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Length of crop growing season and budgeting of soil moisture for intercropping strategies in cotton*

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ABSTRACT

An estimation of rainfall curve through P/PET revealed that the crop growing season ranged from 22 to 44 standard week at Warangal. (Andhra Pradesh, India). Dependable rainfall at 75% probability prevailed from 24 to 38 standard week. The budgeting of water showed that there was no deficit of soil moisture until 37 standard week during two years study. Long duration crop of cotton intercropped with early maturing cowpea, greengram or blackgram significantly enhanced seed cotton equivalent yield over sole cotton. The rainfall in the later period was short of actual evapotranspiration. Therefore intercrops of longer duration viz., sesamum maturing in 75 days, soybean in 91 days and groundnut in 105 days were highly competitive and did not increase the seed cotton yield equivalents over the sole crop.

Key words: Precipitation curve, dependable rainfall, water balance, cotton-intercrops

Cultivation of cotton under rainfed conditions is a common practice. Its performance is extremely variable due to the extreme variations in amount of rainfall and distribution pattern. Still, the crop has an ability to endure moisture stress owing to its deep root system. But the crux for its dwindling productivity is the threat by unassuming infestations through a number of sap sucking pests and bollworms. The farmers have learned to bear with this crop since there is no other alternate crop better suited to the region and that is equally remunerative. The intercropping of compatable crops is one possible way to minimise the risk of complete loss for sustenance of peasants.

A scientific approach is required to workout the budget of soil moisture and estimate the length of crop growing season to understand the options available for crops and cropping systems for successful adaptation in an agroecological region. This prompted the present investigation to search for the best combinations for intercropping in cotton in the agro climatic region of Telangana in Andhra Pradesh.

MATERIAL AND METHODS

A field experiment was conducted at Agricultural Research Station, Warangal Andhra Pradesh in the *kharif* season on Alfisols under rainfed conditions during two consecutive seasons of 2004 and 2005. The length of crop growing season was estimated prior to the formulation of this trial. The meteorological parameters utilized were weekly precipitation (P) and potential evapotranspiration (PET) from 18 to 44 week from the data available over the fourteen year period (1991 to 2005). The PET was estimated following Blaney and Criddle (1950). The ratio of P/PET in each week was plotted on a graph and a smooth curve was drawn. The precipitation curve was sketched out for intersections of weekly P/PET on Y axis and standard week on X axis as suggested by Cocheme and Franquin (1967). Dependable rainfall was worked out at ≥ 75% probability (Hargreaves, 1971). The FAO water balance model (Frere and Popov 1979, FAO 1986) as given by Reddy (1991) was used. Crop coefficients were extracted from FAO, irrigation and Drainage, paper No. 33 (Doorenbos and Kassam 1979).

For estimation of length of growing season, cotton hybrid "Bunny" of 150 day duration was adopted. It was grown at a uniform row spacing of 90 cm or paired rows of 120/60 cm with an intra row spacing of 90 cm.

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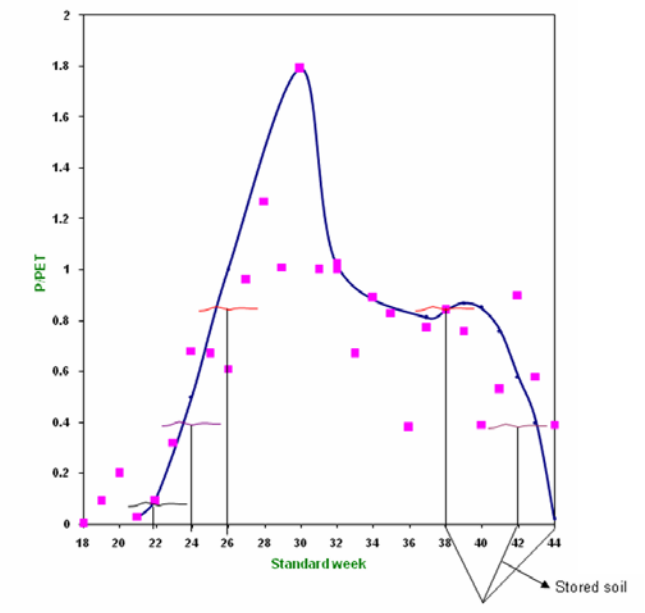

Fig.1: Rainfall curve to estimate length of crop growing season for Warangal

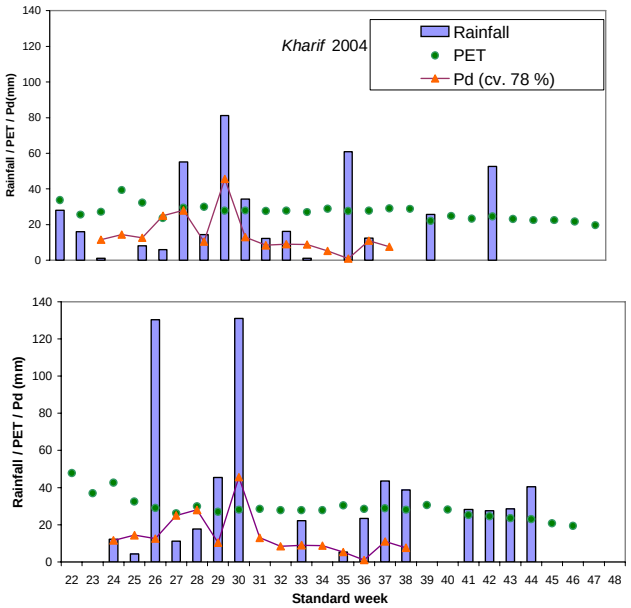

Fig.1: Rainfall curve to estimate length of crop growing season for Warangal

The crop was grown sole in these two planting patterns and intercropped with two and three rows of soybean, greengram, blackgram, cowpea, groundnut or sesamum between the uniform and paired rows of cotton respectively. These 14 treatments were laid out in a randomized block design. Cotton was fertilized with 120:60:60 kg N, P_2O_5 and K_2O ha^{-1} in sole and intercropped system. In proportion to population intercrops were fertilized. All the recommended agronomical practices were followed and crop was raised completely as rainfed.

RESULTS AND DISCUSSION

Precipitation curve

From the precipation curve (P/PET) at Agriculture Research Station Warangal (Fig 1) it was estimated that the length crop growing season period (LGP) commenced from week 22 and terminated by 44 standard week. Hence, it is possible to grow crops that mature in 160 days. The ratio between P/PET was 0.1 to 0.5 during 22 to 24 week (24 to 26 standard week). This is the time for land preparation. With P/PET ranging for 0.5 to 1 for 3 weeks (24 to 26 standard week) seeding of crops can be takenup under rainfed conditions since soil moisture during this period is considered to be fair for germination. Moist period (P/PET $\geq$ 1) prevails between 26 and 38 standard week. The phenology of peak vegetative or reproductive growth of the crop chosen should coincide with above period to meet its peak demand. The soil tends to lose more moisture than its gain through precipitation from 33 to 38 standard week. But, this is likely to be compensated by peak activity of the monsoon with P/PET ratio of $\geq$ 1 in the 30 standard week. The void between supply and demand from 38 to 44 week is made up by the stored soil moisture to support the senile phase of the crop. The capacity of predominently sandy loam soils in this region to hold 110 mm water per meter depth enables the cultivation of deep rooted crops like cotton.

Dependable rainfall

Considering the dependable rainfall $\geq$ 75% probability the length of crop growing season seems to be limited to 38 standard week (Fig 2). Still, rains of less than 75% probability and the assured 110 mm stored soil moisture can be exploited by the crop during its very low water requiring senile phase and ripening during the later part. Cotton is grown in wide rows of 90 to 120 cm. Its growth is very slow up to about two months after sowing. This probable 8 week period is also moist with P/PET $\geq$ 1 and provide an opportunity

Table 1: Weekly water balance pertaining to cotton crop *Kharif*, 2004

Standard week	Potential evapo transpiration (mm)	Crop coefficient	Actual evapo transpiration (mm)	Precipitation (mm)	Precipitation-actual evapo transpiration (mm)	Soil moisture retention (mm)	Surplus (mm)	Deficit (mm)	Water requirement satisfaction index
28	29.54	0.50	14.77	55.2	40.43	40.43	--	--	100
29	30.03	0.50	15.02	14.4	-0.62	39.81	--	--	100
30	27.79	0.54	15.09	81.2	66.11	105.92	--	--	100
31	27.93	0.80	22.34	34.4	12.06	110.00	7.98	--	100
32	27.72	0.80	22.18	12.2	-9.98	100.02	--	--	100
33	27.79	0.80	22.23	16.3	-5.93	94.09	--	--	100
34	27.02	1.06	28.56	1.2	-27.36	66.73	--	--	100
35	28.91	1.25	36.14	--	-36.14	30.59	--	--	100
36	27.65	1.25	34.56	60.9	26.34	56..93	--	--	100
37	27.86	1.25	34.83	12.5	-22.33	34.60	--	--	100
38	29.05	1.25	36.31	--	-36.31	--	--	1.71	100
39	28.84	1.25	36.05	--	-36.05	--	--	37.76	92
40	22.12	1.25	27.65	25.8	-1.85	--	--	39.61	85
41	24.85	1.25	31.06	--	-31.06	--	--	70.67	71
42	23.38	1.25	29.23	--	-29.23	--	--	99.90	52
43	24.64	0.90	22.18	52.7	-30.52	30.52	--	69.38	38
44	23.17	0.90	20.85	--	-20.85	--	--	90.23	21
45	22.54	0.90	20.29	--	-20.29	--	--	110.52	-1
46	22.54	0.81	18.35	--	-18.35	--	--	128.87	-24
47	21.77	0.70	15.24	--	-15.24	--	--	144.11	-52

Table 2: Weekly water balance pertaining to cotton crop *Kharif*, 2005

Standard week	Potential evapo transpiration (mm)	Crop coefficient	Actual evapo transpiration (mm)	Precipitation (mm)	Precipitation-actual evapo transpiration (mm)	Soil moisture retention (mm)	Surplus (mm)	Deficit (mm)	Water requirement satisfaction index
26	28.98	0.50	14.49	130.0	115.81	110.00	5.81	--	100
27	26.18	0.50	13.09	11.1	-1.99	108.01	--	--	100
28	29.96	0.71	21.40	17.8	-3.60	104.41	--	--	100
29	27.02	0.80	21.62	45.4	23.78	110.00	18.19	--	100
30	27.02	0.80	21.62	131.1	109.48	110.00	109.48	--	100
31	28.07	0.86	24.35	--	-24.35	85.65	--	--	100
32	28.56	1.25	35.70	--	-35.70	49.95	--	--	100
33	27.86	1.25	34.83	22.2	-12.63	37.32	--	--	100
34	27.86	1.25	34.83	--	-34.83	2.49	--	--	100
35	30.38	1.25	37.98	5.3	-32.68	--	--	30.19	94
36	28.56	1.25	35.70	23.4	-12.30	--	--	42.49	87
37	28.84	1.25	36.05	43.5	7.45	7.45	--	35.04	80
38	28.07	1.25	35.09	38.8	3.71	3.71	--	31.33	74
39	30.52	1.25	38.15	--	-38.15	--	--	69.48	62
40	28.14	1.05	29.55	--	-29.55	--	--	99.03	44
41	25.20	0.90	22.68	28.2	5.52	5.52	--	93.51	26
42	24.50	0.90	22.05	27.6	5.55	5.55	--	87.96	10
43	23.59	0.90	21.23	28.6	7.37	7.37	--	80.59	5
44	23.03	0.70	16.12	40.5	24.38	24.38	--	56.20	0.1
45	20.86	0.70	14.60	--	-14.60	--	--	70.81	-13

Table 3: Seed cotton, Intercrop and seed cotton equivalent yield (kg ha^{-1}) as influenced by planting pattern and intercrops

Treatment	*Kharif*-2004			*Kharif*-2005		
	Seed cotton	Intercrop	Seed cotton equivalent	Seed cotton	Intercrop	Seed cotton equivalent
Planting pattern						
Uniform rows	1068	-	1533	1240	--	1739
Paired rows	1008	-	1361	1254	--	1623
SE m±	25	-	25	25	--	26
CD at 5%	NS	-	71	NS	--	73
Intercropping						
Sole cotton	1278	-	1278	1564	--	1564
Cotton + Soybean	817	824	1294	1035	724	1454
Cotton + Greengram	1074	523	1652	1358	530	1944
Cotton + Blackgram	1197	409	1714	1404	407	1918
Cotton + Cowpea	1202	483	1634	1476	498	1922
Cotton + Groundnut	798	609	1409	998	547	1545
Cotton + Sesamum	904	212	1149	893	454	1419
SE m±	47	-	46	46	--	47
CD at 5%	137	-	133	134	--	137
Interaction						
SE m±	67	-	65	66	--	67
CD at 5%	NS	-	NS	NS	--	NS

to cultivate crops of domestic and economic importance with varying morphology to extract the surplus water from different layers of soil and increase the total productivity per unit area.

Weekly water balance

In 2005, the crop water requirement was adequately satisfactory for nine weeks from 26 to 34 standard week in contrast to 10 week adequacy from 28 to 37 standard week in the previous year (Tables 1 and 2). The soil retained 104.41 to 110 mm moisture for five weeks from 26 to 30 week. But, in the previous year, the soil retained only about 40 mm moisture in the first two weeks and 100 to 110 mm in subsequent three week period. Moisture retention decreased sharply later, from 31 to 34 weeks. Water deficit commenced from 35th week and increased in magnitude until 46 week. A transparent observation is that though the precipitation of 593.8 mm during crop growing period was slightly more than the AET of 544.7 mm, only the first 9 weeks provided a satisfactory supply of moisture to the crop. On the other hand, the rainfall of 366.8 mm during crop growing season of 2004 was much less than the AET of 516.7 mm with satisfactory amount of water during first 10 weeks.

Seed cotton and equivalent yield

The seed cotton and equivalent yield was differentially influenced by different inter crops (Table 3). During both the years under study cotton intercropped with cowpea yielded onpar with the sole crop. Additionally there was a bonus production of 483 kg and 498 kg seed ha^{-1} from cowpea. These observations are in line with the earlier investigations of Khan *et al*., (2001) Sesamum was highly competitive and reduced seed cotton yields drastically. Soybean maturing in 91 days and groundnut in 105 days competed with cotton at crucial time for higher resource utilisation and the yield reduction was severe. Similar reduction in cotton yield with soybean was earlier reported by Deoche *et al*., (2004). The total productivity in terms of seed cotton equivalent enhanced significantly by intercropping cowpea, blackgram or greengram during the two years. Significantly higher seed cotton

equivalent yields, realised by intercropping different components in the uniformly spaced rows of cotton was mainly due to higher plant population of intercrops (66% of sole optimum) than in paired rows (50% of sole optimum). The seed cotton equivalents due to intercropping soybean or groundnut were at par with sole crop, where as intercropping of sesamum in cotton significantly reduced the seed cotton yield in the second year.

The results of present investigation indicated that initial two months of the growing season of cotton can be best exploited by intercropping cowpea, blackgram or greengram. This could provide higher advantage of increasing the total productivity interms of seed cotton yield on one hand and providing proteinaceous food for man and fodder for animal from the same piece of land.

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