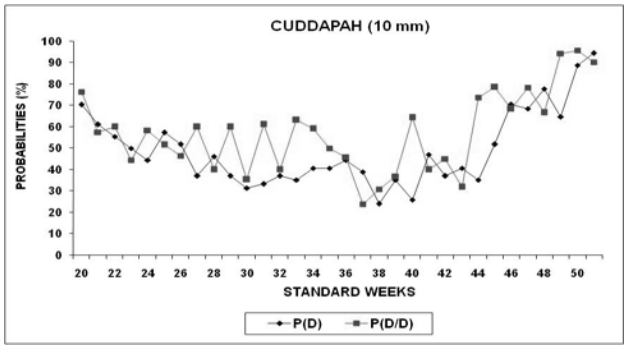
Cuddalore [Fig. 1(a)] and Vellore [Fig. 1(c)] stations come under northeastern zone of Tamil Nadu. As mentioned earlier, parts of Cuddalore receive some rainfall during southwest monsoon also. Hence continuous cropping is feasible during northeast monsoon which is the main source of rainfall. Average rainfall during northeast monsoon is 880 mm and 350 mm, respectively, in Cuddalore and Vellore. Major soil type is clay loam / sandy clay loam with moderate water holding capacity of 160-200 mm in Cuddalore (IMD, 2009). During kharif season, groundnut is the major crop in the region and black gram and maize are the major crops during rabi season (Palaniappan *et al*., 1988). High probability of wet weeks with 30 mm rainfall starts from 29th standard week and fluctuates thereafter. However, there is a well distribution of wet weeks with 30 mm rainfall after 42nd standard week. As groundnut is relatively drought tolerant during early stages of growth, erratic distribution of wet weeks as observed, does not affect much on the crop. Even if rainfall is lower due to poor distribution of rainfall, in such villages short duration varieties of maize and black gram can be selected as they are low water requiring crops.

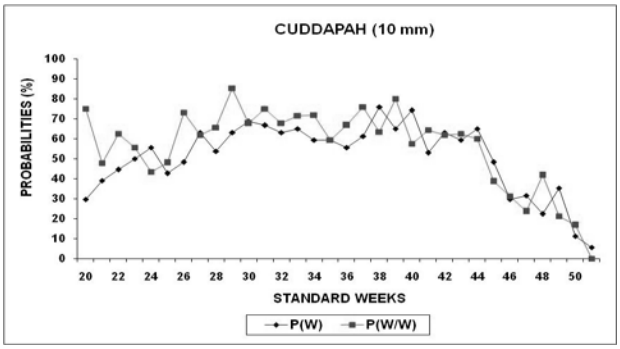
Vellore district receives good rainfall during both the seasons. Alfisols with loam texture is the major soil type followed by clay loam soils. The water holding capacity is 220 mm (IMD, 2009). Groundnut, red gram and sorghum are the major crops grown during kharif season. Groundnut is also cultivated during rabi season. Probability analysis for the wet and dry spells indicates that there is a fairly well distribution of wet weeks starting from 26th to 46th standard weeks. This ensures cultivation of the crops without moisture stress during both the seasons. Probability of weeks with 10 mm rainfall also indicates successful inter-cultural operations even though there is lower probability of weeks with 30 mm rainfall at times.

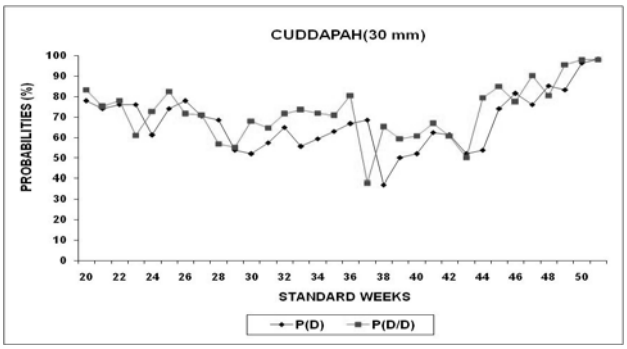
Ramanathapuram [Fig. 1(b)] comes under southern zone of Tamil Nadu with vertisols as major soil type. The water holding capacity is 280 mm (IMD, 2009). This region receives 565 mm rainfall during northeast monsoon season only. Pulses like black gram and green gram are the major crops in the region due to receipt of low rainfall. Millets like jowar are also selected when there is delay in arrival of monsoon. Probability analysis indicates that there is well distribution of wet weeks with 30 mm of rainfall from 37th standard week onwards upto 48th standard week. This ensures successful cropping though with intermittent fluctuations. However, good chance for wet weeks with 10 mm of rainfall during the period assures continuous crop growth.

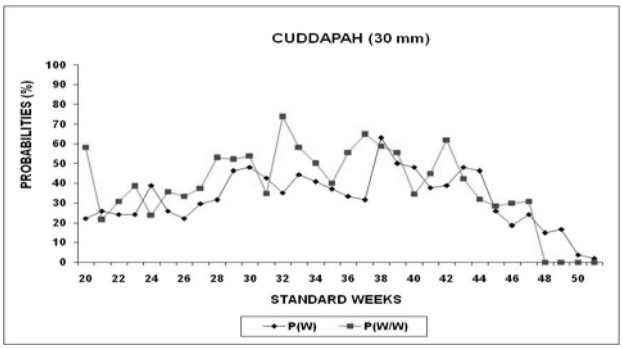
Coimbatore [Fig. 1(a)] is the region under Northwestern zone of Tamil Nadu. Vertisol and alfisols are the major soil types with water holding capacity of 300 mm and 250 mm, respectively (IMD, 2009). This region receives rainfall during northeast monsoon only and rabi crops like groundnut are grown. Maize is also grown after the harvest of rabi crops with residual soil moisture when good monsoon rainfall is received. When monsoon is delayed, pulse crops are selected in lieu of groundnut. Probability analysis for the wet weeks with 30 mm of rainfall indicates that cropping period commences during 40th standard week. Rainfall is received upto 48th standard week only. However probability of wet weeks with 10 mm rainfall assures sustained crop growth when chances for getting 30 mm rainfall in a week are fluctuating.

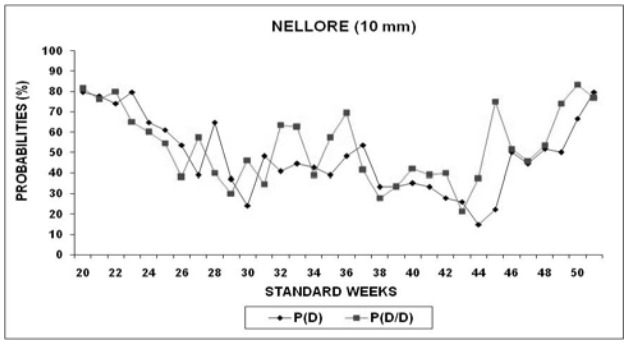
Tanjavur [Fig. 1(b)] is the region under Cauvery delta zone of Tamil Nadu. Deep alfisols are the major soil type. Rainfall is received mainly during northeast monsoon season (625 mm). Pulses like black gram and green gram and sesame are the major crops grown during rabi season. When monsoon arrival is in time, cotton is also selected with residual moisture support during later

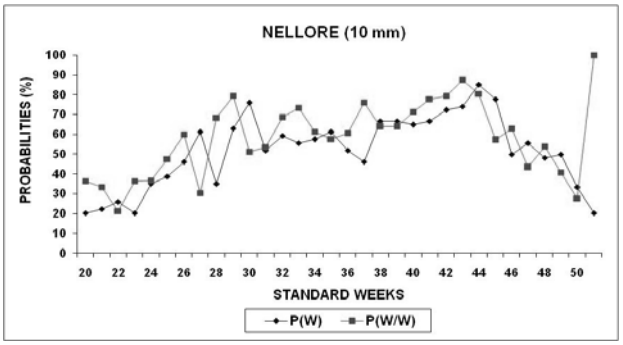


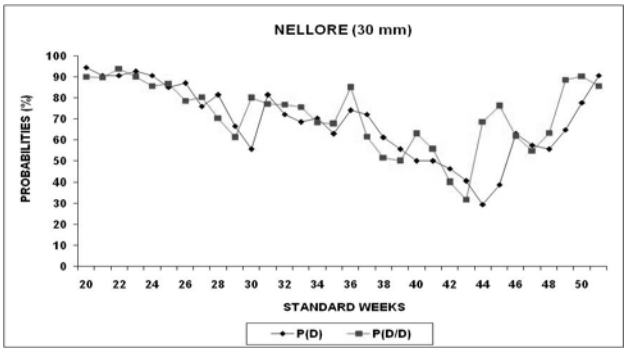












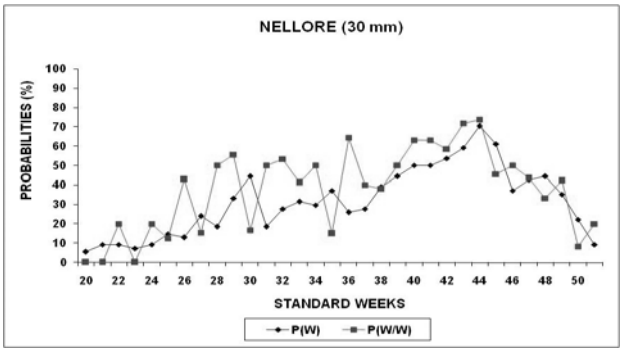


Fig. 2 (a). Probabilities P(D), P(W), P(D/D) and P(W/W) in Cuddapah and Nellore districts of Andhra Pradesh

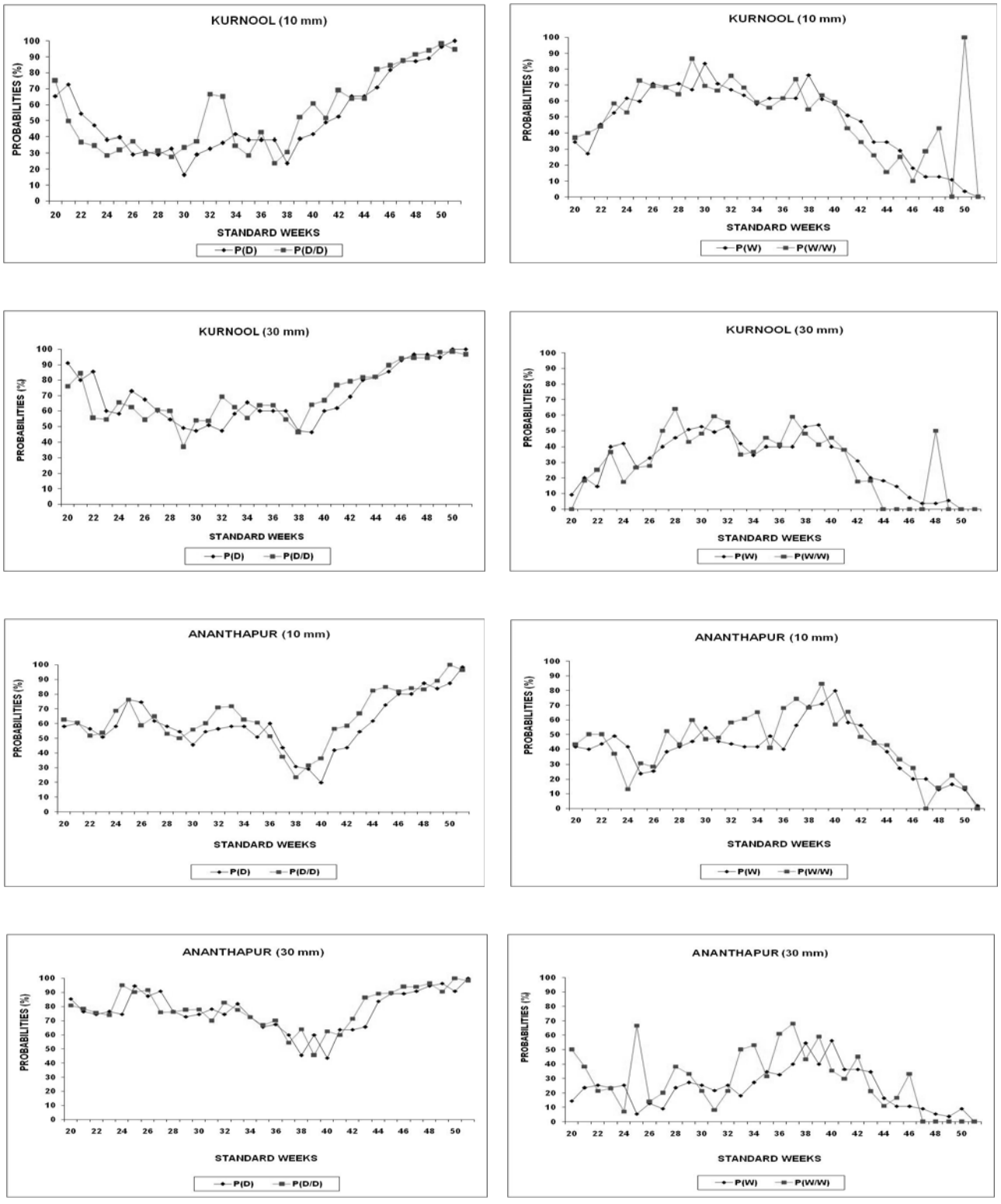


Fig. 2 (b). Probabilities P(D), P(W), P(D/D) and P(W/W) in Kurnool and Ananthapuram districts of Andhra Pradesh

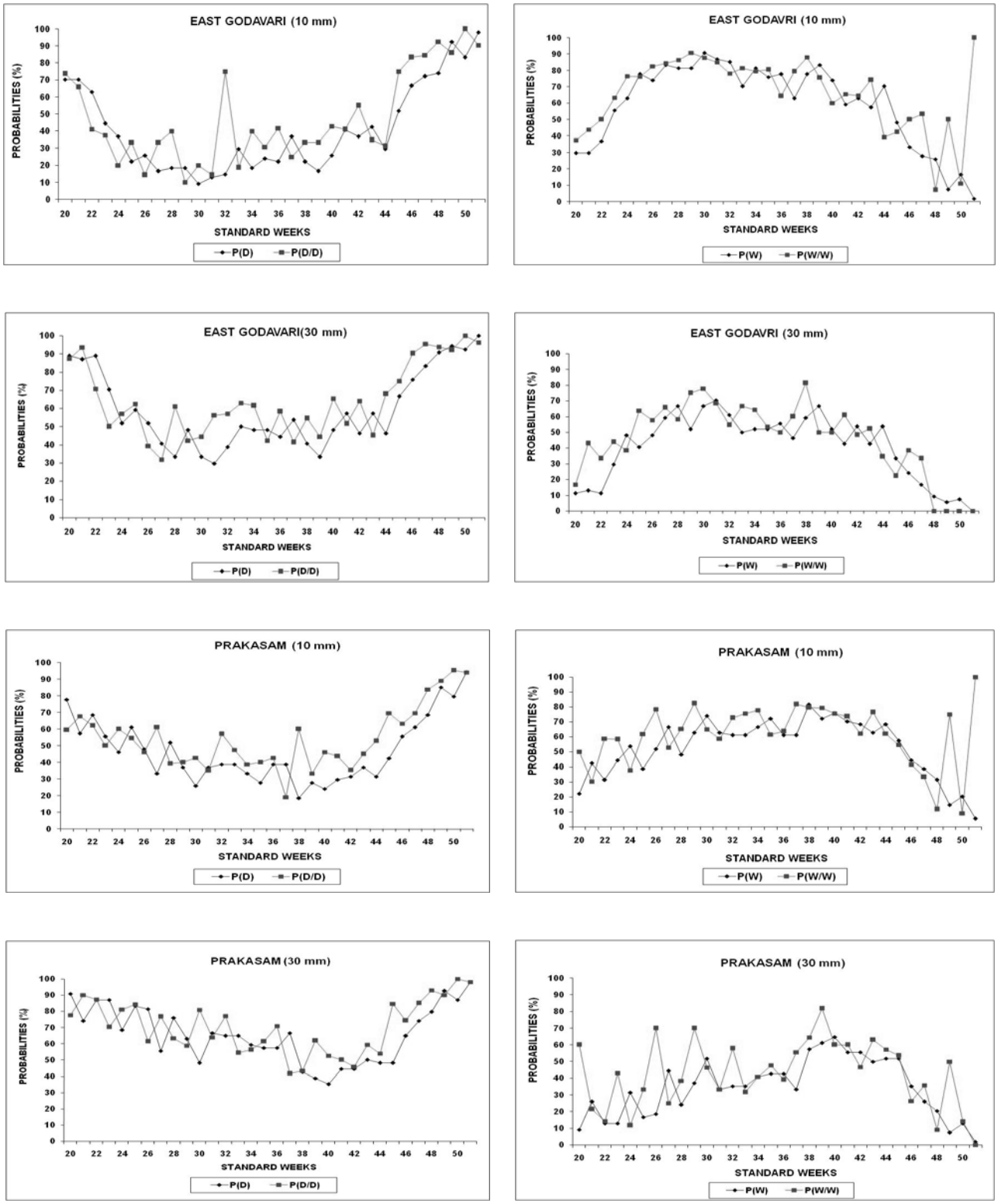


Fig. 2 (c). Probabilities P(D), P(W), P(D/D) and P(W/W) in East Godavari and Prakasam districts of Andhra Pradesh

part of the crop growth. Probability of wet weeks with 30 mm indicates erratic distribution of rainfall even after the start of growing period during 38th standard week. This also indicates that crop production is at stake during rabi season. However, the region receives canal irrigation during kharif season. Rabi crops are sown with residual soil moisture and the crop is supported with subsequent arrival of northeast monsoon rainfall. Though there is erratic distribution of probabilities of getting 30 mm rainfall in a week, probabilities of getting 10 mm of rainfall in a week is consistent and hence supports for continuous soil moisture reserve for satisfactory cropping.

3.2. *Andhra Pradesh*

In Andhra Pradesh, the stations have been selected from extreme northeast region receiving high rainfall to extreme southwest region receiving poor rainfall. Such rainfall variability has influenced in crop selection obviously. Ananthapur and Kurnool [Fig. 2(b)] are the stations under scarce rainfall zone which is considered as rain-shadow area w.r.t. to southwest monsoon. These regions receive a poor rainfall of 363.1 and 493.1 mm respectively during southwest monsoon and 184.1 and 157.3 mm respectively during northeast monsoon. Alfisols is the major soil with poor water holding capacity of 120 mm (IMD, 2009). Crops like groundnut, jawar and pulses (red gram) are grown - with intermittent dry spells during growth period of the crops - in the region (Singh *et al*., 1988).

Analysis of probabilities for dry and wet spells indicates that though the region receives good rainfall during southwest monsoon, probability of wet spell [both P(W) & P(W/W)] is more during northeast monsoon period due to well distributed rainfall. The duration of wet spells during northeast monsoon is also very short (from 40th to 43rd week) indicating very limited length of growing period having a chance for a partly successful crop. Rainfall adequate for crop growth also commences late during 46th standard week. As the crops will be at grain formation statge, the evapotranspiration loss is also high, thereby causing a severe moisture stress. This also suggests need for selection of low-water requring crops as mentioned earlier.

Cuddapah and Nellore [Fig. 2(a)] are the stations under southern zone of Andhra Pradesh in the scarce rainfall zone. This region also receives 380 mm rainfall during southwest and 250 mm during northeast monsoon season. Alfisols are the major soils with water holding capacity of 200 mm (IMD, 2009). As rainfall pattern shows assured rainfall even during northeast monsoon, higher water requiring crops like rice and cotton are also cultivated with supplemental irrigation in addition to groundnut (Singh *et al*., 1988). Due to bi-model type of rainfall, the crops generally face no moisture stress during the crop growth in this region.

In this zone also, probability analysis indicates that during northeast monsoon period, there is well distribution of rainfall and there is higher probability of wet spells [both P(W) and P (W/W)] than dry spell. Hence crops like rice, cotton (with supplemental irrigation) and groundnut can be cultivated without much moisture stress during the northeast season. This also indicates chances of continuous moisture availability to long duration crops like cotton even after southwest monsoon period indicating a successful crop prospect without much dry spells. Cotton crop need to be sown in early February so that it will be in flowering stage during May where there is more chances for rainfall. Hence, the crop sowing must be planned so that the crop is not exposed to wet spells during flowering.

East Godavari [Fig. 2(c)] is under high altitude zone. This zone receives maximum rainfall of 725 mm during southwest monsoon as compared to 300 mm rainfall in northeast monsoon. As the station receives more rainfall during southwest monsoon, successful cropping is ensured during kharif with crops like paddy. The major soil type is alluvial with water holding capacity of 250 mm (IMD, 2009). Crops do not face moisture stress during growing period due to well distribution of rainfall. On the contrary flooding is also reported at times due to heavy rainfall.

Analysis for the probability of dry and wet spells for East Godavari indicates that the probabilities for wet week (P(W)) and [P(W/W)] are quite high throughout the southwest monsoon compared to NE monsoon. Significant rains for cropping commences during 26th standard week itself indicating timely sowing of kharif crops. This also indicates assured crop during kharif season. P(W) and P(W/W) start declining during northeast monsoon due to cessation of rainfall. Higher rainfall during SW monsoon season helps to build up residual soil moisture which supports short duration crops during rabi season.

Prakasam [Fig. 2(c)] is under Krishna Godavari zone of Andhra Pradesh, located at the centre of the state. This station receives high rainfall during northeast monsoon. The average rainfall during northeast monsoon is 356 mm and ensures successful rabi crops. Black soil is the major soil type with water holding capacity of 200 mm (IMD, 2009). In this zone, major crop grown during rabi season is groundnut (Singh *et al*., 1988). Due to poor distribution of rainfall after 45th week, crops are likely to experience moisture stress during later part of growing period.

Rainfall significant for sowing of crop commences during 39th-40th standard week and this ensures timely sowing of rabi crops. Analysis of dry and wet spells (both for 30 and 10 mm rainfall), indicates that P(W) and P(W/W) is very less (6-7 weeks) during rabi season when sowing has to be undertaken timely for a partially successful crop. Alternate short duration crops and varieties need to be selected to tailor with shorter growing period.

4. Conclusions

In the past few years agro advisory bulletins are being issued by IMD from 17 meteorological centers on a weekly basis. Any information on the probability of weekly rainfall in any district is of their concern. Agro advisories based on pattern of actual rainfall during the preceding week, helps in farming need-based advisory bulletins to the farmer. They can suggest to the farmers whether the supplementary irrigation has to be provided or to refrain from application of pesticides and insecticides if chances of rainfall are high.

The technique has also potential use for hydrological purposes. For instance, if there is a spell of rainfall in a catchment area of a dam during a particular period of time, there is a high possibility of rainfall to persist in the succeeding weeks, the hydraulic engineers can take appropriate measures to slowly release the water instead of releasing it in bulk at one time and flooding the downstream localities. Another application lies in identification of vulnerable areas.

Analysis for dry and wet spells indicate the selection of crops and varieties according to the probability of getting wet weeks preceeded by wet weeks with the onset and advance of southwest / northeast monsoon in the given region. Timely advance of monsoon will favour selection of long duration crops like cotton and also high water requiring crops like paddy in the regions like Cuddapah and Nellore. Normal advance of monsoon will lead to selection of crops with medium duration and moisture stress tolerant crops in the moderate rainfall districts of Ananthapur, Kurnool (Scarce Rainfall zone), where erratic monsoon behaviour is observed. Crops like groundnut and millets are recommended in these regions. However, pulses need to be selected often as inter crops for a successful cropping based on varied rainfall situation in both Andhra Pradesh and Tamilnadu. The study also concludes that depending on the advancement of monsoon and distribution of rainfall for the past few weeks, the likely distribution of rainfall in the coming weeks can be assessed with higher chances of occurrennce (based on the probability analysis of wet and dry spells). Such information when included in agro advisories will enable farmers to carry out better weather based management of their crops for sustained higher productivity.

Acknowledgements

The authors express their sincere thanks to AVM (Dr.) Ajit Tyagi, DGM, IMD, New Delhi for providing all the facilities to carry out this work. They are also thankful to Dr. L. S. Rathore, Head (Agromet) for his help, suggestions and support.

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