Engineering News

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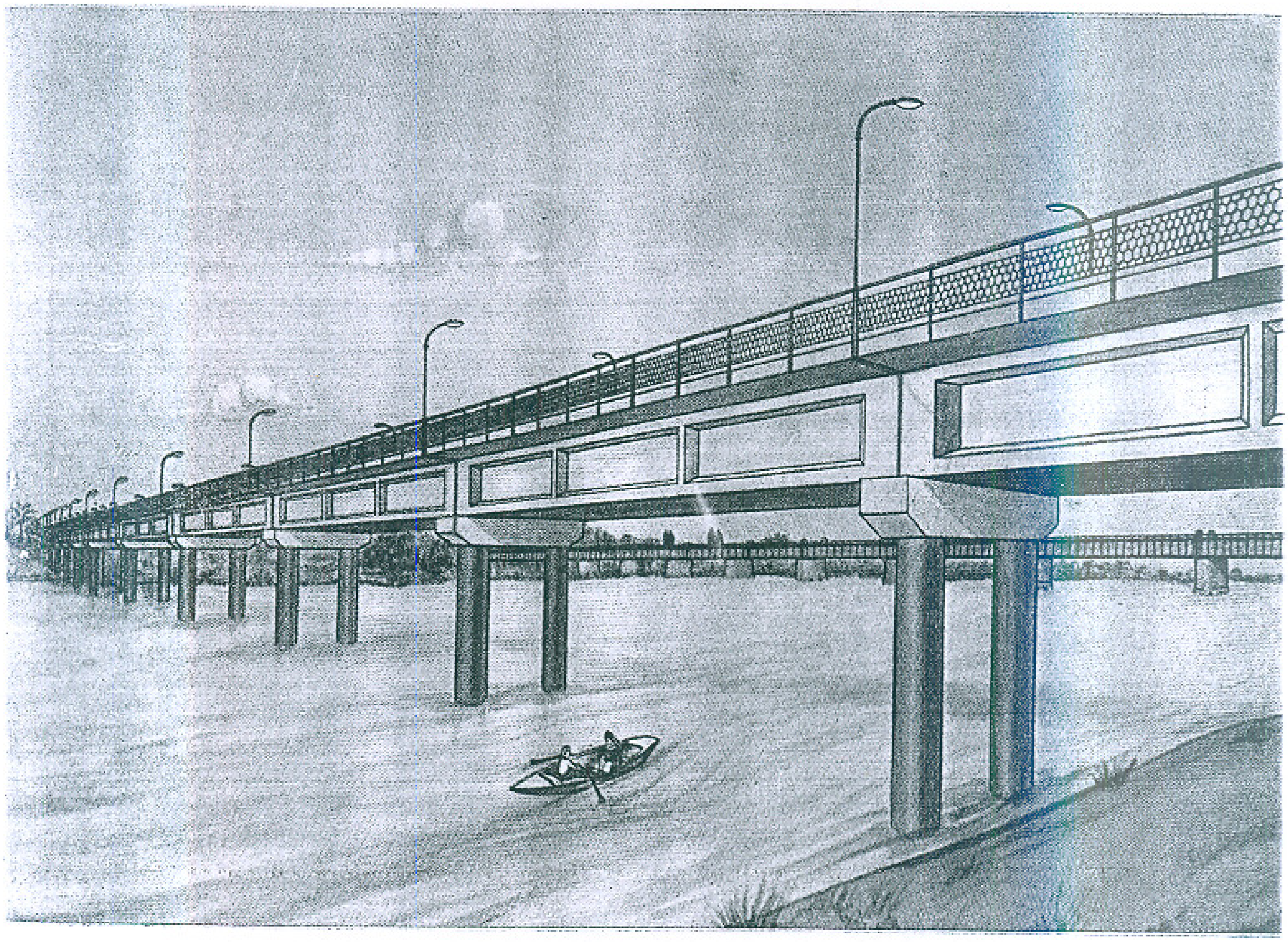
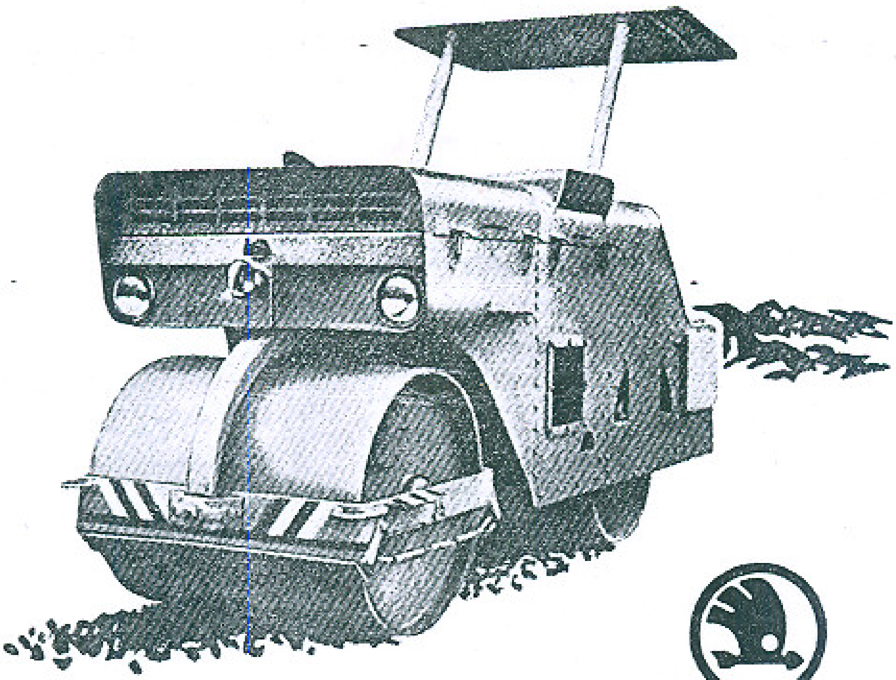


Old Ravi Bridge Near Shahdara, After Renovation



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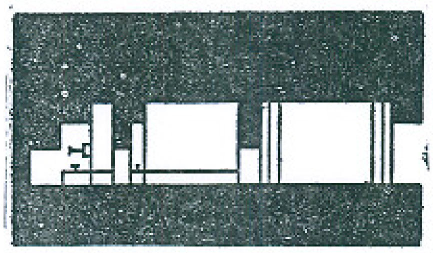

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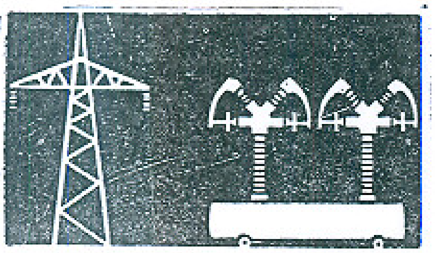

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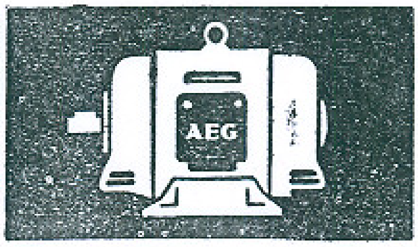

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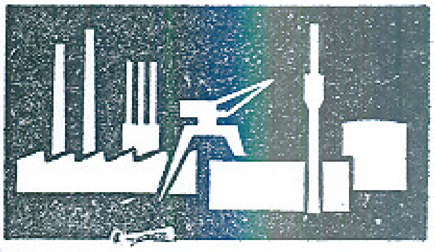

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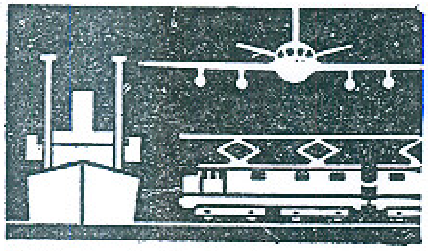

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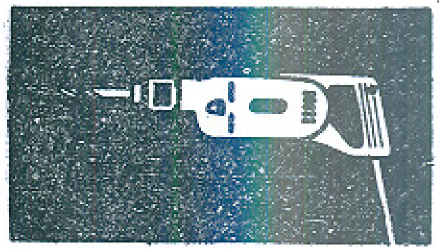

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• Reprints from this journal be made on condition that reference is given to the *Engineering News*, its Vol. No., and the author.

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ELEVENTH YEAR OF PUBLICATION

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Members! Consider

With the publication of this issue *The Egnineering News* completes eleven years of its existence. For all these years the Journal has struggled for its existence and has tried its best to be a forum for engineering knowledge. The present honorary staff of editors have tried their best to issue at least four numbers of the journal in a year. This year, we are sorry to point out, that in spite of our best efforts, the inattention and the apathy of our members has been so great that we seldom received any contribution for publication in the Journal, which naturally can thrive only on the contributions of its members.

In any developed country there are scores of scientific engineering journals issued every month. In our own country there is no lack of engineering works in progress. The engineers are playing important role in its development. Large engineering undertakings are in the process of construction. Projects worth several thousand million rupees are being completed. Only on Indus Basin Works, Rs. 1,600 millions are being spent in this decade. Organization like WAPDA in both wings of the country, Irrigation Department, Communication and Works, Public Health, P.I.D.C., A.D.C., Railways, Military Engineering, Engineering Universities and Technical Institutions, accommodate scores of engineers, working and creating new ideas, new designs, new methods of execution, etc.

The talent of the engineers is well established. It is only the cream of the nation that finds its way into the Engineering Institutions. After four years of hard and intensive training they are entrusted with nation-building projects where their imaginative designs, scientific executions and novel techniques are all combined to build complicated grand engineering works. Each engineer on the job has his own experience. He has done something new. The communication of his experience can be of much use to his fellow engineers, but there is something wrong somewhere. The most talented cream of the nation is shy to pen its learning for fellow workers. With thousands of engineers working under various responsibilities, there is so little of their contributions that even two engineering journals, that of the Institute of Engineers, Pakistan, and *The Engineering News*, of West Pakistan Engineering Congress find it hard to survive.

The Engineering News is a joint responsibility of all the engineers of the country, whether they are members or non-members. The editorial staff waits for months to receive any contribution and then has to rely upon whatever material can be gathered. One really feels small to find articles printed in Foreign Journals on works in progress or under construction in his own country.

We are sorry to point out these bare facts to the members and we do hope that in future we will eliminate this apathy and many young engineers will come forward with contributions for this engineering forum of the country.

Rebuilding Old Ravi Bridge near Shahdara

By

ABDUS SALAM

Director Bridges, West Pakistan Communications and Works Department, Lahore.

The Directorate of Bridges, West Pakistan has recently become very active in the construction of new bridges. At present five major bridges spanning the rivers Jhelum, Ravi and Chenab are under construction. This is the first article by Mr. Abdus-Salam which gives brief information with regard to the old Ravi Bridge being constructed at Shahdara.

Fifty Years Old Ravi Bridge

The Old Ravi Bridge cost Rs. 6.0 lakhs in good old days. Viewed in the context of present-day costs, this figure is insignificantly low. This fact speaks volumes for the engineers of the day. Money has always been a bugbear with various engineering projects and has influenced the design of structures. Old Railway girders, short brick piers with over-hanging steel work, no well caps and siting of bridge close to the old Railway bridge (to economize on the cost of guide banks), are features which reflect the anxiety of early builders to cut down the capital cost. They succeeded admirably well, as in spite of such a low cost, this structure as shown in Fig. 1 being dismantled, has withstood the ravages of flood, storm and time for fifty odd years. It has been subjected to overloading since quite a long time and it was

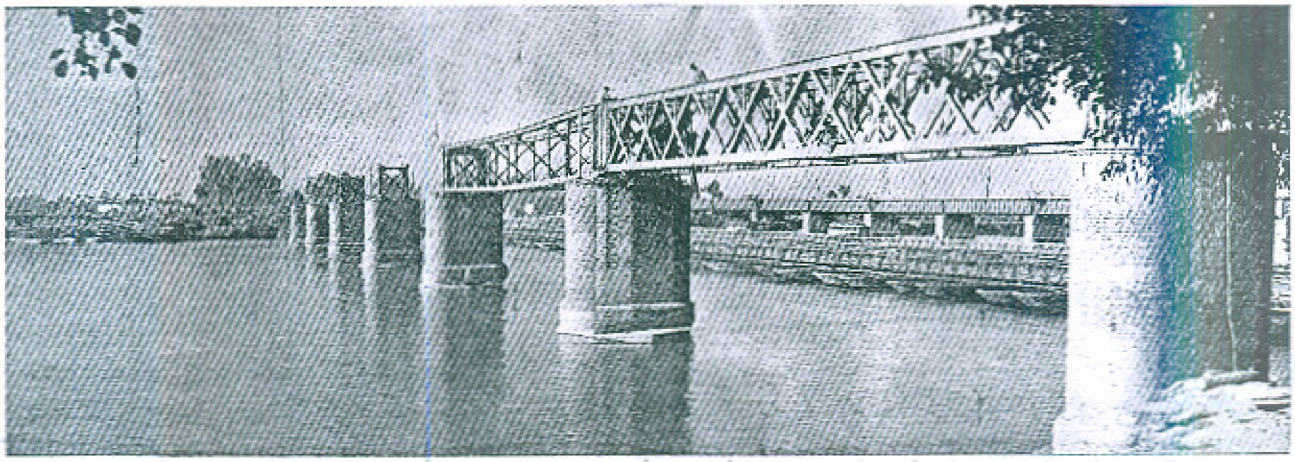

Fig. 1

only recently that it showed signs of serious distress when early replacement became imminent.

Mr. Trever Jones who retired as Chief Engineer, Buildings and Roads, was the Assistant Engineer in charge of this bridge and remembers vividly the various constructional phases. The old man who now lives in the suburbs of London writes nostalgically about his early days when he supervised the construction of this bridge. The writer has been in correspondence with Mr. Trever Jones who lives to talk about this bridge and is eager to know if the piers are also being dismantled.

Heavy Traffic damaged the bridge

In March 1966, when serious damage to the bridge came to light and it was found that the "Old Faithful" could no longer meet the challenge of heavy traffic, its replacement gave anxious moments to the department. It could only be taken in hand after the next flood season and required to be completed before the inset of the following flow season. What alternative crossing arrangements are to be provided in the intervening period, how this old structure is to be remodelled in case of part rebuilding, to what loading this is to be designed and whether the old foundations would permit higher carrying capacity and wider roadway and how to ensure the supply of imported materials in such a tight time schedule, were few of the many major questions which this challenge posed. Planning and designing a new bridge is a lot easier even in a limited time as there are no limitations placed on the various proposals which a designer can conceive. In the present case, the pressure on the soil and the stresses in the steining governed the final design of the proposal.

Old Bridge

This bridge was opened to traffic in April 1915. Situated 450 feet downstream of the Railway Bridge, it consists of 15 simply supported spans of 97′-6″. A roadway of 18′ was carried on steel troughing resting on rolled steel joists which were supported by two old wrought iron lattice girders. These girders had been discarded by the Railway and remained stockpiled at Badami Bagh for about 6 years before they were reused at the present site. The girders for the two spans on the Lahore side were, however, obtained from the remains of old Sutlej Bridge at Phillaur. These girders were placed 8′-0″ centre to centre on 6′-9″ thick brick piers. The piers were carried in turn by single octagonal brick wells sunk to an approximate depth of 70′ below the average low-water level. The piers and the wells were laid in hydraulic lime, as the use of cement at the time of construction was a rare luxury. There were no well caps over the wells and the brick piers rested directly on the top plugs of the wells which are 10′ thick in lime concrete. The bridge was designed for a 15-ton road roller which was the heaviest loading at that time.

The brick piers by and large appeared in good shape except a few which indicated weathering on the surface. The well steining which was built to the same specifications was open to view by a few feet only above low-water level and appeared good. The steel troughing was badly corroded and the main girders in wrought iron were really in bad shape. Some members had snapped and the girders in general showed excessive deflection. The replacement of superstructure was considered urgent as this could not be trusted any more.

While formulating proposals for the renovation, prestressed concrete superstructure was selected. Various factors contributed to this decision. The overriding consideration has been to save foreign exchange by using indigenous materials and local know-how. If total cost and foreign exchange had not been a problem, a steel superstructure would have been a better solution, as strength for strength steel superstructure is much lighter than the concrete superstructure.

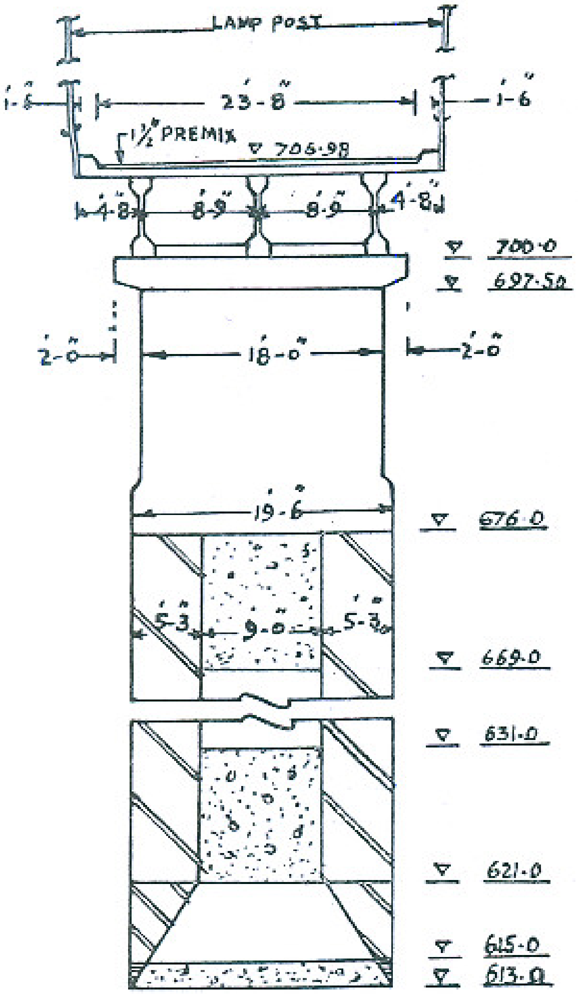

Fig. 2

This would have given higher load classification in view of the limited load carrying capacity of the substructure. But in Pakistan no structural steel is produced and therefore in case of steel bridge, the entire quantity of steel work would have to be imported, meaning a very high component of foreign exchange. The subsequent maintenance expenditure also puts the steel superstructure at a disadvantage. Furthermore, a steel bridge is very expensive in everall cost. Its cost worked out to Rs. 24.0 lakhs against Rs. 11.0 lakhs for prestressed superstructure.

The strength of the substructure dictated the width of the new roadway and its load

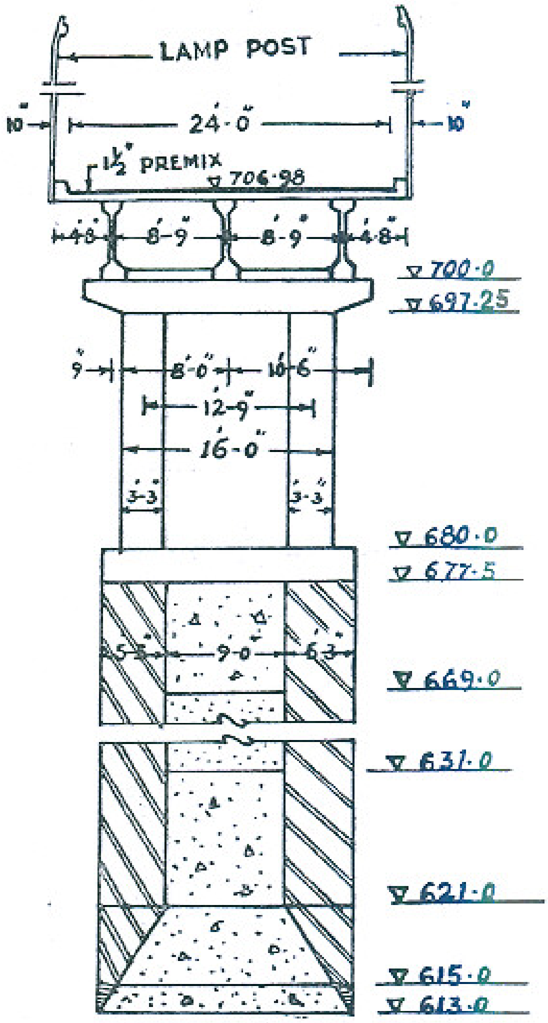

Fig. 3

classification. Various alternatives were prepared starting with 18′ r. adway and ending up with 24′ width. It was found that with I. R. C. class B loading and 24′ width, the

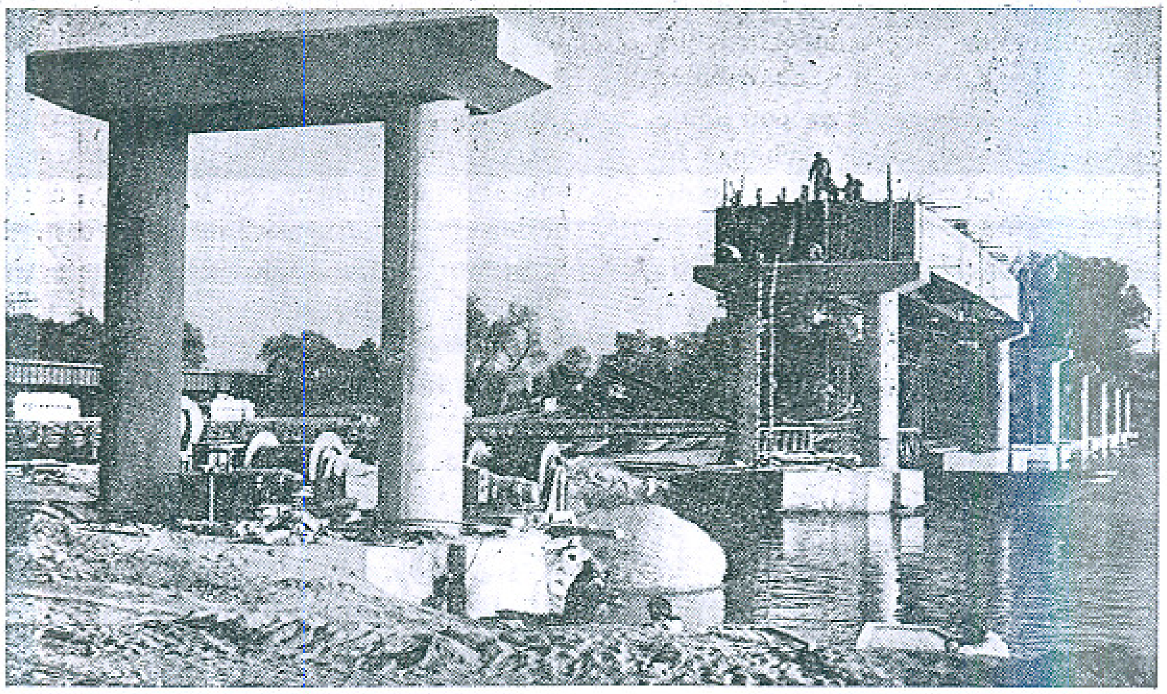

Fig. 4

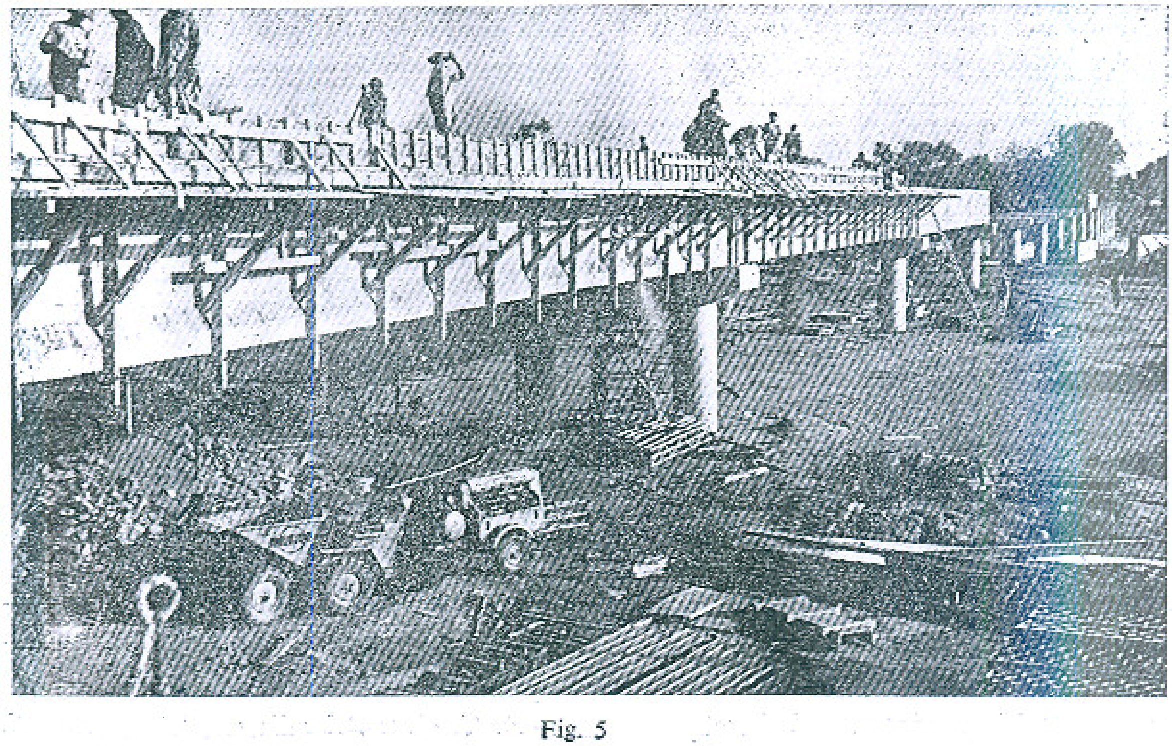

Fig. 5

stresses would be within the limits. Three girders in the cross section gave the most economical arrangement. I-beams were adopted against Tee-beams, as the former were lighter and easier to handle.

First Proposal

This proposal envisaged the laying of an R. C. C. cap over the top of brick piers after dismantling the steel superstructure. Three prestressed concrete beams would carry an R. C. C. slab to support a roadway of 23′-8″ with safety kerbs of 1′-6″. The two outer beams were to rest on the cantilever part of the cap. The arrangement is shown in Fig. 2. The bridge would cater for two lanes of I. R. C. loading class B or one lane of army loading class 50. This scheme envisaged the retention of the maximum part of the old bridge, thus keeping the new work to the minimum and making it possible to complete the replacement of superstructure in the shortest time. A detailed structural analysis, however, indicated that the stresses in the foundations were high and the following table would be of interest:—

Case of loading	Max. stress
1. No live load, wind at 100 M. P. H., river in max. flood ..	7.76 ton/sq. ft.
2. No live load, full seismic effects, river in max. flood ..	11.55 ton/sq. ft.
3. Max. live load and max. seismic load ..	9.0 tons/sq. ft.

Not only were the stresses high but it was also considered that the old brick piers would not go hand in hand with the new concrete superstructure. While the new portion would last for many long years, the old brick piers are likely to be in bad shape after another 30-40 years. Moreover, stresses on the well top under piers were also high. It was therefore decided that we should go in for another scheme which would include new piers with a proper well cap to even out the imposed loads.

Second Proposal

In view of the above, a new scheme was prepared. This is shown in Fig. 3. Bricks piers were replaced with R. C. C. column piers after laying a new well cap over the existing wells. The new roadway is 24′ wide with 9″ wheel guards. The class of loading remains the same as in the case of first proposal. It will be seen that substitution of brick piers with R. C. C. piers (Fig. 4) have not only cut down the dead weight (brick pier weighed 117 tons, R. C. C. pier weighed 41.0 tons) but have also added considerably towards the aesthetic appeal. (See front page). This proposal amounts to rebuilding the bridge and whereas it has increased the quantum of work and enhanced the cost slightly, the ultimate life of the bridge has been increased considerably.

To date, considerable amount of work has been done on the bridge. The dismantling of old superstructure and the brick piers is complete and all the concrete piers are ready. Post-tensioned pre-stressed concrete girders which are pre-cast in the casting yard have been hoisted on 3 spans and the work is in full stride (See Fig. 5). It is expected that the project would be completed before the inset of next flood season. This bridge when complete will be a great boon to Lahorites, as this will supplement the new 4-lane bridge being built 2100 feet downstream. This two-lane bridge would take care of slow traffic.

The Mekong River Plan

International Co-operation

By W. R. DERRICK SEWELL

The article is an abridged version from the contribution of W. R. Derrick Sewell, Ph.D., M.A., B.Sc. issued in May and June 1966 in Water Power. The article is reproduced for the information of the Engineers of the country.

The Mekong is one of the world great river. Its length is 2625 miles from its headworks high in the Himalayas of Tibet to its mouth on the South China Sea. The average annual discharge is 400 million acre ft. (the annual discharge of Indus is 90 maf. and of the three rivers Indus, Jhelum and Chenab is 140 maf.) This river thus ranks tenth in terms of flow. Its drainage basin covers over 307,00 sq. miles being about four times the size of Great Britain. It flows through China, Burma, Thailand, Laos, Combodia and the Republic of Viet Nam. The basin of this river is shown in Fig. 1, and its drainage area lying in different countries is given in Table below:

TABLE No. 1

Drainage area of the Mekong river Basin in various Countries.

Country	Drainage area	Percentage of total area
	sq. miles	
China ..	63,000	20.7
Burma ..	8,000	2.6
Laos ..	100,000	32.4
Thailand ..	73,000	23.8
Cambodia ..	58,000	19.0
Viet Nam ..	5,000	1.5
	307,000	100.0

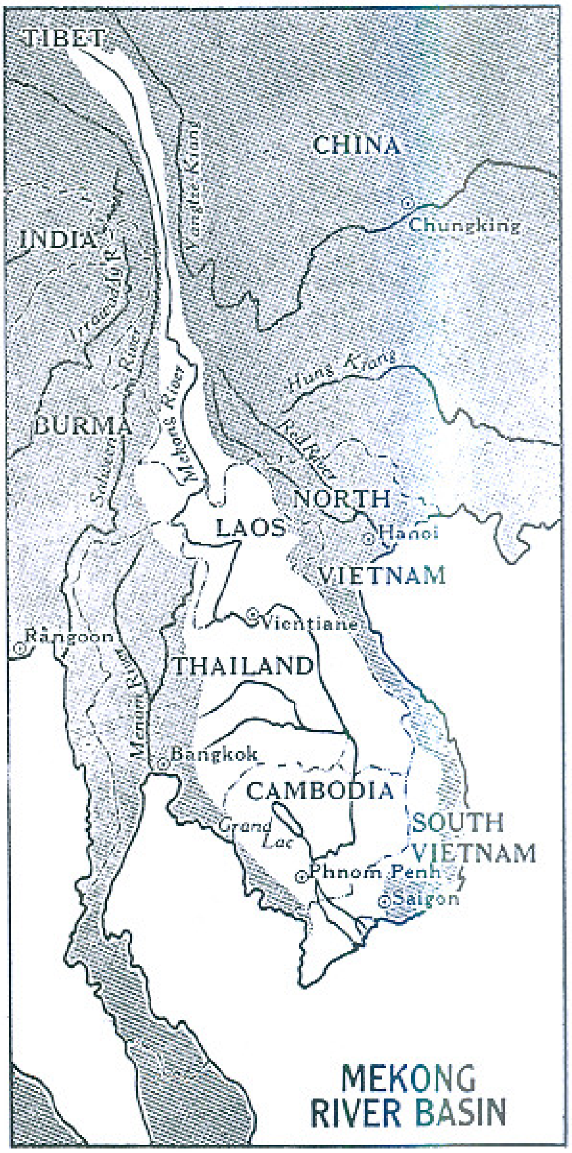

Fig. 1

The river begins to rise following the onset of the monsoon in May or June and attains a maximum level in September or October. A typical hydrograph of the river at Phnom Penh is shown in Fig. 2. Its average flow in summer is 400,000 cusecs and the minimum in winter is equal to 60,000 cusecs.

The most significant fact about the Mekong is not its great length, its huge flow, or the size of its drainage basin but the negligible extent to which it has been developed. So far, no major dam has been built on the main stem of the river.

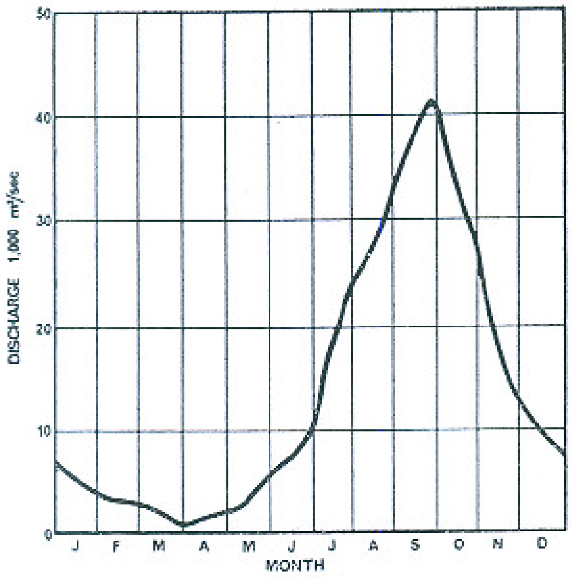

Fig. 2

Harnessing of the Mekong is believed by many of those who know the area through which it flows to be a key in the solutions to problems which beset that part of south-east Asia. Development of the Mekong, for example, might aid food production by providing irrigation water, and a large amount of low cost electric power.

Studies on the River

The Economic Commission for Asia and the Far East (ECAFE) set up A Water Resources Development Bureau in 1949, it gave particular emphasis to the river. In 1956 (ECAFE) called together a team of seven experts to study the potentialities of the Lower Mekong with respect to hydro-electric power, irrigation, navigation, and flood control.

Countries of the world were approached to help in the development of the river. It was also arranged that the sites may be visited by top-ranking engineers, so that a mission headed by General Raymond Wheeler, Chief of the U.S. Corps of Engineers, visited the area in 1957 and 1958. More than 20 countries as listed in Table 2 offered monetary assistance in this project.

Different countries undertook responsibilities for different jobs for completion. On the recommendation of the Wheeler Mission an Advisory Board of the known experts was established. The present board contains Mr. Naranjan Pershad and Mr. Kanwar Sain both of India, General Wheeler of United States, Mr. Paul Bourriers of France, Sir Robert G. Jackson of U.K., and Mr. Filemon Rodriguez of Philippines.

The 1957, ECAFE report outlined a broad plan of development for the Lower Mekong. It consisted of six multiple-purpose projects on the main stem of the river. Luang Prabang, Pa Mong, Thakhek, Khemarat, Khone and Sambore, each of which would generate hydro-electric power and the Tonle Sap Project at the outlet of the Grand Lac which would be used for flood control purposes. The locations of these projects are indicated in Fig. 3. The report estimated that these main stem projects, together with a tributary project at Nan Theun, would make possible the production of 4,300 MW, or 36,930GWH, of firm energy per annum. They would also provide substantial irriga-

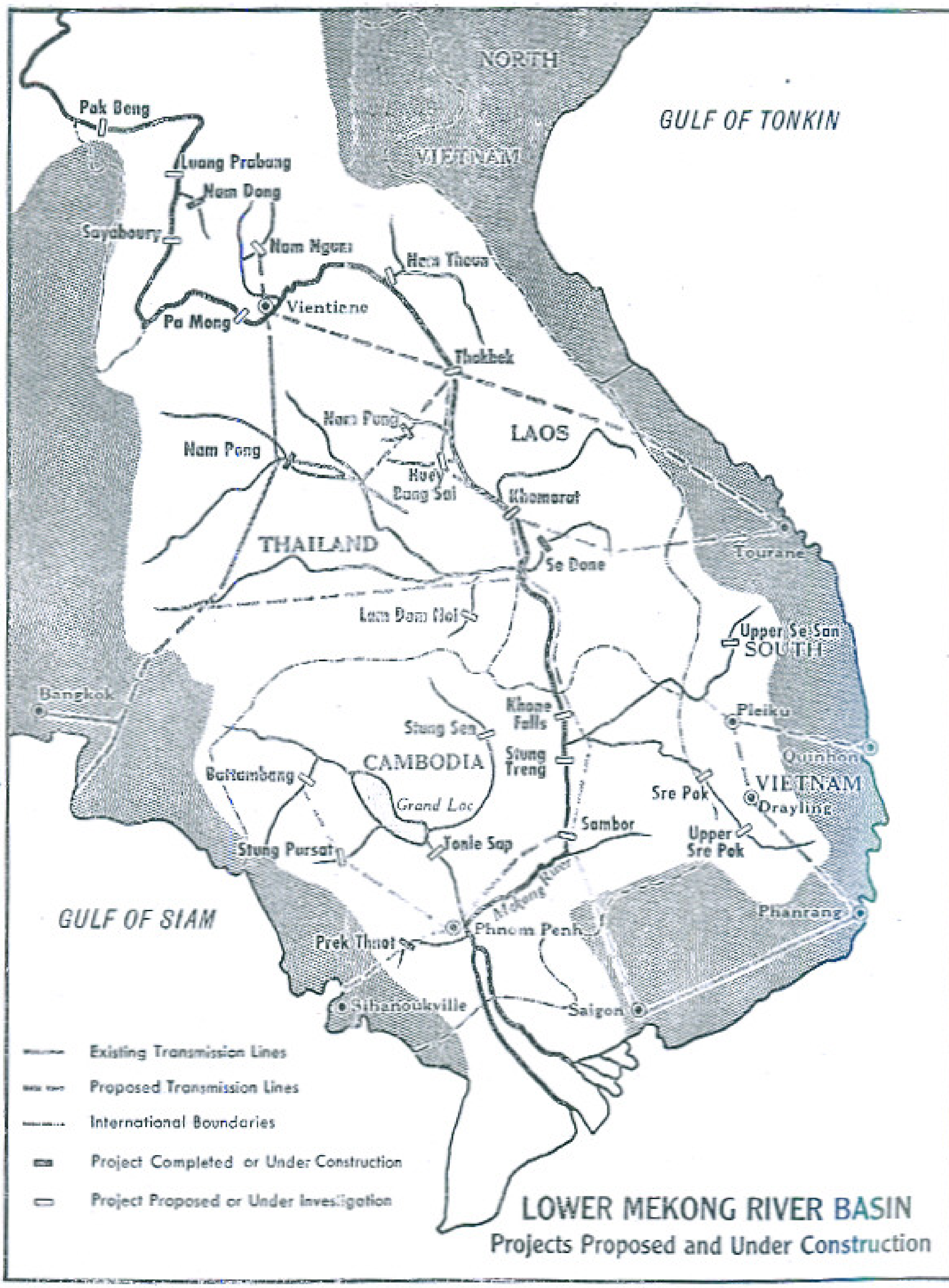

Fig. 3. Lower Mekong River Basin

TABLE 2

Resources contributed or pledged to the Mekong Development Scheme or to Projects sponsored by the Mekong Committee.

Data Collection, Analysis, Investigations, and Planning Phase.

From other Countries	Dollar Equivalent[1]	From International Agencies, and the Riparian Countries	Dollar Equivalent	Totals
Australia	.. 930,000	UN/ECAFE	.. 957,752	
Belgium	.. 30,000	UN/TAB } UN/BTAO }	.. 362,799	
Canada	.. 1,365,000			
China	.. 119,900	ILO	.. 12,104	
Denmark	.. 10,000	FAO	.. 139,930	
Finland	.. 10,000	UNESCO	.. 16,800	
France	.. 1,291,929	WHO	.. 8,277	
India	.. 291,000	WMO	.. 45,300	
Iran	.. 123,300	IAEA	.. 55,650	
Israel	.. 346,000	UN Special Fund	.. 7,059,985	
Italy	.. 24,300	World Food Program	.. 86,440	
Japan	.. 1,089,496			
Netherlands	.. 170,009			
New Zealand	.. 185,927	Cambodia	.. 3,127,129	
Norway	.. 10,000	Laos	.. 1,827,846	
Pakistan	.. 100,000	Thailand	.. 1,916,150	
Philippines	.. 295,050	Viet Nam	.. 1,734,214	
Sweden	.. 20,000			
United Kingdom	.. 400,000			
United States	.. 7,614,000			
Total, Pre-Investment Phase.				$ 31,040,287
Investment for Construction:				
Australia	.. 800,000	World Food Program	.. 1,189,710	
China	.. 45,000			
France	.. 1,493,900	Cambodia	.. 3,431,000	
Germany (West)	.. 16,000,000	Laos	.. 932,500	
Israel	.. 5,000	Thailand	.. 18,400,996	
United Kingdom	.. 190,000	Viet Nam	.. 20,000	
Total, Investment Phase[2]	.. 2,250,000			
Total, Pre-Investment ..				$ 44,758,079
Investment Phase[2] ..				$ 75,798,366

1. Expressed in US dollars; contributions in kind valued at market prices.
2. Does not include provisional pledges of $ 26 million for Nam Ngum project.

Source: Mekong Development Committee Reports.

TABLE 3

Main Stem Projects: Technical Details.

Project	Purpose	Total and Average Head	Power Firm	Capacity Installed	Irrigation	Navigation Improvement
		ft.	MW	MW	acres	miles.
Pa Mong ..	PNIF	230/204	1,100	1,600	2,500,000	210
Khemerat ..	PNI	132/98	580	780	125,000	160
Phone ..	PNI	112/102	660	880	125,000	30
Sambor ..	PNI	89/79	550	740	375,000	50
Tonle Sap. ..	PDIF	Seasonal—for pumping only			2,500,000	75
Total for five main stem Projects ..			2,890	4,000	5,625,000	525

P=Power; N=Navigation; I=Irrigation; D=Drainage.

Sources: C. Hart Schaaf and Russell H. Fifield, "The Lower Mekong," D. Von Nostrand, 1963 and United Nations Economic Commission for Asia and the Far East, Development of Water Resources in the Lower Mekong Basin, Bangkok, 1957.

tion, navigation and flood control benefits as well.

The Pa Mong Project

The Pa Mong Project is envisioned as one of the key elements in the Mekong River Plan. Situated about 15 miles upstream from Vientiane, on the boundary between Laos and Thaliand, the Pa Mong dam would be 295 ft. high and would create an average head of 204 ft. The dam would be about 3,600 ft. long. It would create a reservoir which would have a capacity of 78 million acres feet (Mangla is 4.5 maf). two and a half times the size of Lake Mead, the reservoir behind Hoover dam on the Colorado River. Despite its huge capacity, the Pa Mong reservoir could be refilled almost every year. It would provide irrigation water for about 500,000 acres in Laos and about 2 million acres in Thailand. It would provide regulation for power projects farther down-stream, and would help to improve navigation and control flooding in the lower reaches. An installation of about 1,000 MW is being considered for the Pa Mong Project. Details relating to this project and others on the main stem are set out in Table 3. The Pa Mong Project is expected to cost over $ 600 million.

The Sambore Project

The Sambore, located in Cambodia, about 140 miles north of Phnom Penh, is envisioned as a run-of-river project. The dam would be 118 ft. high and would have a spillway, navigation lock and power house. It is estimated that an average head of 79 ft. would be available. An installation of about740 MW is contemplated, to produce some 4,500 GWH of firm energy per annum. In addition, the Project would provide water to irrigate about 375,000 acres. By submerging the rapids in this stretch of the river, it would help to extend navigation farther upstream.

TABLE 4

Tributary Projects Completed or at the Construction Stage.

Name	Country	Purpose	Power installation	Cost $ million	Sources of Finance	Expected completion date	Status at end of 1965
			MW				
Nam Pong	Thailand	P.I.F.R. Fi.	24.9	28.4	Loan from West Germany Pakistan China Thailand Fund	Dec. 1965	Almost completed.
Nam Pung	Thailand	P.I.F.R.	7.0	5.0	Thailand	Oct. 1965	Completed.
Lower Se Done	Laos	P.	1.4	3.7 mill. Fr.[2] + 120 mill. Kips[2].	Loan from France Laos Funds.	1969	Access road completed turbines ordered from France.
Nam Dong	Laos	P.	1.0	2.3 mill. Fr.	Loan from France Laos Funds.	1969	Access road completed.
Prek Thnot	Cambodia	P.I.F.	18.0	54.0	Australia Cambodian Funds.	..	Construction site cleared. Investigations for sources of materials under way. Earthfill embankment under construction.
Nam Ngum.	Laos	P. I.	120.0	40.0	Under Negotiation	..	Convention signed for exchange of power between Laos and Thailand. Most of required financing pledged.

P=Power; I=Irrigation; F=Flood Control; R=Recreation; Fi=Fisheries.
Sources: Mekong Development Committee Reports.
Note that in 1963, 240 Kips=$ 1.00 (US).
4.937 Fr. =$ 1.00 (US).

The Tonle Sap Project

As presently conceived, the project would be a gated barrage, located between Phnom Penh and the Great Lake. The gates would be closed during the first part of the rainy season, thus allowing the entire flow of the Mekong to pass out to the mouth of the river. The gates would be opened in the months of highest water, thus reducing the peak flow. The gates would then be closed until the beginning of the low-water period on the Mekong. It has been estimated that the artificial storage will make it possible to maintain river levels at about 3 ft. above what they would be in the normal low-water period, thus reducing the problem of salt water intrusion in the delta and making possible the reclamation of vast areas in that region. It is also believed that the higher lake levels will permit increased fish production in the lake.

India has undertaken to prepare the barrage design and the comprehensive feasibility report on the Tonle project.

There are several other projects on the main stream and the tributary streams. Some information about these is given in Table No. 4.

The Mekong Development Committee has achieved a great deal already in fostering a co-ordinated and co-operative approach to the development of one of the world's major international rivers. The success of the Mekong scheme will continue to depend a great deal on support that can be gathered from outside countries. The cost estimates reveal that they will exceed $8,000 million.

The firms which are co-operating in this job are the following:—

Associated Consulting Engineers of Karach
Certeza Surveying Co.
Electric Power Development Co.
Hazra Co. International, U.S.A.
Hunting Survey Corp. Ltd., Canada.
Italconsult, Italy.
Nippon Koei K. K., Japan.
Rogers International Corp., U.S.A.
Sogreah. Grenoble.
Sofrelec. France.

Soil Constituents and Citrus Growth

By MUHAMMD HUSSAIN[1] AND
ABDUR RAHIM[2]

INTRODUCTION

In order to raise healthy fruit plants and to keep them in constant good health and vigour, the usual orchard operations and practices like soil management, irrigation applications and use of fertilizers, etc. need a constant change under ever-varying soil and water-table conditions. The existing irrigation and agriculture practices and changed water-table conditions have brought about radical changes in physico-chemical characteristics of the soil. This has had a marked effect on the cropping patterns and orchard plantation that had been followed during the last 3-4 decades. For instance, in the perennial canal colonies of ex-Punjab, the Kharif (Summer) acreage under cotton has gone down from 56 to 33%. In Dadu Division of Sind this decrease is still marked and has gone down from 44 percent (1937-38) to 2 percent. The soils of the Colony areas of Bari, Chaj and Rechna Doabs of Indus Basin were considered most suitable for growing orange fruit plants some years back. But now with the change in the physico-chemical characteristics of the soil, citrus growing in certain such localities has ceased to be profitable. Despite all care in the orchard operations the citrus plantation has been seriously affected which resulted in decline in growth, death of plants and a complete failure of the orchards in many cases.

In view of these observations, studies were undertaken to find out the inter-relationship of the various constituents both in the soil and in the plants, needed to be suitably maintained, for the healthy plant growth. Two sites, one in Lahore and the other in Sargodha District, were selected for the investigations.

MATERIAL AND METHOD

The site in Lahore District is Tariq Estate, which represents mainly two types of soils *i.e.*, medium textured and medium to fine textured. The depth to water-table in the farm is about 22 feet from the ground surface.

Five healthy citrus plants bearing good fruit and five with poor growth and poor bearing were selected for detailed study. For the collection of soil samples, six feet deep bore holes were made with the help of soil auger in the root-zone of each plant. The soil of each foot was examined for

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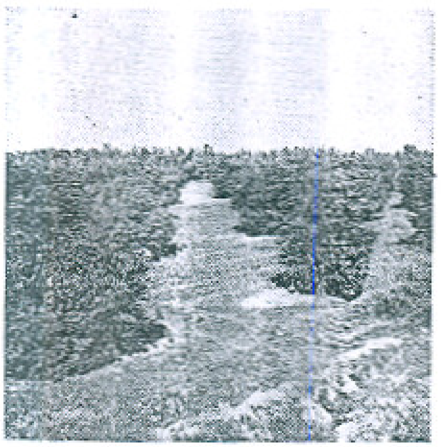
texture, structure, carbonate contents, and kanker percentages in the field. Detailed physico-chemical tests were carried out in the Laboratories of the Directorate of Land Reclamation. Besides that, leaves from both the above-mentioned healthy and sick plants were collected from the branches about two inches below the growing tips, and were dried and powdered for examination of nitrogen contents and other plant nutrients.



Citrus Plantation Showing Good Growth

Similarly six healthy citrus plants bearing good fruits and six plants with poor growth under various stages of deterioration, were selected in the two orchards in Chak No. 8 of Bhalwal Tehsil in Sargodha District for the same study. In one orchard belonging to Ch. Nawazish Ali the water-table was six feet while in the other belonging to Mr. Muhammad Nazir it was below ten feet from the ground surface.

The analysis was conducted for the following determinations:—

(*a*) **Soil samples**

1. Permeability.
2. Humus.
3. Nitrogen.
4. Saturation Paste extract analysis for conductivity, Calcium, Magnesium, Sodium, Carbonates, Bicarbonates, Sulphates and Chlorides, pH was determined from saturation paste.

(*b*) **Leave samples**

1. Ca.O 2. Mg.O 3. Na_2O
4. K_2O 5. P_2O_5

Citrus Plantation Showing Poor Growth

METHOD FOLLOWED FOR ANALYSIS

(*a*) **Soil analysis**

(*i*) Humus was estimated by treating the soil with potassium permanganate solution. Nitrogen was determined by the Kjeldahl's method.

Permeability tests of the disturbed soil samples were carried out by the method 37-B of salinity laboratory, U.S.A.

(*ii*) The soil extract was tested for Electrical Conductivity with solu-bridge. It was further subjected to detailed analysis for Calcium, Magnesium, Carbonate, Bicarbonate, Chloride and Sulphate by the usual methods.[1] Sodium was determined with Flame Photometer.

(*b*) **Leave analysis**

The dried and powdered citrus leaves were passed through 2 mm sieve. In this case too, nitrogen was estimated by the Kjeldahls method.

For ash determination a weighed quantity of the powdered material was ignited and was placed in a muffle furnace at about 700°C to get the constant weight of the ash.

For the determination of CaO, MgO, Na_2O, K_2O and P_2O_5, Hydrochloric Acid extract of ash was prepared by Hissink's method[2].

Calcium was determined by the oxalate method, Magnesium by precipitating it with diammonium hydrogen phosphate solution, sodium and potassium with Flame Photometer and P_2O_5 by precipitating with ammonium molybdate solution.[3]

RESULTS AND DISCUSSIONS

Tariq Estate (Lahore District)

(a) Soil analysis

Typical results of analysis for Nitrogen, Humus, permeability, Kanker percentage and Electrical conductivity for soils under healthy and unhealthy plants for a few sites ane shown in table I. The average figures worked out for various constituents are given in table below:—

The average permeability of soil in case of healthy plants is 0.16 inches per hour while in case of poor plants, it is 0.113 inches per hour.

There is, however, no significant difference in the Humus contents of the soil. The nitrogen level is also the same in both the cases. The electric conductivity of the saturation extract is low and almost identical in both the cases which is 0.65 mmhos/cm in case of the healthy plants and 0.89 mmhos/cm in case of the poor plants. The pH of the saturation paste in both the cases is also within the permissible limits of 8.5. The soil profiles in both the cases contain a lot of calcium carbonate in nodule form. The texture of the soil is medium to fine.

All this shows that physical charateristics except permeability of the soil in both the cases of healthy plants and poor plants are almost identical. The reason for the poor growth of the plants, therefore, cannot generally be attributed to such characteristics. The presence of Humus & Nitrogen, almost in the same quantity, cannot be regarded as the cause of poor growth on account of the deficiency of any of these nutrients. The salinity status of the soil profiles is almost similar and within the permissible limits. The only obvious reason for the difference in plant growth may be due to the impropor-tionate presence of the various soil constituents. The critical examination of the extract analysis of soil far from typical samples under healthy and poor growth as given in table No. 2 shows that the proper ratio of Na: Ca & Mg is the determining factor for the healthy growth of orange plants, other factors being the same. The ratio of Na to Ca and Mg in case of healthy

	Soil of healthy plants	Soil of unhealthy plants
Nitrogen ..	0.0324%	0.0287%
Humus ..	0.400%	0.3117%
Permeability ..	0.16 inches/hour	0.113 inches/hour.
Electrical conductivity ..	0.65 mmhos/cm	0.898 mmhos/cm.
pH of saturation paste ..	8.00	8.00
Na : Ca + Mg ..	0.34	0.43

plants is noticed within the range of 0.176 to 0.4866. In case of unhealthy plants it varies from 0.419 to 0.62.

(a) Leave analysis results

The leave analysis results given in table. No. 3, however, show that the nitrogen contents in case of the healthy plants is comparatively higher as compared with the poor plants. In good plants the average nitrogen percentage comes to 2.37 against 1.95 for the poor plants.

The average ash content of the leaves is also higher in case of healthy plants, the average for healthy and poor plant leaves being 9.32 and 7.7 percent respectively.

The average Calcium Oxide percentage is 3.77 in healthy and 2.875 for poor plants. The average value of Magnesium oxide is 1.5 percent in healthy plants and 0.92 percent in poor plants. The sodium oxide is 0.26 percent in good plants and 0.36 percent in poor plants *i.e.* slightly higher in case of healthy plants. Potassium is also higher in case of poor plants which is 1.12 percent in healthy plants and 1.34 percent in poor plants. The phosphorous level is almost identical.

The ratio of Na_2O and K_2O to CaO and MgO in case of healthy plants vary within the limits of 0.2172 to 0.3010, while in case of the poor plants it is higher and ranges from 0.4229 to 0.5613.

Average ratio of NaO to CaO and MgO is 0.061 for the healthy plants and is 0.102 in case of the unhealthy plants.

BHALWAL AREA (SARGODHA DISTRICT)

(*a*) Soil analysis

The results for Sodium Humus, Permeability, Kanker percentages and electrical conductivity for soil under healthy and unhealthy plant growth were similarly estimated as before. The average figures worked out for various constituents are given in the table below.

The average permeability of the soil is very low in both the cases of healthy and unhealthy plants which is 0.068 inches/hour. The Humus and Nitrogen contents are also the same, but lower than those of Tariq Estate. The electric conductivity of the soil in the root-zone of unhealthy plant is 2.35 mmhos/cm, as compared to 1.23 mmhos/cm of the soil profile of unhealthy plants. Salinity status of the soils is within the permissible limits of plant growth. pH value is also the same in both cases and is within permissible limit.

Calcium carbonate contents range from 15% to 19.6% in both the cases. The texture of the soil is medium to fine.

The saturation extract analysis for a few samples of the two kinds is shown in Table 4.

	Soils of good plants	Soils of unhealthy plants
Nitrogen	0.0406%	0.056%
Humus	0.2315%	0.2243%
Permeability	0.068 inches/hour	0.067 inches/hour.
Electrical conductivity	1.23 mmhos/cm	2.35 mmhos/cm.
pH of saturation paste	8.24	8.22
Na : Ca + Mg	0.41	0.814

It shows that the Na to Ca+Mg ratio of the soil in case of healthy plants are within the range of 0.32 to 0.65 while in case of unhealthy plants it is 0.62 to 1.7 in the majority of cases.

(*b*) **Leave analysis**

The analysis results of leaves are given in Table No. 5.

The nitrogen contents are higher in case of all the healthy plants which are more than 2 percent. In case of poor plants, nitrogen is less than 2 percent almost in all the cases.

Ash percentage on the average is 9.975 and 8.14 for healthy and poor plants respectively. CaO is 5.74 percent on the average in good plants and 3.05 percent in poor plants. Similarly Magnesium is higher in healthy plants and low in poor plants. Sodium and Potassium level is almost the same in both the cases. The phosphorous level is also identical.

The ratio of Na_2O to CaO+MgO is 0.0432 to 0.0664 in case of the good plants and it is 0.0548 to 0.0807 in case of poor plants.

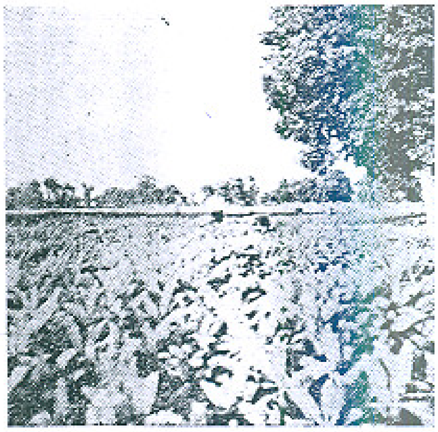
Bhalwal area was considered very good for citrus plantation in the past. Now with the rising water-table and changing irrigation application conditions there has been drastic change in the physico-chemical characteritics of soils. The ground-water of this zone is of inferior quality and with the rise of water-table in this area the salinity has been spreading at tremendous rate. The chemical reactions in the soil has widened the ratio of Na to Ca+Mg.

The average ratio in good plant growth soil profile in Lahore District comes to 0.34 against 0.412 in Bhalwal area, there being not very much difference. But in case of unhealthy plants the variation in ratio is 0.434 in Lahore District against 0.814 in Bhalwal area. This means that Lahore area is more susceptible to damage with even slightest change in the ratio of Na : Ca + Mg. The soil profile in Bhalwal area can, however, stand to even a wider range of this ratio. It would, therefore, be necessary to be more careful for citrus plantation in Lahore District than in Sargodha District.

CORRECTIVE METHODS

There are two methods for setting right the ratio of Na to Ca+Mg, conducive to plant growth. The long-term method is to make use of the presence of unavailable calcium from calcium carbonate nodules. This can be achieved by a gradual process of green manuring which increases the availability of Ca from $CaCO_3$. Green manuring of Sesbania Aculeata (Jantar) has proved a good biological method for keeping low the ratio of Na : Ca and Mg. This practice is at present extensively followed at Tariq Estate and this is bringing tremendous improvement in the soil.

The other quick method is to correct this ratio by increasing the amount of Ca by the use of amendments. The most suitable amendment for our soil conditions is gypsum.



Jantar ready for green manuring

In order to bring the ratio in the growth-conducive range of 0.3 to 0.4, the unhealthy plants would require a dressing of 23 lbs. of powdered gypsum per plant for Lahore soils. To lower down the ratio from 0.8 to 0.4 in Bhalwal soils, an application of 57 lbs. of gypsum will be needed.

The gysum application should, however, preferably be made in two doses. The annual application per plant will be about 12 lbs. for Lahore and 30 lbs. for Bhalwal soils.

APPLICATION TESTS IN THE FIELD

A badly affected block of land measuring about 8 acres was selected to try the effects of the amendments at Tariq Estate in Lahore District. As stated above, it was decided to give an application of gypsum in two doses of 12 lbs. each. In order to make up the deficiency of Nitrogen, it was also considered necessary to apply ½ lb. of ammonium sulphate per plant along with 12 lbs. of gypsum. In order to ensure quick reaction, the amendments were applied by making 10 bore holes one foot deep, five at a distance of 2½ feet and the remaning five at a distance of 5 feet from the trunk of each plant. For better distribution the arrangement of the bore holes was adjusted in such a way that the bore holes falling on the outer circle were cutting the mid lines of the inner circle bore holes as shown in the figure below:

For applying the amendments, one half the quantity (12 lbs. of gypsum and ½ lb. of ammonium sulphate) was put in the bore holes while the balance quantity was spread on the surface and mixed properly with the surface soil. Immediately after the application of the amendments, irrigation was given to the field.

After a period of about 3-4 weeks a marked effect on the plants was noticed. The plants started giving out new shoots and falling of the fruits was arrested to a great extent. With the second application of the dose there will still be improvement and complete cure of the dying plants with withering, yellowish leaves and dried twigs giving way to green, healthy new shoots and changing altogether the condition of the plants. The favourable effect has brought a sigh of relief among the fruit-growers and they are applying to this Directorate to prescribe the treatment for the soils of citrus plantations owned by them.

ACKNOWLEDGEMENT

Research work on this problem was undertaken at the instance of Malik Khuda Bakhsh, Minister for Education and Irrigation & Power Department (now Minister for Food, Agriculture and Co-operative). The authors owe special thanks to him for his valuable suggestions during the course of study of this problem.

REFERENCES

(1) Diagnosis and Improvement of Saline and Alkali soils, U.S.D.A. Handbook No. 60.

(2) Piper C.S., Soil and Plant Analysis.

(3) A.O.A.C., Methods of Chemical Analysis.

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TABLE No. 1

Soil Analysis results of Tariq Estate.

Plant No.	Condition of plant	Depth	Kanker %	Nitrogen %	Humus mg/g.	Permeability inches/hour
I	Healthy plant growth ..	0′—1′	..	.0308	4.29	0.203940
		1′—2′	..	.0272	4.29	0.170550
		2′—3′	..	.0140	4.49	0.101970
		3′—4′	..	..	..	0.13596
		4′—5′	25.71	..	..	0.19291
		5′—6′	25.71	..	..	0.30621
		6′—7′	15.1	..	..	0.28385
		7′—8′	31.9	..	..	0.243595
		8′—9′	17.25	..	..	0.12463
		9′—10′	17.3	..	..	0.13596
IV	Healthy plant growth	0′—1′	..	.0336	4.29	0.6498
		1′—2′	...	.0168	3.12	0.08364
		2′—3′	..	.0112	4.29	0.09747
		3′—4′	..	..	..	0.08664
		4′—5′	..	..	..	0.2166
		5′—6′	..	..	..	0.19494
		6′—7′	..	..	..	0.14079
		7′—8′	17.77	..	..	0.08125
		8′—9′	21.7	..	..	0.12996
		9′—10′	30.2	..	..	0.1083
I	Poor plant growth ..	0′—1′	..	0.0448	2.73	0.1133
		1′—2′	..	.0392	2.73	0.10197
		2′—3′	..	0.0504	2.34	0.06798
		3′—4′	..	..	..	0.06998
		4′—5′	..	..	..	0.1133
		5′—6′	35.30	..	..	0.2492
		6′—7′	26.30	..	..	0.09064
		7′—8′	24.40	..	..	0.10197
		8′—9′	16.00	..	..	0.09064
		9′—10′	20.00	..	..	0.10197
IV	Poor plant growth ..	0′—1′	..	.0336	4.290	0.05990
		1′—2′	15.94	.0028	3.900	0.04792
		2′—3′	..	.0224	3.51	0.05990
		3′—4′	..	..	..	0.05990
		4′—5′	..	..	..	0.05990
		5′—6′	..	..	..	0.05990
		6′—7′	7.30	...	..	0.07188
		7′—8′	17.40	..	..	0.05990
		8′—9′	16.66	..	..	0.062315
		9′—10′	18.18	..	..	0.067980

TABLE No. 2

TARIQ ESTATE

Soil Saturation Paste Extract Analysis.

Plant No.	Condition of Plant	Depth	Milliequivalents per litre								EC×10³ at 25°C	pH paste	Average Na/(Ca+Mg)
			Ca	Mg	Na	Co₃	HCO₃	Cl	SO₄	Total Cation Anions			
1	2	3	4	5	6	7	8	9	10	11	12	13	14
I	Healthy Plant growth.	0′—1′	8.47	1.45	3.08	..	3.60	5.00	5.40	14.0	1.40	8.00	
		1′—2′	4.40	6.00	2.60	..	4.40	6.00	2.60	13.0	1.30	7.80	
		2′—3′	6.05	7.99	0.96	..	4.00	4.40	3.60	12.0	1.20	7.92	.1760
		3′—4′	6.60	3.28	3.12	..	3.60	6.00	3.40	12.0	1.20	7.98	
		4′—5′	10.23	4.54	1.23	..	3.40	5.60	7.00	16.0	1.60	7.90	
		5′—6′	13.20	5.73	0.07	..	3.00	5.60	10.4	19.0	1.90	7.95	
II	do	0′—1′	5.28	2.52	3.20	..	4.6	3.40	3.00	11.0	1.10	7.98	
		1′—2′	6.38	3.19	4.43	..	3.40	4.00	6.60	14.0	1.40	8.10	
		2′—3′	4.40	1.01	4.09	..	3.60	3.40	2.50	9.5	0.95	8.05	.4466
		3′—4′	4.72	2.14	2.64	..	3.00	3.60	2.90	9.5	0.95	7.90	
		4′—5′	4.62	1.10	2.28	..	3.20	3.80	1.00	88.0	0.80	7.82	
		5′—6′	4.62	1.93	1.95	..	3.60	2.60	2.50	8.5	0.85	7.90	
I	Poor plant growth.	0′—1′	3.54	1.96	3.30	..	4.00	4.5	0.30	8.8	7.95	0.88	
		1′—2′	6.24	0.76	1.80	..	4.00	4.5	0.30	8.8	8.15	0.88	
		2′—3′	5.72	5.78	5.5	..	3.50	5.0	8.5	17.0	8.08	1.70	
		3′—4′	2.50	2.50	3.0	..	3.0	5.0	..	8.0	8.02	0.80	0.419
		4′—5′	8.84	0.66	2.5	..	2.00	4.0	6.0	12.0	8.00	1.20	
		5′—6′	3.64	2.86	2.1	..	3.00	5.0	0.6	8.6	8.26	0.86	
II	do	0′—1′	5.72	0.78	5.5	..	3.00	5.0	4.0	12.0	7.80	1.20	
		1′—2′	4.68	.82	4.1	..	4.00	5.0	0.6	9.6	7.92	0.96	
		2′—3′	3.12	1.38	1.3	..	2.00	3.5	0.3	5.8	7.80	0.58	.491
		3′—4′	8.32	2.68	2.0	..	3.00	4.0	6.0	13.0	7.70	1.30	
		4′—5′	3.12	2.38	3.5	..	4.00	5.0	9.0	9.0	7.62	0.90	
		5′—6′	3.12	2.38	1.5	..	3.00	3.0	1.0	7.0	7.85	0.70	

5—6 3.12 2.38 1.5 .. 3.00 3.0 1.0 7.0 7.85 0.70

TABLE No. 3

TARIQ ESTATE

Analysis results of plant leaves showing the percentage of each.

Plant No.	Condition of plant	Nitrogen	Ash	CaO	MgO	Na_2O	K_2O	P_2O_5	$\frac{Na_2O+K_2O}{CaO+MgO}$	$\frac{Na_2O+K_2O}{CaO+MgO}$
I	Healthy plant growth	2.142	10.75	4.900	1.7556	0.3007	1.1454	0.3682	0.2172	0.045
II	do	2.450	8.46	3.570	1.2699	0.3215	0.9105	0.4120	0.2545	0.066
III	do	2.750	8.97	2.695	1.6558	..	1.3099	0.4172	0.3010	0.067
IV	do	2.079	7.04	2.975	1.6434	0.3099	1.0575	0.4738	0.2960	0.068
V	do	2.366	11.37	4.700	1.2699	0.3684	1.1749	0.4584	0.2585	0.059
	Average ..	2.37	9.32	3.77	1.500	.261	1.1200	.426	.225	.061
I	Poor plant growth ..	1.876	8.330	2.100	0.7843	0.3293	1.1454	0.3270	0.5112	.105
II	do	2.058	7.803	2.205	0.8591	0.3085	1.3099	0.4326	0.5281	.100
III	do	1.842	6.370	2.975	1.5687	0.3610	0.5860	0.4403	0.4390	.079
IV	do	1.995	7.810	2.800	0.5602	0.3884	1.4980	0.5536	0.5613	.105
V	do	1.967	8.215	3.950	0.8217	0.4261	1.7818	0.5202	0.4229	.120
	Average ..	1.95	7.7	2.875	.92	.36	1.34	.455	.490	.102

TABLE No. 4

BHALWAL AREA

Soil Paste extract analysis.

Plant No.	Condition of plant	Depth	Milliequivalents per litre								EC×10³ at 25°C	pH Paste	Average Na/Ca+Mg
			Ca	Mg	Na	CO_3	HCO_3	Cl	SO_4	Total Cations/Anions			
1	2	3	4	5	6	7	8	9	10	11	12	13	14
I	Healthy plant	0′—1′	4.95	2.23	2.32	..	5.20	4.0	0.3	9.5	0.95	8.35	
	growth.	1′—2′	2.75	2.45	2.80	..	3.4	4.0	0.6	8.0	0.80	8.10	
		2′—3′	3.52	1.68	2.80	..	2.8	4.0	1.2	8.0	0.80	8.22	.48
		3′—4′	3.85	2.66	2.76	..	3.20	5.6	0.2	9.0	0.90	8.20	
		4′—5′	2.86	1.92	2.22	..	3.0	4.0	..	7.0	0.70	8.25	
		5′—6′	7.81	4.46	5.73	..	2.0	6.4	9.6	18.0	1.8	8.05	
I	Poor Plant	0′—1′	3.85	2.60	2.55	..	3.60	4.00	1.40	9.0	0.9	8.20	
	growth.	1′—2′	6.20	7.20	16.60	..	3.40	8.40	18.20	30.0	3.0	8.08	
		2′—3′	3.85	3.43	11.72	..	3.00	9.00	7.0	19.0	1.9	8.15	1.30
		3′—4′	2.42	2.57	10.01	..	3.00	6.00	7.0	15.0	1.5	8.30	
		4′—5′	3.52	2.10	8.38	..	1.40	7.60	5.0	14.0	1.4	8.20	
		5′—6′	2.86	4.94	8.20	..	3.00	10.40	2.60	16.0	1.6	8.22	

TABLE No. 5

BHALWAL AREA

Analysis results of plant leaves showing the percentage of each.

Plant No.	Condition of plant.	Nitrogen	Ash	CaO	MgO	Na_2O	K_2O	P_2O_5	$\frac{Na)O+K_2O}{CaO+MgO}$	$\frac{Na_2O}{CaO+MgO}$
I	Healthy plant growth ..	2.324	12.55	5.38	1.648	0.351	2.08	.523	0.3459	0.0499
II	do	2.268	12.70	5.60	1.315	0.323	0.82	.489	0.1652	0.0467
III	do	2.254	11.00	5.51	2.282	0.294	1.79	.497	0.3068	0.0432
IV	do	2.016	12.50	5.75	1.888	0.372	1.80	.494	0.2843	0.0487
V	do	2.324	10.90	5.86	1.0308	0.426	1.415	.551	0.2664	0.0618
VI	do	2.54	10.20	4.73	2.670	0.492	1.576	.515	0.2794	0.0664
	Average ..	2.26	9.97	5.47	4.639	1.396	1.579	.519	.549	.0528
I	Poor plant growth ..	1.960	8.00	3.00	0.95	0319	1.140	.504	0.3693	0.0807
II	do	2.024	7.00	3.71	0.538	0.327	1.274	.458	0.3768	0.0769
III	do	1.820	8.06	2.80	0.90	0.244	1.79	.497	0.5497	0.0659
IV	do	2.058	9.00	3.00	1.00	0.274	2.340	.662	0.6500	0.0685
V	do	1.792	8.20	2.80	0.791	0.240	1.72	.481	0.5458	0.0668
VI	do	1.792	8.80	3.00	1.464	0.245	1.60	.525	0.4135	0.0548
	Average ..	1.91	8.14	3.05	0.900	0.274	1.644	.486	.484	.068

An Estimate of Water Consumption

BY SUGAR-CANE, COTTON, AND WHEAT CROPS UNDER HIGH WATER-TABLE CONDITION AND ITS EFFECT ON THEIR YIELD

By NAZIR AHMAD & MOHAMMAD AKRAM

A study was conducted to determine the water utilization by sugar-cane, cotton and wheat crops with water-table maintained at different depths in two different types of soil. The total amount of water consumed at different stages of the growth of the crop was estimated. It included the surface irrigation, the sub-irrigation and the drainage surplus. The order of Blaney Criddle Coefficients for the above-mentioned conditions was also determined. Another important information, collected, pertained to the yield of each crop. These studies explain the one cause for the reduction in yield of wheat crops and the fall in acreage of cotton in favour of sugar-cane.

Introduction

Sugar-cane and cotton are both cash crops. These have identical advantages for the farmers. In spite of this fact, the cotton production in the former Punjab is showing a down-wards trend for the last 30 years. The data of this crop for Lyallpur District for the year 1947 to 1964 (Fig. 1) shows a decreasing acreage under the cotton crop. The studies conducted by Ghulam Mohammad also showed that the acreage of cotton was decreasing every year in comparison to the competing Kharif crop. His analysis is shown in Fig. 2. One of the causes for this fall, according to Ghulam Mohammad, is the rise of groundwater level. In this paper the effects of high water-table on the yield of these three common crops of the country is investigated.

Experimental technique

At the Niazbeg Field Research Station, investigations have been conducted for the last 5 years, under controlled conditions, to study the effects of various parameters which influence the yield of the crops. Maintaining water-table at different depths, the amount of sub-irrigation, drainage surplus, total consumption of water in comparison to evaporation from free water surface and the yield has been investigated.

These studies have been conducted in cement concrete lysimeters, nine of which are 25 sq. ft. in area. These were constructed in three depths so that three lysimeters each were of 5, 10 and 15 ft. in depth. A large number of lysimeters are also made of 3 to 4 ft. diameter hume pipe and are 8 to 10 ft. deep. These are installed in soil by digging. Before er

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FIG: 1

AREA OF SUGARCANE AND COTTON CROP GROWN IN LYALLPUR DISTRICT

1947/48 — 1964/65

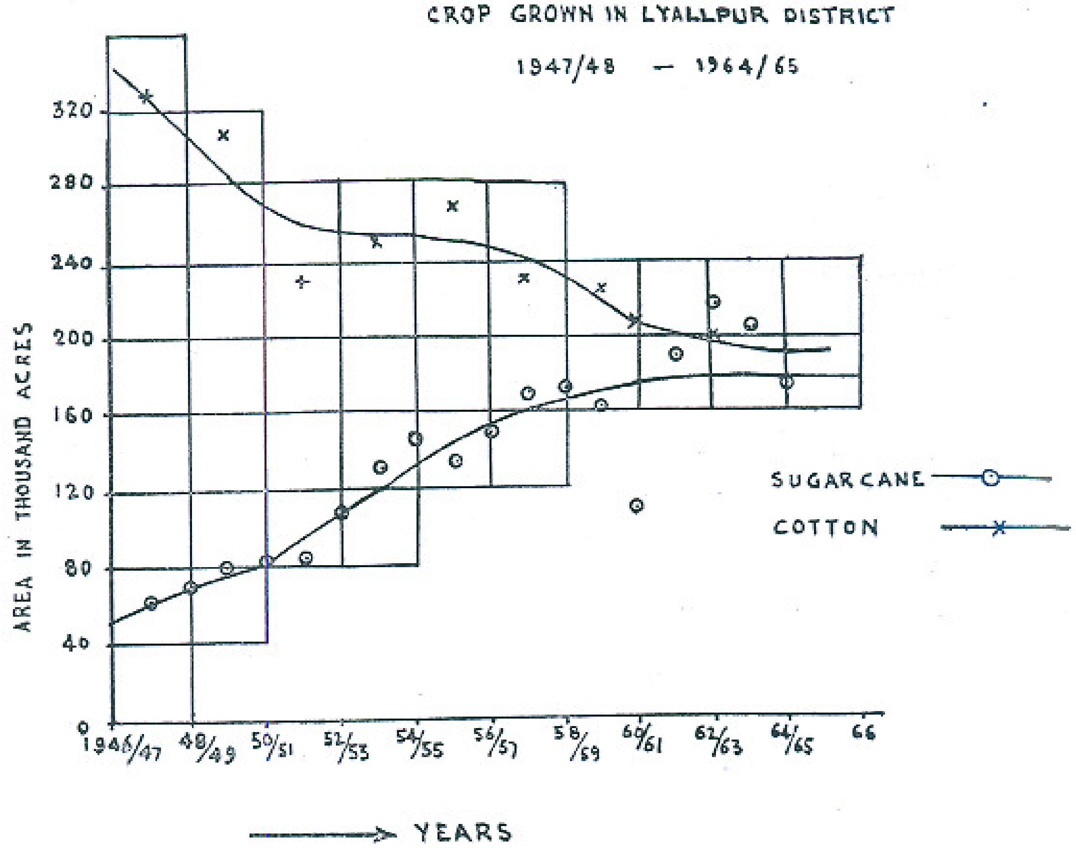

FIG: 2

AREA UNDER COTTON AND COMPETING KHARIF CROPS; ACTUAL AND TREND: OLD CANAL COLONIES OF THE PUNJAB

1935/36 — 1962/63

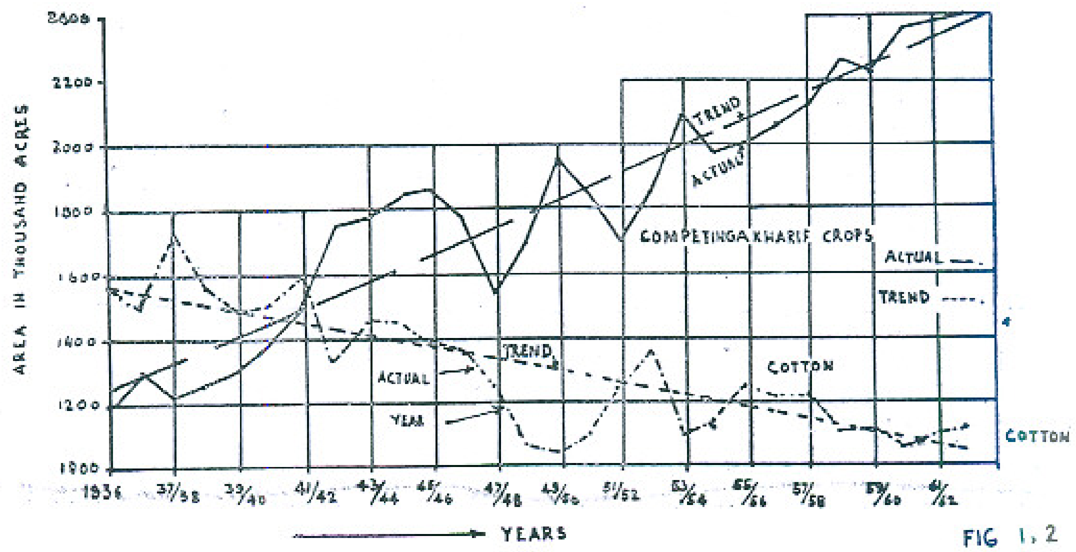

FIG 1, 2

undertaking the studies; the lysimeter were checked for water tightness. It was assured by coating them with bitumen on the inside. At the bottom of each lysimeter, 6 inches thick gravel filter is provided. It consists of three grades. The first two inches consist of gravel between 1½ inches to 1/8 inch. The second two inches layer consist of gravel of 1/8 to 1/16 inches the last two inches layer consist of coarse sand. The soil was added above this filter. The set-up of both types of lysimeters is explained in Figures 3*a* and 3*b*.

Filling of the lysimeters with the soil

The lysimeters were filled with two different types of soil, one had more clay particles and the other had more silt particles. Their mechanical analysis is shown below :—

filled with the selected grades of soil within five inches of the top. In case of hume pipe lysimeter, strainers were also installed in the middle and at about 3 ft. below top surface. Both the strainers had connections outside the walls of the lysimeters through a G. I. Pipe. In case of concrete lysimeters, 1¼" pipe with a short strainer was installed entering into the filter.

Consolidation of Soil Formation

In order to ensure the consolidation of the compacted soil, water was added through the strainer installed in the filter. It was allowed to rise slowly through the soil column. The water head was raised slowly till it reached within one ft. to six inches of the surface. This water was then allowed to drain out. This process of saturation and dewatering was repeated several times to ensure complete consolidation of the soil.

TABLE No. 1

Mechanical Analysis of the Soil.

T.S. %	pH	% Sand		% Silt		%Clay		Remarks.
		Coarse above 0.6 mm.	Medium 0.6 to 0.149 mm.	Fine 0.141 to 0.074 mm.	Coarse 0.074 to 0.02 mm.	Fine 0.02 to 0.002 mm.	Below 0.002 mm.	
0.14	8.2	1.0	7.0	13.0	34.4	30.1	14.5	Clay soil.
0.07	7.8	1.0	17.5	27.0	35.7	10.6	8.2	Silty soil.

The soluble salts at the time of filling the pipes were also determined. These are given in the same Table.

A special technique was adopted while filling the lysimeters with soil. It was done in layers of 6 inches at a time. The soil deposited was at optimum moisture. It was compacted to attain a dry bulk density of about 1.45 gm/cc. Before adding the next layer the previous one was scratched to a depth of half an inch. This was done to avoid stratification. Each lysimeter was thus

A Device to Maintain the Water-table

In the investigations water-table was to be maintained at a fixed level. It was attained by means of a double acting valve details of which are shown in Fig. 4. The valve consists of a brass pipe, 3 inches in diameter and 6 inches long. It has a flange at top and is closed at bottom. A float of thin brass sheet is contained inside it. The float has a pointer which fits in a seat and thus it

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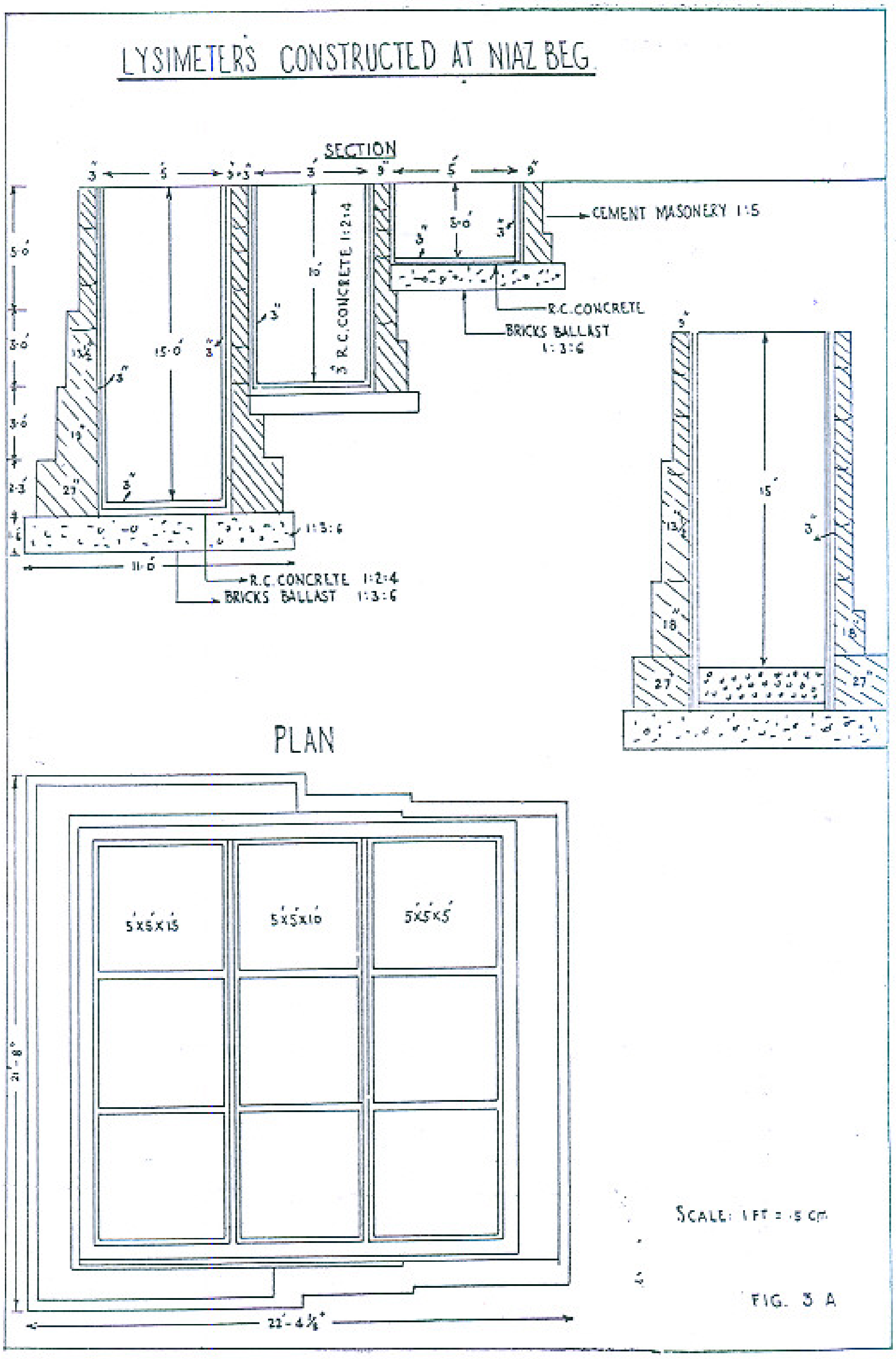
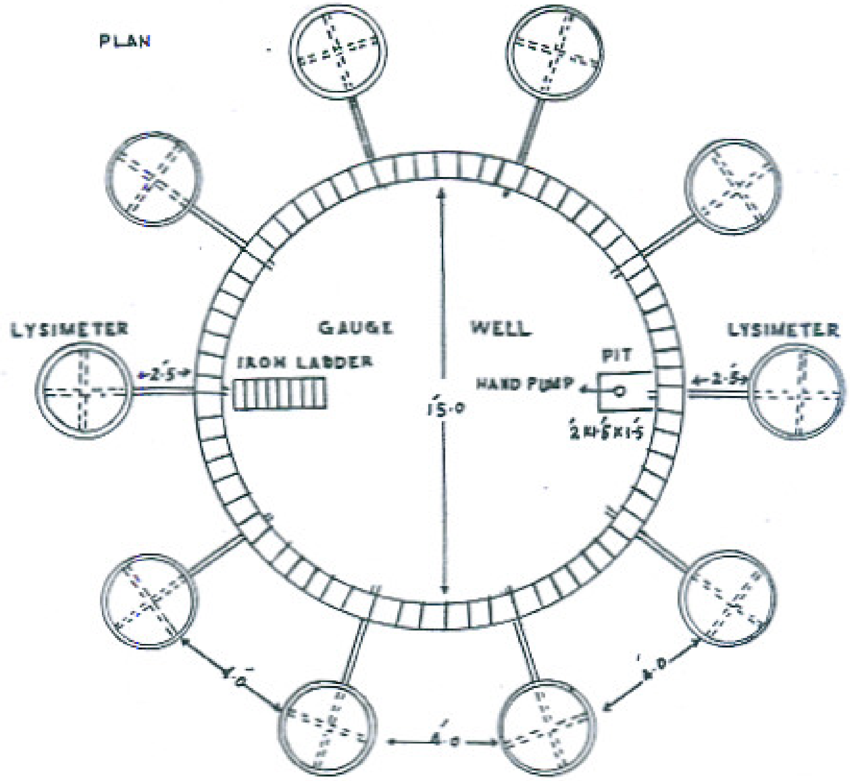


FIG. 3 A

FIG. NO. 3 B
EXPERIMENTAL SET UP

PLAN



LONGITUDINAL SECTION

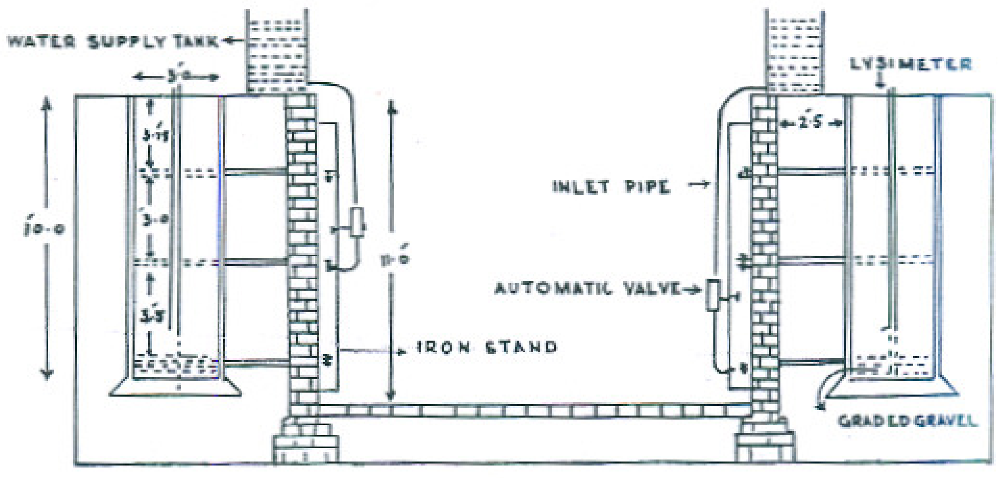
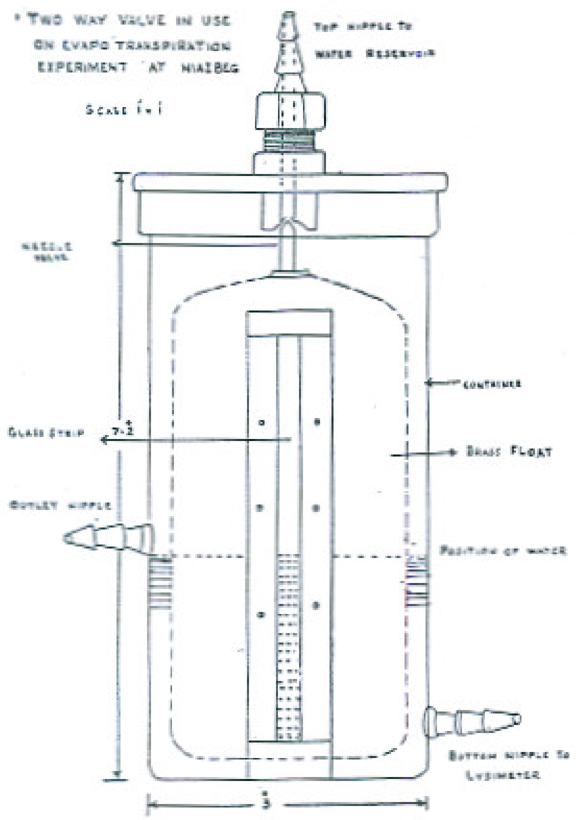


FIG. NO. 4



blocks the flow of water. The valve has three inlets. The bottom one is connected to the lysimeter. The top inlet is connected to the reservoir of water. When the water is needed by the lysimeter, it is drawn through the top inlet and flows through the bottom pipe. In case the lysimeter is irrigated and water drains down, it enters the valve through the bottom inlet and raises the float up to stop the inflow of water from the reservoir. The drained water now flows out of the valve through the middle outlet. This drainage is collected in a vessel.

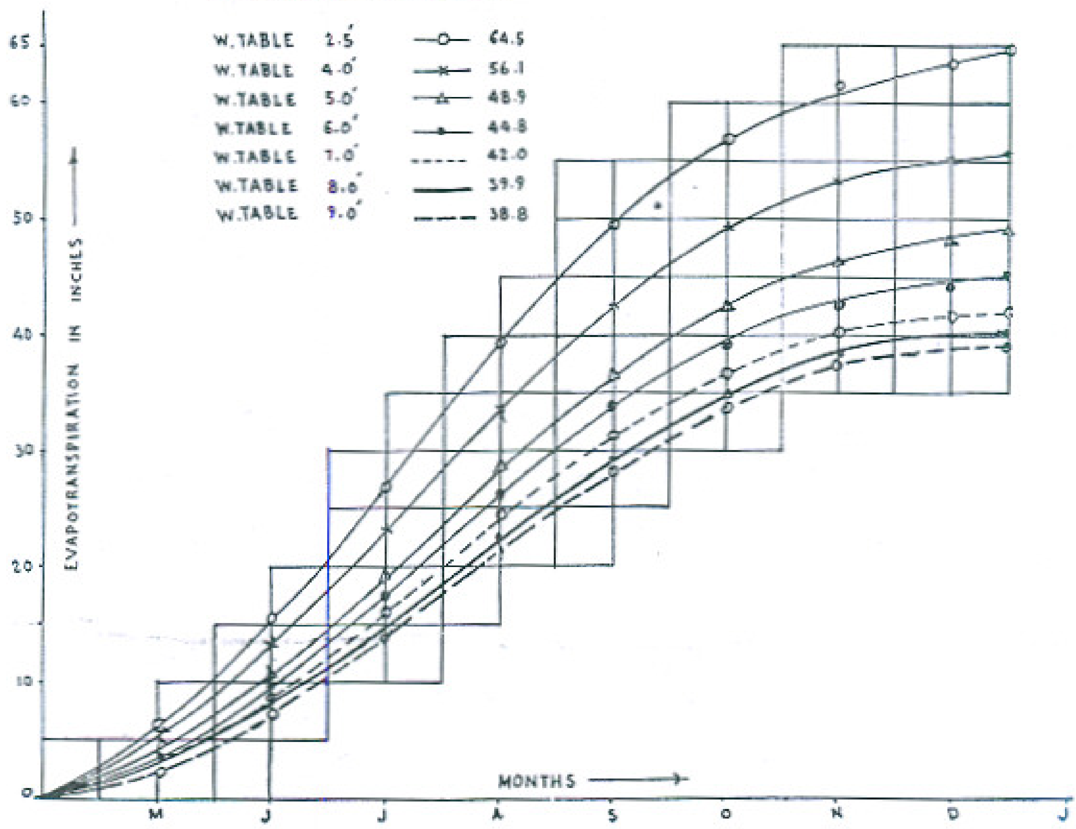
When the drainage stops and the lysimeter needs water, the float moves down, opening the top inlet and water flows back into the lysimeter. This device thus maintains the water-table at a fixed level and helps in recording the amount of water needed by a soil and the crop. The water so consumed by the crop is termed the sub-irrigation. Drainage surplus after an irrigation is also

FIG. 56

EVAPOTRANSPIRATION BY COTTON L.S.S

CLAYEY SOIL

FROM MAY 11 TO JAN. 15



estimated as explained. This technique automatically maintains the water-table at a fixed position.

Experiments with Cotton Crop

Cotton, variety L.S.S., was sown in fourteen lysimeters, seven of which had clay soil and the rest silty soil. Water-table was maintained at different depths, the highest position was 2.5 ft. and the deepest 9 ft. below surface. Full season data for this crop are plotted in Figures 5 (*a*) and (*b*). These figures depict the water consumed by the crop during different months of its growth. Cumulative consumption is plotted in these figures. The full season data for the crop grown under different positions of water-table and soils are shown in Table No. 2. It gives the amount of irrigation and rainfall during the growth period, surface run off and the percolation. The water drawn by the crop from the soil moisture as sub-irrigation is also given. The total evapo-transpiration is represented by ET, sub-irrigation by SI and the amount of evaporation from free water surface by EV. For this crop the actual requirement of water was assumed equal to 32 inches with deep water-table. A study of the table shows that the cotton crop due to high water-table consumes a considerable amount much above its requirement. This water is wasted. A fair amount of water is drawn from the soil formation as sub-irrigation. More water is lost when the soil is silty. With water-table beyond 10 ft. the loss is the same in both the soils.

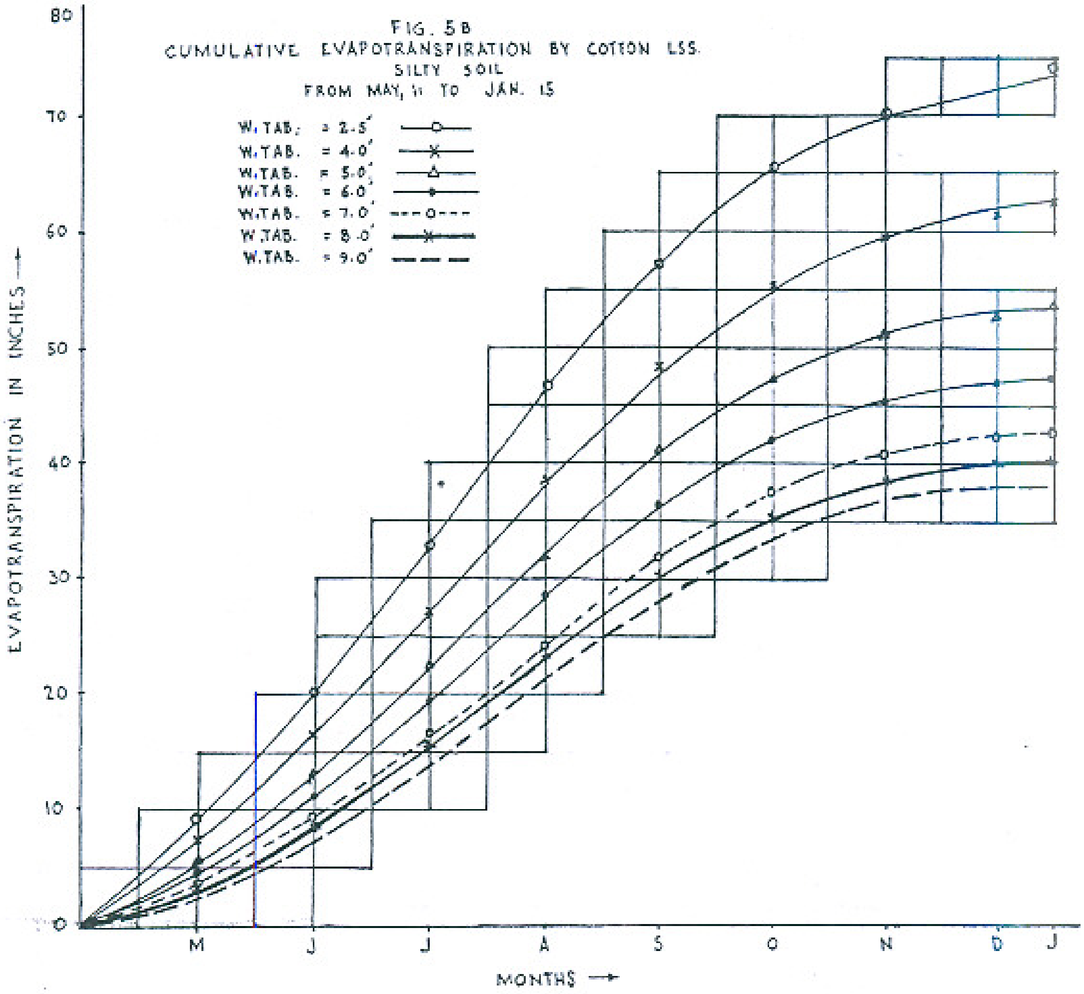


TABLE No. 2

Seasonal Evapo-transpiration Data of Cotton L.S.S. from May 11, 1964 to *January* 15, 1965.
(All Units are in inches).

Soil	Silty							Clay						
Tank No.	1	2	5	6	9	4	5	3	4	7	8	10	6	7
Water-table in ft.	2.5	4.0	5.0	6.0	7.0	8.0	9.0	2.5	4.0	5.0	6.0	7.0	8.0	9.0
Surface Irrigation ..	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Rainfall ..	27.89	27.89	27.89	27.89	27.89	27.89	27.89	27.89	27.89	27.89	27.89	27.89	27.89	27.89
Surface Run off ..	5.25	5.68	9.30	6.0	5.00	6.00	6.5	3.39	5.60	5.50	5.50	7.00	7.00	7.00
Percolation ..	7.06	5.20	9.07	9.97	9.83	7.79	9.27	3.74	1.73	3.02	4.12	6.16	7.04	5.16
Sub-Irrigation ..	46.32	33.47	32.08	23.38	17.64	14.10	14.10	31.74	23.54	17.53	14.53	15.27	14.05	11.07
Total Evapo-transpiration	73.90	62.50	53.60	47.30	42.70	40.20	38.20	64.50	56.10	48.90	44.80	42.00	39.90	38.80
K Value ..	1.45	1.23	1.05	0.93	0.84	0.80	0.75	1.26	1.1	0.96	0.88	0.82	0.78	0.76
%Excess Evapo-trans-* .. piration.	131.0	96.6	67.5	48.0	34.0	25.0	20.0	101.6	75.3	52.8	40.0	31.3	24.7	21.2
Ratio of SI/EV. ..	2.19	1.86	1.59	1.41	1.27	1.9	1.14	1.95	1.67	1.45	1.33	1.25	1.85	1.15
% of SI/ET. ..	62.7	53.58	59.83	49.42	41.3	35.05	36.85	49.20	41.94	35.84	32.42	36.35	35.2	28.52
Ratio of SI/EV. ..	1.38	1.0	0.95	0.70	0.54	0.42	0.41	0.94	0.70	0.52	0.43	0.45	0.42	0.33

The amount of total consumption assumed with water-table at 20 ft. for Cotton was 32 inches.
Lake evaporation during growth period=33.7 inches. K Values at 20 ft. depth=0.63
Blaney Criddle F = 51 where F is sum of monthly consumptive use factor for growth period.

* %Excess Evapo-transpiration worked out assuming ET 32″ at 20 fwl table.