B-1.3.1 Clarification of Carbon Cycling and Budgets in the Cropland Ecosystems

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Total Budget for FY1993-1995 9,277,000 Yen (FY1995; 3,337,000 Yen)

Abstract To clarify the long-term changes of carbon budgets in croplands, we made a sweet potato (*Ipomoea batatas*) - chinese cabbage (*Brasica rapa*) double-cropping field and an abandoned field in the National Institute of Agro-Environmental Sciences and measured their carbon cycle. The carbon budgets (mean±SD) of the double-cropping field and the abandoned field were -236±167 gC m^{-2} yr^{-1} and -305±97 gC m^{-2} yr^{-1}, respectively. They showed marked year-to-year changes, acting as a source of carbon dioxide. It is suggested that the carbon budgets in croplands is markedly influenced by the human management such as a stubble manipulation and that the absorption of carbon dioxide into the abandoned fields increases year by year.

Key Words Abandoned field, Carbon budget, Carbon cycle, Double-cropping field

1. Introduction

Carbon dioxide (CO_2) is a major greenhouse gas (Intergovernmental Panel on Climate Change 1990). Atmospheric CO_2 has been increasing as a result of human activities, and this presents a threat of global warming. Therefore, scientific interests in the carbon cycle in terrestrial ecosystems have grown recently.

Since the areas of cultivated lands cover about 10% of the total land areas of the world, croplands must not be ignored to predict the future climate change. Koizumi et al. (1993) measured the carbon dynamics on three cereal double-cropping agro-ecosystems in Japan and found that those croplands acted as a source of CO_2. However, little is known about the carbon dynamics and budgets in the other types of croplands.

When we abandoned the croplands and kept no cultivation, then annual, biennial and perennial weeds would dominate year after year. It is well-known as secondary succession and very common around the world. However, there is few studies exploring the effects of secondary succession on the carbon dynamics of abandoned fields.

To clarify the long-term changes of carbon budgets in two types of croplands, we made a sweet potato (*Ipomoea batatas*) - chinese cabbage (*Brasica rapa*) double-cropping field and an abandoned field and measured their carbon cycle. The objectives of this study are to clarify (1) how much the year-to-year changes in the croplands are and (2) what a major cause of the temporal variation is.

2. Methods

We made a 5-yr sweet potato - chinese cabbage double-cropping field experiment initiated from 22 October, 1990 and a 3-yr abandoned field experiment from 20 May, 1992 at the National Institute of Agro-Environmental Sciences, and measured their carbon cycle. We calculated net production by measuring the dry weights of sampled plants. We also monitored stubble, harvest and soil respiration to estimate the carbon flux on soil surface. The soil respiration was measured by both the open flow infra-red gas analyzer method (Koizumi et al. 1991, Nakadai et al. 1993) and the closed chamber method (Bekku et al. 1995) covering the spatial heterogeneity of CO_2 fluxes. Plant carbon contents were measured using an automatic carbon and nitrogen analyzer (Yanako C-N Corder, MT-600).

3. Results and Discussion

Double-cropping field experiment

The maximum net production and soil respiration in the double-cropping field were observed in 1992 and 1993, respectively, showing marked year-to-year changes (Fig. 1). Consequently, their annual carbon budgets varied markedly with year and showed minus values in most years, acting as a source of carbon dioxide. This confirms the previous studies conducted in Japan (Kumura 1977, Koizumi et al. 1993).

Air temperature seems to be the most important among the environmental factors and expected to influence strongly on the carbon cycle. However, there were no correlation between the yearly mean air temperature and the carbon budgets (Fig. 1), suggesting that there must be other factors more important than the climate factor.

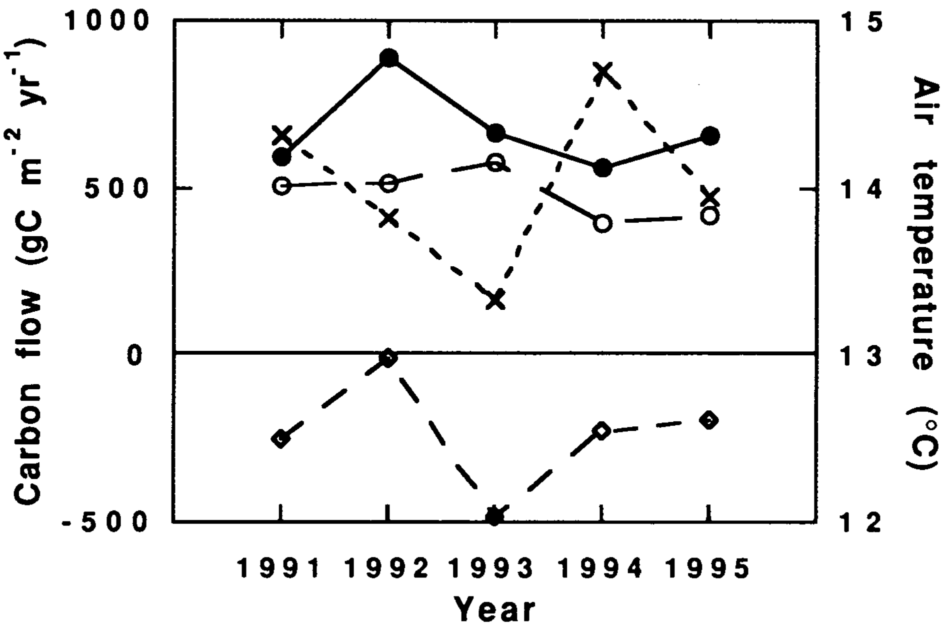

Fig. 1 Year-to-year changes in net production (●), soil respiration (○), carbon budget (◇) and yearly mean air temperature (×) in the double-cropping field

Figure 2 indicates the averaged carbon flow within the 5-yr double-cropping field experiment. During the experiments, mean net production was 672 gC m^{-2} yr^{-1} and harvested those 64%. The residuals were left in the field as a stubble and mean CO_2 evolution from the soil surface was 481 gC m^{-2} yr^{-1}. As a result, mean annual carbon budget was estimated to be -236 gC m^{-2} yr^{-1}. Its standard deviation (SD) was markedly high (167 gC m^{-2} yr^{-1}), reflecting the year-to-year variation. The most varied component through carbon dynamics in the field was stubble with a SD of 154 gC m^{-2} yr^{-1}. This means that this component might cause the variation of the carbon budget. The stubble was easily manipulated by human activities. Therefore, it is suggested that the carbon budgets in croplands is markedly influenced by the human management such as a stubble manipulation.

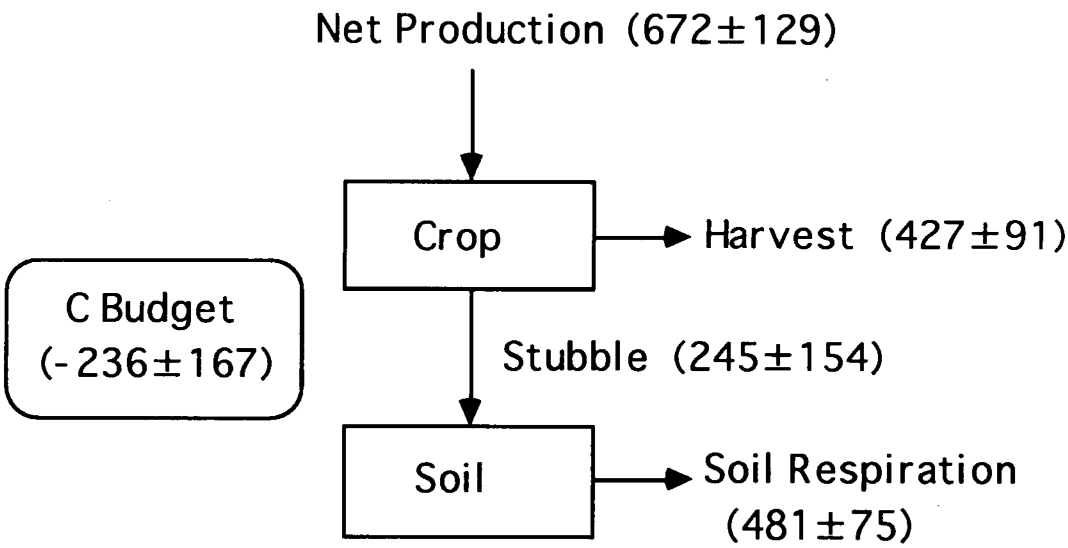

Fig. 2 Carbon flow in the double cropping field (mean±SD; gC m^{-2} yr^{-1})

Abandoned field experiment

In the first and second year after the abandonment, Digitaria adscendens and Ambrosia artemisiifolia var. elatior, both annual species dominated, respectively. In the third year, a biennial species, Oenothera biennis dominated with a perennial Solidago altissima.

The maximum net production and soil respiration in the abandoned field were observed in 1994 and 1992, respectively, showing marked year-to-year changes (Fig. 3). Consequently, their annual carbon budgets varied markedly with year and showed minus values in most years, acting as a source of carbon dioxide similar to the double-cropping field. However, these minus values decreased with year, indicating that the absorption of carbon dioxide into the abandoned fields increases year by year.

There were also no correlation between the yearly mean air temperature and the carbon budgets (Fig. 3), suggesting that there must be other factors more important than the climate factor. Figure 4 indicates the averaged carbon flow within the 3-yr abandoned field experiment. During the experiments, mean net production was 487 gC m^{-2} yr^{-1} and mean CO_2 evolution from the soil surface was 792 gC m^{-2} yr^{-1}. As a result, mean annual carbon budget was estimated to be -305 gC m^{-2} yr^{-1}, nearly equal to that of the double cropping field. Its standard deviation (SD) was 97 gC m^{-2} yr^{-1}, which was lower than that of the double-cropping field. The most varied component through carbon dynamics in the abandoned field was net production with a SD of 148 gC m^{-2} yr^{-1}. This suggests that the variation of the carbon budget in the abandoned field was attributable to the change in plant carbon gain through secondary succession.

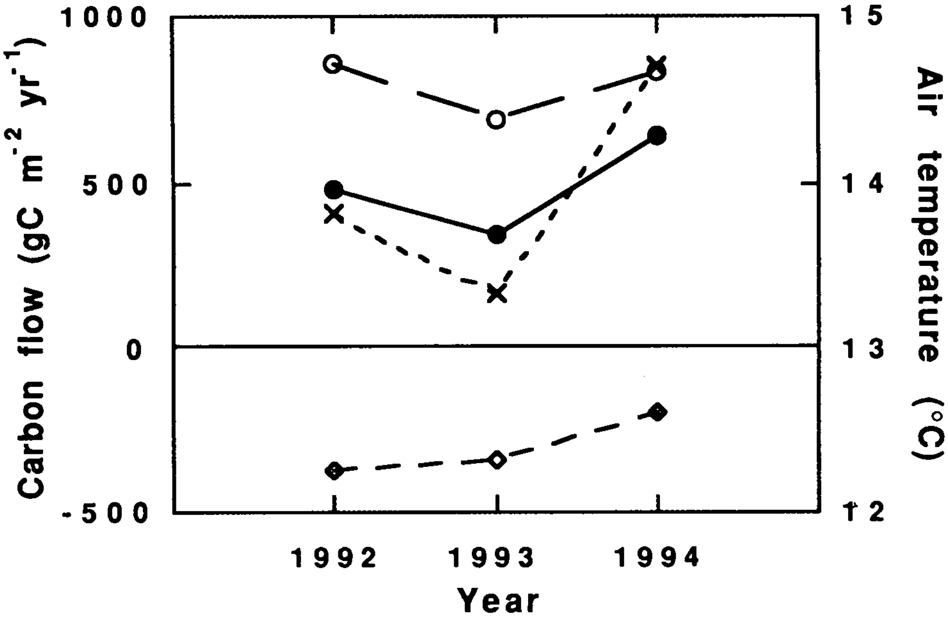

Fig. 3 Year-to-year changes in net production (●), soil respiration (○), carbon budget (◇) and yearly mean air temperature (×) in the abandoned field

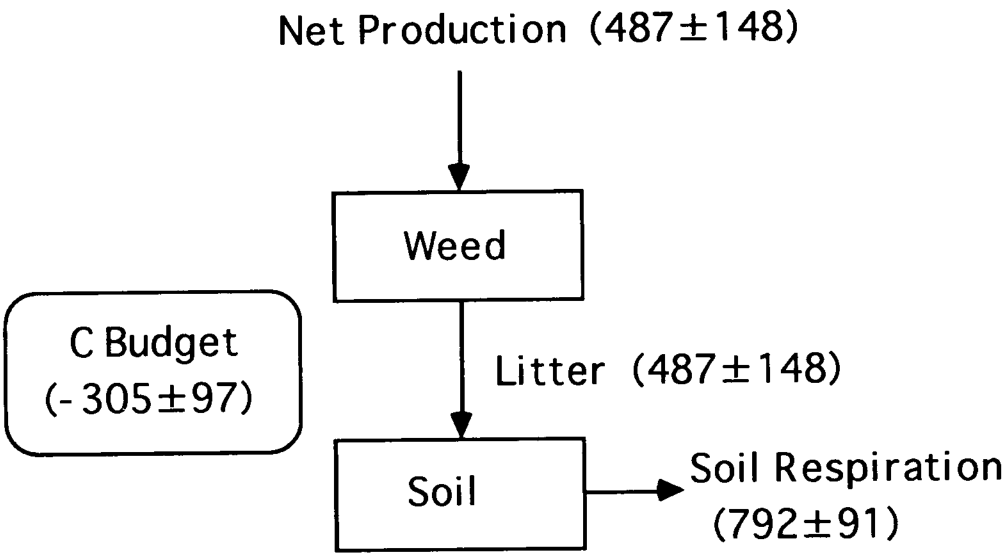

Fig. 4 Carbon flow in the abandoned field (mean±SD; gC m^{-2} yr^{-1})

4. Conclusions

The carbon budgets in the double-cropping and the abandoned field were minus values, indicating that they acted as a source of CO_2. These carbon budgets in the both fields showed marked year-to-year changes with less correlation to the climate factor. The temporal variation in the double-cropping and the abandoned fields seems to be attributable to the stubble manipulation and secondary succession, respectively. These results suggest that the carbon dynamics in croplands depend on the farming management and we can regulate its carbon balance by the proper cropping manipulation. Further studies are necessary to determine which manipulation would be effective to reduce the emission of CO_2 from croplands.

5. References

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