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EFFECT OF LABOR SAVING BY CRAWLER-TYPE TRUCK IN STEEP SLOPE ORCHARDS

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ABSTRACT

The purpose of the present study is to investigate,from the viewpoint of labor science,the effect of labor saving by crawler-type truck, which has been used for the rationalization of transportation labor in the citrus orchard on steep slops, and to find out how effectively to utilize the crawler-type truck.

In order to attain the purpose mentioned above, portable heart rate memory for measuring physical response of laborer was taken, and the experiment was carried out in the citrus orchard on steep slopes in Japan.

I. INTRODUCTION

Farm roads have been established almost completely in citrus orchards of steep slopes and small trucks can be used in these areas, which largely contributes to the improvement in the transportation efficiency[1,2,3]. In recent years, attempts have been made to shorten the distance of human-power transportation by building farm paths in orchards and employing farm trucks so as to elevate the line density of farm roads, thus relieving transportation labor. Under this situation, we have performed human-power and engine-power transportation tests in a farm path in a citrus orchard and thus examined this problem from the viewpoint of labor science[4,5]. We have discussed the relation between the line density of farm roads and human-power transportation distance, and the effect of labor saving by using crawler-type trucks.

II. METHOD AND EQUIPMENT

The experiment was carried out on the farm paths for a citrus orchard (S=0.88ha) in May,1990. Air temperature was 20～22 ℃,relative humidity was 55～74 %,and barometric pressure was 740～750mmHg.

The farm paths in the orchard were the sloped paths(of 0.8～1.8 m breadth and 10～15° gradient) which is connected to a branch farm road and the flat paths (of 0.6～1.0 m breadth and 0～5° gradient) along the contour line of terraced farms.

The farm truck was a rubber crawler vehicle of walking type as shown in Fig.1. The subject was a farm worker(male, 62 years old, 165cm tall and 53kg) who is experienced in the driving of the crawler vehicle and loading and unloading works.

Figure1 The use of crawler truck in a farm path(walkingtype, E:3.0ps, L:1.70m, W:0.60m, H:0.84m, loading capacity:200kg)

The works assigned to the subject were the human power transport(shoulder load, one / going and back) of a citrus container (actual load, 19 kg / one container) and the driving of the crawler vehicle and loading and unloading (six containers / going and back). The investigator observed the contents and time of the workings. The number of heartbeat of the subject was measured continuously at the time of rest,working and recovery with a heart rate memory device[5],and analyzed with an interface(E2) and a personal computer(Fig.2).

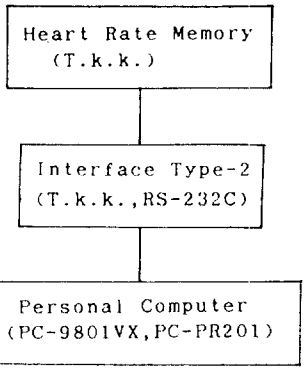

Figure2 Heart rate analysis system

Ⅲ. RESULTS AND DISCUSSION

1) Farm road density and distance between farm road and field

When the degree of improvement of farm roads is evaluated or farm roads are planned , the road density is discussed [1,6]. That line density is high does not always show the good efficiency of the arrangement of roads,but it has been considered to be effective as the tentative criterion. Therefore,the arrangement of farm roads conforming to the actual ground was considered on the plan, and by the equation for determining the relation between line density Rd (m/ha) and the farthest distance between farm roads and a field Lf(m), $Lf=10^4 / Rd$ (Fig.3,4),

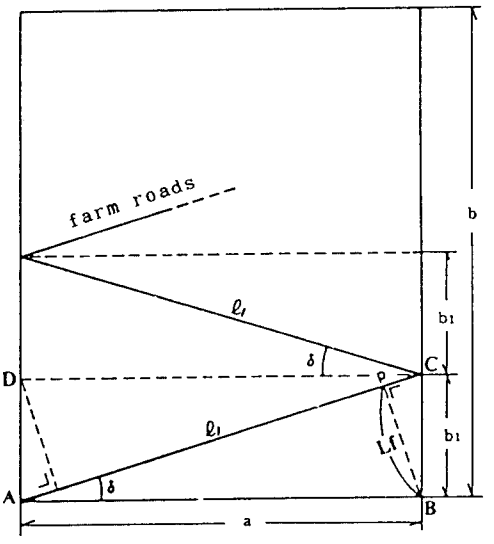

Figure3 The line density of farm roads

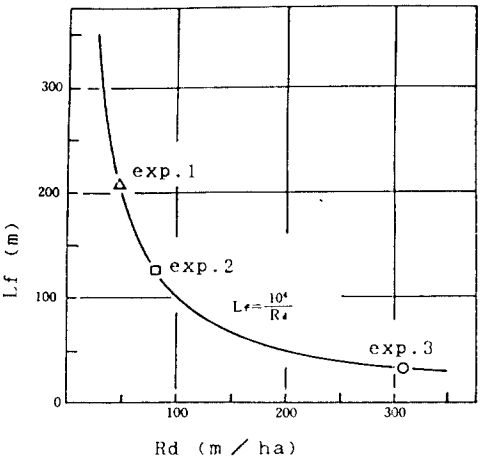

Figure4 The relationship between the density of the road(Rd) and the distance from the road to the farthest spot of field(Lf)

the road network in the object ground(Fig.5) was examined. According to this, the line density before setting up farm paths was 270m / ha, but after setting them up, it became 1320m / ha, and the farthest distance between farm roads and the field, namely the distance which requires human power transport, was shortened from about 40 m to about 10 m the labor saving effect can be expected.

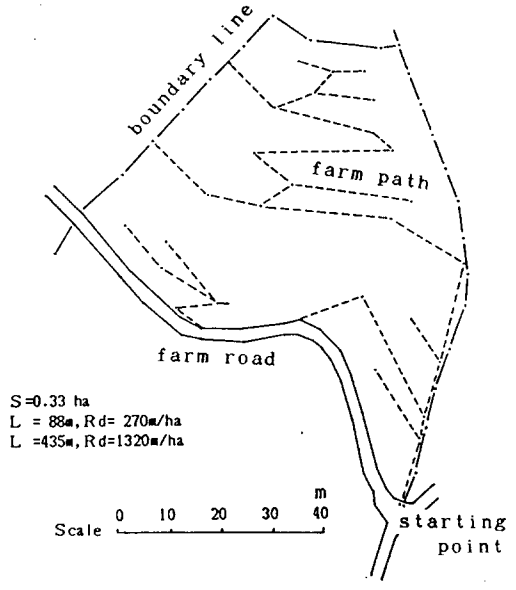

Figure5 The plane figure of citrus orchard

2) Change of heart rate at the time of carrying works

Fig.6 shows the change of the heart rate when six actual load containers were carried by human power and the crawler vehicle on farm paths.

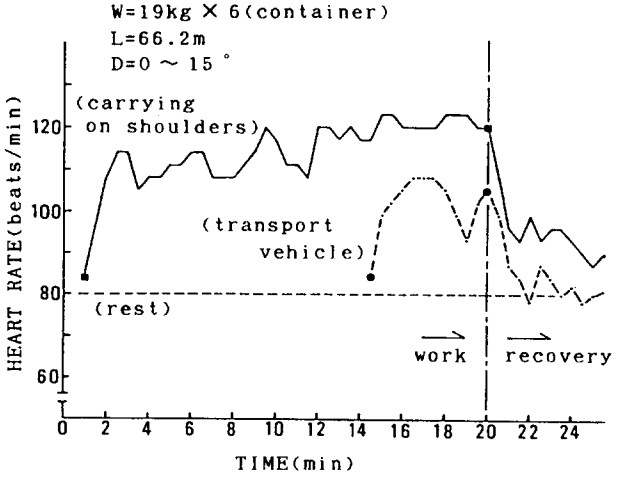

Figure6 The heart rate of human-power and engine-power transportation tests in a farm path

In the case of human power, from the regular wavy change, the state of six going and back was observed,and the low values in no load and the high values in the actual load were shown. The mean value was 114beats / min., and the index of heart rate increase(the value in working / the value at rest) was 1.40.

On the other hand, in the case of using the crawler vehicle, the wavy change was far one going and back, and the low value at the time of driving and the high values at the time of loading and unloading resulted in . The mean value was 102 beats / min., and the index of increase was 1.28, thus both were small as compared with the case of human power. In terms of the increment on the basis of the value at rest,it is presumed that the vehicle is about 65 ~ 70 % of the degree of load bearing by human power. Further, the time for carrying was about 1/3 of the case by human power, therefore, it is considered that the utilization of a vehicle on farm paths is effective in qualitative and quantitative aspects for reducing labor.

3) Time for carrying and number of heartbeat classified by farm paths

Fig.7 shows the time for carrying and the number of heartbeat in the case of human power and using the crawler vehicle when the setting up of farm paths advanced, line density became high, and the farthest distance between farm roads and the field was gradually shortened.

In the case of the object ground,from Rd=270m / ha before setting farm paths up, Lf resulted in about 40 m, and by considering this as farm paths,the time for carrying by human power is 11.6min., and the number of heart beat is 1,330.

Hereupon, by utilizing the vehicle, the time for carrying is reduced to 5.8 min., and the number of heartbeat to 590, in this way, the values became about 1/2 of the case by human power,

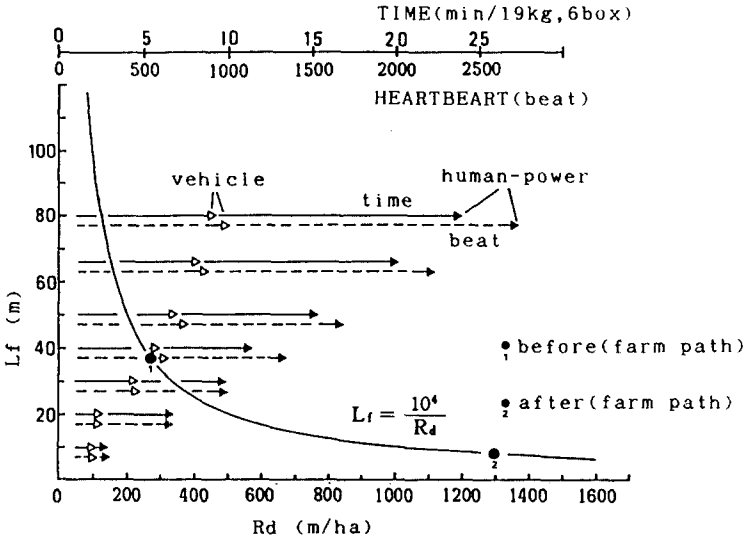

Figure 7 Farm road density and distance between farm road and field, and time of carrying work, number of heartbeat

and the bearing of labor is reduced largely. Next, after farm paths were set up, Rd=1,320 m／ha and Lf=10 m resulted in, and the time for carrying by human power was reduced to 2.5 min., and the number of heartbeat to 270. Namely, as compared with the time for carrying of 11.6 min. and the number of 1,330 before setting farm paths up, after setting them up, the values summing up 4.3 min. and 440 beats for using the vehicle on the additionally set-up paths (Lf = 40-10 m) and 2.5 min. and 270 beats for carrying by human power (Lf=10 m), that is, 6.8 min. and 710 beats, resulted in. By improving farm paths in good condition and utilizing the vehicle, respective values become 1/1.7 and 1/1.9 of the case by human power, therefore, it is considered that the efficiency of transportation can be heightened, and the reduction of labor can be advanced largely.

IV. CONCLUSION

As a result, we have obtained the following findings.

(1) The line density of the farm road in the tested citrus orchard was elevated from 270 m／ha to 1,320 m／ha while the human-power transportation distance was reduced from about 40 m to about 10 m by building farm paths. The use of walking type crawler truck was highly effective.

(2) The increase in heart rate of a worker due to the transportation with the use of crawler truck, based on the heart rate at resting, corresponded to 65 to 70 % of the increase therein due to human-power transportation(carrying on shoulders),which suggests that the physical response on working load was considerably relieved by using the crawler truck. The transportation time required in the case of the crawler truck amounted to 1/2 to 1/3 of that required in the human-power transportation. Thus the building of farm paths and the use of the crawler truck can effectively relieve the transportation labor both in quality and quantity.

(3) It is considered that measures for relieving the transportation labor in citrus orchards of different conditions of location may be effected as follows. Namely, riding type trucks are used in orchards of slow slopes by mainly taking farm roads and farm paths into consideration. In the case of orchards

of steep slopes, on the other hand, it is recommended to use walking type trucks suitable for narrow farm paths in addition to the riding type ones. In the case of orchards of further steep slopes, it is needed to plan the introduction of cableways and monorails for farm use.

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