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Nitrogen, Phosphorus and Potassium Nutrition in Relation to the Growth and Chemical Composition of Pineapple (*Ananas comosus* L.)

by
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Useful growth responses in plants had been obtained by the application of nitrogen, phosphorus and pottassium. Inone and Fukunaga (1957) obtained best results in figs under sand culture studies when N, P and K were supplied at 80 : 40 : 40 ppm, respectively. Chemical composition of the leaves of many plants had also been reported to be altered by the application of these elements. Increasing the level of N in the experiment with the pineapple was associated with the increase N content and decrease in P and K contents in the leaves (Su, 1957). Potassium when supplied in culture media was found to be effective in increasing the N, P and K contents in the leaves of pineapple (Sideris and Young, 1945—46). In India, no systematic work has been done so far regarding the effect of N, P and K nutrition on pineapple. Therefore, the present study was undertaken to analyse their effect in terms of growth and chemical composition on pineapple under sand nutrient culture.

Material and Method: The investigations were conducted on Giant Kew variety of pineapple grown under sand nutrient culture. Suckers of uniform size and age were planted in the cement pots of 45 cm × 30 cm size, filled with washed sand on 12th April 1964. Hoagland complete nutrient solution consisting of (a) macroelements other than N, P and K (b) microelements and (c) iron tartrate at 0.005 gm per litre, was supplied at four litre per pot after planting. One litre of this solution was supplied per pot per month regularly to the whole life period. The pots were watered regularly. Three levels each of N, P and K *i.e.*, 0, 160 and 320 ppm (dry sand basis) in the form of ammonium sulphate, super phosphate (single) and potassium sulphate respectively were supplied in all possible combinations. Thus, there were 27 treatments which were replicated three times. Nine plants were maintained under each treatment. The application of treatments was made in two equal instalments. The first amount was applied on 12th May, 1964 and the application was repeated on 12th November, 1964 to complete the full requirement.

Growth observations were recorded on 255 days after planting, 451 days after planting and 902 days after planting. The responsee of N, P and K were recorded in terms of height of plant, total root extension, fresh and dry weights of roots, total leaf area, fresh and dry weights of plant. The significance of

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these responses was tested statistically. The results at 902 days stage of the growth have been presented in Table 1. The average data of these three observations have been presented in Figure 4. At the middle of the life cycle of the plant *i.e.*, after 451 days planting, leaf samples were taken. These samples were utilized for the estimation of N (Kjeldahl method), P (Ammonium molybdate method), K (Cobaltinitrite method), total carbohydrate (Copper reduction method), crude fibre and ash contents as described in A.O.A.C. (1955). The value obtained on dry weight basis of the pineapple leaves have been presented in Table 2.

Experimental findings: Growth characters: Significant effects of N, P and K and of their interactions were noted in improving the growth characters of the pineapple plant. At 902 days the height of the plant was maximum of 125.1 cm when these elements were applied in $N_2P_2K_2$ combination. It was remarkable to note that P and K in the maximum dose but in the absence of N had produced the smallest plants throughout the plant life cycle. Total root extension was improved by N alone when these elements were applied alone. However, P and K became significantly effective when combined with N. Thus, the highest value of total root extension (28.23 metre) was noted to be under N_2 P_1 K_2 at 902 days. Lowest values in the total root extension were associated with no N. Fresh weight of the root was not signifinantly affected by these elements at 902 days stage of growth. But their effect was pronounced at the early stages of the plant life cycle. Maximum fresh weight of the root as 66.67 g was noted to be under N_2 P_1 K_2 combination at 902 days. Increasing the concentration of N in the combination had increased the fresh weight of the roots. Phosphorus in the highest dose (320 ppm) proved unfavourable for the fresh weight of the roots. Lowest fresh weight of the root was [noted to be under N_0 P_2 K_2 combination at 902 days. Dry weight of the root was affected in a similar manner as fresh weight of the root due to application of these elements.

Maximum dry matter in the roots had been produced by N_2 P_1 K_2 combination. With regard to the effect of leaf area, these treatments did not differ significantly at early stages of growth. With the advance of the age certain combinations became significantly effective in improving the leaf area of the pineapple plant. It was remarkable to note that the highest and lowest values as 1.900 and 0.098 sq. metre had been recorded under N_2 P_2 K_2 and N_0 P_2 K_2 combinations respectively at 902 days. In the absence of N, the high doses of P and K proved unfavourable in increasing the leaf area of the pineapple plant. Nitrogen in the highest dose (320 ppm) and P in the medium dose (160 ppm) were appreciably effective in increasing the fresh weight of the plant. At 902 days highest value of the fresh weight of the plant as 1491.8 g had been recorded when these elements were applied in N_2 P_2 K_2 combination.

Dry weight of the plant was affected by the treatments similarily to the fresh weight of the plant. Highest dry matter was produced under the influence of N_2 P_2 K_2 combination at 902 days (Table 1 and Figure 4).

TABLE 1. *Effect of N, P and K on the growth characters of pineapple after 902 days planting*

	N_0			N_1			N_2			S. EM	C.D. at 5%
	P_0	P_1	P_2	P_0	P_1	P_2	P_0	P_1	P_2		
Height of plant (cm)											
K_0	75.0	84.3	107.0	96.6	109.4	95.0	102.4	102.8	106.1	± 6.6	18.4
K_1	77.0	105.8	85.1	104.8	94.1	119.3	108.6	119.8	98.6		
K_2	86.0	89.9	37.7	88.6	95.1	106.0	94.9	97.0	125.1		
Total root extension (metre)											
K_0	4.39	9.10	13.76	15.75	15.61	12.46	20.65	18.97	14.55	± 4.0	11.04
K_1	6.23	7.14	7.14	12.36	20.40	12.88	16.10	17.36	10.99		
K_2	9.31	9.55	1.82	17.99	11.48	13.30	13.86	28.33	16.87		
Fresh weight of roots (g)											
K_0	10.17	21.67	32.67	37.50	37.17	29.67	59.17	45.17	34.67	± 10.6	—
K_1	14.83	17.00	17.00	29.33	48.50	30.67	38.33	41.33	26.17	(not	
K_2	22.17	22.83	4.33	42.83	27.33	31.67	33.00	66.67	40.17	significant)	
Dry weight of roots (g)											
K_0	4.53	10.03	13.20	15.87	15.13	13.80	15.30	14.03	11.70	± 2.5	6.98
K_1	7.40	7.27	8.13	11.23	13.53	14.30	16.10	19.37	12.37		
K_2	10.40	9.70	2.13	18.00	12.30	11.83	16.17	19.40	18.70		
Leaf area per plant (sq. metre)											
K_0	0.318	0.712	1.120	1.758	1.146	0.910	0.824	0.918	1.010	±0.640	0.590
K_1	0.424	0.796	0.496	0.958	1.292	1.609	1.118	1.716	1.136		
K_2	0.856	0.894	0.098	0.888	0.970	0.998	1.082	1.286	1.900		
Fresh weight of plant (g)											
K_0	250.4	612.6	1052.7	775.5	1002.6	822.3	789.6	844.6	842.3	± 155.2	428.4
K_1	313.5	632.1	416.0	862.6	758.2	1349.8	920.2	1462.5	906.4		
K_2	616.0	812.9	87.9	1005.2	894.0	897.5	953.7	1132.0	1491.8		
Dry weight of plant (g)											
K_0	38.73	87.53	134.30	113.87	147.99	151.62	127.60	143.30	140.37	± 27.1	74.52
K_1	46.50	81.83	57.86	126.63	125.03	205.60	143.07	226.74	128.57		
K_2	83.33	101.77	10.96	170.34	143.26	140.16	155.14	193.64	229.97		

0 = 0 ppm, 1 = 160 ppm and 2 = 320 ppm

Chemical composition of leaves: Remarkable alterations in the leaf chemical composition had been observed. Nitrogen content in the leaves was noted to be highest (1.918%) under N_2 P_2 K_0 combination. Deficiency of these elements had markedly lowered the N content in the leaves (0.168% under N_0 P_0 K_0 ratio). Upper and lower extremes in the values of P content were noted under $N_0 P_1 K_1$ and $N_1 P_0 K_1$ combinations respectively. Highest K content in the leaves was associated with application of K and with the condition of no N or N applied in low (160 ppm) concentration. Maximum K content as 5.363 and 5.257% was noted to be under $N_0 P_2 K_2$ and $N_1 P_2 K_2$ combinations, respectively. High values of ash content were associated with no N, medium P and highest K doses in the combinations. Increasing N with P had given best result in carbohydrate accumulation in leaves. High values as 50.85% (dry weight basis) and 45.88% (dry weight basis) were noted to be under $N_2 P_1 K_2$ and $N_2 P_2 K_1$ combinations, respectively. Potassium in 160 ppm when combined with 320 ppm of N had encouraged the carbohydrate accumulation. Deficiency of these elements had produced the lowest (23.40%) carbohydrate in leaves. It was interesting to note that the C/N ratio was noted to be highest under the deficiency of these elements ($N_0 P_0 K_0$) ratio. The ratio was noted to be minimum when these elements were applied in the highest doses ($N_2 P_2 K_2$ ratio). Crude fibre content was noted to be highest and lowest as 25.85% and 13.20% under $N_2 P_2 K_1$ and $N_0 P_0 K_0$ combinations, respectively (Table 2 and Figure 5).

TABLE 2. *Effect of N, P & K at various levels and ratios on the chemical composition of pineapple leaves*

Constituents % dry wt. basis		N_0			N_1			N_2		
		P_0	P_1	P_2	P_0	P_1	P_2	P_0	P_1	P_2
Nitrogen	K_0	0.168	0.864	0.854	1.596	1.498	1.820	1.624	1.848	1.918
	K_1	0.882	0.920	0.920	1.330	1.442	1.484	1.908	1.582	1.834
	K_2	0.864	0.938	0.948	1.708	1.372	1.512	1.442	1.442	1.834
Phosphorus	K_0	0.712	1.100	0.956	0.743	0.889	0.761	0.700	0.823	0.745
	K_1	0.934	1.291	0.866	0.700	0.948	0.782	0.713	0.938	0.774
	K_2	0.956	1.245	0.957	0.773	0.869	0.800	0.722	0.824	0.756
Potassium	K_0	0.997	0.361	0.151	0.734	0.313	0.943	0.522	0.944	0.576
	K_1	4.047	0.471	5.114	3.259	1.680	3.364	1.115	2.913	2.733
	K_2	5.235	1.365	5.363	4.100	5.094	5.357	2.154	4.574	4.153
Total Carbohydrate	K_0	23.40	44.89	45.80	40.86	36.55	41.67	45.67	41.67	43.42
	K_1	37.89	43.86	41.22	44.97	45.80	43.40	42.60	40.31	45.88
	K_2	28.94	45.80	32.18	44.39	36.88	45.55	36.55	50.85	39.68
Crude Fibre	K_0	13.20	17.50	18.90	18.15	15.60	18.10	16.80	21.20	13.95
	K_1	17.35	17.35	16.50	16.50	14.90	14.00	14.40	16.95	25.85
	K_2	17.35	15 80	16.00	14.25	15.10	14.85	15.90	16.75	21.85
Ash	K_0	10.61	17.93	11.69	13.79	16.00	17.55	16.73	13.82	14.63
	K_1	21.12	20.52	23.31	18.00	15.92	13.88	15.93	17.12	16.52
	K_2	23.60	20.51	20.13	15.42	17.52	16.01	15.61	18.73	16.43

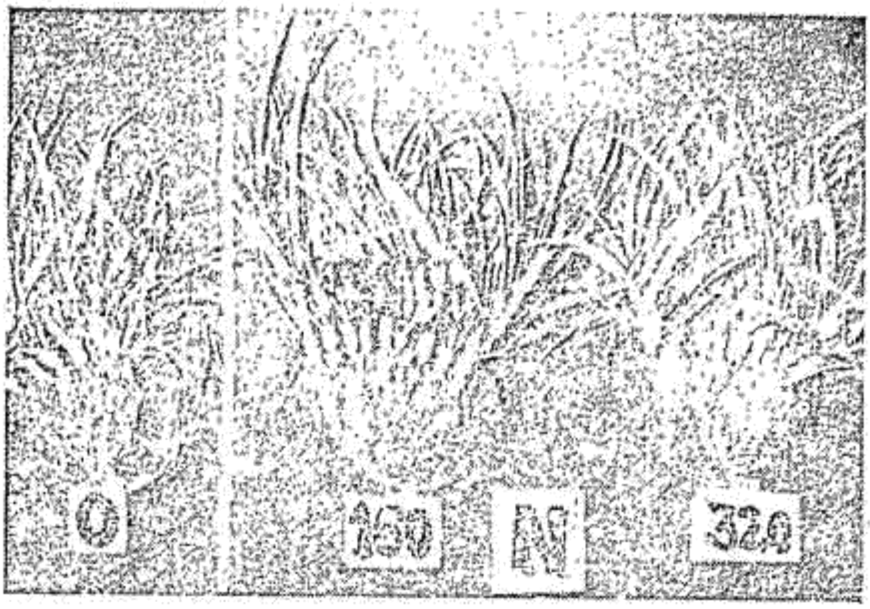

Fig. 1.
Effect of N on the growth of pineapple

0=Control or 0 ppm of N
160=160 ppm of N
320=320 ppm of N

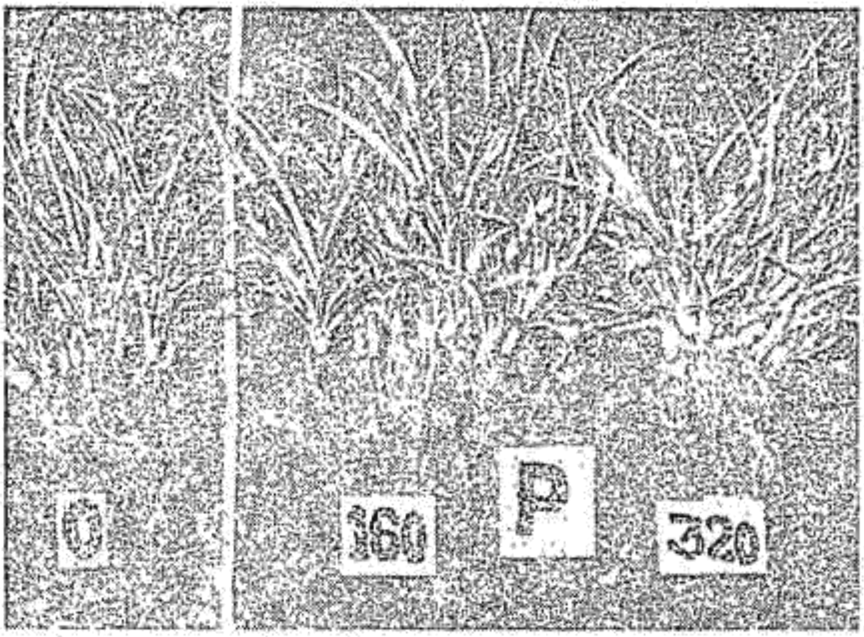

Fig. 2.
Effect of P on the growth of pineapple

0=0 ppm or Control
160=160 ppm of P
320=320 ppm of P

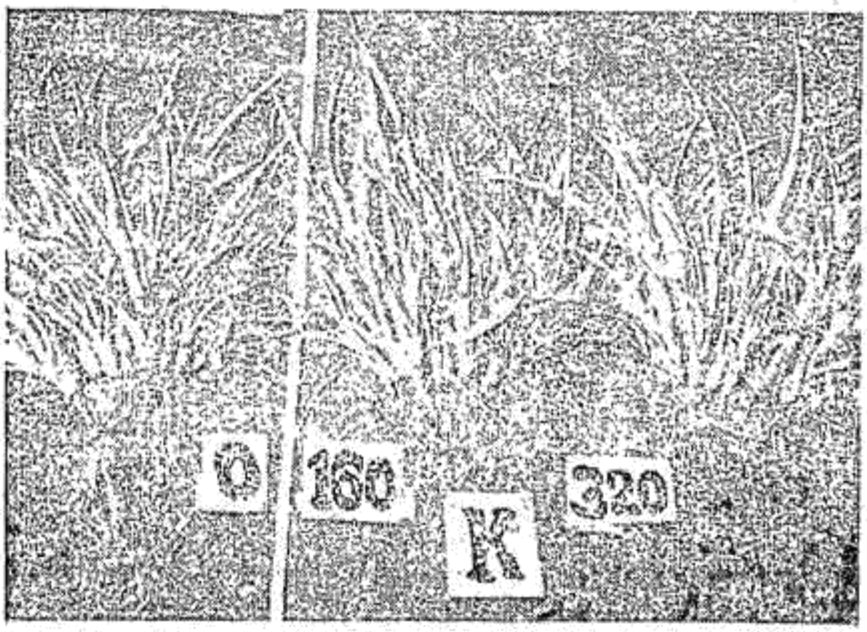

Fig 3.
Effect of K on the growth of pineapple

0=0 ppm or Control
160=160 ppm of K
320=320 ppm of K

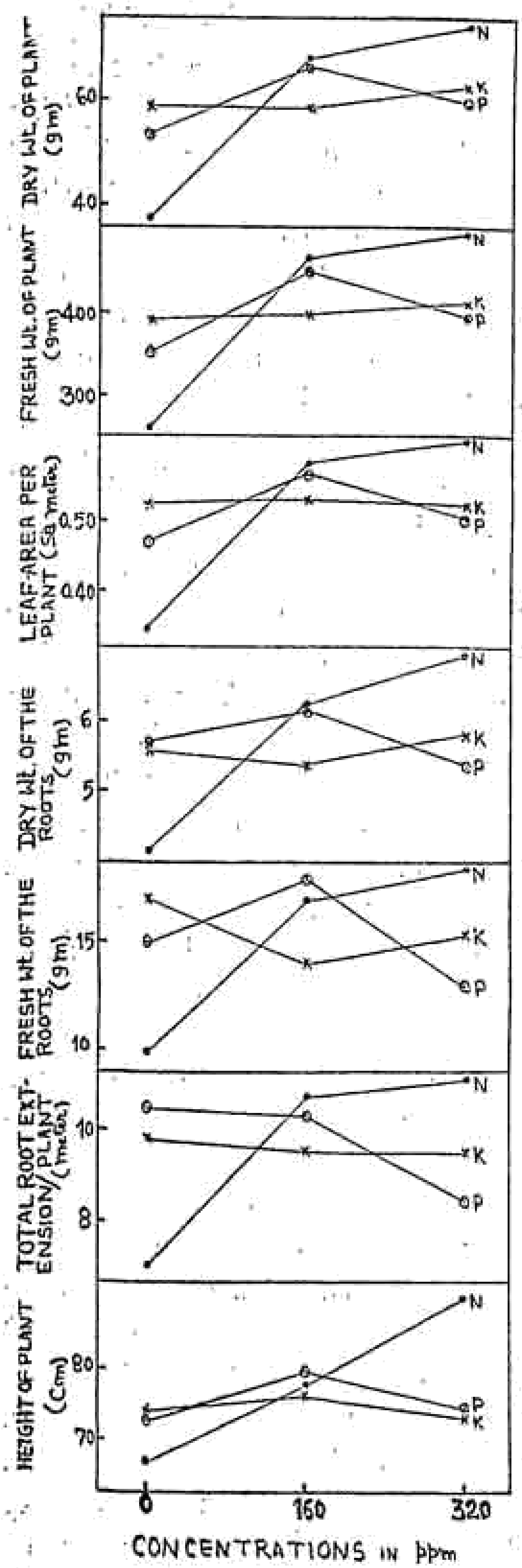

FIG. 4- EFFECT OF N, P & K ON THE GROWTH CHARACTERS OF PINEAPPLE.

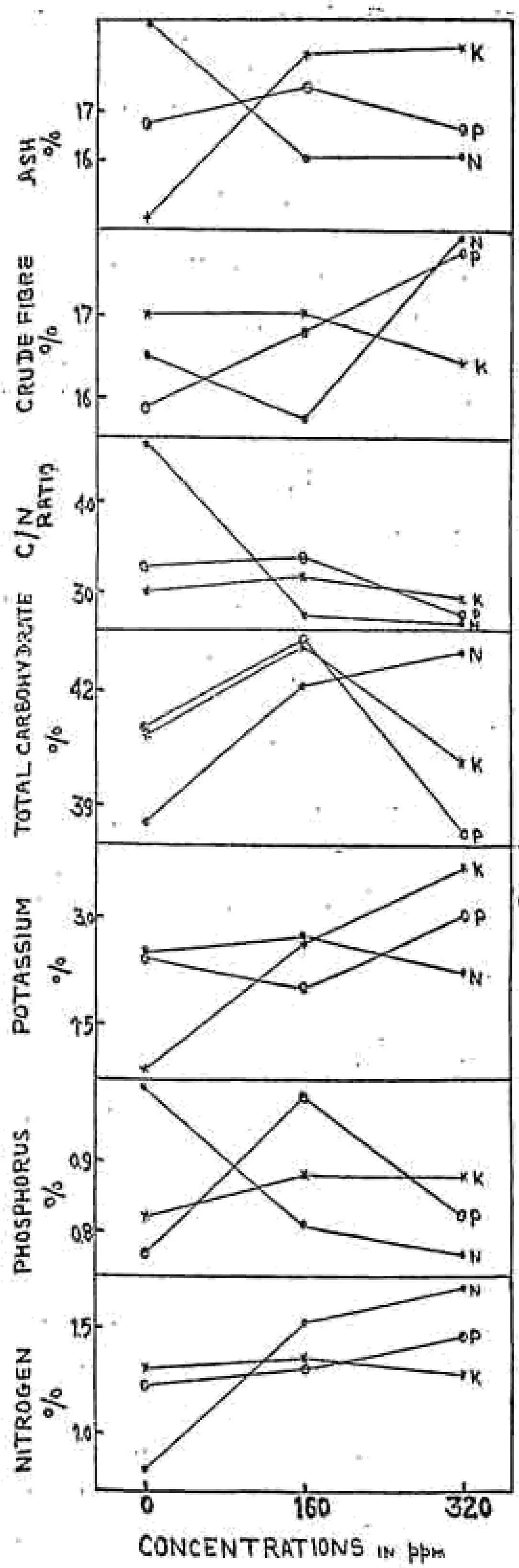

FIG. 5-EFFECT OF N P & K ON LEAF CHEMICAL COMPOSITION OF PINEAPPLE.

Discussion: N, P and K when applied either singly or in combinations were effective in improving the health and vigour of pineapple plant (Figures 1, 2, 3 & 4). N application in the highest dose (320 ppm) proved most effective in improving the root and shoot system of plant. P application in the medium dose (160 ppm) proved optimal for growth. High concentration of this element was unfavourable. Furthermore, its effect was more pronounced at the middle and later stages of plant life cycle. K was least effective in causing variations in the growth of pineapple plant as compared to the effect of N and P. However, in certain growth characters this element had given appreciable response. For example, at 902 days the highest dry matter content in the plant noted under $N_2 P_1 K_1$ was 226.74 g, whereas, under $N_2 P_1 K_0$ combination this value was noted to be 143.3 g (Table 1). High N and low P and K contents in the leaves were associated with high level of N application. P had slightly increased the N content in the leaves. P and K contents in the leaves were increased with 160 and 320 ppm of P and K application respectively. Total carbohydrate was improved with the maximum dose of N and medium doses of P and K. C/N ratio was noted to be highest under the deficiency of the elements. Crude fibre was improved with the highest dose of N and P. Highest ash content in the leaves was noted to be with the highest dose of K application (Figure :). Maximum leaf are and dry weight of the plant at 451 days had been observed when the N, P and K contents in the leaves was 1.582 : 0.938 : 2.943 per cent. Next to the highest value of these two characters appeared the leaf N, P and K contents as 1.498 : 0.889 : 0.313 per cent. Lowest leaf area and dry weight of the plant had been recorded when the leaf N, P and K contents were 0.948 : 0.957 : 5.363 per cent (Table 2). This had indicated that accumulation of K in leaves was unfavourable for the leaf area and the dry weight of plant. N accumulation was favourable and no correlation had been observed with P accumulation. Furthermore, the growth of pineapple plant was effectively stimulated with the low C/N ratio in leaves. The variations in the growth of pineapple plant and leaf chemical composition might be due to that N, P and K when applied had played their specific role in stimulating the various physiological and biochemical activities going on within the plant. N obviously functions as a necessary component of such biologically important molecules as proteins, aminoacids, purines, pyrimidines and co-enzymes (Bould and Hewitt, 1963). P is a constituent of cell nucleus and is essential for the cell division and for the development of the meristem tissues (Arnon, 1953). At the enzymatic level, K acted as an activator of a number of enzymes such as; fructokinase, pyruvic acid-kinase and transacetylase (Webster, 1953).

The application of these elements in various combinations had shown peculiar responses. On certain growth characters wide variations in the proportion of these elements resulted into more or less similar response e. g.

total leaf area under $N_0 P_2 K_0$ and $N_2 P_0 K_1$ ratios was noted to be of 1.120 and 1.118 sq. metre respectively. Dry weight of plant under $N_1 P_1 K_2$ and $N_2 P_1 K_0$ ratios was noted to be of 143.26 and 143.30 g (Table 1). In still other combinations quite distinct effects were produced when one of these elements was altered within limited range (e. g. leaf area under $N_0 P_0 K_0$ – 0.318 sq. metre, under $N_0 P_0 K_2$ – 0.856 sq. metre, $N_1 P_0 K_0$ – 1.758 sq. metre and under $N_1 P_1 K_0$ – 1.146 sq. metre, dry weight of plant under $N_0 P_0 K_0$ – 38.73 g, $N_0 P_2 K_0$ – 134.30 g and under $N_0 P_2 K_2$ – 10.96 g). Such variations in the total carbohydrate and crude fibre contents in leaves had also been observed. With the advance of age, the optimum proportion of these elements required for the growth was variable. Schwabe (1951) and Gregory and Richards (1929) advocated that such types of variations might be due to the interactions of these elements. Hopkins (1949) had pointed out that there was a close relationship between N feeding and K requirement. With high N, K supply should increase. The effectiveness of the foliage increased by abundant N as photosynthetic apparatus depended in turn upon the K in plant. This fact had been noticed in the present investigation with the leaf area and the dry weight of the plant in whole life cycle of the plant (Table 1). Nojoku (1957) under sand culture study with *Ipomoea caerulea* had reported that high N, P & K treatments gave the maximum leaf production. Whereas, P and K treatment with low N gave the opposite extreme. This fact is quite clear with the present experiment with pineapple. The leaf area observed under $N_2 P_2 K_2$ and $N_0 P_2 K_2$ was highest (1.900 sq. metre) and lowest (0.098 sq. metre) respectively at 902 days (Table 1).

Summary: Sand nutrient culture was laid out to investigate the effect of N, P and K in various combinations on pineapple. These elements were directly applied in the sand each as 0, 160 and 320 ppm (dry sand basis).

Significant effect of these elements had been observed on height of plant, total root extension, fresh and dry weights of roots, total leaf area per plant, fresh and dry weights of plant. Maximum improvement in the growth characters had been given out when these elements were applied under $N_{320} P_{320} K_{320}$ combination as observed at 902 days after planting. But on an average life cycle, these elements were most effective under $N_{320} P_{160} K_0$ or $N_{320} P_{160} K_{320}$ combination.

Highest values of N, P, K and ash contents as inorganic constituents and total carbohydrate, crude fibre and C/N ratio as organic constituents in leaves were noted under $N_{320} P_{320} K_0$, $N_0 P_{160} K_{160}$, $N_0 P_{320} K_{320}$, $N_0 P_0 K_{320}$, $N_{320} P_{160} K_{320}$, $N_{320} P_{320} K_{160}$ and $N_0 P_0 K_0$ combinations respectively.

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OUR HEARTY CONGRATULATIONS TO

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