CHAPTER IV

Plant biomass and net primary productivity in young and old jhum fallows during first year and second year of cropping

Introduction

Biomass studies are fundamental to the understanding of the dynamics of ecological systems. Estimation of biomass is essential in determining the distribution and circulation of materials in ecosystem and is necessary to understand the dynamics of these systems (Andersson, 1971). Biomass studies may be employed to describe quantitatively the static distribution of materials in ecological systems (Santantonio *et al.*, 1977).

In Mizoram cropping season of rice on jhum lands begins with sowing of seeds during middle of April to the first week of May. During the course of burning of slashed vegetation most of the seedlings, saplings and live plants of other categories are also consumed. Thus the jhum fields become more or less devoid of any live plants. Some of the weedy species start invading the jhum fields in between burning and sowing operation. First weeding is usually done after about ten days from sowing. The uprooted weeds are spread over the surface of jhum field, so that the same may be dried up and decomposed and act as green manure. However, more and more weeds grow in the agro-ecosystems and compete for various resources available in the jhum fields. Some of these weeds may be facultative heliophytes and therefore, can manage to grow even under the crop canopy. As argued by Tripathi

(1977), the weeds may increase the total organic production by utilizing the light energy which is not intercepted by the crop plants and reaches the lower stratum of agro-ecosystems which is mostly occupied by a number of weeds. The biomass accumulation by the weeds and crops may give an indication of the partitioning of inputs to the jhum fallows between them.

The present chapter deals with the biomass and productivity studies of rice and weeds in 6-yr. old and 20-yr. old jhum fallows during first year and second year of cropping. Biomass (above ground and below ground separately), percentage contribution by weeds to total biomass, and productivity were estimated for rice and weeds.

Methods

In the present study, biomass and productivity were measured by harvesting the plants from known area at periodic intervals (Odum, 1960). For estimation of biomass three monoliths of 25 x 25 x 25 cm were excavated on each sampling date (just before weeding) from each study plot. The roots of plants were washed thoroughly with running water. All weeds encountered in the sample were separated from the rice plants. Below ground parts of rice and weeds were chopped off from their corresponding shoot system. Sampling was done at monthly intervals, starting from one month after sowing of rice seeds till the earing time. The sampling was done in June, July, August and September.

Biomass of aboveground and belowground parts of rice and weeds were determined on the basis of dry weight. For the determination of biomass the plant material was over-dried at 80°C to constant weight and weighed. The net primary productivity was estimated by summing the positive differences in biomass on successive sampling dates as described by Singh & Yadava (1974). While estimating the aboveground biomass standing dead and standing live were not separated, but they were considered together. The net primary production and rate of productivity were estimated for aboveground and below-ground parts of rice and weeds separately. Percentage contribution of weeds biomass to the total biomass was also calculated.

Results

Biomass

Monthly variation of total biomass (rice plus weeds) during the study period on 6-yr. old and 20-yr. old jhum fallows are shown in Fig. 4.1 and 4.2 respectively. In general, a positive increase from first sampling date to the last sampling date was evident on all the study plots. The peak value in the case of all plots was observed at the last harvest taken in September. The biomass production was slightly more during first year of cropping than in the second year on both fallows. The peak biomass was comparatively higher on older jhum fallow than on the younger fallow in both years of cropping.

The monthly changes in biomass of rice and weeds during the study period are shown in Fig. 4.3 and 4.4. Biomass (g. m^{-2}) of aboveground and belowground parts of rice and weeds in each month during the study period is given in Table 4.1 and 4.2 respectively. Generally, the total crop biomass showed a gradual increase till the last harvest. The same trend was also evident in the case of weeds except on the sub-plots treated with chemical fertilizers and farm-yard manure in 20-yr. old jhum fallow where slight decline at the last harvest was observed.

Percentage contribution of weeds to total biomass

Percentage contribution by weeds to the total biomass in different months during the study period is given in Table 4.3. Generally, the contribution of weeds to total biomass decreased with time, being maximum in June and minimum in September on all plots, except the tilled, and fertilized sub-plots in 20-yr. old jhum fallow where the minimum contribution of weeds to total biomass was recorded in July.

Productivity

The aboveground and belowground production of rice plus weeds during the growing season on 6-yr. old and 20-yr. old jhum fallows is shown in Fig. 4.5. Generally, total production was slightly greater during first year of cropping compared to the second year of cropping on both the fallows. The older (20-yr. old) fallow showed greater aboveground and belowground production during both years of cropping.

Among the treated sub-plots, the highest total production was recorded in the sub-plot treated with chemical fertilizers and the lowest was recorded in the tilled sub-plot on the fallows of both ages. In 20-yr. old jhum fallow total production was comparatively higher in the control plot during first year of cropping in comparison to the corresponding control plot as well as the sub-plots in the second year. However, in 6-yr. old fallow the first year control plot gave a much lower total production compared to the treated sub-plots of the second year cropping, although it outyielded the tilled and control sub-plots.

The total production of rice and weeds are shown separately in Fig. 4.6 and 4.7 respectively. In general, both aboveground and belowground production of rice followed the same trend as shown by total production (rice plus weeds). However, weeds showed the reverse trend. Weeds showed lower production in the tilled and fertilizer-treated sub-plots on both jhum fallows during second year as compared to the corresponding control plots.

In 20-yr. old jhum fallow weeds showed a much higher production during second year of cropping than in the first year, while the converse was true in 6-yr. old fallow. Among the treated sub-plots, weeds showed the lowest production in the chemical fertilizer-treated sub-plots on both fallows.

Rate of productivity

Rates of productivity (g. m^{-2} day^{-1}) of rice and weeds in each month of the growing season are given in Table 4.4 and 4.5 respectively. In general there was a marked increase in productivity rate during September in both 6-yr. old and 20-yr. old jhum fallows during first year cropping. Rate of productivity of the crop increased on all the plots in 6-yr. old jhum fallow during second year of cropping. The same trend was also observed in all treated sub-plots of 20-yr. old fallow.

Rate of productivity (g. m^{-2} day^{-1}) of the crop (rice) and weeds separately, and rice plus weeds during the entire growing season are given in Table 4.6. The rate of productivity (weeds and crop considered together) was higher during

Table 4.1. Biomass (g. m^{-2}) of above and belowground parts of rice in different months during the growing season of the crop.

TREATMENT	ABOVEGROUND BIOMASS				BELOWGROUND BIOMASS			
PLOTS	June	July	August	September	June	July	August	September
6 I:C	11±1	98±2	386±15	731±26	3.5±0.5	21±1	70±4	101±6
6 II:C	10.5±1	88±5	361±10	717±55	4±0.6	19±1	64±3	98±9
6 II:T	10±0.5	78±0.5	239±19	617±34	3.5±0.5	20±1	62±4	92±4
6 II:CF	12±1	114±2	374±8	1164±50	4±0.2	38±1	91±5	132±10
6 II:FYM	11±0.5	126±6	331±13	1061±64	3.8±0.1	40±2	84±2	123±5
6 II:CF+FYM	12±1	98±10	349±23	1096±60	4±0.3	23±2	89±6	128±6
20 I:C	13±1.5	101±15	379±24	1325±51	5±0.5	25±1	91±3	148±8
20 II:C	11±0.5	96±8	313±14	908±21	4±0.2	26±1	78±8	109±11
20 II:T	12±0.5	295±9	346±14	909±39	5.5±0.4	75±4	84±4	99±2
20 II:CF	28±2	336±6	405±18	1230±50	5.5±0.6	82±4	96±2	144±2
20 II:FYM	21±2	341±4	386±17	1158±52	5.5±0.6	83±3	87±1	133±7
20 II:CF+FYM	28±1	308±4	435±7	1176±32	6.5±0.4	72±5	98±2	128±4

Table 4.2. Biomass (g. m^{-2}) of above and belowground parts of weeds in different months during the growing season of the crop.

TREATMENT	ABOVEGROUND BIOMASS				BELOWGROUND BIOMASS			
PLOTS	June	July	August	September	June	July	August	September
6 I:C	13±2	36±4	77±7	97±6	4.5±0.7	12±1	15±3	28±3
6 II:C	8±1	33±5	88±8	102±4	3.5±0.7	12±1	17±1	12±2
6 II:T	7.5±0.5	17±1	70±11	74±6	5±0.7	6±1	16±2	21±2
6 II:CF	8±1.5	32±4	75±5	87±5	6±1	11±1	14±1	21±4
6 II:FYM	16±3	24±1	84±6	91±7	8±2	9±2	17±2	25±2
6 II:CF+FYM	16±1.5	30±5	83±9	89±10	7±0.4	11±1	21±2	21±1
20 I:C	16±3	27±3	47±3	56±4	6.5±1	9±1	10±1	11±1
20 II:C	13.5±3	34±2	132±8	145±4	5±0.7	11±1	27±1	29±3
20 II:T	6±0.5	14±3	106±5	119±8	3.5±0.4	5±1	21±1	18±2
20 II:CF	13±4	38±1	120±6	110±14	5.5±0.5	14±2	22±2	23±3
20 II:FYM	18.5±3	34±8	131±8	130±12	7.5±2	10±1	24±2	22±3
20 II:CF+FYM	19.5±2	38±3	133±4	131±6	8±2	13±1	23±3	30±4

Table 4.3. Percentage contribution of weeds to total biomass in different months during crop growing season on 6-yr. old and 20-yr. old jhum fallows during first year and second year of cropping.

TREATMENT	MONTHS			
PLOTS	June	July	August	September
6 I:C	54.6	28.74	16.78	13.06
6 II:C	42.3	29.6	19.81	12.15
6 II:T	48.07	19.0	22.22	11.8
6 II:CF	46.66	22.05	16.06	7.69
6 II:FYM	60.0	16.5	19.57	8.92
6 II:CF+FYM	57.5	25.3	19.18	8.24
20 I:C	55.5	22.22	10.81	4.3
20 II:C	55.2	26.94	25.27	12.93
20 II:T	35.18	4.88	22.8	11.96
20 II:CF	34.61	3.82	22.08	8.82
20 II:FYM	49.52	9.4	24.56	10.53
20 II:CF+FYM	44.35	11.97	22.8	10.98

Table 4.4. Productivity (g. m^{-2} day^{-1}) of aboveground and belowground parts of rice in different months, during the growing season of the crop on 6-yr. old and 20-yr. old jhum fallow during first year and second year of cropping.

TREATMENT	ABOVEGROUND				BELOWGROUND			
PLOTS	June	July	August	September	June	July	August	September
6 I:C	0.36	2.9	7.6	18.5	0.11	0.58	1.6	1.03
6 II:C	0.35	2.58	5.76	15.2	0.13	0.5	1.5	1.13
6 II:T	0.33	2.26	5.36	12.6	0.11	0.55	1.4	1.0
6 II:CF	0.4	3.4	8.86	26.53	0.13	1.13	1.76	1.36
6 II:FYM	0.38	3.85	6.8	24.33	0.12	1.2	1.46	1.3
6 II:CF+FYM	0.4	2.86	8.36	24.9	0.13	0.63	2.2	1.3
20 I:C	0.43	2.93	9.26	31.53	0.16	0.66	2.2	1.9
20 II:C	0.36	2.83	7.23	27.16	0.13	0.73	1.73	1.03
20 II:T	0.4	1.7	9.43	18.83	0.18	0.3	2.3	1.66
20 II:CF	0.93	2.3	10.2	27.5	0.18	0.46	2.55	1.6
20 II:FYM	0.7	1.6	10.6	25.63	0.18	0.13	2.59	1.53
20 II:CF+FYM	0.93	4.23	9.33	24.7	0.21	0.7	2.18	1.16

Table 4.5. Productivity of above and belowground parts of weeds (g. m^{-2} day^{-1}) in different months during growing season of the crop 6-yr. old and 20-yr. old jhum fallows during first year and second year of cropping.

TREATMENT	ABOVEGROUND				BELOWGROUND			
PLOTS	June	July	August	September	June	July	August	September
6 I:C	0.43	0.79	1.36	0.66	0.15	0.25	0.1	0.43
6 II:C	0.26	0.83	1.83	0.46	0.11	0.26	0.16	0.13
6 II:T	0.25	0.31	1.76	0.13	0.16	0.03	0.33	0.16
6 II:CF	0.26	0.8	1.43	0.4	0.2	0.16	0.1	0.23
6 II:FYM	0.53	0.26	2.0	0.23	0.26	0.03	0.26	0.26
6 II:CF+FYM	0.53	0.46	1.76	0.2	0.23	0.13	0.33	0.00
20 I:C	0.53	0.36	0.66	0.3	0.21	0.08	0.03	0.03
20 II:C	0.45	0.68	3.26	0.43	0.16	0.2	0.53	0.06
20 II:T	0.2	0.26	3.06	0.43	0.11	0.05	0.53	-0.1
20 II:CF	0.43	0.83	2.73	-0.33	0.18	0.28	0.26	0.03
20 II:FYM	0.61	0.51	3.23	-0.03	0.25	0.08	0.46	-0.06
20 II:CF+FYM	0.65	0.61	3.16	-0.06	0.26	0.16	0.33	0.23

Table 4.6. Productivity (g. m^{-2} day^{-1}) of rice, weeds and rice plus weeds during the study period on 6-yr. old and 20-yr. old jhum fallows during first year and second year of cropping.

TREATMENT	RICE			WEEDS			RICE AND WEEDS
PLOTS	Above-ground	Below-ground	Total	Above-ground	Below-ground	Total	
6 I:C	6.09	0.84	6.93	0.8	0.23	1.03	7.97
6 II:C	5.97	0.81	5.78	0.85	0.175	1.02	7.81
6 II:T	5.14	0.76	5.9	0.61	0.175	0.78	6.7
6 II:CF	9.7	1.1	10.8	0.72	0.175	0.89	11.7
6 II:FYM	8.84	1.02	9.86	0.75	0.2	0.95	10.83
6 II:CF+FYM	9.13	1.06	10.19	0.74	0.175	0.91	11.11
20 I:C	11.04	1.23	12.27	0.46	0.09	0.55	12.8
20 II:C	7.56	0.9	8.46	1.2	0.24	1.44	11.92
20 II:T	7.37	0.82	8.19	0.99	0.15	1.14	9.54
20 II:CF	10.25	1.2	11.45	0.91	0.19	0.10	12.55
20 II:FYM	9.65	1.1	10.75	1.08	0.18	1.26	12.02
20 II:CF+FYM	9.8	1.06	10.86	1.09	0.25	1.34	12.2

Fig. 4.1 Standing biomass (g. m^{-2}) in different months during the crop growing season on 6-year old jhum fallow in the first year and second year of cropping. M, J, J, A and S stand for May, June, July, Agusut and September respectively.

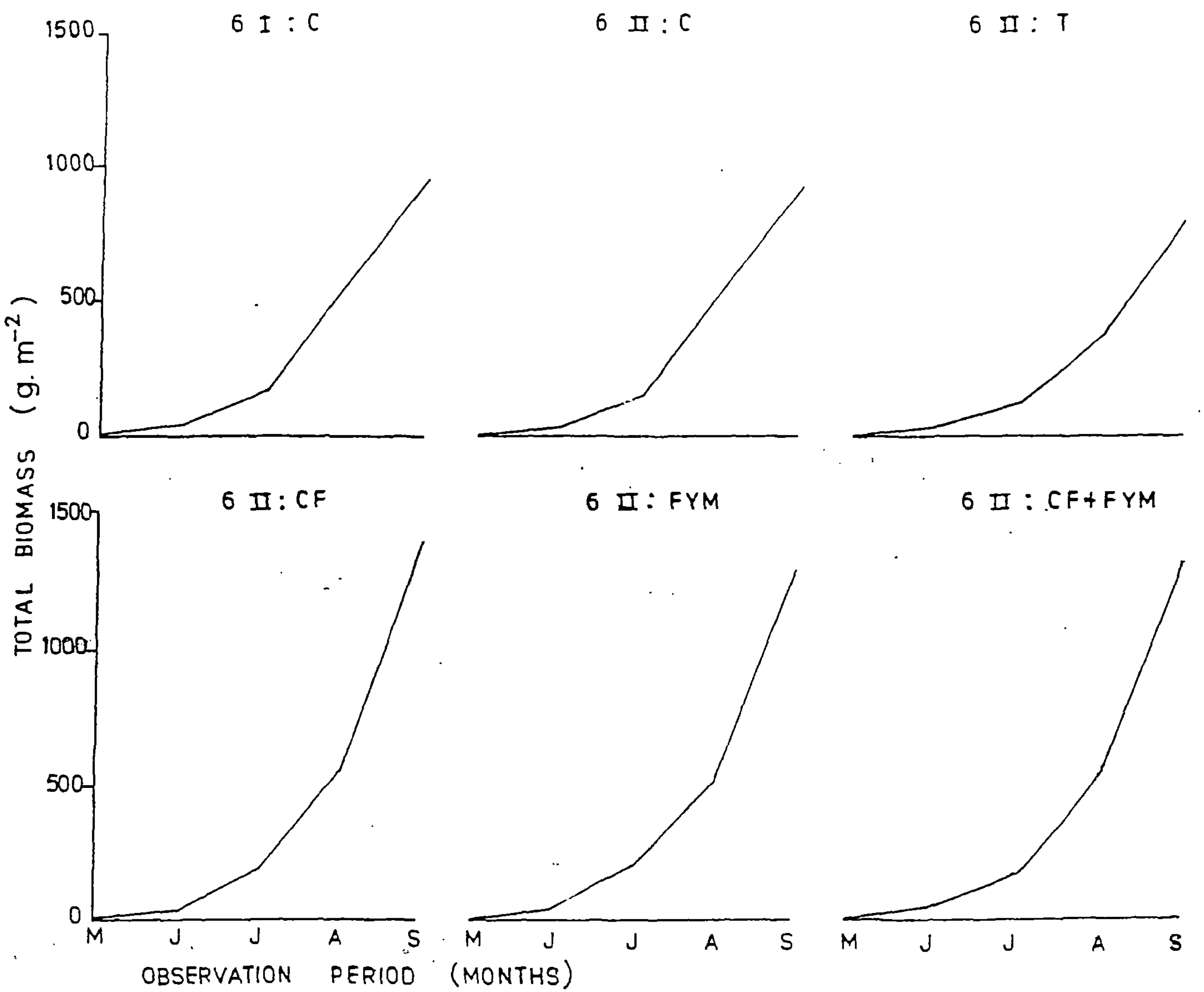

6 I : C
6 II : C
6 II : T
6 II : CF
6 II : FYM
6 II : CF+FYM
TOTAL BIOMASS (g. m-2)
1500
1000
500
0
M J J A S
OBSERVATION PERIOD (MONTHS)

FIG. 4.1

Fig. 4.2 Standing total biomass (g. m^{-2}) in different months during the growing season of the crop on 20-year old jhum fallow in the first year and second year of cropping. M, J, J, A and S stand for May, June, July, August and September respectively.

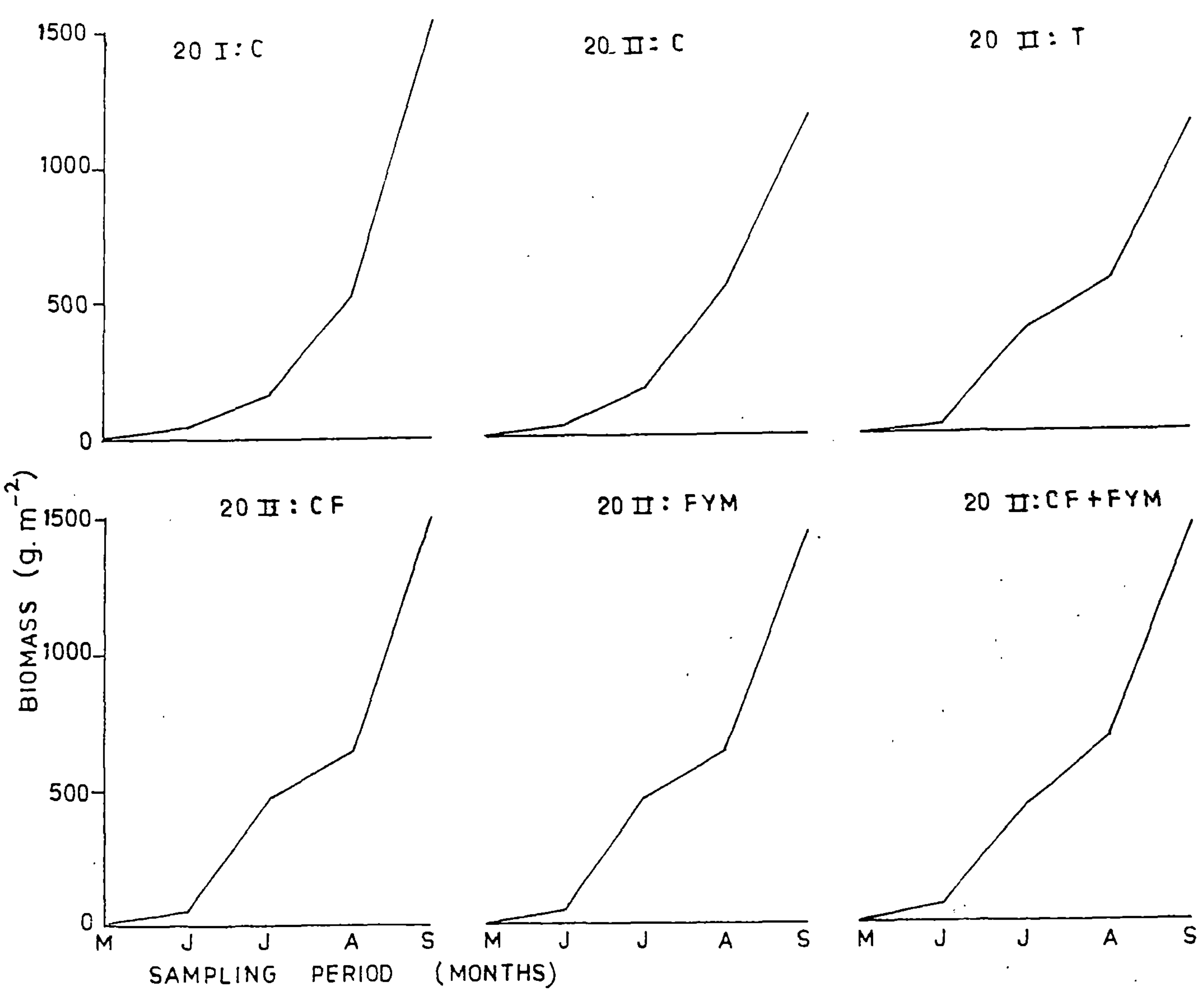
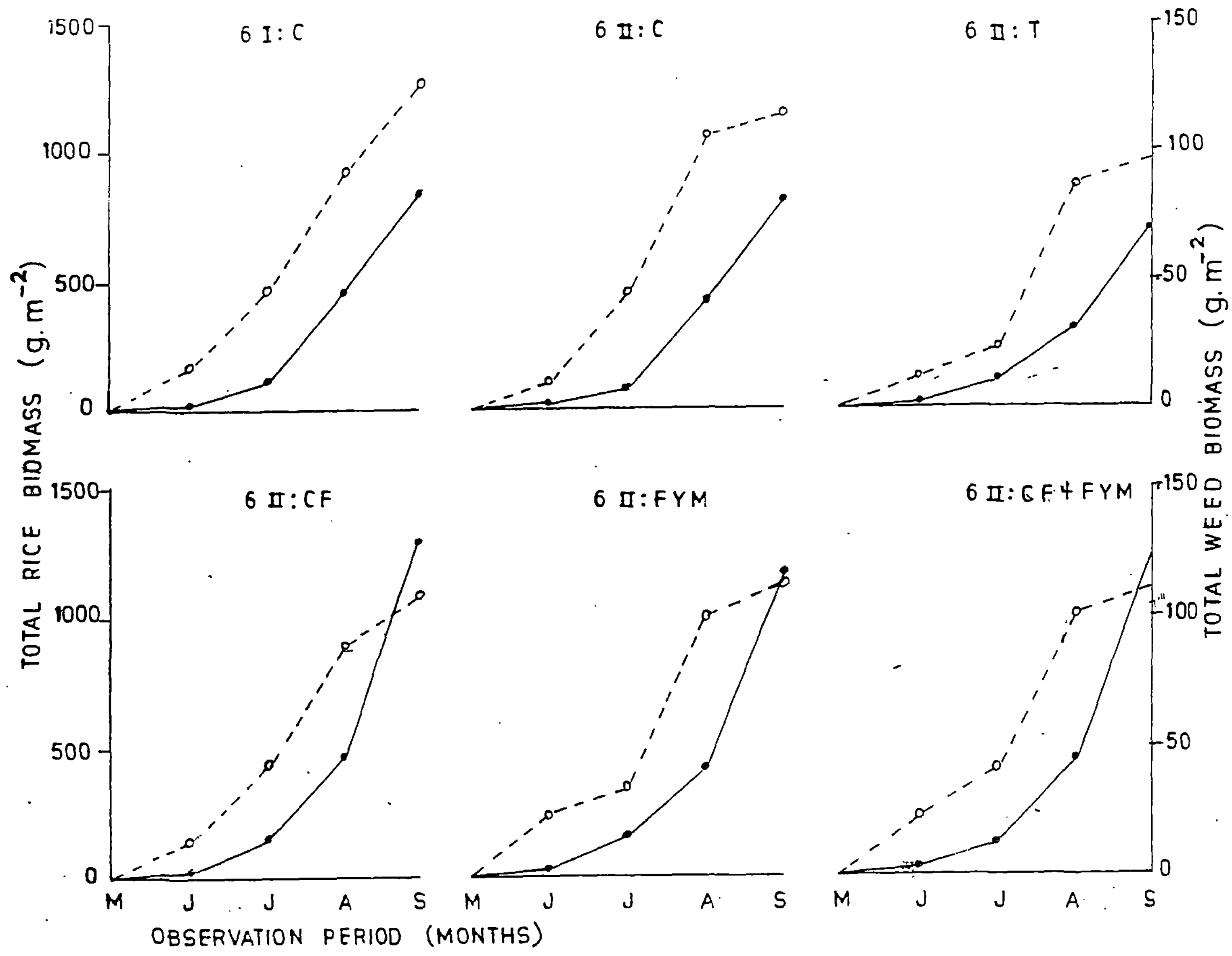

20 I : C
20 II : C
20 II : T
20 II : CF
20 II : FYM
20 II : CF + FYM
BIOMASS (g. m-2)
1500
1000
500
0
M J J A S
SAMPLING PERIOD (MONTHS)

FIG. 4.2

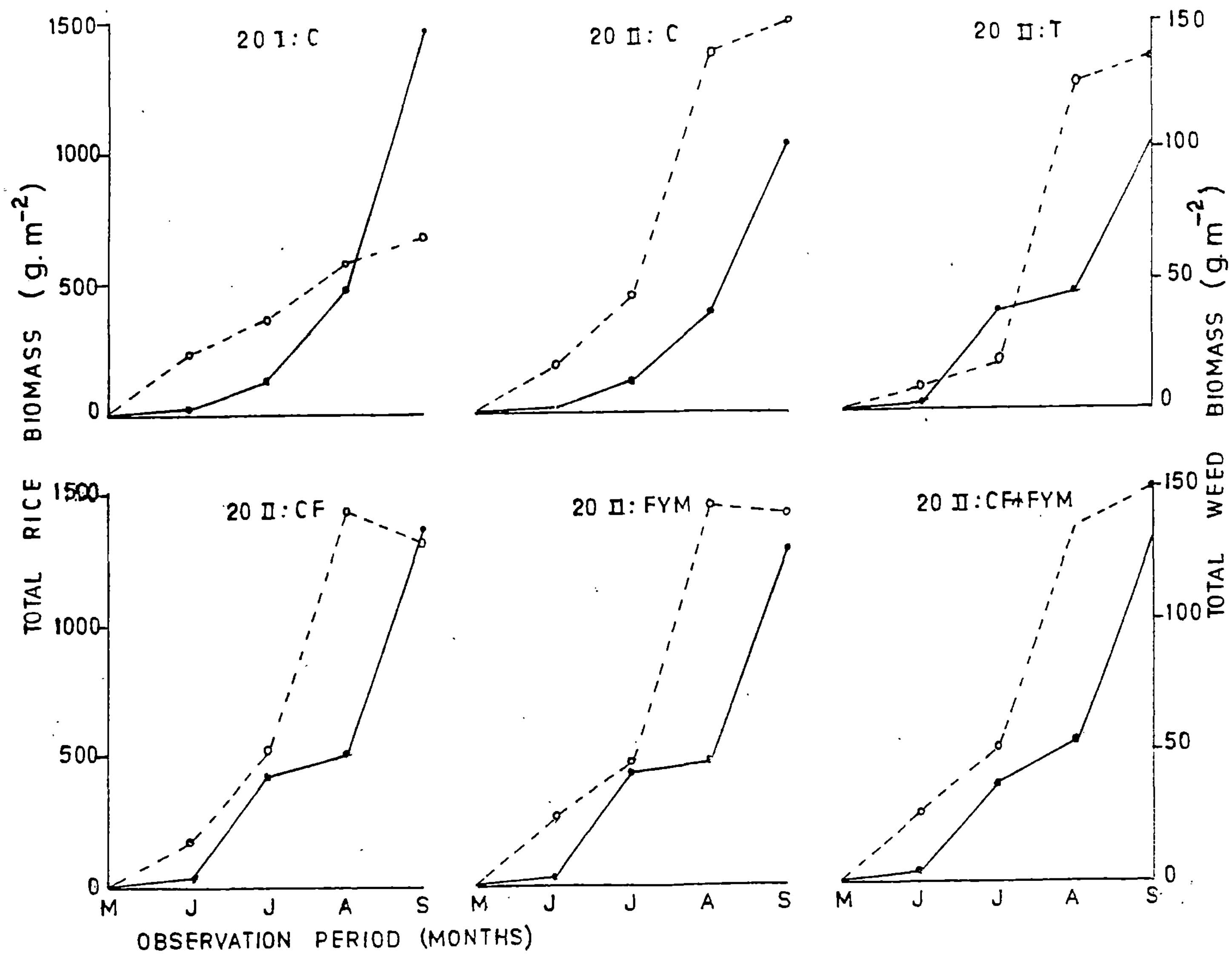
Fig. 4.3 Standing biomass ($g. m^{-2}$) of rice (——) and weeds (o----o) in different months during the growing season of the crop on 6-year old jhum fallow in the first year and second year of cropping. M, J, J, A and S are observation period as May, June, July, August and September. The difference in the scales used for the crop and weed biomass may be noted.



6 I : C
6 II : C
6 II : T
6 II : CF
6 II : FYM
6 II : CF + FYM
TOTAL RICE BIOMASS (g.m-2)
TOTAL WEED BIOMASS (g.m-2)
1500
1000
500
0
150
100
50
M J J A S
OBSERVATION PERIOD (MONTHS)

FIG. 4.3

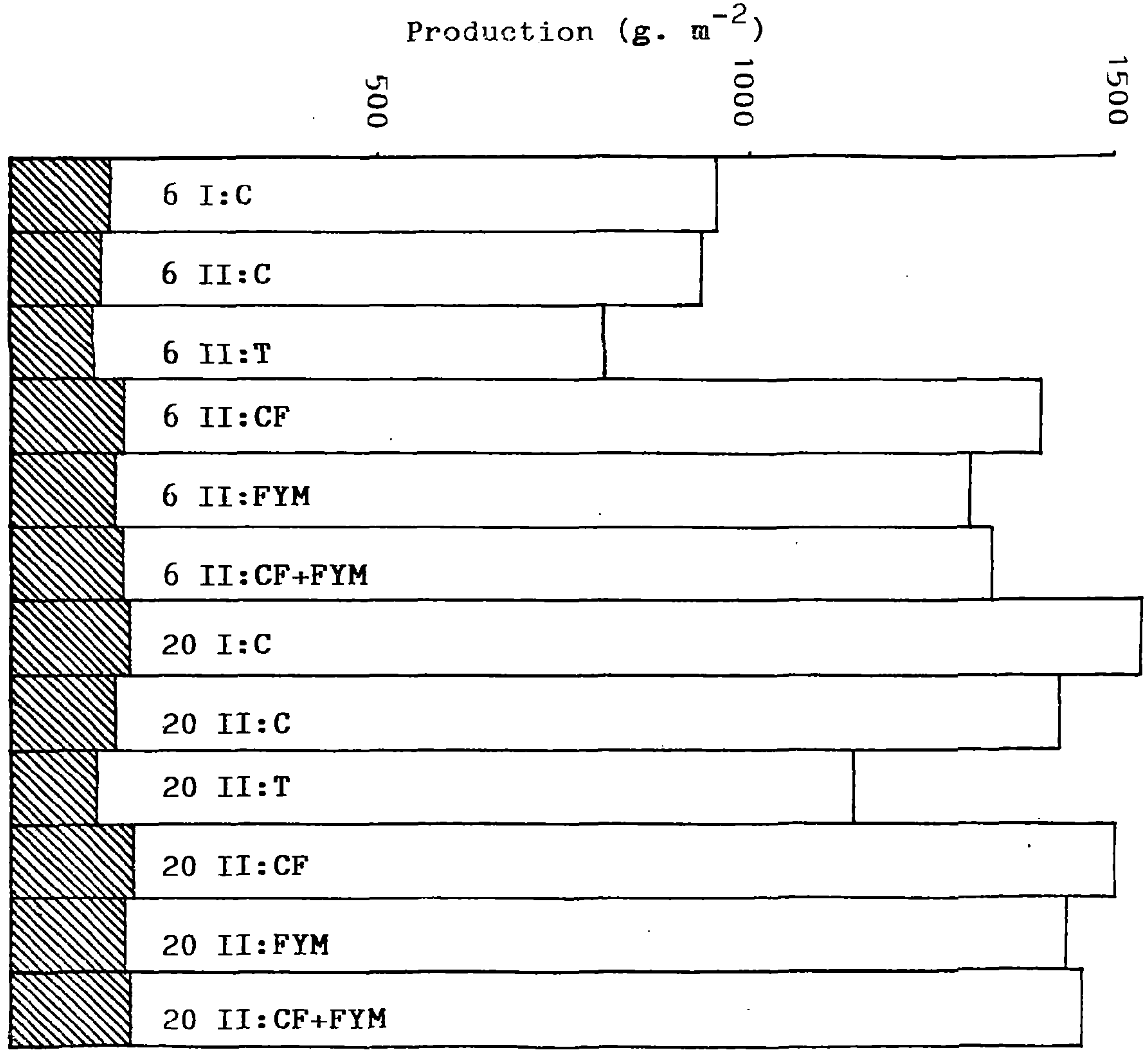
Fig. 4.4 Standing total biomass (g. m^{-2}) of rice (——) and weed (o----o) in different months of the crop growing season on 20-year old jhum fallow during first year and second year of cropping. M, J, J, A and S are observation period as May, June, July, August and Sepatember respectively. The difference in the scales used for crop and weed biomass may be noted.



20 I: C
20 II: C
20 II: T
20 II: CF
20 II: FYM
20 II: CF+FYM
TOTAL RICE BIOMASS (g.m-2)
TOTAL WEED BIOMASS (g.m-2)
0
500
1000
1500
0
50
100
150
M J J A S
OBSERVATION PERIOD (MONTHS)

FIG-4.4

Fig. 4.5 Total aboveground (□) and belowground production (▨) of rice plus weeds during the crop growing season on 6-year and 20-year old jhum fallows during first year and second year of cropping.



Production (g. m-2)
500
1000
1500
6 I:C
6 II:C
6 II:T
6 II:CF
6 II:FYM
6 II:CF+FYM
20 I:C
20 II:C
20 II:T
20 II:CF
20 II:FYM
20 II:CF+FYM

FIG. 4:5

Fig. 4.6 Aboveground (□) and belowground (▨) production of rice during the crop growing season in 6-year old and 20-year old jhum fallows in the first year and second year of cropping.

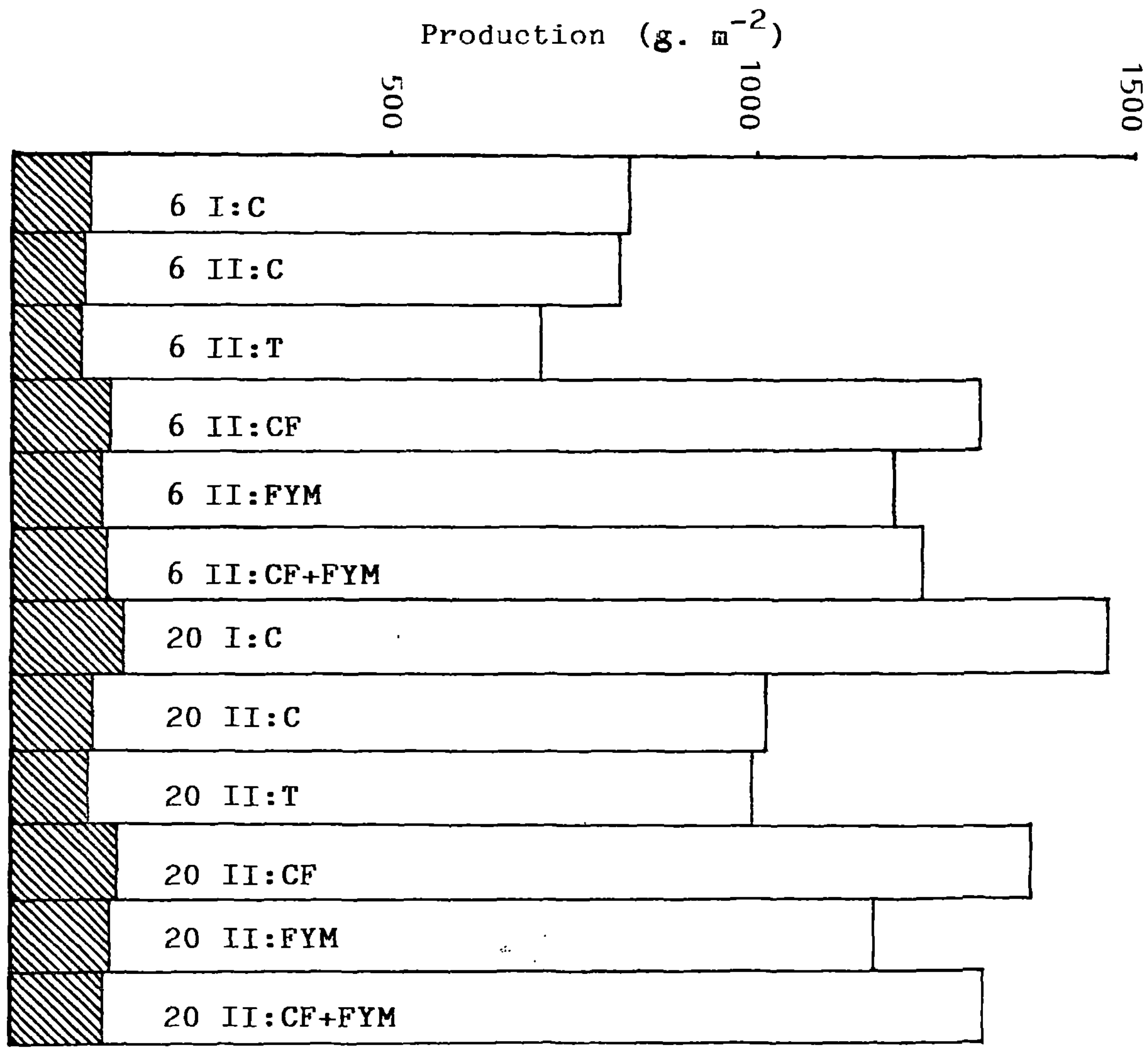
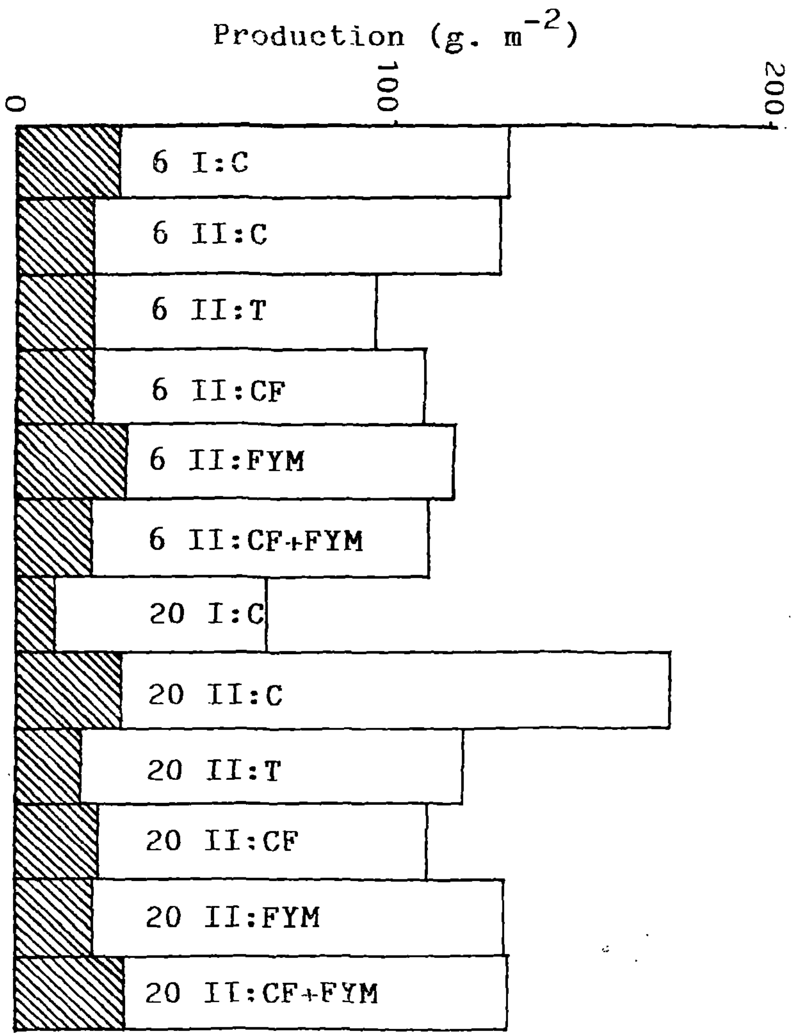

Production (g. m-2)
500
1000
1500
6 I:C
6 II:C
6 II:T
6 II:CF
6 II:FYM
6 II:CF+FYM
20 I:C
20 II:C
20 II:T
20 II:CF
20 II:FYM
20 II:CF+FYM

FIG. 4.6

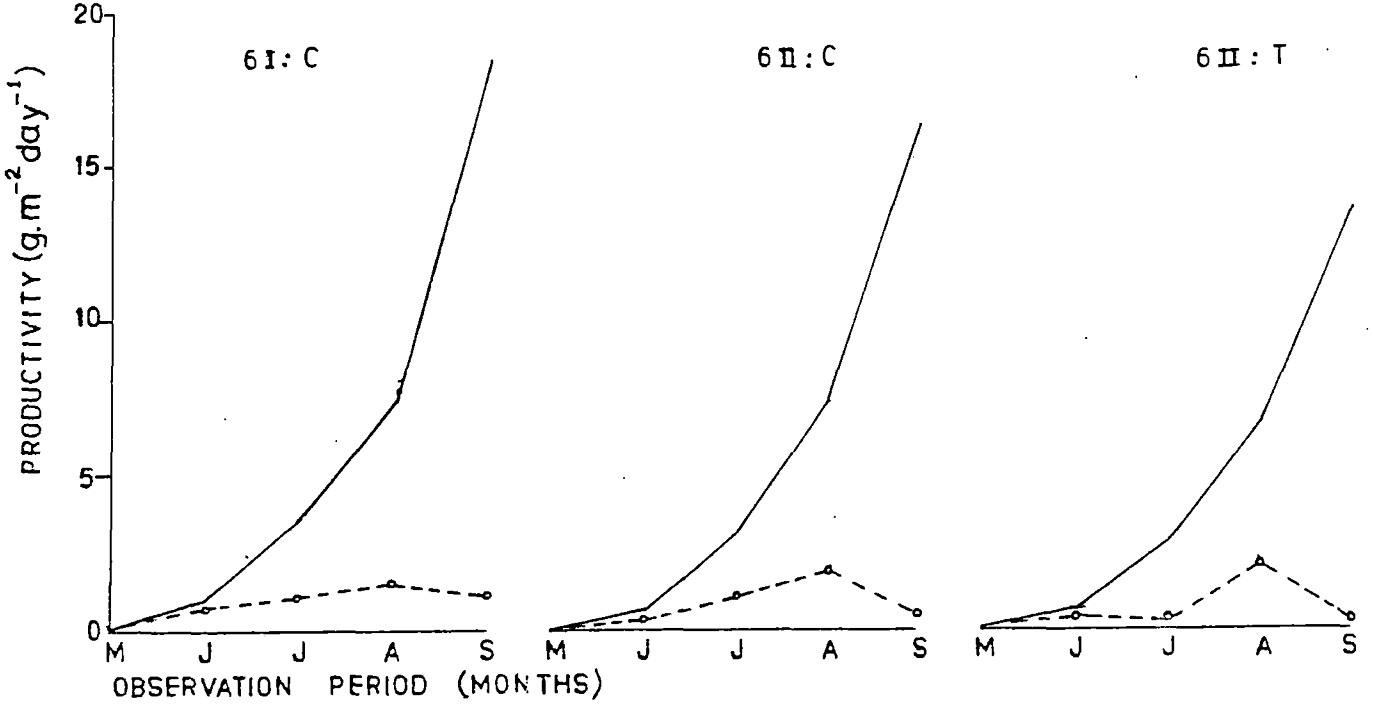
Fig. 4.7 Aboveground (□) and belowground (▨) production of weeds during the crop growing season in 6-year old and 20-year old jhum fallows during first year and secon year of cropping.



Production (g. m-2)
0
100
200
6 I:C
6 II:C
6 II:T
6 II:CF
6 II:FYM
6 II:CF+FYM
20 I:C
20 II:C
20 II:T
20 II:CF
20 II:FYM
20 II:CF+FYM

FIG. 4.7

Fig. 4.8 Productivity of rice (——) and weeds (o----o) in different months on 6-year old jhum fallows during first year and second year of cropping. M, J, J, A and S stand for May, June, July, August and September respectively.



PRODUCTIVITY (g.m⁻²day⁻¹)
20
15
10
5
0
6I: C
6II: C
6II: T
M J J A S
M J J A S
M J J A S
OBSERVATION PERIOD (MONTHS)

FIG. 4.8

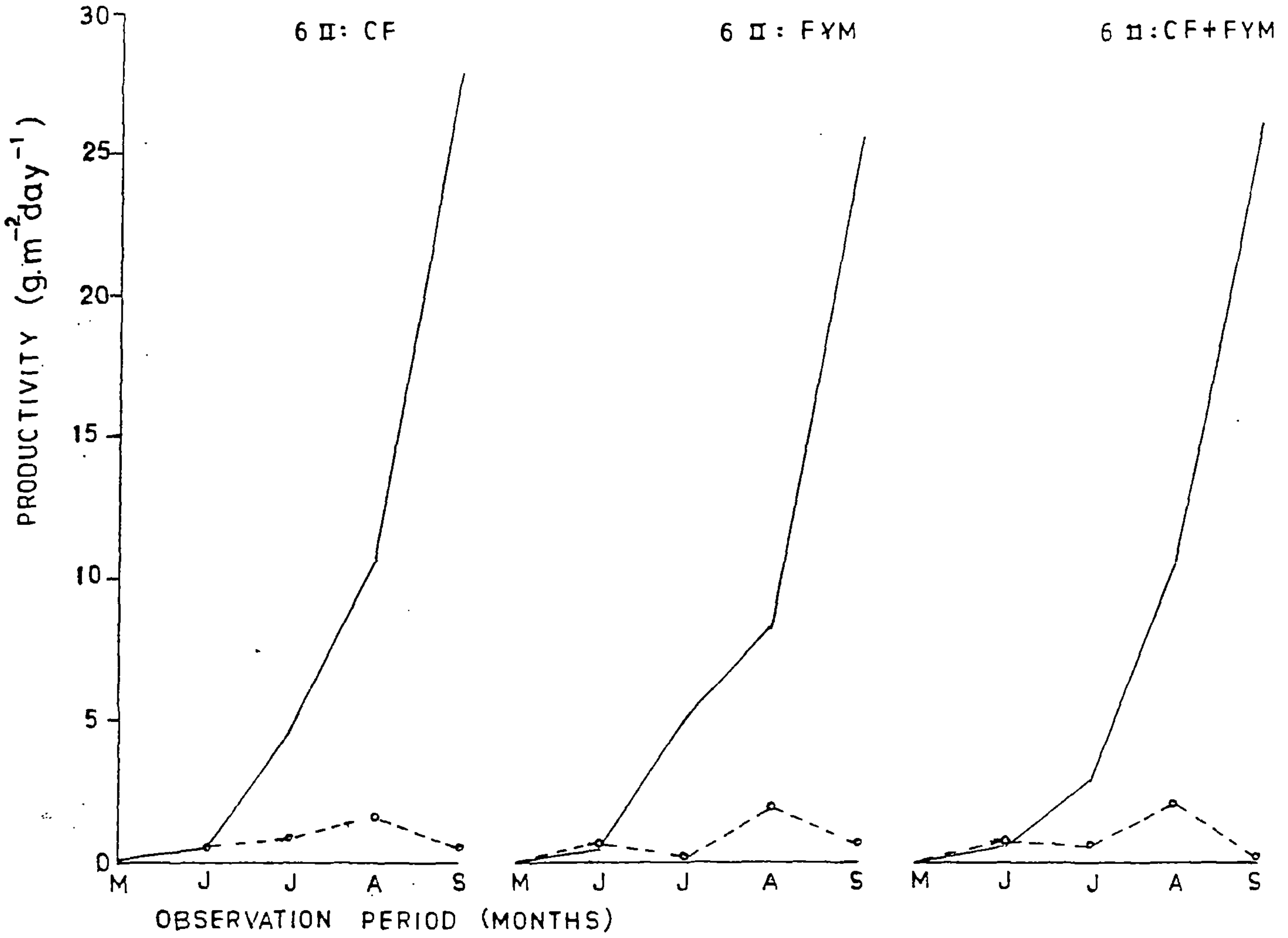

6 II: CF
6 II : FYM
6 II : CF+FYM
PRODUCTIVITY (g.m⁻²day⁻¹)
30
25
20
15
10
5
0
M J J A S
M J J A S
M J J A S
OBSERVATION PERIOD (MONTHS)
FIG·4.8

Fig. 4.9 Rate of productivity of rice (——) and weeds (o----o) in different months on 20-year old jhum fallow during the first year and second year of cropping. M, J, J, A and S stand for May, June, July, August and September respectively.

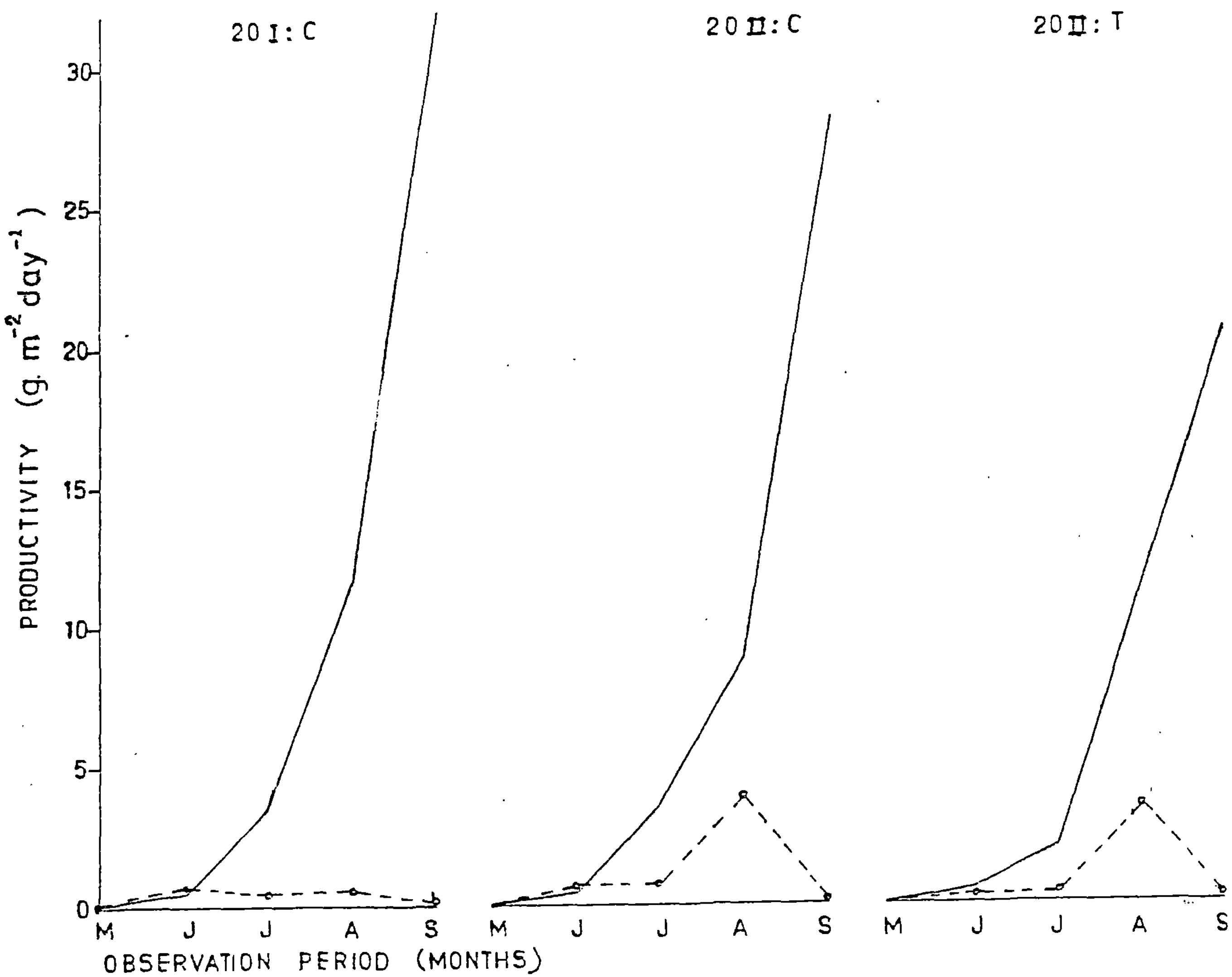
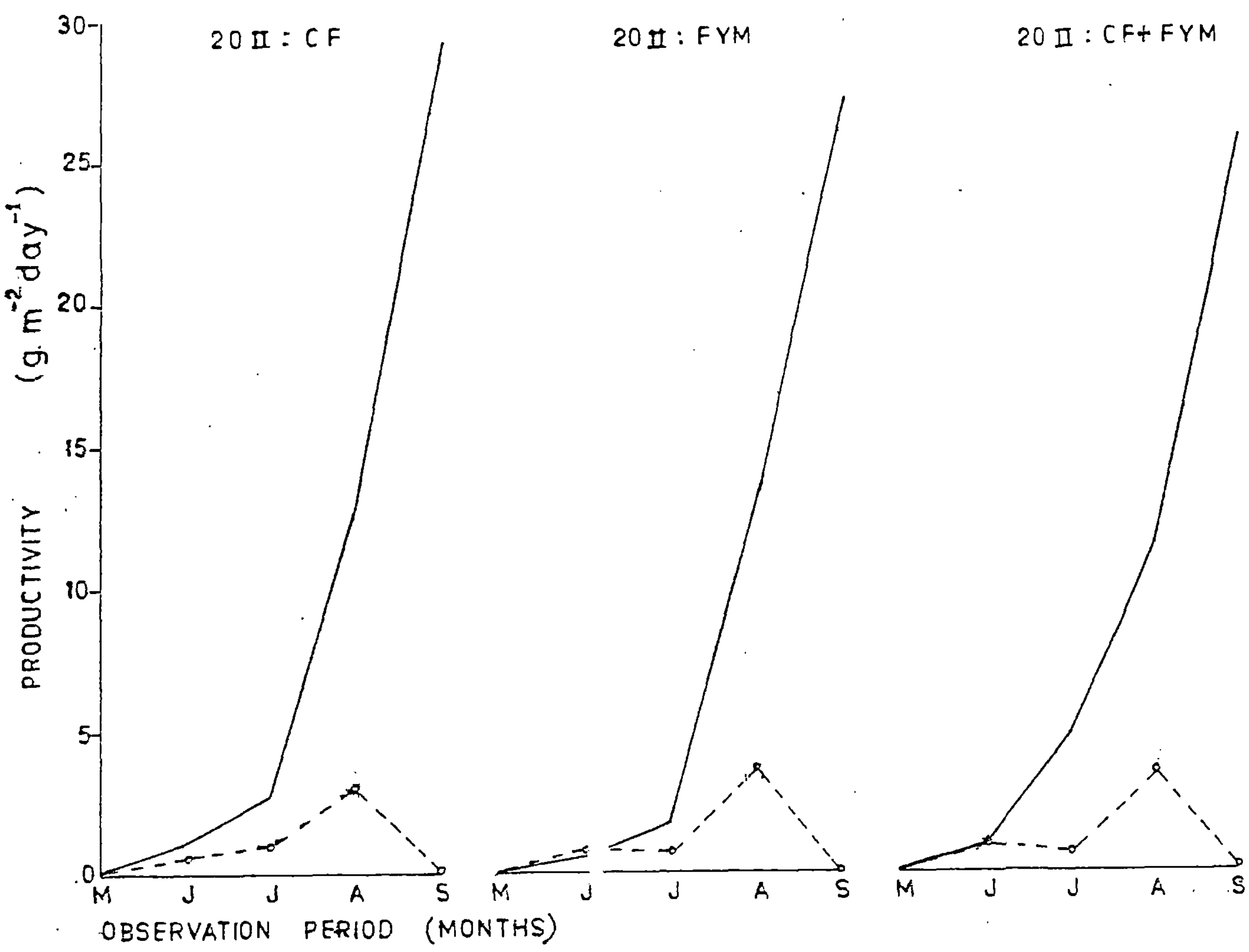

20 I : C
20 II : C
20 II : T
PRODUCTIVITY (g. m⁻² day⁻¹)
30
25
20
15
10
5
0
M J J A S
M J J A S
M J J A S
OBSERVATION PERIOD (MONTHS)

FIG · 4.9


20 II : CF
20 II : FYM
20 II : CF+ FYM
PRODUCTIVITY (g.m-2 day-1)
30
25
20
15
10
5
0
M
J
J
A
S
OBSERVATION PERIOD (MONTHS)
FIG. 4.9

first year than during second year of cropping. The rate of productivity was maximum in the chemical fertilizer treated sub-plots and lowest in the tilled sub-plots during second year of cropping.

In 20-yr. old jhum fallow the control plot in the first year of cropping showed the highest rate of productivity (calculated on the basis of whole growing season) while in case of 6-yr old fallow the rate of productivity in the control sub-plot was lower than in the treated sub-plots.

Discussion

The standing total biomass (rice plus weed biomass) increased with time, the highest value being recorded at the final harvest in all plots. The bulk of the total standing biomass was contributed by the crop plants as jhum fields provided the conditions for more vigorous growth of the crop plants compared to the weeds. Therefore, an increase in standing biomass of the crop, more or less determined the total biomass of the crop plus weeds. A similar trend has also been reported for maize (Williams et al., 1965; Khokhar, 1985), wheat (Singh, 1971) and paddy (Nayar, 1972; Khokhar, 1974; Khokhar & Pandey, 1976) fields. The storage of dry matter in the crop root increased with age while in the case of weeds there was no appreciable increase in root biomass with age.

The highest productivity of the crop observed in September (Table 4.4) was also reflected in the highest total biomass observed in this month. The percentage contribution of weeds to the total biomass incidentally happened to be the lowest in September (Table 4.3) which indicates that a high rate of productivity of the crop brings about suppression in weed growth. It has been demonstrated that weeds and crops growing together modify or suppress the growth of each other (Bleasdale, 1960; Tripathi, 1967, 1968). The density of crop plants and weeds play a crucial role in the outcome of competition between them (Tripathi, 1977).

In the present study the weeds do not really pose much of a problem by way of competition for available reasources on account of frequent weeding operations in the agroecosystems under study. However, as the sampling of plants for biomass determination was done mostly before weeding, the competition between weeds and crop is expected to influence their biomass production to some extent. Competition may be more severe during early part of the cropping season (i.e. June) when rice plants are small. During this period the percentage contribution of biomass by weeds is also relatively high (34 - 60%). The low crop biomass observed in the plots where the contribution of weeds to total biomass was more may be attributed to the competitive suppression caused by weeds. However, as mentioned earlier, in September when the crop biomass was highest, the contribution of weeds to total biomass decreased tremendously which shows a strong smothering effect of vigorously growing crop plants on weeds. Smothering effect of dense crop on weeds has also been reported by other workers (e.g. Donald, 1958, 1963).

In the present study, a steady increase in weed biomass observed on 6 I:C plot may be attributed to high infestation of weedy species before jhuming (Table 2.2 and 2.3) which might have contributed to an increase in weed seed population in soil. Comparatively greater biomass of weeds produced during second year of cropping than in the first year on 20-yr. old jhum fallow, may be attributed to the larger size of weed seed bank that contributed to greater weed infestation during second year of cropping in comparison to the first year of cropping. It may be mentioned that the weed community declines as the shrubs and trees develop on the abandoned fallows (Kushwaha et al., 1981, Yadav & Tripathi, 1981). In 20-yr. old fallow the population of different weeds which are generally present in the agro-ecosystems were really very small and so, when such a fallow is once again brought under cultivation, the weed community development is bound to be poor.

The soil fertility is one of the most important factors determining plant productivity. The biomass and productivity of the crop showed positive correlation with the soil nutrient status in the present study. Relatively lower crop biomass on younger (6-yr. old) jhum fallow during first year of cropping compared to that on 20-yr. old fallow where the input of ash (nutrients) was more, also depicts the dependence of biomass on soil nutrient status.