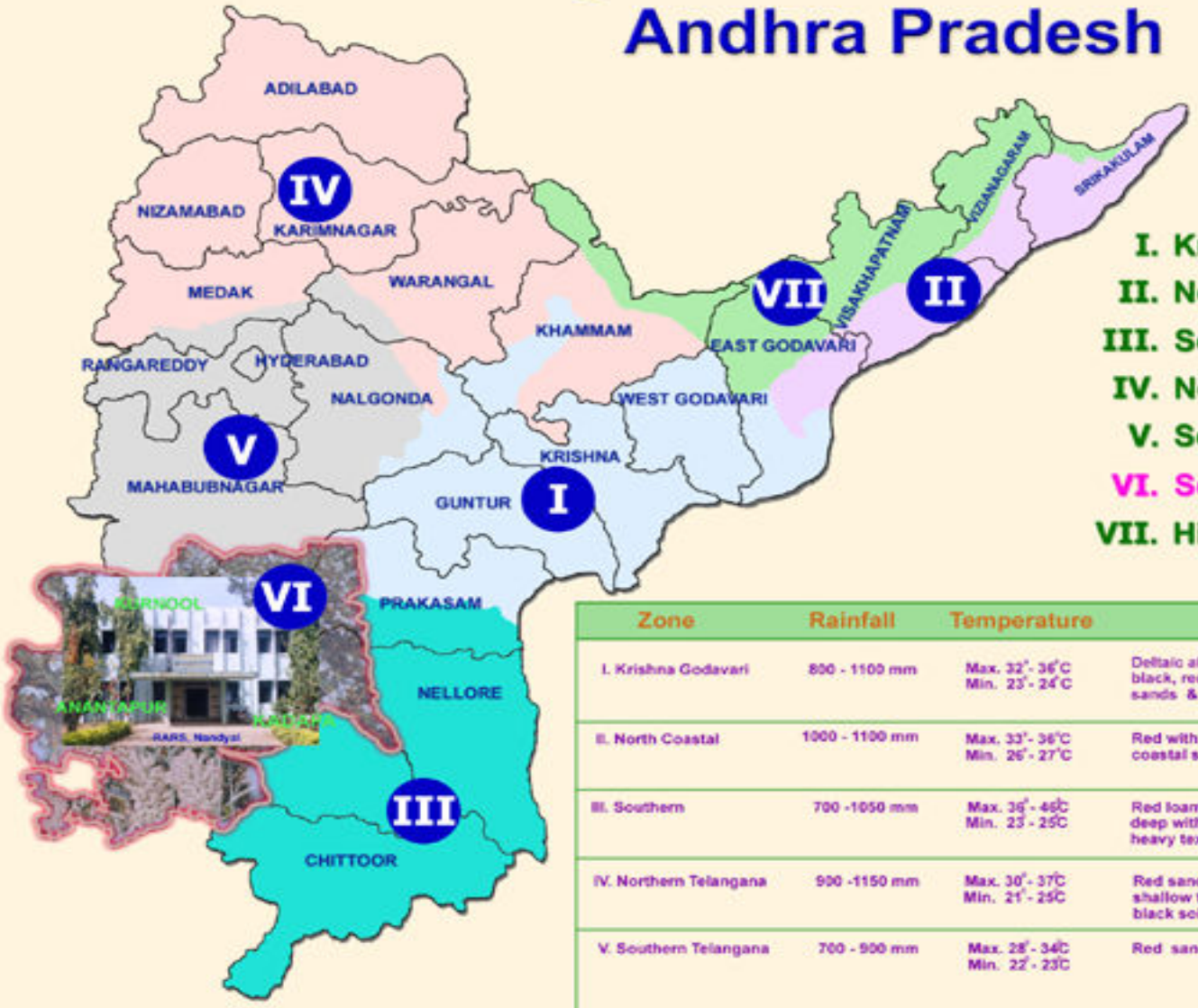


Planning Agricultural Operations Based on Rainfall Analysis in Vertisols of Scarce Rainfall Zone

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Agro-climatic zones of Andhra Pradesh

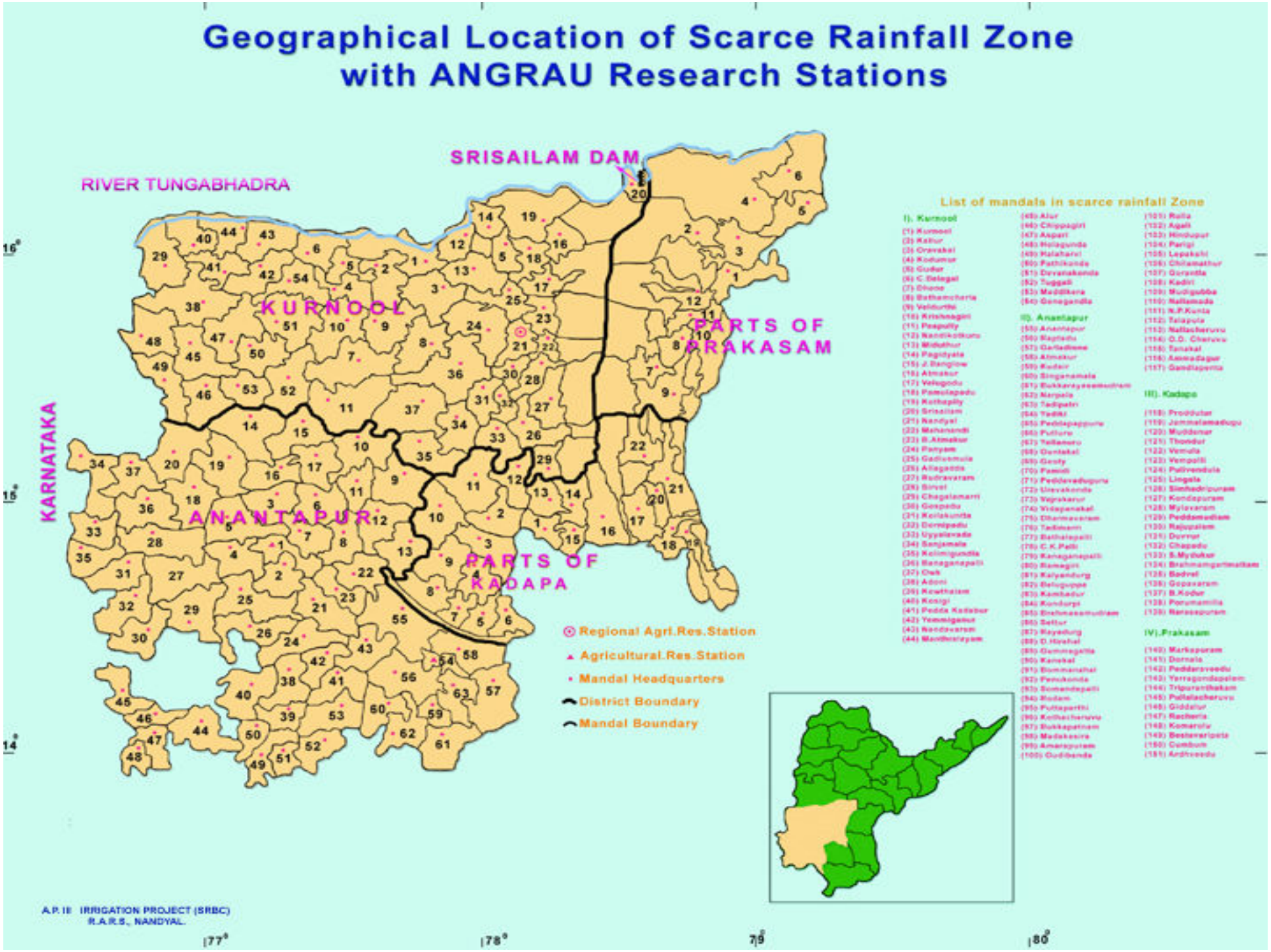


I. Krishna Godavari Zone
II. North Coastal Zone
III. Southern Zone
IV. Northern Telangana Zone
V. Southern Telangana Zone
VI. Scarce Rainfall Zone
VII. High Altitude & Tribal area Zone

Zone	Rainfall	Temperature	Soil type	Crops grown
I. Krishna Godavari	800 - 1100 mm	Max. 32°- 36°C Min. 23°- 24°C	Deltaic alluvium, deep and medium black, red and red loams, coastal sands & saline soils	Rice, blackgram, greengram, redgram, cotton, sugarcane, tobacco, chillies, sesamum, banana, mango, coconut
II. North Coastal	1000 - 1100 mm	Max. 33°- 36°C Min. 26°- 27°C	Red with clay base, alluvium coastal sand and lateritic	Rice, millets, sugarcane, groundnut, sesamum and mesta topica, fruits and vegetables
III. Southern	700 -1050 mm	Max. 36°- 46°C Min. 23°- 25°C	Red loamy shallow to moderately deep with limited occurrence of heavy textured black soils	Groundnut, rice, sugarcane, ragi, bajra, redgram, other pulses, citrus, melons, mango
IV. Northern Telangana	900 -1150 mm	Max. 30°- 37°C Min. 21°- 25°C	Red sandy loams, red loamy, shallow to medium deep black soils	Rice, maize, jower, pulses, cotton groundnut, turmeric, chillies, sugarcane
V. Southern Telangana	700 - 900 mm	Max. 28°- 34°C Min. 22°- 23°C	Red sandy, red earth and black	Jower, castor, rice, groundnut bajra, redgram, horsegram, ragi greengram, maize, sesamum, grapes, vegetables
VI. Scarce Rainfall	500 - 750 mm	Max. 33°- 36°C Min. 24°- 30°C	Black, red earths, loamy sub-soils, red sandy, red earth with clayey sub-soil, light black, red loamy, and problem soils	Groundnut, sorgum, foxtail millets, rice, cotton, coriander, Pulses and pearl millet, sunflower
VII. High Altitude & Tribal Area	1145 - 1288 mm			Rice, ragi, groundnut, jower horsegram, bajra, mesta, niger redgram, aromatic and medicinal plants, flowers

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Geographical Location of Scarce Rainfall Zone with ANGRAU Research Stations



List of mandals in scarce rainfall Zone

I). Kurnool

(1) Kurnool
(2) Kallur
(3) Orvakal
(4) Kodumur
(5) Gudur
(6) C.Belagal
(7) Dhone
(8) Bethamcherla
(9) Veldurthi
(10) Krishnagiri
(11) Peapully
(12) Nandikotkuru
(13) Midduthur
(14) Pagidyala
(15) J.Bangalow
(16) Atmakur
(17) Velugodu
(18) Pamulapadu
(19) Kothapilly
(20) Srisailam
(21) Nandyal
(22) Maharandi
(23) B.Atmakur
(24) Panyam
(25) Gadivemula
(26) Allagadda
(27) Rudravaram
(28) Sirvel
(29) Chagalamarri
(30) Gospadu
(31) Koilakuntla
(32) Dornipadu
(33) Uyyalavada
(34) Sanjamala
(35) Kolimigundla
(36) Banaganapalli
(37) Owk
(38) Adoni
(39) Kowthalam
(40) Kosigi
(41) Pedda Kadubur
(42) Yemmiganur
(43) Nandavaram
(44) Mantheralyam
(45) Alur
(46) Chippagiri
(47) Aspari
(48) Holagunda
(49) Halaharvi
(50) Pathikonda
(51) Devanakonda
(52) Tuggali
(53) Maddikera
(54) Gonegandla

II). Anantapur

(55) Anantapur
(56) Rapthadu
(57) Garladinne
(58) Atmakur
(59) Kudair
(60) Singanamala
(61) Bukkarayasamudram
(62) Narpala
(63) Tadipatri
(64) Tadikl
(65) Pedapapgpuru
(66) Putturu
(67) Tellamaru
(68) Guntakal
(69) Gooty
(70) Pamidi
(71) Peddavadugurru
(72) Uravakonda
(73) Vajrakarur
(74) Vidapanakal
(75) Dharmavaram
(76) Tadimarri
(77) Bathalapalli
(78) C.K.Palli
(79) Kanaganapalli
(80) Ramagiri
(81) Kalyandurg
(82) Beluguppa
(83) Kambadur
(84) Kundurpi
(85) Brahmasamudram
(86) Settur
(87) Rayadurg
(88) D.Hirehal
(89) Gummegatta
(90) Kanekal
(91) Bommanahal
(92) Penukonda
(93) Somandepalli
(94) Rodam
(95) Puttaparthi
(96) Kothacheruvu
(97) Bukkapatnam
(98) Madakasira
(99) Amarapuram
(100) Gudibanda

III). Kadapa

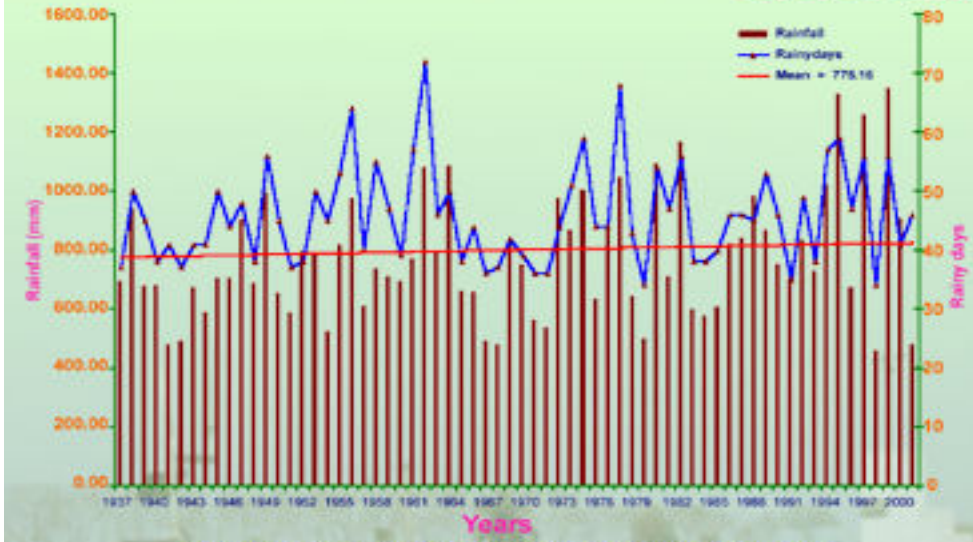
(158) Proddutur
(159) Jammalamadugu
(120) Muddanur
(121) Thondur
(122) Vemula
(123) Vempolli
(124) Pulivendula
(125) Lingala
(126) Simhadripuram
(127) Kondapuram
(128) Mylavaram
(129) Peddamudiam
(130) Rajupalem
(131) Duvvur
(132) Chapadu
(133) S.Mydukur
(134) Brahmamgarimattam
(135) Badvel
(136) Gopavaram
(137) B.Kodur
(138) Porumamilla
(139) Ramapuram

IV).Prakasam

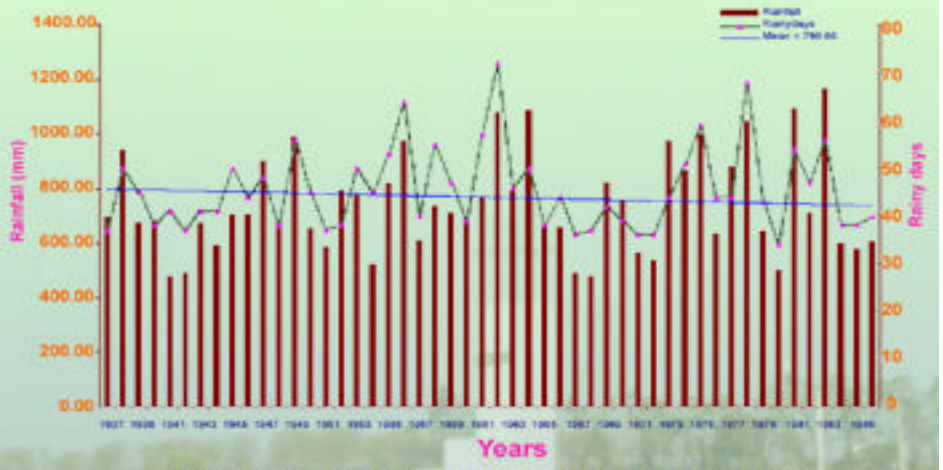
(140) Markapuram
(141) Dornala
(142) Peddaravedu
(143) Yerragondapalem
(144) Tripuranthakam
(145) Pullalacheruvu
(146) Giddalur
(147) Racherla
(148) Komarolu
(149) Bestavaripeta
(150) Cumbum
(151) Ardhveedu
(101) Rolla
(102) Agali
(103) Hindupur
(104) Parigi
(105) Lepakshi
(106) Chilamathur
(107) Gorantla
(108) Kadiri
(109) Mudigubba
(110) Nallamada
(111) N.P.Kunta
(112) Talapula
(113) Nallacheruvu
(114) O.D. Cheruvu
(115) Tanakal
(116) Ammadagur
(117) Gandlapenta

Average rainfall of kharif season
(22nd to 39 standard week) = 560 mm
Average rainy days of kharif season
(22nd to 39 standard week) = 33
Average rainfall of rabi season
(40th to 52 standard week) =130 mm
Average rainy days of rabi season
(40th to 52 standard week) =7.6
Kharif crops : Rice , Cotton and Pigeon pea
Rabi crops during post rainy season: Chickpea, Sorghum, Sunflower and Coriander.
Soils : Vertisols.

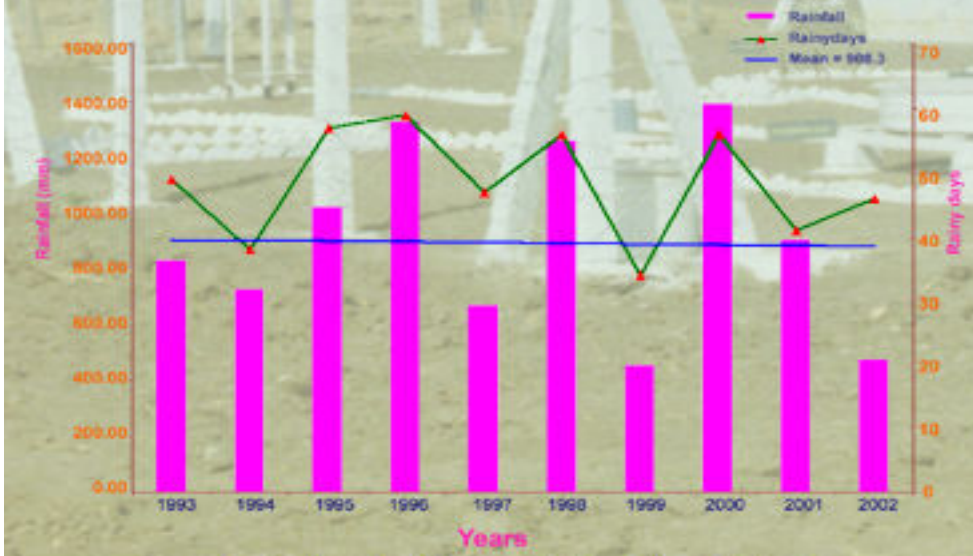
RAINFALL DATA



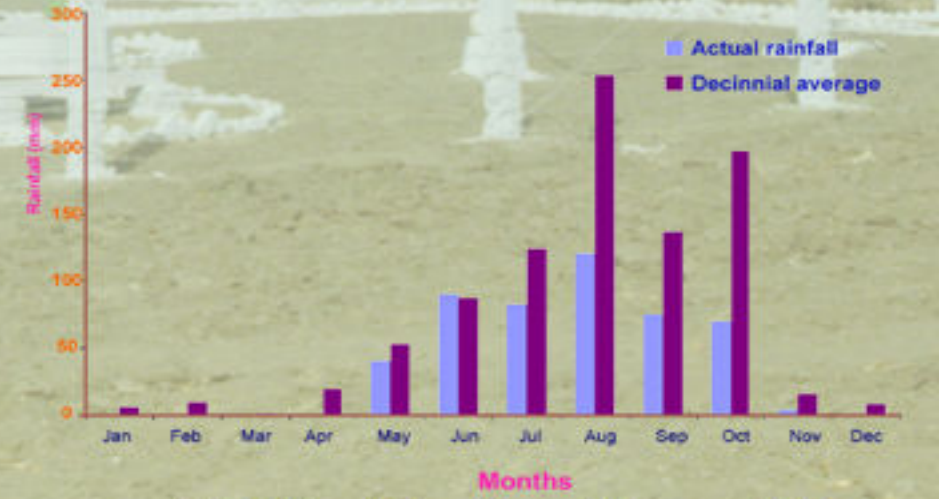
Graph showing 66 years of Rainfall and Rainydays
at RARS Nandyal (1937-2002)



Graph showing 50 years of Rainfall and rainydays
at RARS, Nandyal (1937-1986)



Graph showing 10 years of Rainfall and Rainy days
at RARS, Nandyal (1993-2002)



Rainfall during 2002 and Decennial Average rainfall
at RARS, Nandyal

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RAINFALL ANALYSIS- METHODOLOGY

The rainfall data from 1937 to 2006 recorded at Nandyal, Kurnool District, Andhra Pradesh has been analysed for its distribution and suitability for different agricultural operations

In Markov chain model both initial and conditional probability are used

Based on the amount of rainfall received the weeks are divided in to wet and dry weeks.

RAINFALL ANALYSIS- THRESHOLD LIMITS

A certain amount of rainfall is fixed as threshold limit based on either the stage of the crop or a particular field operation that is to be performed on field.

If the amount of rainfall received is ≥ to the threshold limit , the week is considered as wet week and if the amount is less than the threshold limit, the week is considered as dry week.

A minimum of 10 mm rainfall for land preparation,

20 mm rainfall at > 50% probability or W/W and or W/D at > 50 % probability preferably 75 % for sowing,

40 mm of rainfall for fertilizer application preferably at 75% probability and or W/W or W/D at 75 % probability and

80 mm at >25% probability is not conducive for pesticide/insecticide spray / fertilizer application as threshold levels.

For initial probability the following formulae are used

$$\text{(I)} \quad P(W) = \frac{F(W)}{F(W) + F(D)} \qquad \text{(II)} \quad P(D) = \frac{F(D)}{F(W) + F(D)}$$

Where P(W) = probability of week being wet
P(D) = probability of week being dry
F(W) = Frequency of week being wet
F(D) = Frequency of week being dry

Conditional probability : **It helps to estimate the extent of dry spell as well as wet spell.**

The formulae used for conditional probability are

$$\text{(I)}\quad P(W/D) = \frac{F(W/D)}{F(W)} \qquad \text{(II)}\quad P(W/W) = \frac{F(W/W)}{F(W)}$$

$$\text{(III)}\quad P(D/D) = \frac{F(D/D)}{F(D)} \qquad \text{(IV)}\quad P(D/W) = \frac{F(D/W)}{F(D)}$$

Where P(W/D) = probability of wet week followed by dry week
P(W/W) = probability of wet week followed by wet week
P(D/W) = probability of dry week followed by wet week
P(D/D) = probability of dry week followed by dry week
F(W/D) = Frequency of wet week followed by dry week
F(W/W) = Frequency of wet week followed by wet week
F(D/D) = Frequency of dry week followed by dry week
F(D/W) = Frequency of dry week followed by wet week
F(W) = Frequency of wet week
F(D) = Frequency of dry week

Conditional Probability for 20 mm Threshold level

S. W.	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953
23-24	WD	DD	DD	DD	DD	DW	WD	DD	DD	WW	WD	DD	DW	WW	WD	WD	DW
24-25	DW	DW	DW	DW	DW	WW	DD	DD	DD	WW	DW	DD	WW	WW	DD	DD	WD
25-26	WD	WD	WW	WD	WW	WD	DD	DW	DW	WD	WW	DD	WW	WD	DD	DD	DW
26-27	DD	DW	WW	DD	WD	DD	DW	WW	WW	DD	WW	DW	WD	DW	DW	DD	WD
27-28	DW	WW	WD	DD	DD	DD	WD	WW	WD	DD	WW	WW	DW	WW	WW	DD	DD
28-29	WW	WD	DD	DD	DD	DW	DD	WD	DW	DD	WD	WW	WD	WW	WW	DW	DD
29-30	WD	DW	DD	DW	DD	WW	DD	DD	WW	DW	DW	WW	DW	WD	WD	WD	DW
30-31	DD	WW	DD	WD	DD	WD	DD	DD	WW	WD	WD	WW	WW	DW	DW	DD	WW
31-32	DD	WW	DW	DW	DW	DD	DD	DD	WW	DW	DD	WW	WW	WD	WD	DW	WD
32-33	DD	WW	WW	WW	WD	DW	DD	DD	WD	WW	DW	WD	WD	DD	DD	WD	DW
33-34	DD	WW	WW	WW	DD	WW	DD	DD	DD	WD	WW	DD	DD	DD	DD	DW	WW
34-35	DD	WD	WD	WD	DW	WW	DW	DD	DW	DD	WW	DD	DD	DD	DW	WD	WW
35-36	DW	DD	DD	DD	WW	WW	WW	DW	WW	DW	WD	DD	DW	DW	WW	DD	WW
36-37	WD	DW	DW	DW	WD	WD	WW	WW	WD	WD	DW	DW	WD	WW	WD	DD	WW
37-38	DW	WW	WW	WW	DW	DD	WW	WW	DD	DD	WW	WW	DW	WD	DD	DW	WW
38-39	WW	WW	WD	WD	WD	DD	WW	WW	DW	DW	WD	WD	WD	DD	DW	WD	WW
39-40	WW	WD	DD	DD	DW	DD	WW	WW	WD	WW	DD	DD	DD	DW	WD	DD	WD
40-41	WW	DD	DW	DW	DD	DD	WD	WW	DD	WW	DD	DW	DW	WW	DD	DW	DW
41-42	WD	DD	WW	WW	DD	DD	DW	WD	DW	WD	DW	WW	WD	WD	DD	WW	WW
42-43	DD	DD	WD	WD	DD	DD	WW	DW	WD	DD	WD	WD	DW	DD	DD	WD	WW
43-44	DD	DD	DD	DD	DD	DD	WD	WD	DD	DD	DD	DD	WD	DD	DD	DD	WD

	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
23-24	D	W	D	W	D	D	D	W	W	W	W	D	W	D	D	D	D
	D	D	D	W	D	W	D	D	D	D	W	W	D	W	D	D	D
24-25	D	D	D	W	D	W	D	D	D	D	W	W	D	W	D	D	D
	D	D	D	D	D	W	D	W	D	D	W	D	D	W	D	D	W
25-26	D	D	D	D	D	W	D	W	D	D	W	D	D	W	D	D	W
	W	D	W	D	D	W	W	D	W	W	D	W	D	D	D	W	D
26-27	W	D	W	D	D	W	W	D	W	W	D	W	D	D	D	W	D
	D	D	D	W	W	W	W	D	W	D	D	W	D	D	W	D	D
27-28	D	D	D	W	W	W	W	D	W	D	D	W	D	D	W	D	D
	D	D	D	D	W	D	W	D	D	D	W	W	D	W	D	W	D
28-29	D	D	D	D	W	D	W	D	D	D	W	W	D	W	D	W	D
	W	W	W	D	D	W	W	W	W	W	W	D	D	W	W	D	D
29-30	W	W	W	D	D	W	W	W	W	W	W	D	D	W	W	D	D
	W	W	W	W	D	W	W	D	D	D	W	D	W	D	D	W	W
30-31	W	W	W	W	D	W	W	W	D	D	W	D	W	D	D	W	D
	W	W	W	W	W	D	D	D	W	W	W	D	D	W	D	D	D
31-32	W	W	W	W	W	D	D	D	W	W	W	D	D	W	D	D	D
	D	W	D	W	W	D	D	D	W	D	W	W	D	D	D	D	W
32-33	D	W	D	W	W	D	D	D	W	D	W	D	D	D	D	D	W
	D	W	D	D	W	W	D	W	W	W	D	D	D	D	D	D	W
33-34	D	W	D	D	W	W	D	W	W	W	D	D	D	D	D	D	W
	D	W	D	W	W	W	D	D	D	W	W	W	W	D	W	W	D
34-35	D	W	D	W	W	W	D	D	D	W	D	W	W	D	W	W	D
	W	W	W	D	W	W	W	D	W	D	W	W	W	W	D	W	D
35-36	W	W	W	D	W	W	W	D	W	D	W	W	W	W	D	W	D
	D	D	D	W	D	D	W	D	W	D	D	D	W	D	W	W	D
36-37	D	D	D	W	D	D	W	D	W	D	D	D	W	D	W	W	D
	D	D	D	W	D	D	W	D	W	D	W	D	D	D	W	D	D
37-38	D	D	D	W	D	D	W	D	W	D	W	D	D	D	W	D	D
	D	W	W	D	W	W	W	D	W	D	W	W	D	W	W	W	W
38-39	D	W	W	D	W	W	W	D	W	D	W	W	D	W	W	W	W
	W	D	D	D	W	D	D	D	D	W	W	W	W	W	W	D	D
39-40	W	D	D	D	W	D	D	D	D	W	W	W	W	W	W	D	D
	D	W	W	D	D	W	D	W	D	D	W	D	D	W	D	D	W
40-41	D	W	W	D	D	W	D	W	D	D	W	D	D	W	D	D	W
	D	D	W	D	W	W	D	W	D	D	W	D	W	D	W	D	W
41-42	D	D	W	D	W	W	D	W	D	D	W	D	W	D	W	D	W
	D	D	D	D	W	D	D	D	W	D	D	D	D	D	D	W	D
42-43	D	D	D	D	W	D	D	D	W	D	W	D	D	D	D	W	D
	W	D	D	D	D	D	D	W	D	W	D	D	D	D	D	D	D
43-44	W	D	D	D	D	D	D	W	D	W	D	D	D	D	D	D	D
	D	D	W	D	D	D	D	W	W	D	D	D	D	D	D	D	D

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
23-24	DW	DD	DW	WD	DD	DD	DW	DW	DD	DW	DW	WD	WD	DW	WD	DW	DD
24-25	WD	DW	WW	DD	DD	DW	WW	WW	DW	WD	WD	DD	DD	WD	DD	WD	DD
25-26	DD	WW	WW	DW	DD	WD	WD	WD	WW	DD	DW	DW	DW	DD	DW	DD	DW
26-27	DW	WW	WD	WD	DD	DW	DW	DW	WD	DD	WW	WD	WW	DD	WD	DD	WD
27-28	WD	WD	DD	DD	DW	WW	WW	WW	DD	DD	WD	DW	WD	DW	DD	DW	DD
28-29	DD	DD	DD	DD	WW	WW	WW	WW	DW	DW	DD	WD	DD	WW	DW	WW	DD
29-30	DD	DD	DD	DD	WW	WD	WD	WW	WW	WD	DW	DW	DW	WD	WW	WD	DD
30-31	DD	DD	DW	DW	WW	DD	DW	WD	WD	DW	WW	WD	WW	DW	WW	DW	DW
31-32	DD	DD	WW	WW	WD	DW	WW	DW	DD	WD	WD	DW	WW	WD	WD	WW	WW
32-33	DD	DD	WW	WD	DW	WD	WW	WW	DD	DW	DD	WW	WD	DD	DW	WD	WW
33-34	DW	DD	WD	DD	WD	DW	WW	WD	DD	WD	DW	WD	DW	DD	WD	DD	WD
34-35	WD	DD	DD	DD	DW	WW	WD	DD	DW	DW	WW	DD	WW	DD	DD	DD	DD
35-36	DD	DW	DD	DW	WW	WW	DD	DD	WD	WW	WW	DD	WW	DD	DD	DW	DD
36-37	DD	WD	DD	WW	WD	WD	DD	DW	DW	WD	WW	DW	WD	DW	DW	WD	DD
37-38	DD	DD	DW	WW	DD	WW	DD	WD	WW	DD	WW	WW	DW	WW	DD	DD	DW
38-39	DW	DD	WW	WW	DW	WD	DW	DW	WW	DD	WD	WW	WW	WD	DD	DW	WD
39-40	WW	DW	WD	WW	WW	DD	WW	WD	WD	DD	DW	WD	WW	DW	DW	WD	DW
40-41	WW	WD	DD	WW	WW	DD	WD	DD	DD	DD	WD	DD	WW	WW	WD	DW	WD
41-42	WD	DD	DD	WW	WW	DW	DD	DW	DD	DD	DD	DW	WD	WD	DD	WD	DW
42-43	DD	DW	DW	WW	WW	WD	DD	WW	DD	DD	DW	WD	DD	DW	DD	DD	WD
43-44	DD	WW	WD	WD	WW	DD	DW	WD	DD	DD	WD	DD	DD	WD	DD	DW	DW

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
23-24	DD	WD	DW	WW	DD	DW	WD	DD	WW	DD	DD	DD	WW	WD	WD	DW	DD
24-25	DD	DD	WD	WW	DD	WD	DD	DD	WD	DD	DD	DD	WW	DD	DW	WW	DD
25-26	DD	DD	DD	WW	DW	DD	DD	DW	DD	DD	DD	DD	WW	DD	WD	WD	DD
26-27	DD	DW	DW	WW	WW	DD	DW	WD	DW	DD	DD	DW	WW	DD	DD	DW	DW
27-28	DW	WW	WD	WW	WW	DD	WD	DW	WD	DW	DW	WD	WD	DD	DD	WW	WW
28-29	WW	WW	DW	WD	WD	DD	DD	WD	DW	WD	WD	DD	DD	DD	DW	WW	WD
29-30	WW	WW	WW	DD	DD	DW	DW	DW	WD	DD	DW	DD	DD	DW	WD	WD	DW
30-31	WW	WD	WD	DW	DW	WD	WD	WD	DD	DD	WW	DW	DD	WW	DW	DD	WW
31-32	WW	DW	DW	WD	WW	DD	DW	DW	DW	DW	WW	WD	DW	WW	WW	DW	WD
32-33	WW	WW	WW	DD	WW	DW	WD	WW	WW	WD	WW	DD	WW	WD	WW	WD	DD
33-34	WW	WD	WD	DD	WD	WD	DW	WW	WW	DD	WW	DW	WW	DD	WD	DW	DD
34-35	WW	DW	DD	DD	DD	DW	WW	WW	WW	DW	WD	WD	WW	DW	DD	WD	DD
35-36	WW	WD	DW	DD	DD	WD	WD	WD	WW	WW	DW	DD	WD	WD	DD	DD	DW
36-37	WW	DD	WD	DD	DD	DD	DD	DD	WW	WW	WW	DD	DD	DD	DD	DD	WW
37-38	WD	DW	DD	DW	DD	DW	DD	DD	WD	WW	WW	DD	DW	DW	DW	DW	WW
38-39	DW	WW	DW	WD	DW	WD	DD	DD	DW	WW	WW	DD	WD	WW	WD	WW	WD
39-40	WD	WD	WW	DD	WD	DW	DW	DD	WW	WD	WW	DD	DD	WW	DD	WW	DW
40-41	DD	DD	WD	DD	DD	WW	WD	DW	WD	DD	WW	DD	DW	WW	DD	WD	WD
41-42	DD	DD	DD	DD	DW	WD	DW	WW	DW	DD	WW	DD	WW	WW	DW	DW	DW
42-43	DD	DD	DD	DD	WD	DD	WD	WD	WW	DD	WD	DD	WW	WD	WD	WW	WD
43-44	DD	DD	DD	DW	DD	DD	DW	DD	WD	DD	DD	DD	WD	DD	DD	WD	DD

	2005	2006	WD	WW	DW	DD		Initial Probability	
23-24	DD	DW	18	7	18	27	Std.weeks	Wet	Dry
24-25	DD	WW	11	14	12	33	23	25	45
25-26	DD	WW	15	11	18	26	24	25	45
26-27	DD	WD	15	14	19	22	25	26	44
27-28	DD	DW	17	17	13	23	26	29	41
28-29	DW	WD	14	16	19	21	27	34	36
29-30	WW	DW	16	18	19	17	28	30	40
30-31	WD	WW	19	18	18	15	29	34	36
31-32	DW	WD	16	20	19	15	30	37	33
32-33	WW	DD	15	24	10	21	31	36	34
33-34	WD	DD	18	15	13	24	32	39	31
34-35	DD	DD	11	17	17	25	33	33	37
35-36	DW	DD	16	18	14	21	34	28	42
36-37	WD	DW	17	15	12	26	35	34	36
37-38	DW	WD	6	21	23	20	36	32	38
38-39	WD	DD	24	20	15	11	37	27	43
39-40	DD	DW	17	17	17	19	38	44	26
40-41	DW	WD	14	17	12	27	39	34	36
41-42	WW	DD	16	12	15	26	40	31	39
42-43	WW	DD	17	9	11	33	41	28	42
43-44	WW	DD	14	5	7	44	42	26	44
							43	19	51
							44	8	62

The analysis of 70 years rainfall data revealed that

1.The onset of S-W monsoon is below 50% probability in the standard week 20th , 21st and 22nd and above 50% probability during 23rd , 24th and 25th standard weeks.

2. The standard weeks 22nd (28th May- 3rd June) to 26th are suitable for land preparation.

3.The standard weeks 29th (16th July-22 July) and 30th (23rd July-29th July) are best suitable for taking up sowing operations as 20 mm of rainfall occurs at 50 % probability W/W also possible at 55 % probability.

3. The standard weeks 30, 33, 36, 38 are suitable for taking up fertilizer application operations since W/W occurs at >50 %.

4.The standard weeks 37 (10^{th}- 17^{th} Sept), 38^{th} , 39^{th} are not conducive for spraying and fertilizer application as 38^{th} standard week receives > 80mm rainfall at >25 % probability.

5.The probable withdrawal of S-W monsoon is likely to occur in 43^{rd} Standard week (22nd -29th Nov.) at >50% probability.


THANK YOU