Andreas Block, Göttingen

Fire-Free Area Preparation in Brazil

Performance of Suitable Chopping Machines Depending on the Vegetation Structure

The replacement of slash-burning with mechanized mulching techniques is an approach towards sustainable agriculture in tropical agro-forestry systems. The evaluation of the performance of suitable machines must be based on the properties of the vegetation to be treated. Therefore, parameters have been determined which are suitable for the description of vegetation with regard to subsequent mechanical treatment. With the aid of these parameters, the technical and economic preferability of two chopper systems has been established depending upon the vegetation structure.

Dipl.-Ing. agr. Andreas Block is a scientist working at the Institute of Agricultural Engineering of Georg-August University in Göttingen (director: Prof. Dr. Wolfgang Lücke), Gutenbergstr. 33, D-37075 Göttingen; e-mail: *ablock@gwdg.de*.
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Keywords

Bush-chopper, forestry mulcher, fallow vegetation, tropical agricultural systems, slash-burning

Even today, traditional slash-burning techniques are employed to prepare tropical fields for a subsequent cultivation period of approximately two years after the mandatory fallow phase, which lasts several years [4, 5, 7]. In the medium run, however, this leads to a loss of biodiversity and yield potential of the areas and, ultimately, to the abandonment of the fields, which are generally replaced by clearing primary forests [5, 8, 9]. Mulch farming is a sustainable alternative to the previously practiced slash-burning technique. However, it requires mechanized area preparation. In principle, suitable machines for mulch farming are available [1, 2, 3, 6, 7, 10, 11]. Their work output and -quality, however, are strongly dependent on the vegetation to be treated. For this reason, parameters have been determined in typical secondary vegetation in East-Amazonia, Brazil, which can sufficiently describe the properties of the vegetation in order to establish the technical and economic suitability of the machines tested in reference [3]. These parameters will be specified below, and the essentials of the relation between the measured machine output and the parameters of vegetation will be shown.

Data Collection on the Experimental Fields

Immediately before the cultivation phase, the fields are cleared of the secondary vegetation (the so-called "capoeira"), which has grown there and must be removed after the fallow phase [8, 11]. Whenever possible, different kinds of fallow areas were chosen for the study in order to gain comprehensive information about the capacity of the chopping machines. The first distinctive criterion of the areas is the length of the fallow phases during which the secondary vegetation was able to grow without being disturbed. The duration of the fallow phase alone, however, does not allow any conclusion about the mass and the composition of the vegetation to be drawn. Therefore, generally ten to twelve representative lots per hectare, each 4 to 10 m^2 in size, were marked in the sampling areas from which all plants having a diameter of more than 1 mm were taken as samples. Based on the number of plants in these representative sampling lots, average plant density per area unit was calculated. In order to describe the floristic composition of the area, all plants taken as samples were determined and measured (diameter and height). Only then was the area treated with the aid of a chopping machine which seemed suitable and thus prepared for crop cultivation. The duration of work- and nonproductive times was registered separately. In addition, fuel consumption was measured separately in the individual phases.

Machines and Sensors Used

The second prototype of the chopping machine "Tritucap" developed at the Institute of Agricultural Engineering of the University of Göttingen and the forestry mulcher FM 600 from the company AHWI Maschinenbau were used to treat the areas [3]. For the measurement of fuel consumption, two flow measurement turbines were installed on the tractor which registered both the flow to the engine injection pump and the reflux into the fuel tank and sent the values as a digital signal to a mobile computer installed on the tractor. Moreover, a so-called DLC measuring hub from the company Walterscheid (Lohmar) (type SE 250) was installed at the tractor PTO in order to measure the torque and the engine speed. In addition to the fuel flows as well as the torque- and rotational speed data of the PTO, the continuously registered data included the current phase of treatment at a frequency of approximately 56 measurements per second. Furthermore, the area size was registered with the aid of a hand-held GPS receiver (Garmin GPS 12CX) and later calculated using a geo-information system.

Evaluation of the Botanical Data

First, the characteristics of the areas under consideration were analyzed based on the available data of the botanical examinations. A variance analysis of different characteristics showed that a certain homogeneity pre-

Fig. 1: Version 2.0 of the wood chopper prototype „Tritucup"

Fig. 2: Forestry mulcher AHWI FM600

vailed within the areas, whereas the different areas can be distinguished from one another based on the examined characteristics.

The analysis of the degree of correlation between plant diameter, plant height, the phytomass of the area, the number of plants, and the duration of the fallow period confirmed the assumption that average plant diameter, plant height, and phytomass grow with increasing duration of the fallow period, while the average number of plants diminishes. Statistically, the results are highly significant. In a very simplified manner, it is therefore possible to characterize the condition of the fallow vegetation by means of its age. The measured phytomass alone, however, is not sufficient to describe an area. This indicates significant differences in phytomass in areas which lay fallow for the same period of time.

Performance of the Chopping Machines

The time-, torque-, engine speed-, and fuel consumption data recorded for both chopper types during the treatment of the areas were correlated with the botanical data of the areas where they were used. The consideration of two exemplary areas shows the following results: For the "Tritucap" prototype, a mass throug-put of 11.51 t of chopped fresh mass per hour at a phytomass of 41.58 t/ha and a fallow period of three years was determined. This corresponds to an area capacity of 0.2768 ha/h. Since area preparation with the forestry mulcher requires two treatment steps in contrast to "Tritucap" [3], the single values of the individual treatment steps were averaged. For the forestry mulcher FM 600, a mass throughput of 21.04 t/h (16.39 t/h and 25.68 t/h) at a phytomass of 35.46 t/ha and a fallow period of four years was measured. The area capacity of 0.4622 ha/h in the first treatment step and 0.7242 ha/h in the second step results in a total duration of treatment of 3.54 h/ha or an area capacity of 0.2821 ha/h.

The energetic consideration of area treatment was deduced from the evaluation of the torque- and engine speed data. The results showed that the chopping of one tonne of fresh mass with the aid of Tritucap required 5.78 kWh of energy, while the forestry mulcher needed 6.55 kWh.

For the determination of the costs of machinery use, the "ideal" vegetation conditions for the individual machine were considered [3]. Based on Brazilian cost structures, the use of Tritucap thus caused expenses of ~ R$ 393 per ha (approximately 110 € per ha). The expenses for the FM 600 amounted to R$ 496 per ha (~ 138 €/ha). If one additionally considers the possible expenses for debt service, the difference becomes even bigger due to the higher purchasing costs of the FM 600.

For the preparation of areas which lay fallow for up to four years, the Tritucap chopper is superior under technical and economic aspects. After a longer fallow phase, however, areas can practically only be prepared with the FM 600 [3, 7]. Even if the Tritucap were technically suitable, the FM 600 could be used more economically due to its higher area capacity.

Summary

The secondary vegetation in the tropical East Amazonia region of Brazil, which predominantly consists of trees, can be cleared by means of mechanized implements. This technique provides a sustainable alternative to slash-burning. The economic efficiency of the machines, however, can only be measured with regard to the conditions of the vegetation to be treated. Suitable parameters have been found for these measurements. The calculation of the performance data allowed an initial cost estimate of machinery use on typical fields to be given. According to the estimate, the expenses for the use of Tritucap on fields which lay fallow for up to four years are lower than the expenses for the use of the forestry mulcher. After a fallow period of more than four years, the FM 600 is technically and economically superior.

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