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# The Present Situation and the Problems of Land Use and Crop Production in Central and West African Countries —A Comparison of the Annual Amount of Precipitation and Net Primary Productivity in those Countries

Akio SUMI and Tadao C. KATAYAMA*

(*Laboratory of Tropical Crop and Experimental Farm**)

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## Introduction

In 1984 and 1985, "Studies on distribution and ecotypic differentiation of wild and cultivated rice species in Africa**" were carried out in eight African countries, i.e., Gambia, Ivory Coast, Kenya, Liberia, Madagascar, Nigeria, Senegal and Tanzania[7]. During the period of these surveys, members for field survey drove several hundred kilometers a day by car in order to collect various types of the wild and cultivated rice. These trips also gave us a good chance to observe various types of climate and vegetations, and to observe, also, the various forms of agriculture used under a wide variety of climatic conditions ranging from tropical forest zones to semi-arid zones.

Most of the African countries have been faced with serious food crises in recent years. At first, most reports linked the majority of food crises in African countries with the unusual weather like severe droughts. Recently, we have some reports which are going to connect food shortages not only with drought conditions but also with the social, economic and political problems in each country. It has been definitely shown by recent research that food crises in African countries may be ascribed to a lot of deep-seated factors, such as the stagnation and low level of agricultural productivity[11], the rapid population growth[11], and miscarriages of government agricultural policy and enforcement plans[3,4,5,10]. It is clear that unless these difficulties were settled quickly, most African countries would be left far from realizing their full potentialities and might be confronted with a bleak future.

This paper will give attention to the relationship between the annual amount of precipitation and net primary productivity, with the consideration of the land use and the maximum potential yield of food crops in each country, it will also attempt to discover why the agricultural productivity has been left stagnant and at a low level in Africa, especially in sub-Saharan Africa.

## Materials and Methods

The investigated regions involve 21 countries*** which are situated in central- and

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***: Senegal and Gambia were treated in one lot as Senegambia.

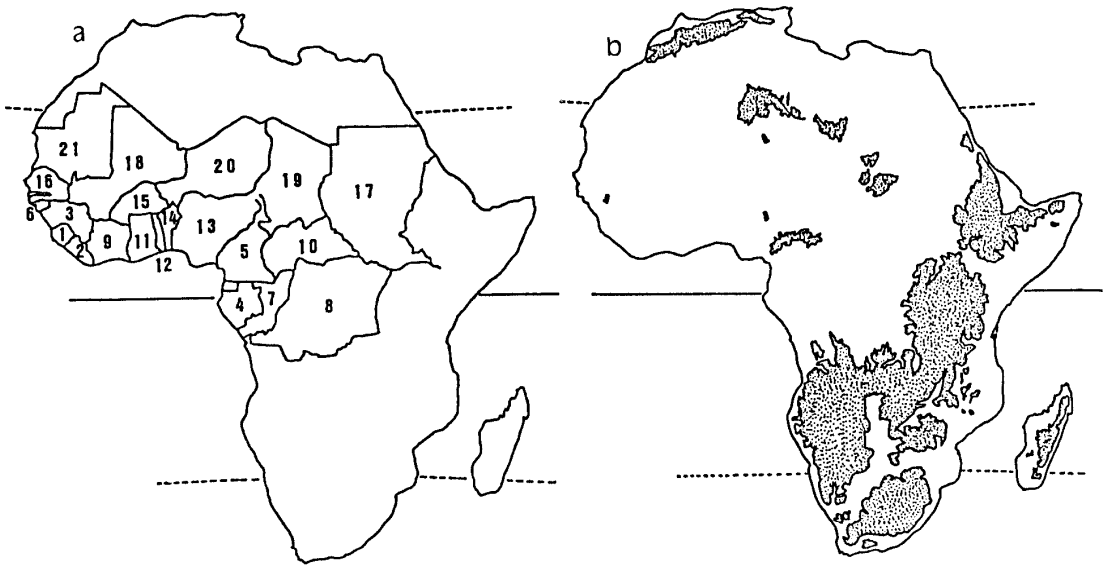


Fig. 1. The countries* investigated in this paper and African topography.
*: Senegal and Gambia was treated in one lot as Senegambia
1: Sierra Leone, 2: Liberia, 3: Guinea, 4: Gabon, 5: Cameroon, 6: Guinea Bissau, 7: Congo, 8: Zaire, 9: Ivory Coast, 10: Cent. Afr. Rep., 11: Ghana, 12: Togo, 13: Nigeria, 14: Benin, 15: Burkina Faso, 16: Senegambia, 17: Sudan, 18: Mali, 19: Chad, 20: Niger, 21: Mauritania
▒ indicates the highland more than, or equal to, 1,000 meters in altitude.

west-Africa (Fig. 1a). The topography of this area is relatively monotonous because most of the region consists of flat ground or gently-sloping hills below 1,000 meters in altitude, excepting the Tibesti Plateau in Chad, Adamoua Mountains in Cameroun and Marra Mountains in Sudan (Fig. 1b), where the annual mean air temperature is higher than 20°C[9], and where the annual amount of precipitation changes considerably and regularly from those greater than 4,000 mm in west and east coastal districts to those less than 100 mm in the inland districts with increasing latitude[9].

According to the "isohyetal map method"[6], the average annual amount of precipitation in each country was estimated. Furthermore, according to the "Miami model"[8], the average net primary productivity in each country was assessed.

In order to grasp the present situation of land use in each country, the land, according to the FAO Production Yearbook[2], was parceled out into the four lots, i.e., the land under temporary and permanent crops, forests and woodland, permanent meadows and pastures, and the other land (including fallow land caused by shifting cultivation). The data used in the present paper were quoted from the average value for three years, from 1974 to 1976, and are from the FAO Production Yearbook[2].

Furthermore, the yielding capacity of food crops in each country was assessed by the following equation.

$$Y_F = \frac{Y_C/\bar{Y}_C \times A_C + Y_R/\bar{Y}_R \times A_R + Y_P/\bar{Y}_P \times A_P}{A_C + A_R + A_P} \qquad \text{Eq. (1)}$$

where; $Y_F$: Yielding capacity index of food crops in each country.
$Y_C$, $Y_R$, $Y_P$: Mean yield for three years, from 1974 to 1976, of cereals, roots and tubers, and pulses in each country, respectively.
$\bar{Y}_C$, $\bar{Y}_R$, $\bar{Y}_R$: Mean yield for three years, from 1974 to 1976, of cereals, roots and

tubers, and pulses throughout the world.

$A_C$, $A_R$, $A_P$: Mean harvested area for three years, from 1974 to 1976, cereals, roots and tubers, and pulses in each country, respectively.

To grasp the population density in each country, the estimated value in 1975 was used[1].

## Results

### 1. Land use and net primary productivity

The present situations concerning the land use in the world and in the central and west African region are shown in Table 1. The region was distinguished by the percentage of land under temporary and permanent crops, and by that of permanent meadows and pastures comprising only 6.3% and 19.5% of land in this region, being 4.7% and 4.8% less than the world average. The percentage of other land reached 40.4%, which was 7.6% greater than the world average.

Table 1. The present situation of land use in central and west African regions and the world

| | L 1 | L 2 | L 3 | L 4 |
|---|---|---|---|---|
| A | 11.0 | 31.9 | 24.3 | 32.8 |
| B | 6.3 | 33.8 | 19.5 | 40.4 |
| B−A | −4.7 | +1.9 | −4.8 | +7.6 |

Note: L1, L2, L3, and L4 indicate the percentage of land under temporary and permanent crops, forests and woodland, permanent meadows and pastures, and other land, respectively. A and B indicate the world's average and the region's average, respectively.

The percentage of land under temporary and permanent crops (L1) and that of forests and woodland (L2) showed positive correlations with the net primary productivity (NPP), and the percentage of permanent meadows and pastures (L3) and that of other land (L4) showed negative correlations with NPP. In particular, the correlations between NPP and L2 and L4 were significant at the 1% level ($r=0.687^{**}$ and $r=-0.627^{**}$). Fig. 2 shows the fact that the relationships between NPP and [L1+L2] and [L3+L4] tended to increase and decrease with an increase in NPP, respectively, the correlation coefficient 0.784 being significant at the 1% level. However, the [L1+L2]/NPP ratio in the region was only 70% of the world average.

The relationships between L1 and NPP and population density (PD) are shown in Fig. 3. L1s of the region's countries, except Togo (No. 12), Nigeria (No. 13) and Senegambia (No. 16), were situated on the lower part of the line, showing the average L1/NPP ratio in the world. In this connection, the average L1/NPP ratio in the region was only 45% of the world average. In addition, there was no significant correlation between L1 and NPP ($r=0.266^{ns}$). On the other hand, there was a significant and positive correlation between L1 and PD. And, the average L1/PD ratio, that is, the cultivated acreage per capita in the region tended to be greater than the world average.

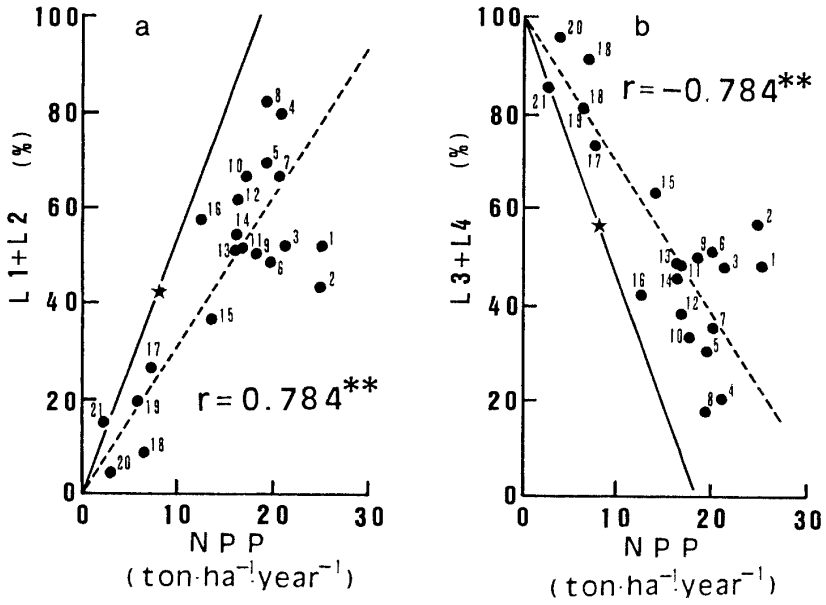


Fig. 2. Relationships between net primary productivity (NPP) and the sum of L1 and L2 [L1+L2] and the sum of L3 and L4 [L3+L4].
L1, L2, L3 and L4 are the same as those decribed in Table 1.
Figures are the same as those shown in Fig. 1.
★: The world's average, ＊＊: Significant at 1% level.

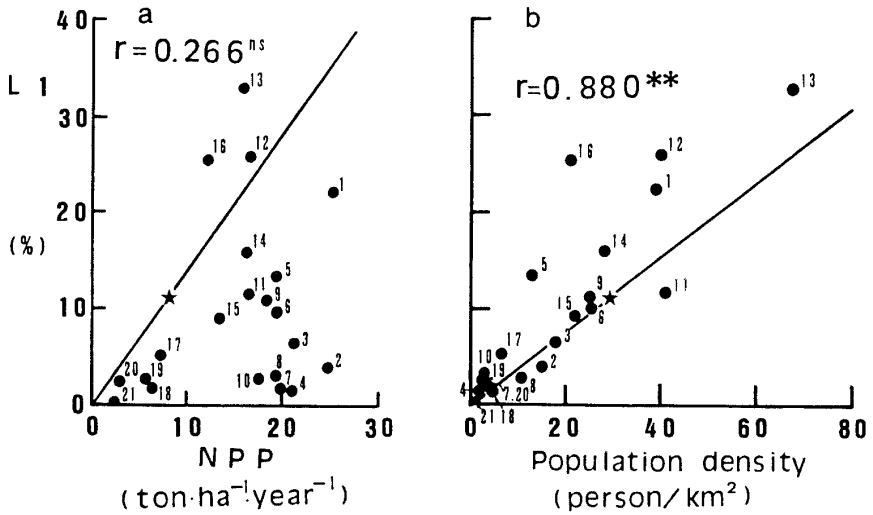


Fig. 3. Relationships between net primary productivity (NPP) and population density and L1.
Figures are the same as those shown in Fig. 1.
★: The world's average, ns: No significant, ＊＊: Significant at 1% level.

## 2. Yielding capacity of food crops and annual amount of precipitation and net primary productivity.

The relationships between the yielding capacity index of food crops ($Y_F$) [based on Eq. (1)] and the annual amount of precipitation (P) and NPP are shown in Fig. 4. There were significant and positive correlations between $Y_F$ and P and NPP, respectively ($r=0.785^{**}$ and $r=0.746^{**}$). However, the degree of the increase in $Y_F$ with the increase in P and/or NPP was remarkably

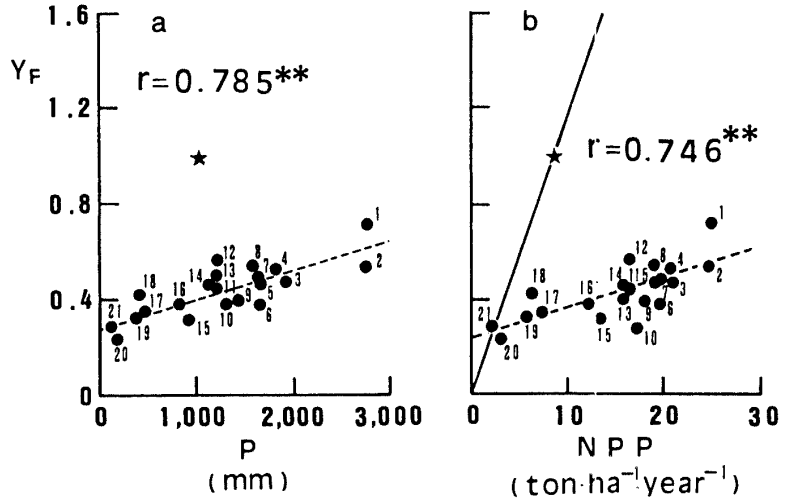


Fig. 4. Relationships between average annual amount of precipitation (P) and net primary productivity (NPP) and average yielding capacity of food crops ($Y_F$) [based on Eq.(1)].
Symbols and figures are the same as those in Fig. 2.

slower in the region. Furthermore, in all of the region's countries, the absolute value of $Y_F$, itself was remarkably below the world average.

The relationships between the $Y_F$/NPP ratio, which was regarded as the efficiency of climatic resources utilization, and P and NPP are shown in Fig. 5. In the region, there were significant and negative correlations between the $Y_F$/NPP ratio and P and NPP, respectively ($r=-0.904^{**}$ and $r=-0.929^{**}$). Most of the region's countries, excepting Mauritania, where the greater part of the country has been situated on the Sahara Desert, showed a smaller $Y_F$/NPP ratio than the world average. For example, in all the countries having more than, or equal to, 1,000mm in P, the $Y_F$/NPP ratio was exactly 13–27% of the world average.

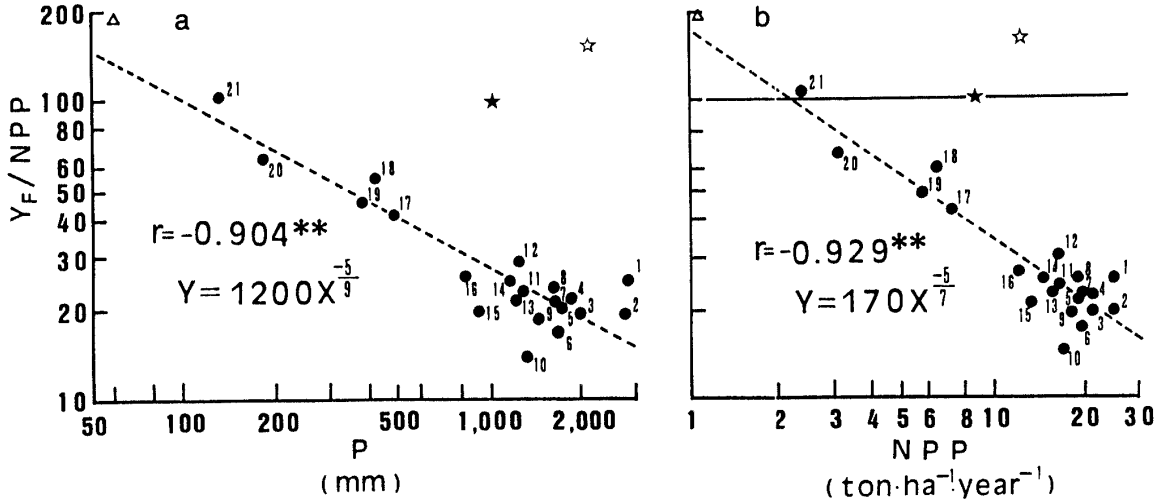


Fig. 5. Relationships between average annual amount of precipitation (P) and net primary productivity (NPP) and ratio of yielding capacity index of food crops ($Y_F$) to net primary productivity (NPP) ($Y_F$/NPP). $Y_F$/NPP in each country was indicated to regard the world's average as 100.
Figures are the same as those shown in Fig. 1.
★: The world's average, ☆: Japan's average, △: Libya's average, **: Significant at 1% level.

## Discussion

The present situation of land use in central and west African regions were closely connected with NPP contingent on P (Fig. 2). In particular, the fact that L2 and L4 have increased and decreased with an increase in NPP, respectively, is of great interest, because the relationships are in accord with the changes in the region's vegetations, from tropical rainforest, via savanna and steppe, to desert, with a decrease in P. It may be assumed that such a close connection between the region's land use and NPP and/or P may be affected a little by other factors, such as the topography and temperature.

Secondly, land use in the region was distinguished by the fact that both L1 and L3 were smaller, and L4 was remarkably greater, than the world average. The reasons why the region has less L3 may be connected partly with the tsetse fly which is a carrier of trypanosomiasis and inhabits most of the region, and also with the vanishment of permanent meadows and pastures caused by desertification (See Fig. 6 that will be shown later). On the other hand, judging from the fact that there was no significant correlation between L1 and NPP (Fig. 3a), and that L1 was closely connected with PD (Fig. 3b), it may be assumed that L1 has been prescribed, not by NPP and/or P, but by PD. The region's PD in 1975, by the way, was only about half the world average.

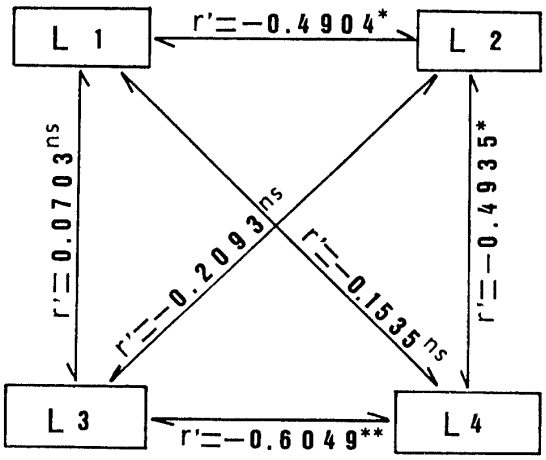


Fig. 6. Partial correlations, in case NPP was kept constant, among L1, L2, L3 and L4.
ns: No significant, *: Significant at 5% level, **: Significant at 1% level

Because Africa has the greatest population growth rate of all the continents[1], it is a good bet that a rapid rise in PD will be brought forth in the region in the future. Concerning how such a rapid rise of population pressure will affect land use in the region, Fig. 6 shows the partial correlationship. In this case NPP was constant, among L1, L2, L3 and L4. L1 was significantly and negatively connected with only L2. This suggests that the extension of L1 with the increase in PD will progress mainly with the decreasing in L2, which has been getting an important position for the maintenance of the ecosystem. In addition, in the region, L2 was also closely and negatively connected with L4. This relationship may be depending upon deforestation and woodcutting for fuel and construction, and shifting cultivation in the region. The average L2/NPP ratio in the region, by the way, was already only 80 percent of the world average. There are some suggestions that the rapid decrease in L2 has worked havoc upon the order of the ecosystem,

accelerating the fragility of the ecosystem by causing unusual weather[3]. Therefore, it can reasonably be imagined that more extension of L1 may become dangerous even to the conservation of national land and to the maintenance of fertility.

Judging from only the L1/NPP ratio in the region, it can be understood that it is possible to extend the arable land further. Maybe, such an inconsistency suggests that there is an extreme unbalance between agroclimatic resources and land use in the region. Therefore, land redeveloped with the agroclimatic resources and the ecosystem in mind is to be strongly expected in the region. On the other hand, judging from the fact that the cultivated acrage per capita tended in the region to be greater than the world average, it may be difficult to correlate directly the inadequate food production capability in the region with the lowness of L1.

It has been definitely shown in Fig. 4 that the yielding capacity index of food crops ($Y_F$) in the region was considerably less than the world average. To what is the extremely low yielding capacity in the region due ? In view of the fact that the $Y_F$/NPP ratio in most of the region's countries except Mauritania was less than the world average (Fig. 5.), it comes to be a likely assumption that the extremely low $Y_F$ figures for the region arise, not from the loss of climatic resource, but from the low efficiency of climatic resource utilization. Such a tendency becomes more conspicuous in the wetter countries. Therefore, in order to achive a food production increase, it is of urgent necessity for the wetter countries, to make plans which will promote the efficient utilization of climatic resources, such as the introduction of high-yielding varieties, improvements in fertilizer application techniques and disease-, insect- and weed-controllings.

It has been also definitely shown in Fig. 5 that the restriction of climatic resources on the increased yield of food crops becomes greater in the drier countries. Though Egypt is a country of remarkably little rain, its $Y_F$ was about two times as large as the world average (unshown). Such a high $Y_F$ is likely to be supported by the fact that the percentage of irrigated land is very high (about 100%) and that the amount of fertilizer application is also very high (greater than 4 times of the world average of nitrogenous fertilizers). In comparison with Egypt, the percentage of irrigated land in the region's countries was only a few percent except in Sudan (12.7%). Therefore, in the drier countries, it is expected that the remedy for climatic problems will be the perfection of irrigation equipments.

Although it is necessary to consider the influence of annual fluctuation in P on NPP further, it was estimated that the region is, fundamentally or on an average, in possession of a larger NPP than the world average. According to a model, the potential food productivity in sub-Saharan Africa is said to be greater 128 times than, or equal to, the production level of 1965[10]. These results suggest that the possibility of increased food production in the region will be far from negative, and that factors such as the improvement of the infrastructure, the technical revolution, etc. are very important for solving the food problems in the region.

## Summary

The present situation and the problems of land use and crop production in central and west African countries were discussed, compared with the annual amount of precipitation and the net primary productivity in those countries.

The results obtained are summarized as follows;

1. The present situation of land use in the region was distinguished by both the percentage of land under temporary and permanent crops (L1), and that of permanent meadows and pastures

(L3) which was less than the world average, and also by the fact that the percentage of other land (L4) is considerably greater than the world average (Table 1).

**2.** Although the sum of L1 and the percentage of forests and woodland (L2) [L1+L2] tended to be increasing with an increase in net primary productivity (NPP) which is estimated on the basis of annual amount of precipitation (P), the [L1+L2]/NPP ratio in the region was only 70% of the world average. This result was based on the evidence that both the L1/NPP ratio and the L2/NPP ratio were less than the world average (Fig. 2).

**3.** There was a significant and positive correlation between L1 and population density. On the other hand, it was indicated that the extention of land under temporary and permanent crops tended to make a progression mainly with a decreasing in forests and woodland (Figs. 3 & 6).

**4.** The yielding capacity index of food crops ($Y_F$) [based on Eq. (1)] in the region was significantly and positively connected with P and NPP. However, the degree of increase in $Y_F$ with the P and/or NPP was considerably slower, and the absolute value of $Y_F$, itself, was remarkably below the world average (Fig. 4).

**5.** The $Y_F$/NPP ratio in most of the region's countries except Mauritania was less than the world average, in addition, the $Y_F$/NPP ratio became smaller in the wetter countries. These results suggest that the extremely low efficiency of climatic resource utilization has limited $Y_F$ in the region, and that the influencing power of climatic resources upon $Y_F$ has been greater in the drier countries (Fig. 5).

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## References

1) Demographic Yearbook (27). p. 1–1118, United Nations, New York (1976)
2) FAO Production Yearbook (36). p. 1–320, Rome (1982)
3) Franke, R. W. and Chasin, B. H.: *Seeds of famine; ecological destruction and the development dilemma in the West African Sahel.* Montclair, Osmun, 1–266 (1980)
4) Glantz, M. H.: Drought in Africa. *Sci. Ame.*, **256**, 34–40 (1987)
5) Imura, S.: Present situation of food problem study in Africa. *AICAF*, **7** (2), 52–60 (1984) (in Japanese)
6) Ishibashi, Y., Tanabe, K., Naito, T. and Hayashi, H.: *Agricultural Hydrology*. p. 34–35, Corona Pub., Tokyo (1969) (in Japanese)
7) Katayama, T. C.: Studies on distribution and ecotypic differentiation of wild and cultivated rice species in Africa. *Kagoshima Univ. Res. Center S. Pac., Occasional Papers*, **No. 10**, 1–158 (1987)
8) Lieth, H.: Primary production; terrestrial ecosystem. *J. Human Eco.*, **1**, 303–332 (1973)
9) Tsuchiya, I., Aoki, S., Ochiai, M., Kawamura, T. and Kurashima, A.: *Climate of Africa*. p. 1–637, Kokon-Shoin, Tokyo (1972) (in Japanese)
10) U. S. Dept. of Agriculture. Economic Research Service: *Food problems and prospects in Sub-Saharan Africa; the dacade of 1980's*. Washington, D. C., 1–293 (1981)
11) Watanabe, T.: Problems of food strategy in Africa. *AICAF*, **7** (2), 15–32 (1984) (in Japanese)