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COMMENTS, DEFINITIONS, AND PERSONAL OPINIONS TO EXPLAIN THE TROPICAL RICE PRODUCERS' CONDITIONS AND PROBLEMS TO MACHINERY MANUFACTURERS

by

Loyd Johnson[1]

Continued contacts with manufacturers indicate their increasing interest in developing machinery that will perform an economic service for the rice-producer. Climate, soils, irrigation, farm size, stage of development, wage rates, savings, educational levels, and many other factors are different in the tropical rice-producing areas and difficult to accept by a person who has spent his lifetime working on machines for wheat and corn production. A two-week trip or even a year's assignment can be seriously influenced by one's background.

Problems

The first consideration in developed areas is to locate a serious problem, solve the problem, and sell the solution. Unfortunately, the solutions to the corn and wheat producers' problems are not solutions to the monsoon rice producers' problems, and past attempts to market machinery has failed since the machinery did not perform a service economically. Most of the rice producer's problems are in transportation, irrigation, land preparation, weed control, pest control, harvest, drying, and storage. Land preparation is a major problem at the present time that should be solved by manufacturers.

Land preparation problems are lack of adequate low cost power. Animals are becoming more expensive each year as meat prices increase. Theft of animals to slaughter for the urban market and the decreasing land available for pasture make the maintenance of draft animals more expensive. The power of the animal is not adequate to plow the hard soils and the animal's endurance is not adequate for a long day's work during the rush land preparation season. The operator's wage is deplorably low, usually less than $0.10 per hour, yet when coupled with the animal's cost of $0.10 per hour or more the total cost exceeds $0.20 per horsepower hour of work. Comparable costs with a 50-horsepower tractor would be about $0.05 per horsepower hour including operator's wage of over $1.00 per hour. My personal opinion on land preparation is that primary tillage of equal quality will require about the same power regardless of the method or size of power unit, whether man labor, 1 animal, 6-Rhp tractor, or 30 to 60-Rhp standard tractors. Primary tillage with a plow requires a draft of 5 to 20 psi of furrow section or 20 to 78 draft horsepower-hours per hectare for a 6-inch depth. Conversion of Rhp to draft horsepower for tillage will seldom exceed 60 percent on dry soils which would indicate that plowing or primary tillage would require 33 to 130 Rhp-hrs. All my field work and references that I have reviewed support the computation. Weight and strength are problems in plowing dry soils of 10 to 20 psi furrow sections while traction, flotation, and balling of mud are problems in primary tillage of wet soils. Since rice lands are planted in wet soils during months when rainfall exceeds 6 inches, the wet land problem seems to merit major attention. Small fields, sizes averaging about 66 x 100 feet; wet soils with a cone index of less than 70 psi at a depth of

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12 inches and 35 psi at a depth of 6 inches; vertical levees and ditches 12 inches high or deep and 16 inches wide; vegetation of 2 to 6 tons per hectare; and many other factors must also be considered to solve the land preparation problem.

For contract land preparation on areas growing one crop of rice per year, I propose a solution of the problem by using two-wheel drive 40 to 60 Rhp tractors equipped with cage wheels. These tractors should weigh under 90 lbs. per Rhp; have forward speeds at full PTO rated speeds of 0.7, 1.0, 1.3, 1.7, and 2.1 miles per hour in the low speed range; and have a PTO transmission that will withstand continuous use with a rotary tiller. The basic rotary tiller would be 8 feet wide with provisions for extending the width to 10 feet and 12 feet.

For the two-crop-per-year areas, I propose a 40 to 60 Rhp four-wheel drive tractor equipped with cage wheels, the same low speed range, and rotary tiller, but with a weight of under 60 lbs. per Rhp. Tire sizes for both units should exceed 60 inches outside diameter and ground clearance over 24 inches. The only real solution, however, must come from design and field tests.

Transportation problems are lack of adequate roads and right-of-ways for standard machines. The solution is by improvement of the roads and easier legal means of obtaining right-of-way for fields off the public roads. Land preparation equipment will prove useful in building the roads.

Irrigation problems are lack of storage to hold the excess water from the monsoon season for use in the dry season. The solution is large storage dams and reservoirs and deep wells and pumps. Standard well drilling machinery and pumps may be used. Diesel engine power units able to run 5000 hours per year with a minimum of attention would be the most immediate solution while rural electrification and electric motors would be the best solution.

The weed control problem will be partially solved by better land preparation and by hand weeding. The final solution will be better water control, clean cropping, and herbicides.

The pest control problem will be largely chemical. The major pests are now being controlled by hand broadcast application of granulated insecticides so that the need for equipment is not pressing at the present time.

The harvest problem requires mobility on wet soils and the ability to thresh and separate while free water is on the surface of the leaves. Present rice combines have the mobility but lack of right of way and ability to separate wet leaves and grain limit their use.

Drying and storage problems depend on the harvest method and will change when the combine is introduced.

Stages of Mechanization

A second consideration is to better define the stages of mechanization. Often a person from a developed country wishes to talk down or design down for the underdeveloped areas in order to keep more people employed. Yet if machines and tools are to be bought or sold they must aid in production, or decrease cost of production. Attempts to keep farmers in Stages 1 and 2 at "make work" with hand tools create a problem of low producing subsistence farmers. The majority of the rice producers are now in Stage 2 and use animals to their capacity. These farmers need power to augment or replace the animal to enter Stage 3. The skilled designers are at present working on machines for Stages 6 and 7. The solution is to

divert some designers back to the more basic, less sophisticated application of power, and sell efficient power units and implements suitable for the climatic conditions of the rice producing area.

Stage 1. Man uses tools and skills to better use his own power.

Stage 2. Man uses animals, tools, and skills to augment, supplement, and/or displace his own efforts as a power producer to permit him to better apply his power and skills as a food producer.

Stage 3. Power from men and work animals is augmented, supplemented and replaced by machines. Animals are displaced from being food consumers and power sources to become high-quality food producers. Man is displaced to use his limited power on specialized tasks (planting, hoeing, chopping, harvesting, etc.).

Stage 4. Machines displace or augment man as a special purpose power source to permit the employment of his visual and manipulative skills -- to operate cultivators and planters and handpick cotton, fruits, vegetables, care for animals, etc.

Stage 5. Machines displace man in routine manipulations to permit the employment of his vision, sensing, and routine decisional skills -- operation of milking machines, cotton pickers, and hand harvesting vegetables, fruits, etc. at proper degree of ripeness.

Stage 6. Machine displaces man as from routine sensing and decisions to permit the employment of his intelligence for sensing, assimilating, deciding, and reacting to unusual but predictable conditions -- to permit him to design, fabricate, repair, set, and operate machines of Stage 5, and practice unusual skills as plant propagator, breeder, animal care, etc.

Stage 7. Machines displace man from sensing, assimilating, deciding, and reacting to predictable conditions to permit him to design, manufacture, set up and operate machines of Stage 6 and delve into the unknown, as in research, development, arts, and leisure.

Soil and Water Conditions

A third consideration is the different concept of machines required for the monsoon tropical rice areas. This concept can best be understood by considering the different methods of weed control under wet and dry conditions. Weeds and grasses are uprooted to dry-out under dry conditions, while in most of the present rice areas weeds and grasses are pushed under water to drown-out under wet conditions. In one case water is the limiting factor and in the other case water is the excess factor. The rice plant is well suited for wet conditions as it is one of the few plants with the ability to conduct air to the roots. The wet tropical rice producer takes advantage of the wet weather to grow a crop and control weeds. He cannot afford to wait for dry weather for cultivation any more than the corn farmer could afford to wait to cultivate during a rain. What seems sensible to one person may be the reverse to another. Thus, the mechanization of rice in the monsoon and wet tropics has proceeded at a slow pace due to lack of appreciation of the soil and water conditions under which the machines must operate. Most farm machinery was developed to solve the problems of the wheat and corn producers between Latitudes 40° to 60° North. The rainfall, evapotranspiration, and soils and

crops between 40° to 60° North Latitudes are very different from those in the tropical areas.

Table 1 lists precipitation for cities in the tropical rice growing area and for the wheat and corn producing areas, and Figure 1 compares the rainfall and potential evapotranspiration (ET) patterns of Des Moines, Iowa, and Manila, Philippines. Rainfall at Des Moines exceeds the potential ET slightly from late November to early January; however, on the average, soil would be moist, that is, neither excessively wet nor dry. Each rain would bring the surface layer back to field capacity but the lower soil profile would always be under field capacity. This type of soil and water condition would permit dry tillage most of the year, but temperatures limit crop growth, mainly to the period of May to October. Temperatures in Manila and other tropical rice growing areas permit growth at any time of the year, but available water usually restricts the growing period from late June to December. Rainfall in Manila exceeds ET starting in late May and the soil profile becomes saturated by late June.

The rice crop is grown from June to December under saturated soil conditions and harvested from December to January while the soil is drying out. During the drying out, a hard surface crust forms over the soft plastic under-layer. Cracks form at the surface and proceed downward. Attempts to plow dry riceland in early December, even if possible, would result in a ribbon made of wet mud adhering to a dry layer. By January the cracks are deep enough so that plowing merely results in pulling out large clods 8 to 12 inches in size and about as hard as asphalt pavement. From early February to May the soil profile is at the wilting point and may be broken into small clods when adequate power is available. The animal does not have adequate power so that the soil is usually not disturbed by animals until late May and June. Tractors may plow, and harrow from early February to late June with varying degrees of success. Power take-off driven rotary tillers and spading devices offer more promise in preparing soil under the various conditions from wet to dry. When water is available the wet condition will predominate.

Irrigation

A previous statement that when water is available the wet condition will predominate leads to a discussion on irrigation. In most temperate areas irrigation is thought of as the availability of water to grow a crop during a dry period. The term "irrigation" in the monsoon rice producing area may mean many things, but seldom will one find large areas irrigated during the dry season. The best market for rice machinery will probably be in the irrigated areas, particularly in double-crop areas. Some categories are listed to better describe the term "irrigation". Most of the presently irrigated tropical rice is grown under Categories 2, 3, and 4. Probably less than 15 percent of the monsoon tropical rice areas would fall under Category 5; less than 10 percent would fall under Category 6, and less than 5 percent under Category 7. Many irrigation specialists from developed countries are shocked when they visit irrigation systems designed for rice production. They can only comment on the lack of water when needed and the poor drainage conditions. Unfortunately the rice farmer is at one stage and development must start at his present level. He is usually more interested in maintaining water on his fields than he is in drainage. I believe that he will also prefer to plant another rice crop immediately after harvesting the preceding crop when water is available without ever drying out the fields. Immediate replanting on wet soils reduces the time between crops, the weed growth, nitrogen losses, water losses, etc. However traction and flotation problems become more difficult.

CATEGORIES OF IRRIGATION IN THE TROPICAL RICE PRODUCING AREAS

0 Single Crop, Monsoon Season. - Rainfed only. Rice direct seeded as an upland or dry grain crop without puddling of soil or entrapment of water.

1 Single Crop, Monsoon Season. - Land prepared by plow or harrow in dry condition in low areas during the late dry season. Rice broadcast on the dry soil to germinate with the first rains. Low areas flooded due to rainfall and stream flooding. Floating rice varieties used for deep water, and photosensitive varieties generally used to mature as flood water subsides.

2 Single Crop, Monsoon Season. - (a) Rainfall and overland flow entrapped in paddies on lower slopes. (b) Upper slopes rainfall entrapment only. Rice transplanted in puddled soil.

3 Single Crop, Monsoon Season. - Rainfed and partially irrigated by stream diversion. No provision for rapid irrigation of individual fields. Water held in level fields. Rice transplanted in puddled soil.

4 Single Crop. - Fully irrigated in the monsoon by rainfall plus irrigation in adequate quantities of water and field arrangement for rapid flooding and maintaining water at all times after transplanting. Some irrigation water available for seedbed and land preparation in the early wet season. Rice transplanted in puddled soil.

5 Double Crop. - Fully irrigated in the monsoon season by rainfall and stream diversion irrigation, and partially irrigated in the dry season for 100 to 120 days but short of water at the end of the dry season. Water held in fields until after the dry season crop. Land generally prepared wet and rice transplanted due to water shortage.

6 Multiple Crop. - Fully irrigated with adequate water available at all times but no means of avoiding an excess of water at times during wet season. Fields may be dried out after wet season crop and reflooded or irrigated and drained at will during the dry season. Crop may be planted dry or wet as desired.

7 Multiple Crop. - Fully irrigated in a low rainfall zone with control of water and soil moisture possible at all times. Crop may be planted wet or dry as desired.

Stages of Development

For final consideration we must start with the present time, place, climate, and stage of development. My own experience and discussions over the past few years indicate that any one coming from a temperate developed area is shocked to find the wide differences that exist side by side in the underdeveloped countries.

A list of stages of development has been prepared to help in discussing the tropical rice areas. Often within a 100-kilometer radius one can find communities which fall in all the stages listed. Machinery manufacturers and salesmen are interested in areas that are in Stages 7, 8, and 9. Recent research results on varieties, insect control, and nitrogen response should move large areas from Stages 6 and 7 to Stages 8 and 9. Every one should be vitally interested that all groups move forward and not revert back to subsistence farming.

Anyone sincerely interested in aiding in the development of the rice producing area can start by asking a few simple questions:

(1) If I gave all my money to the most destitute, would they be better off 10 years from now?

(2) If I worked physically with them, with their food, shelter, and other limitations, could I accomplish more than they could?

(3) If they or others were encouraged or forced to work harder and save, would the situation change?

(4) Will the presently available machinery and technology be adequate to accomplish the physical work?

(5) Could an intelligent plan be devised to develop machinery to keep land in production more days per year than the present production methods, and could machines be used to lower present costs?

believe the last question to be the start of the solution.

APPROXIMATE STAGES OF DEVELOPMENT IN TROPICAL RICE AREAS

Stage

0 Gathering of wild seeds for subsistence.

1 Bushing, burning, planting, and harvesting seeds for subsistence either on hillsides or in dry marshes at the end of a long dry season and before the heavy rains. Shifting cultivation.

2 Land preparation with a hoe in marshes and old clearings, planting, weeding, and harvesting for subsistence in a settled community. Farm size may be large but the area cultivated is usually less than 3 hectares.

3 Building of levees in old fields to catch rainfall and runoff from higher areas, land preparation with a hoe or animal, transplanting, weeding, and harvesting for subsistence in a settled community. Some land may be taxed or rented and some surplus grain traded. Farm operating size may increase to about 3 hectares to pay rental and leave adequate supplies for subsistence. Ownership may be large or small.

4 Diversion of runoff from small streams into leveled fields with levees, puddling with animal, transplanting, weeding, and harvesting for subsistence, taxes, rent and trade. Some transportation required for marketing. Farm operating size will increase to a maximum for the animal and man or the maximum needed for subsistence and trade.

5 Developed stable community with trading center and urban relations. The developed land farmers are near community facilities. Goods and services are traded for surplus grain. Land rent increases, diversion irrigation of medium size streams develop, new lands are opened. The price of food increases to the non-subsistence farmer and urban population. The farm operating size increases to the maximum capacity of the man and animal and may exceed 3 hectares.

6 Pressure on developed one-crop land becomes greater, rents increase, food prices increase, transportation and diversion irrigation systems are installed, and labor, animals and machines are used to open new land areas. Some areas are double cropped from the low water flow of the larger or more uniform streams. Farm sizes in the new crop areas are large but operating size depends upon the machine capacity for land preparation and the capacity of hired labor or share tenants for planting, weeding, and harvest.

7 Pressure on developed one-crop land becomes acute, rent and food prices cause social unrest, the infrastructure for opening new lands is excessive in costs for land clearing, housing, health, schools, churches, roads, irrigation and trading centers. Higher crop yields are promoted by the use of fertilizer, insecticides, and better seed. Most of the crop is still from subsistence farms and the marketable portion is from rental and services such as loans and threshing. Operations are still animal plowing, puddling, transplanting, weeding, and hand cutting and bundling. Threshing may be by hand, animals, or stationary thresher. Farm size owned may be large but farm operating size starts to decline from about 3 hectares which creates a problem for the subsistence tenant farmer to pay a higher rent and still have enough left for his own consumption and some for sale. Agitation for land reform and high grain prices create an interest by landowners in mechanization for the large farms in both land reform areas with excess labor and in the underpopulated and undeveloped areas. The first type of owner wishes to salvage a high-value but neglected farm, while the second type wishes to develop a new area for production and/or partially develop and hold the land for speculation. Suitable machines, operators, credit, social stability and agricultural knowledge are not available and must be developed by research or trial and error. Machines are viewed as weapons in the social struggle rather than as productive tools.

Stage

8 New agricultural knowledge in seeds, fertilizer, pesticides, and management skills permit increased production per unit area. The higher food prices and higher production create an interest in commercial farming both on the part of the landowner and the subsistence tenant. They begin to cooperate to increase production per crop and crops per year. The relative cost of land preparation, fertilizer, pesticides, seeds, harvesting, irrigation, etc. must now be considered on a business basis as net income is the difference between value of production and cost of production. Formerly the owner-tenant relationship was feudal, with land as one resource, water a product of nature, while labor and animal power the obligation of the tenant. Now the true cost and limitations of land preparation, irrigation, and harvesting become apparent and require a solution. Machines are viewed as productive tools to help man create wealth and the most efficient ones are needed to increase everyone's welfare.

9 Machines are used to decrease cost of production and permit additional production by more timely operations. Construction machines are needed by civil engineers for roads, dams, reservoirs, and canals. However, wells and pumps may tap the underground water reservoir to provide equal or better irrigation than dams, reservoirs, and canals. Tractors replace animals for land preparation while threshers and combines become necessary to avoid the excessive labor peak requirement which occurs while harvesting, preparing land, and immediately planting another crop. The cost of machines, seeds, supplies, and services transform agriculture from a subsistence to a commercial orientation which provides a market for urban production, jobs, and schools for displaced agricultural labor. Increased production at lower costs can result in higher income and

Table 1. Precipitation (in Inches per Month). From CLIMATES OF THE CONTINENTS by W. G. Kendrew. Oxford University Press, 1961. Fifth Edition, Reprinted 1963. 608 pages.

Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year	Approx. Latitude
Canton, China	1.8	2.7	3.6	5.9	9.9	10.6	9.9	9.6	5.4	2.3	1.6	1.4	64.7	23°N
Dacca, Pakistan	0.3	1.3	2.6	5.4	9.7	13.6	12.8	13.1	9.8	4.6	0.8	0.2	74.2	23°N
Calcutta, India	0.4	1.2	1.4	1.7	5.5	11.7	12.8	12.9	9.9	4.5	0.8	0.2	63.0	22°N
Madras, India	1.4	0.4	0.3	0.6	1.0	1.9	3.6	4.6	4.7	12.0	14.0	5.5	50.0	13°N
Rangoon, Burma	0.1	0.2	0.3	2.0	12.1	18.9	22.9	20.8	15.5	7.1	2.7	0.4	103.0	17°N
Darwin, Australia	15.2	12.3	10.0	3.8	0.6	0.1	< 0.1	0.1	0.5	2.0	4.7	9.4	58.7	12°S
Manila, Philippines	0.9	0.5	0.7	1.3	5.1	10.0	17.0	16.6	14.0	7.6	5.7	2.6	82.0	14°N
Hanoi, Vietnam	1.0	1.3	1.9	3.6	8.4	10.4	11.1	13.9	10.5	4.3	2.0	1.2	69.9	21°N
Saigon, Vietnam	0.7	0.1	0.7	1.7	8.0	13.3	12.0	10.3	13.7	11.0	4.7	2.7	79.2	11°N
Bangkok, Thailand	0.3	0.8	1.4	2.3	7.8	6.3	6.3	6.9	12.0	8.1	2.6	0.2	55.0	13°N
Penang, Malaysia	3.7	3.1	5.6	7.4	10.7	7.7	7.5	11.6	15.8	16.9	11.9	5.8	107.7	5°N
Jakarta, Indonesia	11.7	13.5	8.4	5.6	4.3	3.6	2.6	1.5	2.8	4.5	5.7	7.6	71.3	6°S
Hannover, Germany	1.7	1.4	1.6	1.5	2.0	2.7	3.0	2.7	1.8	1.9	1.7	1.9	23.9	52°N
Des Moines, Iowa	1.1	1.1	1.8	2.9	4.4	4.8	3.4	3.6	3.6	2.5	1.5	1.2	31.9	41°N
Indianapolis, Ind.	3.0	2.7	4.0	3.6	3.9	4.0	3.9	3.3	3.2	2.8	3.3	3.0	40.7	40°N
Omaha, Nebraska	0.7	0.9	1.3	2.7	3.7	4.6	4.0	3.4	3.3	2.3	1.2	0.9	29.0	41°N
Winnipeg, Man., Can.	0.9	0.8	1.1	1.2	2.1	2.6	2.7	2.5	2.3	1.4	1.1	0.9	19.7	50°N
St. Louis, Missouri	2.3	2.5	3.5	3.8	4.5	4.5	3.5	3.4	3.2	2.9	2.8	2.5	39.4	39°N
Raleigh, N. Carolina	3.6	4.2	3.8	3.8	4.5	5.3	5.3	5.3	3.7	2.8	2.3	3.5	46.3	36°N
Melbourne, Australia	1.9	1.8	2.2	2.3	2.1	2.1	1.9	1.9	2.3	2.6	2.3	2.3	25.7	37°S

ft/
5-18-67

Table 2. COMPUTED EVAPOTRANSPIRATION IN INCHES PER MONTH COMPUTED FROM SOLAR RADIATION REACHING THE GROUND WITH ATMOSPHERIC TRANSMISSION COEFFICIENT OF 0.6 AND ASSUMING 920 GM CAL OF SOLAR RADIATION REQUIRED TO VAPORIZE ONE GM OF WATER 1/

Latitude	March 21	May 6	June 22	August 8	September 23	November 8	December 22	February 4
90°N	-	1.62	3.83	1.60	-	-	-	-
80	.08	2.02	3.96	2.00	.06	-	-	-
70	.60	2.99	4.47	2.97	.59	-	-	-
60	1.54	3.99	5.20	3.94	1.51	.13	-	.13
50	2.59	4.81	5.76	4.76	2.55	.74	.24	.74
40	3.61	5.45	6.11	5.39	3.56	1.66	.96	1.68
30	4.48	5.80	6.16	5.75	4.42	2.73	1.95	2.75
20	5.17	5.88	5.95	5.81	5.09	3.75	3.03	3.79
10	5.58	5.68	5.48	5.62	5.50	4.68	4.13	4.74
0	5.72	5.21	4.76	5.17	5.63	5.40	5.08	5.47
10 S	5.58	4.52	3.88	4.47	5.50	5.90	5.85	5.95
20	5.17	3.61	2.84	3.57	5.09	6.08	6.36	6.14
30	4.48	2.64	1.83	2.61	4.42	6.02	6.58	6.08
40	3.61	1.60	.90	1.59	3.56	5.64	6.52	5.70
50	2.59	.72	.23	.70	2.55	5.00	6.16	5.06
60	1.54	.13	-	.13	1.51	4.14	5.56	4.19
70	.60	-	-	-	.59	3.10	4.77	3.14
80	.08	-	-	-	.06	2.10	4.22	2.12
90	-	-	-	-	-	1.68	4.08	1.70

1/ Smithsonian Institution Tables, 6th Revised Edition 1963, Table 135, page 421 and IRRI 1964 Annual Report page 286.

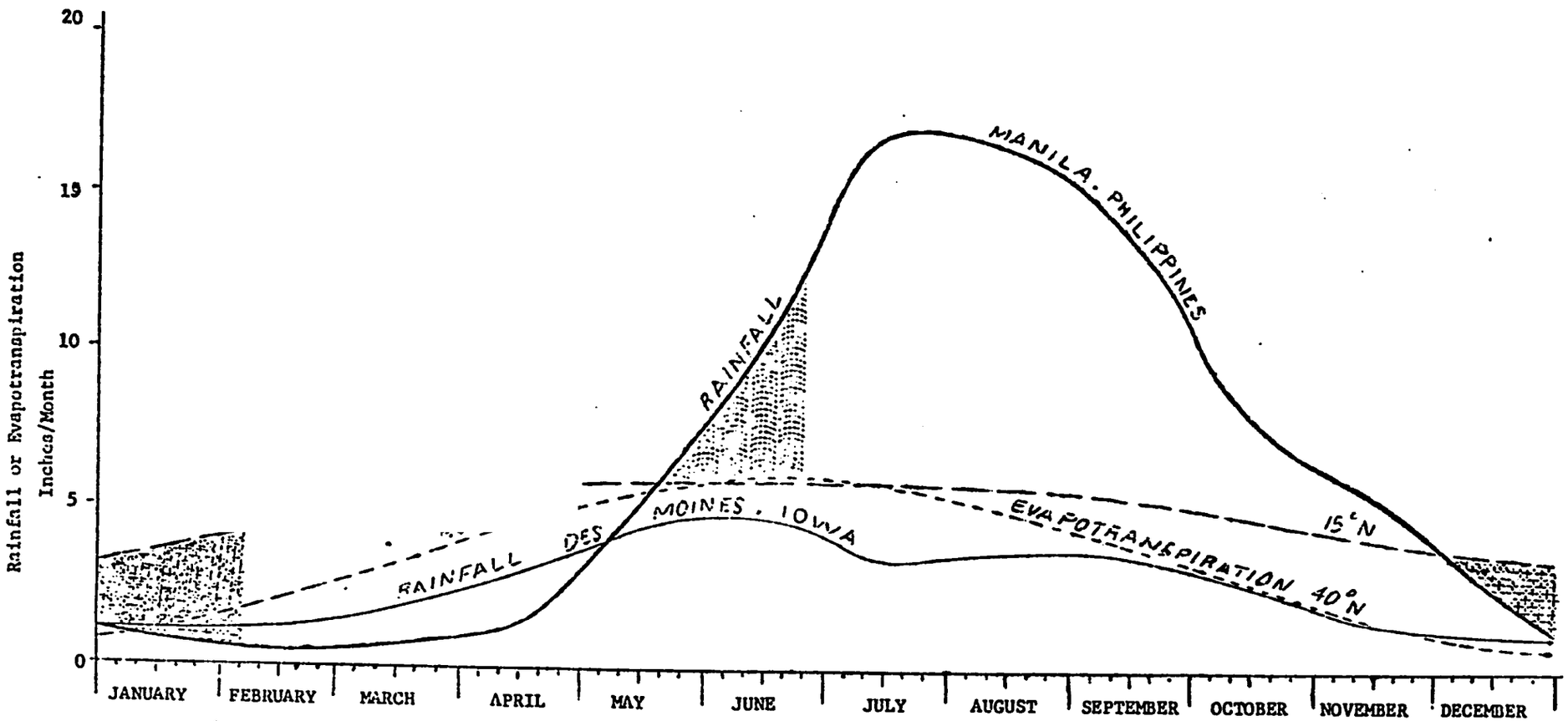

Fig. 1. Average Rainfall for Des Moines, Iowa and Manila, Philippines and computed Evapotranspiration for 40° and 15° North Latitudes based on Solar Radiation from Smithsonian Metrological Table 135 with a = 0.6 and 920 gm cal/gm of water vaporized.