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The effect of milk yield per cow on efficiency of labour use in dairy parlours

by

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INTRODUCTION

Labour has been shown by various authors in South Africa¹⁾ to be one of the most important cost items in dairying. According to these writers, the contribution of labour to total expenses varied between 14.5 per cent and 28.3 per cent in different dairying regions. During the past decade or more, price movements have generally not been favourable to agriculture. It is known that, in common with other countries, South African agriculturists have had to cope with a cost price squeeze, since cost of inputs have risen relatively to prices of farm products.²⁾ This cost price squeeze makes it imperative for the agricultural industry to increase its efficiency in the use of its resources if farmers are to maintain or improve their economic status.

Owing to the importance of labour as a cost item, it appears that an improvement in labour efficiency will contribute substantially to the overall efficiency of dairy farming. To promote this efficiency, more attention should be given to factors involving labour control and human

relations. Such studies were carried out in the Western Transvaal by du Preez.³⁾ Attention should also be given to the functional efficiency of machinery, buildings, etc. as was done by Semmelink,⁴⁾ and to the efficiency of work routines by means of motion and time studies. All these factors are of prime importance and influence each other.

Research involving motion and time study techniques was carried out in the vicinity of Pietermaritzburg. In this analysis efficient milking routines were developed for machine milking in four types of parlours (abreast - one stall per unit, abreast - two stalls per unit, double tandem walk-through and herringbone parlours), and also for milking sheds.⁵⁾

A major factor which, in addition to working routines, functional efficiency and labour organisation, has a profound effect on labour efficiency, is the general level of productivity of the dairy herd, as expressed in the milk yield per cow per milking. This aspect will be dealt with in this article.

CLASSIFICATION OF TIMES

Time usage in a dairy parlour may be divided into two categories : fixed and variable time. Fixed time elements consist of those which are not influenced by the amount of milk obtained from a cow; variable time elements are those which are affected by milk yield. In order to understand these differences more clearly it is necessary to review the different operations

1) Tomlinson, F.R. : Economic Study of fresh Milk Farming in the Witwatersrand Area, 1947/48. Department of Agriculture, Bulletin No. 315, 1951.

Tomlinson, F.R. : Ekonomiese Onderzoek van Varsmelkboerdery in Natal, 1947/48. Departement van Landbou, Pamflet No. 314, 1951.
Anon. : Economic Investigation of Industrial Milk Production in Four Dairy Farming Areas. Unnumbered Report, Division of Economics and Markets, Pretoria, 1957.

Anon. : Results of Farm Record Keeping by Dairy Farmers in Natal Midlands, 1963/64. Unpublished Report, Division of Agriculture Economic Research, 1964.

2) Anon. : Economic Tendencies in the South African Agriculture. Agrekon. Vol. 3, No. 3, p. 3, 1964.

De Swardt, S.J.J. : Problems of Adaption in Agriculture. Agrekon, Vol. 1, No. 1, p. 13, 1962.

3) Du Preez, P.H. : Die Verkryging van hoër Werkverrigting by die Bantoe in die Landbou. M.Sc. (Agric.) Thesis, University of Pretoria, 1961.

4) Semmelink, B.D. : Die Ekonomiese Beplanning van Melkportaalstelsels. M.Sc. (Agric) Thesis, University of Pretoria, 1967.

5) Graham, J.D. : A Study of Work Routines in Milking Parlours and Sheds. M.Sc. (Agric.) Thesis, University of Natal, 1966.

which are carried out on a cow in the parlour during milking. The operations preceding milking, consist of the following:⁶⁾ the letting in of the cow, the feeding of concentrates, washing of the udder, testing for mastitis, and attaching the cluster of the milking machine. The attachment of the cluster coincides with the start of actual milking. After the cow has been milked, the worker will strip the cow, remove the cluster, record the yield and let the cow out. While the cow is in the actual process of being milked, i.e. the period between the attachment of the cluster and the stripping, the worker is able to attend to other cows or to perform other duties. He may also be idle during this time if he does not have anything else to do.

The interval from the washing of the udder to the attachment of the cluster is defined as the stimulation period. The importance of the stimulation interval for efficient milk ejection by cows has been illustrated by various authors.⁷⁾ Use of standard times obtained from observations on 1,272 cows resulted in recommendation of 0.96 minute per cow for the stimulation period.

The distinction between fixed and variable time can now be made clear by pointing out that for any particular milking parlour, the operations preceding and following actual milking are not affected by milk yield. These may therefore be labelled as fixed time elements. The actual time of milk secretion - hereafter called true milking

time - has however, been illustrated to be positively correlated with milk yield.⁸⁾

In this analysis, regression was used to determine the relationship between milk yield and true milking time for two breeds. The samples consisted of 185 Friesian and 108 Jersey cows. The equations were of the following nature:

$$Y = a + bX$$

where

Y = true milk-out time in minutes,

X = yield of milk in pounds,

a = intercept,

b = regression coefficient.

The equations thus derived were as follows:

$$\text{Friesians : } Y = 1.83 + .2947X \text{ (r = .717)}$$

$$\text{Jerseys : } Y = 2.63 + .2165X \text{ (r = .526)}$$

In both equations, the regression coefficients as well as the correlation coefficients were significantly different from zero at the $p = 0.01$ level of significance. It may be added that only cows in parlours where stimulation intervals were satisfactory and where stripping was done correctly, were included in the regression analysis.

Thus, the effect of milk yield on variable time has been ascertained. Fixed time has also been identified. In order to assess the effect of milk yield on the efficiency of labour use, it will be necessary to discuss some criteria of labour efficiency.

CRITERIA OF LABOUR EFFICIENCY

Three criteria of labour efficiency will be used in this discussion:

1. The optimum allocation of milking units per man, hereafter called the man/machine ratio;
2. cows handled per man per hour;
3. pounds of milk per man-hour.

Of these three, the last may by itself be said to be the best test of labour efficiency, but because of the importance of the first two from an organisational point of view, these will also receive attention. It will also be made clear that these criteria are closely interrelated.

6) These have all, for the purposes of time study procedures been divided into smaller elements. However, only the key operations are mentioned here because they give a clear indication of the logical sequence of operations.

7) Dodd, C.F. and Foot, A.S. : Experiments in Milking Technique. 1. Effect of washing the udder with hot water. 2. Effect of reducing milking time. Journal of Dairy Research, Vol. 15, p. 1, 1947.

Miller, K. and Petersen, W.E. : Some Factors involved in Efficient milking. Journal of Dairy Science, Vol. 24, p.225, 1945.

Dodd, C.F., Foot, A.S. and Henriques, E. : Experiments in Milking Technique. 5. Effect of Temporary Changes in the Interval between Washing and Milking. 6. Comparison of Established Washing and Milking Routines. Journal of Dairy Research, Vol. 16, p. 301, 1949.

Elliot, G.M. : The Effect on the Amount of Residual Milk of the Interval between Milkings, Duration of Milking and Delay between Udder Stimulation and Milking. Journal of Dairy Research, Vol. 28, p. 123, 1961.

8) Anon. : Machine Milking. Ministry of Agriculture, Fisheries and Food, Bulletin 177. 1959.

Clough, P.A. : Machine Milking in Loose Housing Systems, Proceedings Alfa Laval Symposium on Machine Milking, Sweden, 1963.
Smith, A. and Naudé, R. T. : Die Verskil in Melkvloei-eienskappe van Rasgroepe in 'n Kudde Friese, Jerseys en Bruinswitsers. Proceedings S. Afr. Society of Animal Production, Vol. 3, p. 104, 1964.

The times defined as fixed time elements are all part of the labourer's routine. For purposes of simplification, these may be labelled as basic work cycle time (B.W.T.). Another time unit needs to be defined at this stage : Unit-on time. Unit-on time is the total time period during which a milking unit is attached to the udder of a cow, and consists of true milk-out time plus stripping time, provided machine stripping is being practiced.⁹⁾

Similarly, unit cycle time can be defined as the time taken by a full cycle of the milking unit, i.e. the time lapse between its attachment to one cow and its attachment to the next cow.

Being armed with these time concepts, we are now able to explain how the efficiency criteria may be calculated:

1. The man/machine ratio

Once the cluster has been attached to the udder of a cow, the worker is free to attend to another cow. He will, therefore, move to another stall, strip a cow, let her out, bring in another, prepare her and attach the cluster. Depending on the milk-out time of the first cow, it may be possible to repeat the same work cycle on another cow, or it may be necessary to return to the first cow and strip her.

Now, if a correct milking routine is to be followed, and no overmilking is allowed,¹⁰⁾ the milker must start stripping the first cow at the required time. In other words, the number of times the basic work cycle can be repeated before returning to the first cow, is determined by (a) the length of the unit-on time for the first cow, and (b) the length of the basic work cycle time. This relationship is illustrated as follows:

$$\text{B.W.T.} \times n = \text{Unit-on time (U.O.T.)} \text{ minus stripping time (S.T.)}$$

Such work cycles performed on other cows involve the use of other units; thus, n is the number of units one man can handle, excluding the original one. The total number of units a worker can handle (N) is equal to $n + 1$.

At this stage, it may be noted that the basic word cycle time may be subdivided into two parts:

part a - stripping time, during which the milking machine is in operation,
part b - all other operations. The milking machine is idle during these operations.

Thus, $\text{B.W.T.} \times n \leq \text{U.O.T.} - \text{S.T.}$

Add S.T. to both sides of the equation:

$$(\text{B.W.T.} \times n) + \text{S.T.} \leq \text{U.O.T.}$$

If b = time when machine is idle, (U.I.T.) is added to each side, the equation becomes

$$(\text{B.W.T.} \times n) + \text{S.T.} + b \leq \text{U.O.T.} + \text{U.I.T.}$$

But, $\text{S.T.} + b = \text{B.W.T.}$

and $\text{U.O.T.} + \text{U.I.T.} = \text{U.C.T.}$

where U.C.T. = unit cycle time.

Therefore, $(\text{B.W.T.} \times n) + \text{B.W.T.} \leq \text{U.C.T.}$

$$\text{B.W.T.} \times (n + 1) \leq \text{U.C.T.}$$

$$\text{B.W.T.} \times N \leq \text{U.C.T.}$$

If $\text{B.W.T.} \times N = \text{U.C.T.}$, the worker will be fully occupied all the time. If $\text{B.W.T.} \times N < \text{U.C.T.}$, he will have some idle time, in that he will wait for a cow to finish milking before he starts stripping her. Conversely, if $\text{B.W.T.} \times N > \text{U.C.T.}$, the cow will be overmilked. If this is a general occurrence the farmer may expect udder damage.¹¹⁾

In practice, contingencies which are not part of the basic cycle time have to be dealt with. Such contingencies occur in almost all types of work, and should find their way into all standards through the increase of net standards by some predetermined percentage.¹²⁾ A contingency allowance of 10 per cent was decided on.

$$\text{Thus, } (\text{B.W.T.} \times N) + 10\% \leq \text{U.C.T.}$$

Using the above formula, the optimum number of units one man can handle may be calculated.

2. Cows per man per hour

The number of cows that can be milked by one unit per hour (i.e. unit performance) may be estimated by dividing unit cycle time into 60. Man performance as measured by cows per man per

9) According to the available literature, machine stripping is favoured for various reasons. Thus it was decided to include machine stripping in all these analyses as being preferred practice. References on this point include the following:
Anon. : *Machine Milking*, op. cit.
Politiek, R.D. : *Hand Stripping versus Machine Stripping*. Proceedings Alfa Laval Symposium on Machine Milking, Sweden, 1963.
Fell, L.R. : *Machine Milking and Mastitis - A Review*, Dairy Science Abstracts. Vol. 26, p. 551, 1964.

10) Cf. Fell, L.R., op. cit.

11) Ibid.

12) Presgrave, Ralph. : *Dynamics of Time Study*, McGraw-Hill, New York, 1945.

hour, is estimated by multiplying unit performance by the number of units one man can handle.

Thus, $P_m = P_u \times N$

where P_m = cows per man per hour,

P_u = cows per unit per hour

3. Pounds of milk per man per hour

It has previously been pointed out that the fixed time elements are not influenced by milk yield. They are largely a function of the method and pace of work of the worker, and of parlour lay-out. Variable time, i.e. true milking time, is a function of milk yield per cow and is directly proportional to it. Thus, the higher the milk yield per cow, the longer will be unit cycle time, and the more units will a worker be able to handle. Variable time will also occupy a larger percentage of total time if milk yields are high; thus, a higher performance in terms of pounds of milk per man-hour may be expected as milk yields per cow increase.

EMPIRICAL RESULTS

Different parlour lay-outs cause optimum routines to vary. Dimensions typical of parlour types also cause differences in fixed time to occur among different parlours. For the purposes of this article, results of only one type of

parlour lay-out, i.e. the abreast parlour with one stall per milking unit will be used. It may be added here that the results obtained with other parlour lay-outs showed the same general trends.

Results will be given for Friesian and Jersey herds. The lay-out of this type of parlour and the subsequent operations cause the stimulation interval to last for 0.96 minute, thus acceptable from a sound milking point of view. The machine is idle for 1.61 minutes per cow. The basic work cycle time amounts to 2.14 minutes.

Results showing some data needed to calculate efficiency criteria as well as the criteria themselves, are shown in Table 1.

DISCUSSION

The most salient points emerging from the analyses are the following:

1. An increase in milk yield per cow per milking is associated with an increase in the optimum number of units being handled per man. Labour efficiency is enhanced in this respect. From the viewpoint of economic theory, it is interesting to note that milk yield per cow has an important effect on capital/labour substitution ratios.

TABLE 1 - Performance characteristics and efficiency of labour use with Friesian and Jersey herds, classified according to milk yields in abreast parlours (1 stall per unit)

Milk yield	Unit-on time	Unit cycle time	Unit performance	Efficiency of labour use		
				Man/machine ratio	Cows per man per hour	Pounds of milk per man per hour
lb per cow per milking	Min. per cow	Min. per cow	Cows per unit per hour	Units per man		
FRIESIANS						
5	3.30	4.91	12.2	2	24.4	122
10	4.78	6.39	9.4	2	18.8	188
15	6.25	7.86	7.6	3	22.8	342
20	7.72	9.33	6.4	3	19.2	512
25	9.20	10.81	5.5	4	22.0	550
30	10.67	12.28	4.9	5	24.5	735
35	12.14	13.75	4.4	5	22.0	770
JERSEYS						
5	3.71	5.32	11.3	1	11.3	56
10	4.79	6.40	9.4	2	18.8	188
15	5.88	7.49	8.0	3	24.0	360
20	6.96	8.57	7.0	3	21.0	420
25	8.04	9.65	6.2	4	24.8	620
30	9.12	10.73	5.6	4	22.4	672
35	10.20	11.81	5.1	5	25.5	892

The higher man/machine ratio is caused by the longer period it takes to milk out a cow as milk yields increase. Note the unit-on and unit cycle times. Thus, the number of cows per unit per hour decreases but a worker can handle more units.

It is further noted that with higher milk yields, increased efficiency of capital also results because the milking units are more fully utilized. For example, with yields of 5 pounds per milking, a machine is working 67.2 per cent and 69.7 per cent of the time for a Friesian and Jersey herd respectively, (i.e. unit-on time is expressed as a per cent of unit cycle time). But, if milk yields are 35 pounds per cow per milking the effective machine time is 88.3 and 86.4 per cent respectively for Friesians and Jerseys.

2. Cows per man/hour are, in general, not closely associated with milk yields. The reasons for this, lie in the complex nature of relationships; while increased yields are positively associated with the optimum number of units, they are negatively associated with the number of cows per unit per hour.

3. Table 1 clearly shows that increased milk yields per cow have a very beneficial effect on pounds of milk per man per hour - perhaps the best criterion of labour efficiency.

SUMMARY AND CONCLUSIONS

An analysis was made of the effect of milk yield per cow on the efficiency of labour use in milking parlours. The abreast parlour (one stall per unit) was used as an example. It may be pointed out that the general trend of results in all parlour types will be similar - only the magnitudes can be expected to differ.

Owing to the existence of fixed and variable time elements the optimum man/machine ratio changes with increased milk yields. This change is such as to enhance efficiency both of labour and machinery (i.e. capital). Coupled with this, high yields can also be expected to increase the efficiency of fixed capital, in the form of higher milk production per parlour (given equal herd sizes).

Milk yields do not materially affect the number of cows handled by one worker per hour but they have large and important effects on labour productivity (pounds milk per man/hour).

Thus it appears that a high level of labour and capital efficiency cannot be attained in dairy-ing while milk yields are low. Due to the larger optimum number of units handled per man with high yielding cows, and also because of the higher capital investment ordinarily associated with them, high producing cows do, however, necessitate more adept handling of cows and equipment. Thus it may be stated that this higher efficiency of capital and labour can be sustained only if two conditions are met: Firstly, that the labourers involved possess the skill to handle such cows and equipment and secondly, that supervision and organization of labour in the dairy parlour are of a sufficiently high standard.

Thus it appears that these three factors - milk yields, labour skill and organisation - together with others may be regarded as of prime importance in the dairy parlour.

Note: The authors intend to prepare further reports on the optimum routines in parlours, the effects of variation in milk yield within a single herd on labour efficiency and on efficiency comparisons among different parlour types.