

INTERCROPPING COCONUT WITH CACAO¹

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ABSTRACT

Growing cacao under coconut results in effective utilization of coconut plantation and increased net return from the land. A given coconut plantation is most suitable for cacao growing if its soil is clay loam which is slightly acidic, capable of holding sufficient amount of organic matter. The plantation must be situated in a place where rainfall is abundant, for cacao thrives best in areas with little or no dry season.

To optimize growing condition for cacao, the following farm activities must be observed:

a) proper nursery practices such as careful selection of seeds for planting, germination of such with minimum delay, and provision of appropriate climatic conditions; b) timely field-planting and; c) good farm maintenance involving weed control, pruning of cacao, fertilizer application and, pest and disease control.

INTRODUCTION

The planting of cacao under coconuts is not new. Mixed plantings have long been established in the Philippines (Anon; 1966) and in Papua, New Guinea (Urquhart, 1961) as a means of increasing the income derived from a coconut farm. The characteristic features of the coconut palm make the coconut plantation very suitable for growing other compatible crops in the inter-spaces of coconuts.

Studies have shown that coconuts planted at a distance of 7 m x 7 m to 10 m x 10 m leave much of the spaces between the palms ineffectively utilized. Using the maximum effective root zones of 2 m (Neliat *et al.*, 1974), it is estimated that only 12.6 to 25.7% of total available area in a pure stand of coconut is used effectively. This would leave 74.3 to 87.4% of the available area for other crops.

There is little change in the spread of the crown of the coconut palm after it has attained maturity although a slight reduction in the size of the fronds may occur (Neliat *et al.*, 1974). However, the canopy coverage of the ground progressively decreases with the increase in height and results in the increase in the amount of sunlight or solar radiation that percolates down the lower profiles and to the ground surface of a coconut plantation. This surplus solar energy can support other crops grown under coconuts.

BENEFITS FROM COCONUT-CACAO INTERCROPPING

Effects on coconut. It has been found that cacao is one of the most profitable perennial crops that can be planted under coconuts. Not only was there little evidence of depressing effect of cacao on coconuts (Brant, 1978) but the yield of the latter could even increase under such set up. The practice actually augments instead of depressing the yield of coconuts. It has been recorded that the yield of coconuts in Malaysia increased up to 30% with the introduction of cacao (Ramadasan *et al.*, 1976). Similar increases in yields of coconut palms were observed in Davao and in Papua, New Guinea two years after they were intercropped with cacao (Creencia, 1978).

In Jamaica, Malayan Dwarf coconuts planted in 1968 at 21 feet triangular spacing were interplanted with cacao in 1971 to determine the performance of three cacao varieties at three planting densities and to determine whether the income from coconuts can be improved (Brant, 1978). Results from this study showed that the number of female flowers produced by coconuts was not affected up to 1976. The percentage of nuts that set however decreased in palms intercropped with variety C of cacao planted at 5.25 feet apart. The other two varieties did not affect female flower production and nut set at all planting distances (10.5 ft., 7.0 ft. and 5.25 ft.) tried.

Effects on cacao. A certain amount of shade is necessary in the establishment of a cacao plantation specially during transplanting of seedlings from the nursery to the field. Although the amount of shade provided by mature coconut palms is inadequate for young cacao seedlings, it has been observed that this is sufficient for mature cacao trees. The availability of partial shade provided by the coconut trees in a coconut-cacao intercropping minimizes the need for planting shade trees when compared to planting cacao as a monocrop. With coconuts, the fronds can be used as temporary shade. Coconut husks from harvested nuts can also be utilized as mulch around the base of the cacao plants to reduce the growth of weeds, conserve moisture during dry months and prevent direct impact of rainfall during rainy months.

Economic advantage. The planting of cacao under coconuts maximizes the use of land which would otherwise lie idle if not planted to other crops. Establishment cost is small because most of the money necessary in preparing the coconut area for planting cacao is spent

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anyway during the regular maintenance of a pure stand of coconuts. The income derived from the increased yield of coconuts due to underplanting of cacao plus the income from cacao harvests will certainly be much greater than from coconuts alone.

Indications are that the cacao at maximum production should increase the net return from the land by at least 50 percent.

FACTORS TO CONSIDER IN PLANTING CACAO UNDER COCONUTS

Not all coconut areas are suitable for cacao planting. As a general rule, the areas that give high yields of coconut are expected to better support cacao production. As a rule of thumb, coconut areas producing at least 50 nuts per tree per year maybe intercropped with cacao provided the following soil and climatic factors are met.

Soil. Clay loams of good structure support the best growth of cacao since the aggregates of sand, silt and clay provide large pore spaces for aeration and drainage, while at the same time retaining moisture. The better the soil structure the deeper the root penetration, and hence the greater volume of soil exploited by the roots for moisture and nutrient uptake.

Of great importance in a good cacao soil is the amount of organic matter in the surface layer. It is the loss of this organic matter that is closely associated with soil degeneration and falling yields in cacao. To preserve the organic layer the soil must be shaded well to slow down the rate of decay of leaf litter.

Soil pH is also an important consideration in selecting good soil for cacao. The soil must be slightly acidic, or else problems of induced deficiencies particularly of iron and zinc will arise. On the other hand, high soil acidity may lead to problems of aluminum and manganese toxicity.

Although a soil well supplied with both the major and minor plant nutrients is highly desirable, a deficiency of any one is the least important factor in the soil environment since it can be corrected fairly easily. A deficiency of phosphate in a soil would not rule out the successful growing of cacao, whereas a pH of above seven (7) most certainly would.

Climate. The cold limit of cacao is set at 21°C for the average annual temperature with a mean daily minimum in the coldest month not lower than 15°C and an absolute minimum of 10°C. The opinions regarding the hot limits for cacao vary. Hardy (1960) suggests 30°C, whereas Voelcker (1955) has put it at 38°C. Work in Trinidad (Murray, 1964) however indicates that growth is abnormal at a constant temperature above 31°C, though good growth can be obtained at temperature up to 35°C with a fluctuating temperature between day and night.

The most important factor that influences the suitability of the area for cacao and its yield is rainfall. Cacao thrives best in areas with little or no dry season. In general, the main crops of cacao is produced at the end of the wet season, with a light crop following 4 to 6 months later, maturing during the dry season. In countries where the dry season is very mild, the monthly distribution of the crop is more uniform.

It is estimated that if the monthly rainfall in an area drops below four (4) inches per month, cacao will suffer from water stress. One of the first signals of water stress condition in cacao is the accentuated leaf fall.

Closely linked to rainfall and soil moisture is relative humidity. Although normally thought of as a very sensitive crop, cacao will grow under exposed conditions at quite low humidities. If grown under hard conditions, cacao will eventually become adopted to them. What it is very sensitive to is the change in its environment. Thus the soft, thin cuticled leaves that have developed under shade and high humidity are lost rapidly when shade is removed and humidity falls. The leaves that developed under exposed conditions can however, better stand such conditions. It is very important therefore, in cacao growing to produce an environment with the least fluctuation. This brings us to the role of shade in cacao growing. Shade acts as a buffer against changes in the environment, and makes the crop easier to maintain in the field.

CULTURAL MANAGEMENT OF CACAO UNDER COCONUTS

a. Nursery Practices

The use of seeds is the most common method of planting cacao although other methods of propagation are employed. These include rooted cuttings and in special cases, budding and marcotting. The need for planting vegetatively propagated material is gradually giving way to the use of clonal or hybrid seeds. In Peninsular Malaysia and Sabah most of the cacao planted commercially at present are of the Upper Amazon hybrids or crosses between Upper Amazon and Ameno-lado and some of the Upper Amazon and Trinitario hybrids.

Selection of planting materials. If hybrid seeds are not available, seeds for planting must be carefully selected. They must come from big pods obtained from healthy and heavy yielding trees. They must be large and weighing at least 2.5 g including the mucilage. Seeds of Criollo varieties or those of high Criollo character must be avoided because this variety is very susceptible to pests and diseases. This is done by checking the color of the seed after the seedcoat is removed. Seed color of non-Criollo varieties is violet which is associated with tolerance/resistance to pests and diseases. Violet-colored cacao seeds are generally of the Trinitario or Forastero varieties. Pure Forastero is hard to find in the Philippines today because most of the introductions made are from

seeds. For all practical purposes violet-colored seeds maybe called hybrid Forastero or Trinitario.

Planting the seeds in the nursery. Every effort must be made to germinate the seeds with minimum delay on account of their limited viability. Germination can be hastened if the mucilage of the seed which contains a germination inhibitor is removed. This is done by rubbing the seeds with dry sand or sawdust after bulking them in a bamboo basket for a day, during which time the mucilage becomes softer. After removing the mucilage the seeds may be spread one layer thick in a nursery bed as in a wet gunny sack under shade and kept moist. When the radicle breaks through the seedcoat, the seeds are planted in polyethylene bags arranged in beds of about a meter wide and any convenient length. Paths of $\frac{1}{2}$ meter wide are left between beds. The size of the bags depends upon the length of the time the seedlings are to be retained in the nursery. For seedlings that will be retained in the nursery for 3 to 4 months, bags of size 6 x 8 inches laid flat are sufficient. Where the nursery period is extended to more than 4 months to 6 months, the larger 8 x 12 in size bags are preferred. All bags are perforated to provide drainage. Bags are filled with good friable clay top-soil mixed with coarse river sand in a ratio of 2:1 except in the top inch of the bag where the ratio of 1:1 is used to improve aeration and drainage. Various organic supplements, e.g. up to 15% well-rotted chicken dung are sometimes added to the soil mixture.

Nurseries are shaded above to shield the seedlings from strong solar radiation and at the side to safeguard against strong winds which may occur. The initial shade intensity is about 80% and coconut palm fronds can be used for this purpose. After the first whorl of leaves has hardened, the shade is progressively reduced until by the sixth week to the second month from germination the light intensity is reduced to about 50 percent.

Nursery maintenance. When seedlings are grown under good conditions, nursery maintenance is minimal. The seedlings are watered during the early morning and late evening, taking care not to saturate the rooting medium. The most usual nutrient deficiency symptom of seedlings is the pale foliage associated with low level of nitrogen. This is readily corrected by weekly application of 15 grams of urea dissolved in one gallon water per 200 seedlings. Abnormal seedlings or poorly developed ones must be discarded. In Malaysia about 90% of the Upper Amazon hybrid seedlings are suitable for field planting.

b. Field Planting

Land Preparation and Planting. The soil is frequently strip rotovated before planting the seedlings in the field. However, where the soils are of favorable structure, it is sufficient to eradicate weeds along the planting rows with either the use of herbicides or by slashing. In Malaysia a mixture of 3 pints Anzar, 1 pint Amine-80 and 5 lbs sodium chlorate in 40 gallons of water is enough to control weeds over an area of seven acres.

Utmost care is necessary during transport of the seedlings from the nursery to the field as the seedlings are very sensitive to transplanting shock. Shock is intense when the seedlings are retained in the nursery up to a period when the tap root will have forced its way through the bottom of the bag. Pruning of emergent roots one week prior to field planting appears to reduce the intensity of shock attributable to tap root disturbance.

Planting technique depends on soil structure. If the structure is poor, the hole is prepared a few weeks or one month in advance of planting. In good quality soils a small hole of sufficient size for the plant can be dug at the time of planting. The seedlings are planted at the same depth as they were in the nursery. The bags are removed carefully with the minimum of disturbance and soils are filled and packed carefully a few inches at a time around the soil core until the hole is filled.

Planting System. Coconuts are normally planted 7 to 10 meters apart and cacao is planted in 2 rows, 3 meters apart and equidistant from the palms. Within the rows cacao is spaced 2.5 meters giving a stand per hectare of 900 to 1,292 seedlings. Triple rows have also been tried under coconuts planted 10 m x 10 m with the cacao rows spaced 2.5 meters and the plants within the row at 2.5 meters planted in quincunx. Triple-row planting however results to very dense population at maturity although selective thinning based on vigor and yield can be done. Initial thinning is carried out at the end of the second year to reduce the cacao population to slightly above the double-row system. In thinning it must be kept in mind that more precocious trees usually give higher yields for longer periods. Subsequent thinning may be done when yield of about two tons per hectare is achieved. Close planting followed by thinning of trees is advantageous because higher yield per unit area is obtained earlier. In general 60 percent of the yield in a cacao plantation comes from about 20 percent of the trees so that close planting gives the grower the chance to eliminate or top-work less productive trees.

Shade. Coconuts provide certain amount of shade for the young cacao seedlings during transplanting. The amount of shade is greater where the coconuts are of the dwarf variety which are planted closer. In most cases, the amount of shade provided by the coconut stand is often inadequate during transplanting. Additional shade is usually provided by three feet long fallen palm fronds which are firmly set upright in the ground nine inches from the cacao seedlings. These are later removed when the plantings have become well established. Where overhead shade is insufficient, three to five seeds of rapidly growing shade plant are sown two feet from the cacao seedlings at right angle to the row of cacao to provide low shade for longer period. Pigeon pea (*Cajanus cajan*) or Croton (*Croton* sp.) can provide suitable shade for this purpose. This form of shade also helps raise the height of jorqueting which is important in management operations.

In cases where there are vacant patches in the coconut stand, overhead shade is provided by larger trees. These gaps are filled whenever possible well-in-advance of cacao planting. The trees that are usually recommended for this purpose are Madre de cacao (*Gliricidia* sp.) and Ipil-ipil (*Leucaena leucocephala*).

c. Maintenance

Weed Control. The weeds immediately surrounding the newly planted cacao seedlings may be controlled by a heavy mulch of coconut husks. This is done by placing around the seedlings, but not against them, two layers deep and two husks wide of the material. This practice has additional value in that it provides nutrients as the mulch slowly decomposes, promotes better rooting of cacao, reduces water loss from the soil and reduces soil temperature. The mulch also reduces the risk of spray drift damage to the seedlings when herbicides are used because it obviates the need for spraying the chemicals close to the plant.

In controlling weeds, either one method is preferred; slashing or herbicidal weed control. Soil cultivation must be avoided as much as possible to prevent the superficial roots of the cacao plants from being disturbed. A herbicide formulation which was found to be safe for both coconut and cacao was reported in Malaysia. This consists of a mixture of 2 to 3 pints Anzar (MSMA) with 5 lbs sodium chlorate in 40 gallons of water. In using herbicides every precaution must be taken to prevent spray drift onto the seedlings. It is enough that weeds are controlled in a strip 3 ft beyond the spread of the cacao canopy. Spraying is normally repeated before 50 percent weed regeneration has occurred. At about the end of the third year from transplanting the complete canopy of the cacao trees restricts the development of weeds. At this time very little weed control is necessary.

Pruning. The first pruning done in a cacao plantation aims at controlling the height at which the first jourquette is formed. It is important that the first jourquette develops at a height of at least 5 ft, because when it does not, harvesting and maintenance operations will be greatly impeded. Satisfactory height of the jourquette is achieved by undertaking monthly inspection of the plantation followed by pruning off those which start to develop below the desired height. After pruning, a new (single) vertical growth is allowed which will eventually form a new jourquette at a desirable height. All chupons that may arise after pruning must necessarily be removed as early as possible.

The fan branches in a jourquette must also be controlled. Overcrowding results to ineffective utilization of solar energy. In fact some of the leaves of overcrowded branches become liabilities rather than assets with respect to cacao nutrition. To prevent overcrowding, it is necessary to reduce the number of branches in a jourquette to two. This is done by pruning the fan branches that are parallel to the row of cacao and retaining the two branches perpendicular to the row. This is applicable when the distance between the rows

of cacao is farther than the distance between plants in the row. When the row and in-the-row plants are equidistant, four fan branches perpendicular to each other may be retained. The over-all aim in the control of fan branches is to spread the branches and leaves more uniformly throughout the area and to prevent overlapping and overcrowding of branches and leaves. Maintenance pruning must be observed by all workers in the plantation. Chupons must be removed while they are still young and succulent. Pruning grown chupon will create bigger wounds that can be detrimental to the plant. Well-formed small twigs inside the canopy with less than five leaves are also pruned because they are not capable of supporting fruits to maturity. Broken and diseased branches and those attacked by pests must be likewise removed.

In areas frequently visited by strong winds formation of jourquette at lower heights may be allowed. Observation in Davao showed that the plants whose jourquette developed at the height of 5 ft or higher became top heavy and the trees lean badly.

Fertilizers. Accurate information on the nutrient requirements of cacao grown under coconut is not yet available and fertilizer trials now in progress should provide the much-needed information. Early responses in fertilizer trials have indicated that nitrogen is the main requirement during the immature stage of cacao plantings.

Differential fertilizer requirements by the two crops raise problems of application. Observation suggests a nitrogen and magnesium requirement for both crops, a high calcium for cacao, and potassium mainly for coconuts. The antagonistic activity of calcium and potassium is capable of inducing an imbalance in available nutrients, which is probably less critical for coconut nutrition. Indirect reduction of calcium availability may occur if an acidifying fertilizer such as ammonium sulfate is used. This is corrected in Malaysia by applying calcium ammonium nitrate. Fertilizer is applied (in circles around the young cacao trees) at six months intervals (after leaf and flower flushes) during the first two years from field planting. The application is done by broadcast thereafter.

The general fertilizer recommendation being followed in Malaysia both in a pure stand of cacao and those planted under coconuts are as follows:

a) Immature

| Months after planting | Fertilizer type | Amount/tree |
|-----------------------|------------------------------|-------------|
| 1 | 15:15:6:4 | 30 - 60 g |
| 3 | Calcium Ammo-Sulfate (26% N) | 30 - 60 g |
| 5 | 15:15:6:4 | 60 - 90 g |
| 8 | Calcium Ammo-Sulfate (26% N) | 60 - 90 g |
| 10* | Ground Magnesium Limestone | 240 - 300 g |
| 12 | 15:15:6:4 | 60 - 90 g |
| 15 | 15:15:6:4 | 90 - 120 g |

| | | |
|----|------------------------------|-------------|
| 18 | Calcium Ammo-Sulfate (26% N) | 90 - 120 g |
| 21 | 15:15:6:4 | 90 - 120 g |
| 24 | 12:12:17:2 | 120 - 150 g |
| 27 | 12:12:17:2 | 180 - 240 g |
| 30 | 12:12:17:2 | 180 - 240 g |

*Only if pH is below 5.5

b) Mature

| 3 rounds/yr | Fertilizer type | Amount/tree |
|--------------|-----------------|-------------|
| 1st 4 months | 12:12:17:2 | 180 - 240 g |
| 2nd 4 months | Ca-Ammo-Nitrate | 180 - 240 g |
| 3rd 4 months | 12:12:17:2 | 180 - 240 g |

One pound limestone per tree per year is applied if pH is below 5.5. Higher dosages are used for poorer soil types.

The suggested standards for foliar and soil analysis being used in Papua, New Guinea are presented in Tables 1 and 2.

Pest and Disease Control. Information regarding the control of pests and diseases on cacao planted under coconuts is still inadequate in the Philippines. For our guidance the report of Leach *et al.* (1971) maybe useful for the present.

a) Pest Control - Caterpillars quite frequently cause significant damage on young seedlings soon after transfer to the field, and prophylactic monthly sprays with Rogor 40 have been found effective. Great attention is paid to protecting the terminal flushes so that growth is not retarded. The dangers of taint from this product are well-recognized, so it is not used more than 12 to 14 months after field planting. Thereafter, lead arsenate is the favored spray for caterpillar control, but, if found ineffective, Dipterex SP80 or Sevin 85S are applied. These two formulations are also used for cockchafer beetle control, *Apogonia* sp. and *Lepidoretus* sp. the two species being the most frequently encountered.

Lindane is still effective for the control of *Helopeltis clavifer* attacks that occur in Malaya, which seem to occur more on pods than on shoots. At present they are of slight significance but there is the very real danger of severe attacks as the size of plantings increases. Mealybugs and scale insects sometimes require control, and this can be done by the application of Albolineum or a kerosene/soap mixture. When the various formulations do not contain spreading or sticking agents, 0.025 per cent Citowett is added to the spray solution. Knapsack sprayers are used in young plantings but in older stands, motorized mistblowers are employed.

Once the trees have become well-established, selective insecticide sprays are applied only when there is appreciable damage and no indication of control by natural predators can be found. This practice is adopted to prevent any disturbance in the natural population

balance which may occur following excessive use of pesticides.

Mammalian pests can be serious if not controlled regularly. Chief amongst these are rats, which are normally present in significant numbers in the coconut stand. Both paper-wrapped and paraffin wax-based baits have been used with success. In each case the poison ingredient is an anticoagulant, usually Warfarin, which is incorporated in a mixture of maize, fish heads and palm oil. Other mammalian pests are musang (*Arctogalidia* sp.) and squirrels, these being controlled largely by hunting. An unusual and infrequent type of pod damage is caused by birds.

b) Disease Control - Although root diseases caused by *Ganoderma pseudoferreum*, *Fomes lignosus* and *F. noxius* occur on rubber in West Malaysia, this type of disease is very rare in cacao grown under coconuts, since the forest timbers of the original stand have long since disappeared and there are virtually no infection foci.

Similarly, stem infections occur only infrequently. Pink disease, caused by *Corticium salmonicolor*, can be successfully controlled by spraying with copper fungicide. Following branch damage caused by falling coconut fronds or nuts, thread blight is quite common. This is caused by various fungi, but controllable by copper fungicide application and pruning off dead branches. Leaf diseases have no economic significance.

Most pod rots follow rodent attack and are associated especially with *Botryodiplodia theobromae* and *Fusarium* sp. Experiments have shown that as elsewhere, these fungi are unable to attack undamaged pods, and their incidence appears to be directly related to the efficiency of rodent control.

Black pod caused by *Phytophthora palmivora* has been recorded in areas of cacao monoculture in Malaya, together with infrequent infection by another species, *P. heveae*. So far these fungi have not been recorded on cacao under coconuts. There is, however, every likelihood that this apparent absence is merely temporary, since the monsoonal climate of Malaya seem to favor more the development of the pathogen on other hosts rather than on cocoa.

By far, the most serious disease of cacao in Malaysia is dieback. This has been especially severe where cacao of the Amelonado variety was planted, and in such areas dieback has been considered the major factor limiting yield. The upper Amazon varieties and the crosses between these and Amelonado planted more recently, appear to be less susceptible to the disease. The causes of dieback in Malaysia are obscure, a situation which is normal for this particular disease complex. In the coastal clay soils where the underplantings are situated, the number of factors possibly associated with dieback are numerous and these may include 1) wide fluctuation in the water table; 2) periodic salinity of soil moisture; 3) inhibition of root develop-

ment in close-textured soils; 4) improper soil acidity (the correct range is usually pH 4-5); 5) low total sunlight during monsoon periods and 6) inadequate nutrition, especially that of calcium. Many fungi have been isolated from branches affected by dieback but it seems unlikely that they are the primary pathogens; diseased tissues from early stages of dieback are fre-

quently without fungal infection, indicating an underlying physiological cause of this condition. Lesser branches affected by the disease are pruned off to a distance of about 2 ft below internal symptoms. In very severe cases the trees are cut and basal chupons are allowed to replace the main trunk.

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Table 1. Suggested standards for foliar analysis for cacao.

| | pH | N % | P % | K % | Ca % | Mg % |
|---------------|-----|--------|--------|--------|---------|---------|
| Above Normal | 7.5 | .80 | 9.0 | 1.2 | 13 | 8.0 |
| Normal | 6.5 | .60 | 7.0 | .8 | 8 | 3.0 |
| Hidden Hunger | 5.5 | .40 | 5.5 | .5 | 5 | 1.0 |
| Critical | 5.0 | .30 | 4.5 | .3 | 3 | .5 |
| Deficient | 4.0 | .20 | 3.5 | .2 | 1.0 | .2 |

Table 2. Suggested standards for soil analysis for cacao.

| | N % | P3 % | K % | Ca % | Mg % | Mn ppm | Fe ppm | Zn ppm | Cu ppm | Bo ppm | S ppm |
|---------------|--------|---------|--------|---------|---------|-----------|-----------|-----------|-----------|-----------|----------|
| Above Normal | 3.3 | .35 | 3.0 | 3.0 | 1.5 | 100 | 100 | 70 | 10 | 70 | 800 |
| Normal | 2.7 | .25 | 2.3 | 1.6 | .6 | 50 | 62 | 40 | 7.2 | 38 | 400 |
| Hidden Hunger | 2.3 | .16 | 1.6 | .8 | .4 | 30 | 50 | 30 | 6 | 25 | 300 |
| Critical | 2.1 | .13 | 1.2 | .6 | .34 | 21 | 40 | 24 | 5 | 18 | 250 |
| Deficient | 1.9 | .11 | 1.0 | .4 | .3 | 15 | 30 | 20 | 4 | 15 | 200 |