Journal of Agrometeorology 6 (2) : 249 -253 (Dec 2004)

Impact of rainfall on the yield of rainfed groundnut*

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ABSTRACT

A long term (1975-1999) fertilizer experiment conducted at the Sagadividi farm of Junagadh Agricultural University, Junagadh indicated that the average pod yield of groundnut increased with the increase in nitrogen levels but decreased with the increase of phosphorus levels. Generally the pod yields of groundnut were lower during the drought years but, during wet years, nitrogen levels did not show any advantage to the crop. It was generally observed that the late sowing beyond 27th week gave poor yields; however under early (24th week) or timely sowing (25th and 26th M.S.W), the yields were either higher or lower depending on the duration and distribution of rainfall.

A poor but positive significant correlation coefficient was observed between total rainfall during the crop period and pod yields. The critical examination of the rainfall pattern indicated that along with the rainy days, the rainfall during either flowering or pod formation and development stages influenced the yields adversely.

Keywords: Rainfall distribution, groundnut yield, reciprocal hyperbola

Groundnut (*Arachis hypogaea*) is cultivated under different and diverse agro climatic conditions in Gujarat State. In semi-arid tropical areas of Saurashtra region it is an important crop in the cropping system. The rainfall in Saurashtra is low and the distribution is quite erratic (Sahu *et al.*, 1994). Fluctuation in the total seasonal rainfall, its intraseasonal distribution and frequency of rainy days have a strong influence on groundnut yield in Junagadh district (Sahu *et al.*, 2000). Singh (1999) has pointed out that the yield of groundnut was very low due to integrated problems of erratic rainfall, dry spells and prolonged drought periods especially during flowering, pegging and pod-development stages in Uttar Pradesh.

Out of several factors, which factors particularly, essentially and eventually determine the productivity of groundnut in semi-arid regions is not known. Hence, the present investigation was carried out to find out the impact of rain related factors such as total and phenophasic rainfall, dry and wet seasons, late and early sowing etc on the yield of groundnut under the agro climatic situations of Junagadh.

*Paper presented in the National Seminar on "Agrometeorological Research for Sustainable Agricultural Production", held at G.A.U., Anand during 27-28 September 2001.

MATERIALS AND METHODS

A field experiment was carried out at the Sagadividi farm of Junagadh Agricultural University, Junagadh (21° 31′ N Lat. And 70° 33′ E Long., 61 m, msl) for 23 kharif seasons (1975-1999). The soil was medium black calcareous having available nitrogen (0.112%), medium in phosphorus (23 kg ha^{-1}) and high in available potassium (383 kg ha^{-1}). The moisture content at 30 to 50 cm, depth was 39% at field capacity and 19% at permanent wilting point. The soil was composed of 12, 17.6 and 70.4% sand, silt and clay respectively. The treatments comprised of three nitrogen levels (0, 12.5 and 25 $kgha^{-1}$) and four-phosphorus levels (0, 25, 50 and 100 $kgha^{-1}$). The 12 treatment combinations were tried in three replicated factorial randomized block designs. The net plot size was 9.2 m X 3.7 m with spacing of 75 cm X 15 cm. The spreading variety Punjab-I (GG11 after 1986) was used in the study. Sowing was not done during 1992 and 1993 due to strip virus epidemics for which yields were not recorded. The yields of the year 1987, the disastrous drought year was also not considered to avoid inconsistency of rains and yield relations.

Daily rainfall for the growing period of the crop was collected from the agro meteorological observatory. The 17 week crop period was divided into five growth stages such as (i) Germination and establishment- 4 weeks (ii) Flowering – 2 weeks (iii) Pegging- 2 weeks (iv) Pod formation and development – 5 weeks and (v) Maturity – 4 weeks. The correlation coefficients between rainfall and groundnut yields from different treatments, stepwise regression analysis and curve fit programme was adopted in order to study the impact of rainfall at various stages of the crop.

Earlier results (Golakia *et al*, 2000) showed that the interaction affect of phosphorus x season on the pod and haulm yields were significant, but nitrogen and season was non-significant. Hence the impact of rainfall distribution during the growth stages on groundnut is studied.

RESULTS AND DISCUSSION

Effect of sowing time

The sowing time varied from 24th to 29th MSW as sowing was done after receipt of sufficient rains for crop establishment. Twenty-fifth standard meteorological week (18-24, June) is the normal sowing time for groundnut in the region. In most of the late sowing years the yield was lower as compared to normal and early sowings before 25th week (Table 1). The growing season was found to commence from 25th and 26th week in 11 out of 23 years, out of which the yield was below normal in five years.

Effect of total rainfall

Fluctuations in the phenophasic and total seasonal rainfall (Table 1) have strong relationship with groundnut productivity. The average rainfall for 23 years from sowing to maturity period is 817 mm ranging from as low as 284 mm in 1986 to as high as 1535 mm in 1980. In general, during low rainfall years (1982, 1985, 1986, 1991 and

Table 1: Impact of phenophasic and total rainfall on groundnut yield

Year	Growing period (std week)	P1	P2	P3	P4	P5	Total rainfall (mm)	Pod yield kg ha^{-1}	
								Mean	CV* %
1975	25-42	267.2	57.9	50.0	202.5	185.1	763	1784	7.5
1976	25-41	248.4	236.9	26.5	228.8	35.3	776	582	9.4
1977	25-42	225.9	268.2	69.1	149.9	16.1	729	612	5.7
1978	25-41	346.8	14.4	6.0	266.0	2.6	636	1736	1.8
1979	26-44	304.7	377.4	421.8	96.1	62.4	1262	1370	3.3
1980	24-40	1242.8	0.0	162.9	72.4	56.8	1535	1074	4.7
1981	28-46	652.4	226.7	13.3	88.0	0.0	980	872	3.1
1982	28-44	308.0	235.0	42.5	32.0	0.0	618	364	12.1
1983	26-44	617.6	183.2	264.0	264.0	26.0	1355	743	3.9
1984	25-43	418.0	94.0	117.5	157.5	223.0	1010	458	6.2
1985	29-46	205.3	33.8	7.5	50.5	0.0	297	133	7.4
1986	26-41	83.0	35.2	143.5	21.9	0.0	284	466	6.1
1988	27-44	1017.8	95.9	58.4	198.5	0.0	1371	1655	11.2
1989	24-43	287.4	100.0	155.1	41.2	157.0	741	519	13
1990	29-48	49.0	440.6	26.1	201.9	72.6	790	539	8.7
1991	29-48	266.6	52.9	29.6	0.0	0.0	349	228	8.1
1994	25-43	396.1	442.1	45.5	296.7	7.0	1187	634	15.9
1995	28-45	621.2	21.7	96.7	88.1	13.0	841	627	2.8
1996	25-41	247.7	278.2	32.5	59.3	0.7	618	1233	6.5
1997	25-42	279.9	127.6	30.0	248.9	93.3	780	1310	8.2
1998	27-44	300.0	161.8	39.3	115.5	123.7	740	317	10.4
1999	27-43	219.6	21.8	4.3	33.9	33.3	313	209	6.2

P1=Establishment, P2=Flowering, P3=Pegging, P4=Pod development, P5=Maturity

1999) the yields were low and also during high rainfall years (1981, 1983, 1984, 1994 and 1995). Higher yields were recorded in moderate rainfall years (1975, 1978, 1979, 1988, 1996 and 1997).

Effect of phenophasic rainfall

The amount of rainfall received at different phenophases of the crop plays a crucial role in the final yield of the crop. The results indicated that the yields were low when the rainfall during P2 (flowering) was very high (1976, 1977, 1981, 1982, 1983, 1990, 1994) and conversely the yields were good when the rainfall during this period was low (1975, 1978, 1980, 1988). Further, it can be inferred that higher yields in the above years were supported by higher rainfall during P4 (pod formation and pod development). Excess rainfall during the years (1984, 1989, and 1998) in maturity stage caused yield losses.

Table 2 : Correlation coefficient between total phenophasic rainfall and pod yields from different fertilizer treatments

Treatment	Total rainfall	Phenophase				
		P_1	P_2	P_3	P_4	P_5
P_0	0.480*	0.405	-0.032	0.144	0.450*	0.062
P_{25}	0.456*	0.369	-0.029	0.144	0.462*	0.067
P_{50}	0.436*	0.319	-0.016	0.163	0.481*	0.092
P_{100}	0.372	0.203	0.040	0.169	0.453*	0.148

*Significant at 5 % level

Table 3 : Stepwise regression analysis

Treatment	Equations	R^2
N_0	$219.1846 + 0.6078P_1 + 204254\ P_4$	0.353
$N_{12.5}$	$448.3032 + 2.6130\ P_4$	0.218
N_{25}	$461.7262 + 2.6084\ P_4$	0.219
P_0	$234.9524 + 0.6729P1 + 2.3618\ P_4$	0.338
P_{25}	$222.8590 + 0.6275P1 + 2.5373\ P_4$	0.323
P_{50}	$436.7686 + 2.6623\ P_4$	0.231
P_{100}	$464.0100 + 2.4778\ P_4$	0.205

Effect of intra seasonal rainfall

The coefficient of variability of pod yield from different treatments in a particular year (Table 1) shows that it varied from 1.8 % in 1978 to 15.9 % in 1994. Similarly with the same amount and distribution of rainfall in a particular season the yields differed widely from one treatment to another. It was further observed that if the yields were higher due to well-distributed rainfall, the variability in yield was low. Conversely, if the yields were lower due to lower either due to low or erratic rainfall the variability in yield between treatments was higher. This indicates the impact of rainfall on the fertilizer use efficiency process of the crop.

Phenophasic rainfall and pod yields

Correlation (Table 2) between total rainfall during growth period and the pod yield was poor but positive and significant except for the yield of the treatment P_{100}. Further, the results showed that the rainfall during all the phenophases were poor but positively correlated with the pod yield of groundnut from different treatments, except the rainfall during flowering stage (P_1). The rainfall during pod formation and development (P_4) was significantly

Table 4: Yield prediction equations.

Treatments	Reciprocal hyperbola		
	A	B	R^2
P_0	0.0011	0.5621	0.640
P_{25}	0.0012	0.5674	0.560
P_{50}	0.001095	0.5912	0.610
P_{100}	0.0005	1.0130	0.857

correlated with the yield of groundnut. The order of magnitude of correlation coefficient indicated the order of importance of rainfall during the phenophases. The results indicated that if there was sufficient rain during establishment stage (P_1) then, no rain is required during the flowering stage. Similarly pod maturation stage does not require rains if there was sufficient rain during the pod development stage (P_4).

The correlation coefficients between total rainfall, phenophasic rainfall with yields obtained from phosphorus treatments are presented in Table 2A positive and significant correlation was observed for yields obtained from P_0, P_{25} and P_{50}, whereas a low and non-significant correlation coefficient was observed from P_{100}. The rainfall during flowering period was negatively correlated except for P_{100}.

The stepwise regression analysis was carried out to find out the most important and critical stages for rainfall requirement under different levels of fertilizer application. The results (Table 3) indicated that rainfall was essential during P_1 and P_4 stages.

Rainfall modelling for yield prediction

Among various equations fitted, reciprocal hyperbola of the form,

$$Y = \frac{X}{A * X + B}$$

represented the yield – rainfall relationship better and explained higher percentage of variation in yield of groundnut (Table 4). The R^2 values indicated that the models fitted satisfactorily for all the treatments except P_{25}. The yields can be predicted within the range of independent variables revealing 56-86 % variation in yield.

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