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Trends of Groundnut Productivity in Long Term Experiment

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ABSTRACT

With a view to study the trend of groundnut productivity due to various fertilizer treatments under intensive cropping system, the yield data were collected from a long term experiment conducted at Gujarat Agricultural University, Junagadh Campus, Junagadh. The use of moving average values reduced the seasonal/irregular fluctuations in the data effectively and gave better fit as compared to that of original set of data. For groundnut crop, third degree polynomial equation (X^ 0.5 as base) expressed the trend for all the treatments. The initial decline, followed by a rapid increase upto the point of maxima was the characteristic of the best fitted equation. Comparative picture which emerged from the trend in productivity of groundnut crop showed that for majority of the treatments, the productivity declined after 6 point of time. The average rate of change from the point of minima to maxima and maxima to the end point was the highest in the case of direct effect of FYM (FYM1) treatment.

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INTRODUCTION

Long term field experiments help in studying the changes in the productivity of the soil over the time along with direct, residual and cumulative effects of fertilizer application. In all the long term experiments, time is a quantitative factor, hence a common practice is to partition time into components associated with orthogonal polynomials (Gomez and Gomez, 1984). In most of the cases, a simple linear trend either positive or negative may be sufficient to describe a long term trend. However, in the case where, the yield fluctuates substantially over the time, the trend may not be easily described. The method of adjustment of such fluctuations in statistical analysis can be studied using time series analysis. Keeping this in view, an attempt has been made in the present study to examine the trend in yield due to various fertilizer treatments in groundnut crop under intensive cropping system of groundnut-wheat-sorghur (fodder) in medium black soil of Junagac (Gujarat).

MATERIALS AND METHODS

The data for the present study were collected from a long term experiment conducted by the Department of Agricultural Chemistry in collaboration with the Department of Agronomy, Gujarat Agricultural University, at Junagadh for the period 1979 to 1992. The treatments tried on the crop were :

(1) Control : No nutrient (organic or inorganic) application.

(2) FYM1 : Application of FYM @ 25 t/ha every third year starting from first year of experimentation to the *kharif* crops only.

(3) FYM2 : Application of FYM @ 25 t/ha to the *kharif* crops every third year, starting fro second year of experiments.

(4) FYM3 ; Application of FYM @ 25 t/ha to *kharif* crops every third year starting from thir year of experimentation.

(5) N50 : Half dose of nitrogen as recommended for the crop under irrigated conditions.

(6) NP50 : Half dose of N and P as recommended for the crop under irrigated conditions.

(7) NPK50 : Half dose of N and P as recommended for the crop under irrigated condition wit K application.

(8) N100 : Full dose of N as recommended for the crop under irrigated conditions.

(9) NP100 : Full dose of N and P as recommended for the crop under irrigated conditions.

(10) NPK100 : Full dose of N and P as recommended for the crop under irrigated conditions with K application.

(11) NsPs : Application of N and P as per the initial soil test values.

(12) NsPsKs : Application of N, P and K as per initial soil test value.

Methods of Analysis

In order to explore the possibility of identifying the trend equations for various treatments over the period of time, 24 different equations (Table 1) were tried using curve fitting approach i.e. by fitting different equations (i) using original treatment mean and (ii) using three years moving average so as to partly take care of the inter year fluctuation due to climatic differences.

TABLE 1

List of equations.

Eq. No.	*Form of equation*	*Equation name*
1	Y=A+B*X	Straight line
2	Y=B*X	Line through origin
3	Y=A+B*X^.5+C*X	2nd deg. poly. with x ^.5 as base
4	Y=A+B/X^.5+C/X	2nd deg. poly. with 1/X^.5 as base
5	Y=A+B*X+C/X	Linear and reciprocal
6	Y=A+B/X	Hyperbola
7	Y=X/(A*X+B)	Reciprocal hyperbola
8	Y=A+B*X^.5 + CX + D* X^ 1.5	3rd deg. poly. with x^.5 as base
9	Y=A+B/X+C/X^2	2nd order hyperbola
10	Y=A+B*X+C*X ^2	Parabola

1.	2.	3.
11	Y=A+B*X+C/X^2	Mod. parabola
12	Y=A+B*X+C*X^2+D*X^3	3rd deg. polynomial
13	Y=A+B/X+C/X^2 + D/X^3	Reciprocal 3rd deg. polynomial
14	Y=A+B/X^.5+C/X+D/X^1.5	3rd deg. poly. with 1/X^.5 as base
15	Y=A*X^B	Power function
16	Y=A*B^X	Mod. power function
17	Y=B^ (1/X)	Root function
18	Y=A*X^ (B*X)	Super geometric
19	Y=A*X^ (B/X)	Mod. geometric
20	Y=A*e^ (B*X)	Exponential
21	Y=A*e^ (B/X)	Mod. exponential
22	Y=A+B* ln (X)	Logarithmic
23	Y=1/[A+B* ln (X)]	Reciprocal logarithmic
24	Y=A*B^X*X^C	Hoerl function

Using original treatment means the respective equations for each of the treatment for various crops were fitted and the best fitted equation was identified as the one having the highest adjusted coefficient of determination ($\bar{R}^2$). The adjusted R^2 was calculated as

$$\bar{R}^2 = 1 - \frac{n-1}{n-p}(1-R^2)$$

n = number of years
p = number of regressors
R^2 = unadjusted coefficient of determination.

In the second approach, taking first year of the experiment as the base year, three years moving average values of the original treatment means were obtained and using these values the best fitted equation was identified from the equations tried for each treatment of the crops under study. The regression coefficients for the fitted equations were tested for their significance using 't' test.

After identifying the best approach for fitting the trend equation, the best fitted equations were used to study the trends in yield due to various treatments over the of time. The points of maxima and minima and minima were estimated as given by Arya and Lardner, (1979).

Let Y = f (x) then,

for the point of maxima :

$$\frac{dy}{dx} = 0; \quad \frac{d^2y}{dx} < 0$$

for the point of maxima :

$$\frac{dy}{dx} = 0; \quad \frac{d^2y}{dx} > 0$$

The average rate of change between the two points (initial to minima/maxima, minima to maxima, maxima to last points) was calculated as :

$$\text{Average rate of change} = \frac{\bar{Y}m - \bar{Y}n}{m-n}$$

Where,

$\bar{Y}m$ = expected productivity at time point m

$\bar{Y}n$ = expected productivity at time point n

(m –n) = difference between two time points.

TABLE 2

Comparison of trend equations fitted through original data and moving average values in various treatments.

	Treatments																							
	Control		FYM1		FYM2		FYM3		N50		NP50		NPK50		N100		NP100		NPK100		N_sP_s		$NsPsKs$	
Eq.	R_1^2	R_2^2	R_1^2	R_2^2	R_1^2	R_2^2	R_1^2	R_2^2	R_1^2	R_1^2	R_1^2	R_2^2	R_1^2	R_2^2	R_1^2	R_2^2	R_1^2	R_2^2	R_1^2	R_2^2	R_1^2	R_2^2	R_1^2	R_2^2
No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	-.10	-.15	-.12	-.16	-.12	-.16	-.12	-.16	-.10	-.13	-.11	-.16	-.10	-.16	-.10	-.14	-.11	-.14	-.10	-.16	-.10	-.16	-.10	-.16
2	.01	-.15	-.05	-.13	.04	-.12	-.01	-.15	-.00	-.16	.07	-.12	-.01	-.10	.00	-.16	.10	-.14	-.00	-.12	.14	-.09	-.06	-.13
3	-.13	.19	.03	.48	-.01	.45	-.05	.41	-.17	.07	-.16	.10	-.04	.22	-.15	.12	-.20	.02	-.07	.23	-.18	.00	-.04	.31
4	-.21	-.09	-.17	-.06	-.21	-.07	-.22	-.09	-.22	-.12	-.24	-.18	-.19	-.13	-.22	-.11	-.23	-.18	-.21	-.14	-.24	-.23	-.19	-.08
5	-.20	.07	-.09	.16	-.14	.11	-.17	.10	-.23	.01	-.23	.06	-.15	.10	-.22	.01	-.24	.03	-.17	.15	-.23	-.02	-.15	.17
6	-.08	.00	-.06	-.01	-.08	-.02	-.08	-.00	-.09	.04	-.10	-.01	-.06	-.03	-.09	.01	-.11	.02	-.07	-.03	-.11	-.04	-.06	-.03
7	-.08	-.09	-.12	-.11	-.10	-.13	-.11	-.10	-.07	-.03	-.03	-.14	-.10	-.14	-.07	-.08	-.02	-.12	-.09	-.12	-.01	-.16	-.11	-.11
8	-.03	.78	-.05	.81	-.16	.81	-.19	.80	-.04	.78	-.04	.73	.04	.78	-.04	.78	-.03	.77	.02	.77	-.09	.73	.02	.79
9	-.19	-.17	-.21	-.17	-.23	-.17	-.24	-.17	-.20	-.14	-.23	-.20	-.20	-.21	-.20	-.17	-.21	-.16	-.20	-.19	-.24	-.24	-.18	-.17
10	-.03	.65	.17	.72	.05	.57	.04	.67	-.08	.59	-.07	.63	.06	.68	-.06	.59	-.12	.61	.03	.69	-.10	.56	.06	.70
11	-.22	-.13	-.15	.01	-.19	-.00	-.21	-.03	-.24	-.18	-.24	-.21	-.19	-.13	-.23	-.15	-.24	-.23	-.20	-.14	-.24	-.26	-.19	-.08
12	-.09	.76	.03	.72	-.09	.76	-.10	.73	-.10	.78	-.10	.73	.00	.76	-.09	.78	-.09	.77	-.03	.69	-.13	.69	-.02	.72
13	-.31	-.04	-.16	.48	-.28	.34	-.24	.36	-.33	-.10	-.34	-.10	-.31	-.01	-.33	-.10	-.34	-.13	-.31	.00	-.39	-.22	-.27	.06
14	-.22	.21	-.02	.70	-.17	.60	-.13	.60	-.25	.12	-.25	.16	-.19	.24	-.25	.12	-.26	.12	-.19	.30	-.31	.04	-.15	.34
15	-.11	-.11	-.12	-.13	-.11	-.14	-.12	-.12	-.10	-.05	-.08	-.13	-.11	-.15	-.10	-.09	-.05	-.11	-.11	-.14	-.04	-.15	-.10	-.14
16	-.09	-.16	-.07	-.16	-.10	-.16	-.09	-.15	-.05	-.16	-.09	-.15	-.09	-.16	-.02	-.16	-.09	-.15	.00	-.15	-.10	-.15	-.11	-.02
17	-.10	-.05	-.10	-.05	-.12	-.07	-.12	-.04	-.10	.02	-.09	-.07	-.10	-.09	-.11	-.01	-.06	-.03	-.10	-.07	-.07	-.11	-.09	-.06
18	-.08	-.16	-.09	-.14	-.05	-.14	-.08	-.15	-.09	-.16	-.03	-.14	-.07	-.12	-.08	-.16	-.00	-.16	-.08	-.13	-.01	-.13	-.10	-.13
19	-.10	.04	-.04	.07	-.06	.05	-.09	.05	-.10	.03	-.11	.01	-.07	.02	-.11	.01	-.10	.02	-.09	.05	-.11	-.04	-.08	.07
20	-.09	-.16	-.10	-.16	-.07	-.16	-.10	-.16	-.09	-.15	-.05	-.16	-.09	-.15	-.09	-.16	-.02	-.16	-.09	-.15	.00	-.15	-.10	-.15
21	-.11	-.02	-.10	-.05	-.12	-.07	-.12	-.04	-.10	.02	-.09	-.07	-.10	-.09	-.11	-.01	-.06	-.03	-.10	-.07	-.07	-.11	-.09	-.06
22	-.08	-.07	-.10	-.10	-.10	-.11	-.10	-.08	-.09	-.02	-.10	-.09	-.08	-.11	-.09	-.05	-.11	-.05	-.09	-.12	-.11	-.10	-.07	-.12
23	-.05	-.15	-.10	-.14	-.04	-.16	-.07	-.15	-.04	-.11	.01	-.16	-.06	-.16	-.04	-.14	.03	-.16	-.06	-.16	-.06	-.16	-.09	-.16
24	-.15	.33	.02	.43	-.01	.29	-.07	.36	-.20	.27	-.14	.31	-.05	.36	-.18	.25	-.12	.27	-.10	.42	-.08	.20	-.08	.44

R_1^2 = Adjusted R square of the equation using original data.

R_2^2 = Adjusted R square of the equation using moving average.

TABLE 3

Best fitted equations for different treatments in groundnut.

Treatment	*Equation*	*Coefficients*				
		A	*B*	*C*	*D*	R^2
Control	Y=A+BX^.5 + CX + DX^ 1.5	4475.61	-7922.07*	4694.33*	-840.15*	86
FYM 1	Y=A+BX^.5 + CX + DX^ 1.5	6365.85	-12419.26	8374.84	-1674.99*	89
FYM 2	Y=A+BX^.5 + CX + DX^ 1.5	4649.92	-8840.38	5851.73*	-1156.97*	90
FYM 3	Y=A+BX^.5 + CX = DX^ 1.5	3905.76	-7696.00	4846.88*	-950.57*	89
N50	Y=A+BX^.5 + CX + DX^ 1.5	5468.39	-9545.95*	5509.63*	-967.44*	87
NP50	Y=A+BX^.5 + CX + DX^ 1.5	5151.43	-9006.60*	5259.41*	-934.46*	84
NPK50	Y=A+BX^.5 + CX + DX^ 1.5	7525.71	-13379.10*	8004.30*	-1445.53*	86
N100	Y=A+BX^.5 + CX + DX^ 1.5	4837.20	-8484.09*	4953.78*	-877.07*	83
NP100	Y=A+BX^.5 + CX + DX^ 1.5	5813.78	-10152.68*	5825.57*	-1020.85*	84
NPK100	Y=A+BX^.5 + CX + DX^ 1.5	7942.03	-14258.77*	8564.34*	-1551.72*	85
NsPs	Y=A+BX^.5 + CX + DX^ 1.5	5514.57	-9523.48*	5495.68*	-963.15*	81
NsPsKs	Y=A+BX^.5 + CX + DX^ 1.5	6759.14	-12210.38*	7483.47*	-1372.09*	85

* Significant at 5 % level.

Expected response at different points of time was calculated using the best fitted equation for different treatments for the period under study. Using these expected values the productivity trend over the period of time under various treatments was also examined using graphical approach.

RESULTS AND DISCUSSION

The trend equations fitted through both the methods are presented in Table 2. The results indicated that the use of moving average values reduced the irregular fluctuations in the data remarkably and gave better fit (adjusted $\bar{R}^2$) as compared to original treatment mean equations.

Trend in yield corresponding to various treatments

For all the treatments in case of groundnut, the trend in yield due to various treatments was measured by third degree polynomial equation with x ^ 0.5 as base.

Control

The results presented in Table 4 and depicted in Figure 1 indicated an increase in productivity at the average rate of 147.03 kg preceded by a decline in the productivity in the early stage of experimentation. Diminishing productivity was observed after reaching the maxima at 5.92 point of time.

FYM1

The results (Table 4 and Figure 2) indicated that, average decline of 371.07 kg in the productivity during early stage was followed by increasing productivity at the average rate of 300.19 kg up to the point of maxima (5.81).

FYM2

A persual of Table 4 and Figure 2 indicated declining trend in the productivity (at the average rate of 273.16 kg) in the early stage. There was an increasing trend at the rate of 194.40 kg up to 5.84 point of time (maxima), followed by continuous decline in the productivity at the average rate of 274.87 kg during the period under study.

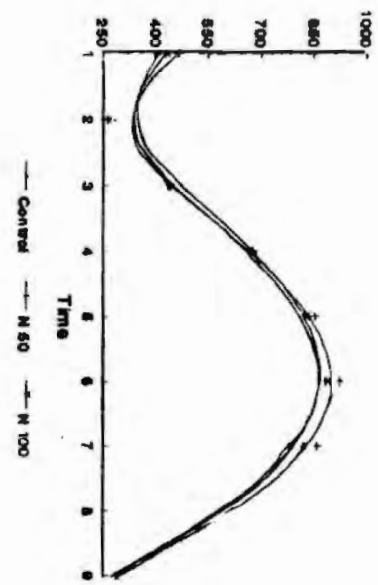
TABLE 4

Average productivity of groundnut for different treatments and rate of change under different segments of fitted equations.

Treatment	*Average production (kg/ha)*	*Moving initial product.*	*Average final product.*	*Expected initial product.*	*Average final product.*	*Av. rate of change*			*Point of*	
						A	*B*	*C*	*Minima*	*Maxima*
Control	553	379	267	408	274	-213.87	147.03	-199.67	1.67	5.92
FYM 1	1027	680	437	646	337	-159.10	307.87	-606.45	1.24	4.93
FYM 2	740	511	317	504	280	-136.46	202.61	-409.37	1.31	4.97
FYM 3	597	412	276	404	247	-122.23	165.42	-327.26	1.34	5.03
N50	551	394	264	430	288	-241.62	149.16	-199.63	1.73	6.00
NP50	563	443	225	470	236	-249.92	171.98	-204.89	1.68	6.13
NPK50	935	662	410	705	398	-349.99	251.92	-358.80	1.64	5.82
N100	569	428	275	465	296	-281.99	160.38	-213.04	1.79	6.05
NP100	537	433	191	466	223	-305.75	162.74	-225.26	1.83	6.02
NPK100	958	667	423	696	348	-367.33	274.36	-390.51	1.62	5.79
NsPs	545	467	191	503	215	-281.30	162.85	-208.72	1.78	6.10
NsPsKs	979	634	481	660	433	-286.99	255.72	-357.61	1.53	5.76

A = Average rate of change in the productivity from initial point of time to the point of minima.
B = Average rate of change in the productivity from the point of maxima to minima or minima to maxima.
C = Average rate of change in the productivity from the point of maxima to last point of time.

Trends of crop productivity in different treatments



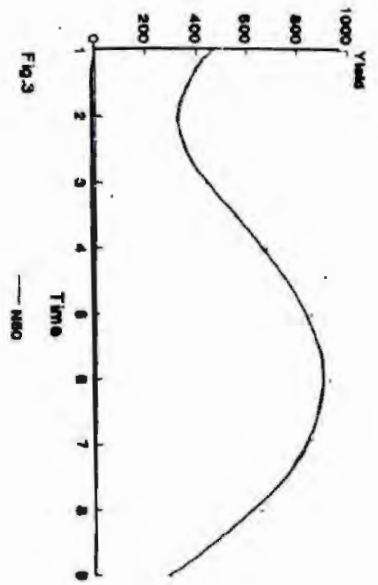


Fig.3

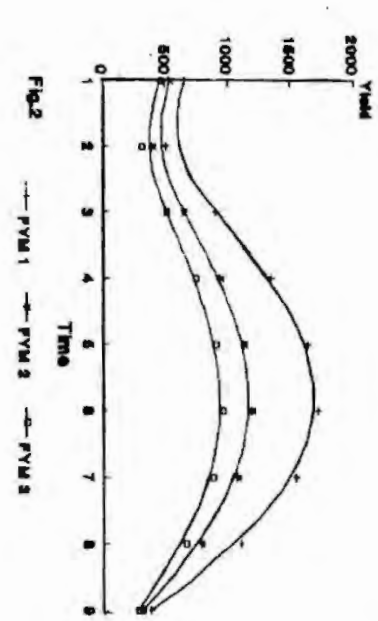


Fig.2

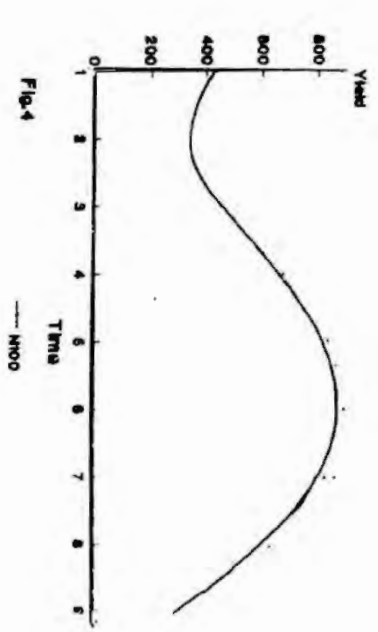


Fig.4

Trends of crop productivity in different treatments

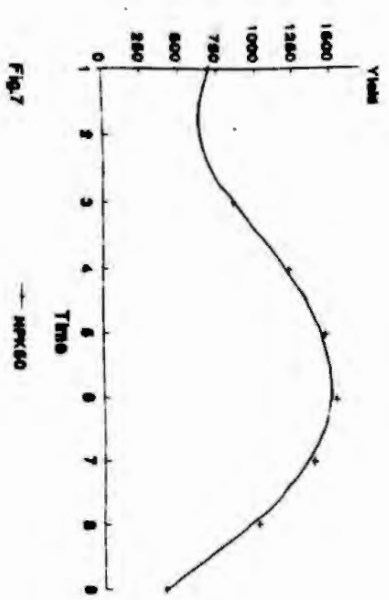


Fig.7

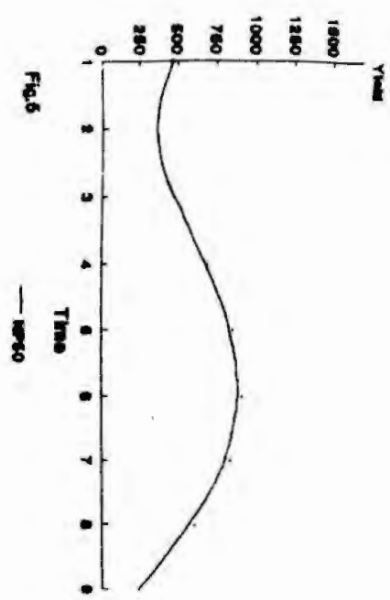


Fig.6

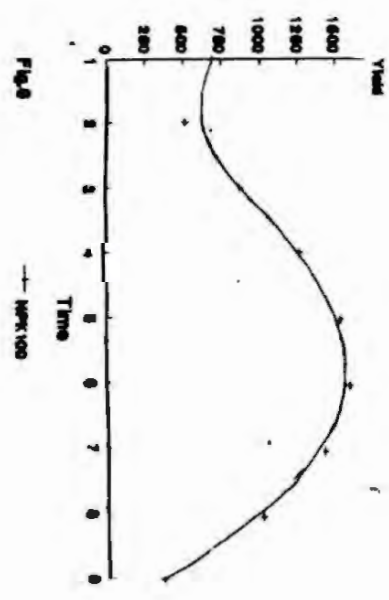


Fig.8

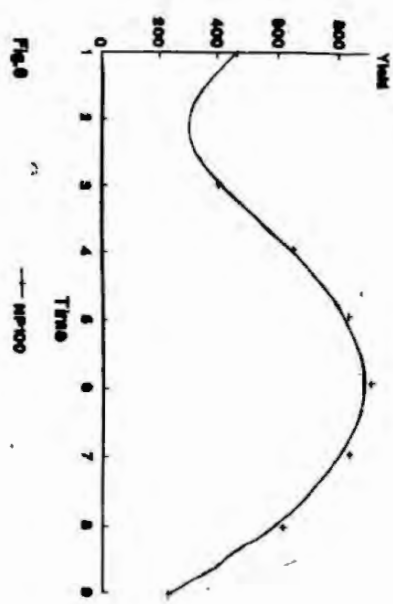


Fig.9

FYM3

Table 4 indicated a decrease in the productivity in early phase of experimentation (average rate of 235.23 kg), followed by increasing productivity at the average rate of 155.60 kg. However, after attaining the point of maxima at 5.90, a continuous decline in the productivity at the average rate of 217.17 kg was observed.

Nitrogen (N 50 and N 100)

The results (Table 4 and Figure 3 and 4) revealed that there was an initial decline at the average rate of 281.99 and 241.62 kg for the lower and higher level of nitrogen, respectivety. This decline was followed by increase in the productivity at the average rate of 160.38 and 149.16 kg, respectively.

Phosphorus in presence of Nitrogen (NP 50, NP 100 and NsPs)

The results furnished in Table 4 and depicted in Figures 5, 6 and 7 indicated an initial decline in the productivity in case of all the three treatments of N and P combinations. These initial declines were followed by the increase at the average rate of 171.98 kg (NP50), 162.74 kg (NP100) and 162.85 kg (NsPs) up to the point of maxima.

Potash in presence of Nitrogen and Phosphorus (NPK50, NPK 100 and NsPsKs)

The results presented in Table 4 and Figures 8, 9 and 10 indicated that for various levels of NPK, the declining trend in the productivity at different rates was observed during the initial period of experimentation. The maximum average rate of increase in the productivity up to the point of maxima was observed in case of NPK100 (274.36 kg), followed by NsPsKs (255.72 kg) and NPK50 (251.92 kg).

Trends of crop productivity in different treatments

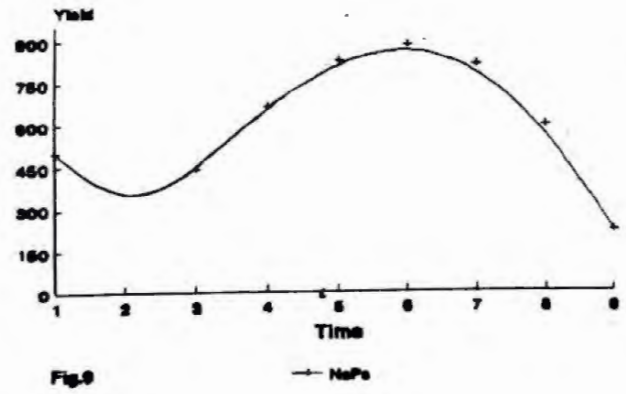


Fig.9

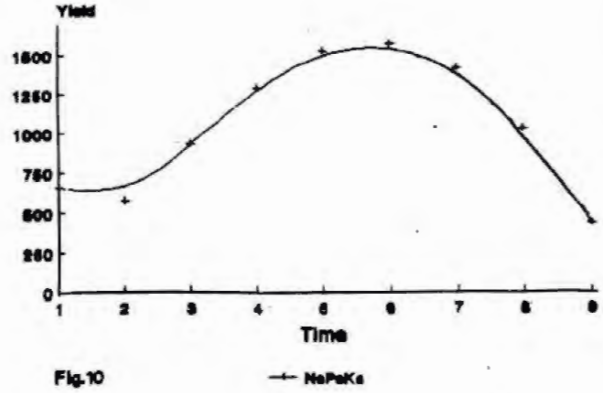


Fig.10

Thus, the results of the present study revealed that for groundnut crop, use of moving average reduced the irregular fluctuations in the data effectively and gave better fit as compared to that of original set of data.

Further, for the groundnut crop which requires quite low level of nutrients, a single form of the equation expressed the trend for all the treatments. However, regression coefficients (linear, quadratic and cubic) i.e. rate of change, showed variation. The initial decline, followed by a rapid increase was the characteristic of this fitted equation. The decline in the productivity of the crop was noticed for most of the treatments after 5 to 6 points of time. The average rate of change from the point of minima to maxima and maxima to minima to the end point was the highest in case of direct effect of FYM application for the period under study.

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