THE BOILING HOUSE LOSSES OF SOUTH AFRICAN DIFFUSION FACTORIES

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Abstract

Boiling house losses of three South African factories equipped with diffusers are surveyed. In two cases boiling house losses have increased following the introduction of diffusion. In the third factory boiling house losses are lower than those of a neighbouring milling factory. In all cases the trend during the past two seasons has been towards a reduction in losses. Possible causes for higher losses in molasses are examined but no correlation has been established.

Introduction

The first cane diffuser to operate in South Africa was commissioned in 1966 and three other units started operating in 1967 and 1968. All four diffusers are of the percolation type and are preceded by a mill. Two of the units are BMA and two De Smet. Although the two makes of diffuser differ mechanically, they can be considered to be of the same type from a processing point of view.

In all cases, the introduction of diffusion brought about serious teething troubles during the first year. The results of the first season have been included in the tables and curves discussed in this paper but they should be interpreted with reservations. The larger boiling house losses during the first year of operation may be due more to irregular factory operation than to a change in process.

Factors in diffuser operation which may affect boiling house losses

The four factors in diffusion which may affect boiling house recovery are:

(a) Temperature

(b) pH

(c) Retention time

(d) Press water treatment

Conditions under which diffusers are operated in South Africa with respect to these factors are reviewed below:

(a) *Temperature*

All diffusers in South Africa are operated at about 70°C although in some cases the temperature in the first washing stages is raised to about 85°C. At least one diffuser operator claims a direct correlation between temperature and extraction and would prefer to work nearer to 90°C than to 70°C. This is in accordance with the experimental findings of Buchanan and Jullienne[1] and those of Foster and Hill[2] in Australia. Variations of 2 to 3°C along the length of the diffuser are common and appear to have no influence on operation.

Effects of temperature losses on molasses in the 60 to 90°C range have not been reported and, as far as is known, have not been noted in industrial scale operation.

(b) *pH*

There does not appear to be full agreement on the optimum pH in diffusers. In one factory (EM) juice is limed to a pH of 7,0 in the diffuser while at UC a pH of about 6,5 is aimed at. In both these diffusers milk of lime is introduced at two places: at the feed end of the diffuser and half way along its length. At EN the juice is limed to a pH of about 6,5 halfway along the length of the diffuser while at ML there is no pH correction other than that obtained by returning limed press water to the tail end of the diffuser.

Results obtained at UC and discussed later in this paper seem to invalidate the claim made by some technologists that liming in the diffuser will result in increased boiling house losses at least for the pH range 6,0 to 7,0.

Graham *et al*[3] have shown that the effect of pH on the extraction of commonly determined impurities was negligible but that pH did influence the enzymatic destruction of sucrose in the diffuser. Research is being continued at the S.M.R.I. to find out if liming has any effect on non-sucrose formation in diffusers. The study of pH curves along diffusers with and without liming seems to indicate that pH control is necessary to control sucrose destruction. The effect on corrosion can only be beneficial.

Local overliming is probably just as objectionable in diffusers as in mixed juice liming and the milk of lime should be introduced in the diffuser at a place where it can be properly mixed. The suction pipe of juice circulation pumps is suitable. Drawing a pH curve at least once a shift should be part of routine diffuser control.

(c) *Retention time*

It is generally agreed that reducing the retention time of products in the factory can only have beneficial effects. There is, however, very little data on the effect of retention time on losses even for tradiional equipment such as clarifiers.

The effect of retention time on losses in diffusion is still debatable. Research has been started at the S.M.R.I. on the effect of retention time under conditions duplicating those of a diffuser and preliminary results indicate only marginal differences in juice composition. Some diffuser operators claim that molasses % cane increases when retention time is increased by slowing down the diffuser. Others report no changes. In general the diffuser operator has little choice with regard to retention time and has to operate the diffuser at the required conveyor speed to maintain capacity. The effort in South Africa has tended towards a reduction in juice retention time by eliminating press water treatment. This is reviewed below.

(d) *Press water treatment*

Clarification of press water involves all three factors discussed above: pH, temperature and retentime time. The process is cumbersome and is the bugbear of all diffuser operators.

When diffusion was introduced in South Africa it was believed that it was essential to obtain a clear press water and this was only possible at high pHs. Press water was therefore limed to a pH of 9 or 10 and settled in clarifiers with retention times of one to two hours.

The evolution has been first towards reducing the pH and then returning the press water to the diffuser without clarification. The procedure followed in each of the diffuser factories during the 1970 season was as follows:

ML Press water was limed to a pH of about 8, clarified and returned to the diffuser. An appreciable amount of mud was separated in the clarifier but the "clarified" press water was still dark and at a pH of 7 to 7,5.

EM The press water was returned to the diffuser without any treatment. To allow it to percolate through the bed, the bagasse mat is churned up by vertical screws at the point of application of the press water.

EN Press water was heated to about 80°C and settled in a clarifier without liming. Retention time was about one hour. Some mud settled out and the dirty press water was returned to the diffuser.

UC The press water was returned to the diffuser after filtration through a 40 mesh vibrating screen and without other treatment. There was no physical agitation of the bagasse mat in the diffuser.

It is probable that every diffusion factory would have liked to do what UC did. Percolation rate presented practical difficulties and was affected by cane preparation and the fibre loading of the diffuser. Return of untreated press water affects percolation rate and UC for example reported that they very often operated at near flooding conditions. Even when mechanical devices are employed to force press water into the bed, such as at EM, there appears to be a tendency for the front part of the diffuser to operate in a semi-flooded condition.

Rein[4] has postulated that juice hold up in percolation diffusers could be long at low flow rates and it is worth considering if the elimination of press water treatment is not defeating its purpose, at least partially, when the effect is to reduce percolation rate in the diffuser. The increase in juice hold up time in the diffuser must be balanced against the retention time in the press water clarifier.

A reduction in boiling losses has been noted for all diffusion factories during the past season and no correlation can be established between losses and the method of treatment of press water.

It may not be out of place to speculate on a process for press water treatment which would combine the advantages of low retention time with those of clarification. This is centrifugal separation which has proved to be technically very satisfactory but unfortunately very costly. Development of new, large capacity desludging centrifugals for effluent treatment may modify the economics of this process. Clarification by flotation with a low retention time has also been proposed.

Boiling house losses of diffusion factories

The results of EM, EN and UC are reviewed below. The losses of ML have been plotted on some of the curves but will not be discussed in this paper. It is felt that the mechanical difficulties experienced by the factory during the first two seasons and the fact that refinery and rawhouse losses are combined create special conditions which may overshadow the effect of diffusion.

Losses of each diffusion factory have been compared with those of one or more milling factories and with the industrial average. EM has been compared with FX and UF which are neighbouring milling factories which showed losses very similar to EM when it was still a straight milling factory. UC has been compared with JB which is the only other factory in the midlands region. MV has been chosen as the milling factory with which to compare EN because, prior to the installation of a diffuser at EN, the boiling house losses of these two factories were very similar.

The losses have been expressed as "boiling house losses % sucrose in cane" and "sucrose in molasses % non-sucrose in mixed juice". This second formula which is also referred to as the "molasses factor" has been selected to compensate for changes in mixed juice purity as a result of variations in cane quality from season to season. It is realised that it is not entirely satisfactory because, being based on mixed juice analysis, it will be affected by any change in non-sucrose composition of the juice due to conditions in the diffuser.

Empangeni (EM)

Examination of Figure 1 shows that boiling house losses at EM were comparable to those of FX and UF before 1968. With the introduction of a diffuser during the 1968 season losses have increased and during the 1970 season the boiling house losses at EM were 12,5 while those of UF and FX were 11. The purity of final molasses is not strictly comparable for years with diffusion and those with milling because in 1967 the factory changed from spindle to refractometric brix. Inspection of the results tabulated in Table I shows that the purities are in the same range with as much variations between seasons using the same process than between milling and diffusion seasons.

The evolution in molasses production is plotted in Figure 4. It shows that EM follows the average trend of the whole industry in producing more molasses per ton of cane. The increasing divergence between EM and the industrial average curve since the introduction of diffusion indicates that the new

TABLE I

Purity of final molasses

Year	EM	EN	UC	JB	ML
1963	40,0	39,8	—	—	—
1964	42,5	40,2	—	—	—
1965	40,5	42,1	—	—	—
1966	41,5	43,1	43,8	41,5	—
1967	41,5(R)	41,7	37,3	39,0	40,9
1968	42,7(R)	41,2	38,2	39,7	39,0
1969	40,7(R)	42,1	39,1	38,9	41,0
1970	41,0(R)	42,9	36,8	39,4	42,9

EN and UC : Apparent Purity
EM, JB, ML : Gravity Purity
ML and EM as from 1967 : Refractometer Brix.

process may be responsible for increased molasses production.

Finally, if the change in "sucrose in molasses % non-sucrose in cane" for the past seven seasons is considered, the trend is almost the reverse of that for boiling house losses with the molasses factor at a low value for the season during which the diffuser was commissioned and increasing steadily during the next seasons. The average value is about the same for the years with mills and with a diffuser.

Entumeni (EN)

The boiling house losses curve for EN is very similar to that of MV for the last three years during which EN operated a straight milling tandem. Inspection of Figure 2 shows that in both factories the losses increased considerably during the 1965 season (when EN still had mills) but whereas the MV losses fell back to below the industrial average during subsequent years, those of EN have remained above average since the introduction of diffusion.

As in the case for EM, there has been a marked reduction in boiling house losses during the past two seasons: from 13,4 to 11,7, or 1,4 points, while during the same period the average reduction in boiling house losses for the industry as a whole was only 0,8 points.

Molasses production at EN was below the industrial average before the introduction of diffusion except for the last season with mills. It remained above average during the next four seasons with diffusion but during the past two seasons the molasses % cane has remained constant while the industrial average has gone up so that in 1970 the molasses production of EN is slightly lower than the average, just as it was with mills in 1965. Purity of final molasses was slightly higher for the past years with diffusion than it was during the last three years with mills.

The molasses factor was for the past three seasons approximately the same as for the last season with mills but is much higher than the values recorded by MV during the same period.

Union Co-op (UC) and Jaagbaan (JB)

Both these factories are new, started operations during the same year and process cane from the same region. JB has a new mill tandem and UC a diffuser preceded by a mill. Both factories achieve a high level of extraction and the resulting increase in extraction of impurities should be of the same order.

The curves plotted in Figures 3, 4 and 6 show that the performance of the boiling house is better at UC than at JB with regards to boiling house losses, molasses produced % cane and sucrose lost in molasses % non-sucrose in mixed juice and for both factories the reduction in boiling house losses during the past season has been over 1,5 points.

Purity of final molasses is not strictly comparable because during past seasons UC has reported apparent purity and JB gravity purity. No systematic difference is apparent and if last season's average results are compared on the basis of gravity purity, we find that UC reported 37,5 and JB 39,4.

Conclusion

Losses in the boiling house are subject to influences over which the factory has little control. Many more results are therefore needed for statistical analysis in order to draw valid conclusions and it will be a number of years before these are available for diffusion factories. The situation is further complicated by the fact that other changes in factory equipment and operation also affect boiling house losses. These have not been considered in this paper.

The preliminary conclusions which can be drawn so far from the results of diffuser operations in South Africa are:

(a) In the case of two factories which have changed from milling to diffusion, the introduction of diffusion has led to increased boiling house losses during the first seasons of operation. These losses have been reduced in the subsequent seasons and the boiling house losses of these two factories are approaching the industrial average.

(b) One new diffusion factory reports boiling house results which are superior to those of a neighbouring well equipped milling factory processing cane from the same region. The boiling house losses of this factory (UC) have been below the industrial average for the past season.

(c) No correlation can be established between the method of press water treatment and boiling house losses. Results of the past season have established, however, that return of unclarified press water does not appear to have an adverse effect on boiling house losses.

(d) Liming to a pH of about 6,5 to 7,0 in the diffuser has not prevented three diffuser factories from improving to a considerable extent the performance of their boiling house.

These conclusions are mainly negative but throw some light on the influence of some of the factors which have been postulated as being detrimental to good recovery from diffusion juice.

The effect of operating temperature on boiling house losses has not been systematically studied but variations in temperature in the 65-90°C range do not appear to have an effect on losses in molasses.

Investigation of the operation of diffusers in South Africa fails to reveal why in two cases boiling house losses are higher with diffusion than they were with milling. One might speculate that, since the increased losses are due to higher molasses production, while exhaustion remains the same or is better, destruction of sucrose and production of reducing sugars in the diffuser may have taken place.

Unfortunately reducing sugars to sucrose ratios for first expressed juice are not available and no comparison can be made of the drop in reducing sugars to sucrose ratio in diffusion and milling factories. Examination of the reducing sugars to sucrose ratio in final molasses of diffusion and milling factory reveals no particular trend.

Research carried out at the S.M.R.I. and which is still being continued has failed so far to reveal any significant difference in composition of milling and diffusion molasses which could account for difference in losses between the two processes.

The tentative conclusion that can be drawn is that the higher boiling house losses reported by some diffusion factories have been due mainly to lack of experience with a new process and that these losses are being reduced at such a rate that if the present trend continues they will not be higher than the industrial average within two or three seasons.

REFERENCES

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3. Graham, W. S., Morris, R. M. and Oosthuizen, D. M., 1968. Proc. Int. Soc. Sug. Cane Tech., 13, 122.
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Discussion

Mr. Hulett (in the chair): It is comforting to note that the boiling house losses in diffusion factories are decreasing and Dalton is already below the industrial average.

Mr. van Hengel: I agree with Mr. Lamusse that it is difficult to come to a definite conclusion at this stage about various factors in the diffusion process.

However, I think Malelane factory should have been included and that Entumeni should have been compared with Amatikulu.

If Empangeni and Felixton, which often interchange cane during the season, are compared it is seen that, in boiling house losses, EM sometimes has a higher undetermined loss and FX has a very favourable molasses purity.

We have clouded the issue of boiling-house losses by showing a blanket loss. To know if the losses are caused by the diffuser it is necessary to measure, either by spindle or refractometer, the amount of non-sucrose entering the factory and then find how much is in the final molasses. FX had 12% less in final molasses than EM last year, although in one month's performance this year the difference dropped to 4%.

Had Malelane not been omitted the non-sucrose picture would have been much worse. We have still got a problem even though we might be overcoming it without fully understanding the nature of it.

I am in favour of diffusers but I do not think we should close our eyes to some of their disadvantages, and we must evaluate them further.

At the moment with diffusers the molasses production is 10% too high.

Mr. Lamusse: I agree we have a problem and I am not suggesting that we should gloss over it.

I do not think too much emphasis should be placed on EM because this factory and ML are the worst two cases. Dalton has a diffuser similar to others and yet has very good results.

I do not agree with non-sucrose ratio being set as the standard by which to judge process work. It is an important index in one given factory to follow the change in non-sucrose ratio but it has certain weaknesses for comparative purposes. Biggest changes in non-sucrose ratio appear to occur in clarification rather than in the boiling house. Non-sucrose ratios based on clarified juice give much better agreement than on mixed juice.

Mr. van Hengel: Unfortunately non-sucrose ratio was not reported in the 46th Annual Summary, as was customary, so it is difficult to quote figures.

I am now quoting from memory so I apologise for any mistakes.

UC had a non-sucrose ratio of ,97 but boiling house losses were within limits because the undetermined loss was just over 1,0 and it had one of the best molasses purities of all factories.

Had UC made less molasses of the same purity they would have had an even better boiling house recovery.

Mr. Lamusse: UC reported their non-sucrose ratio weekly and it was so erratic it was not possible to plot it.

I am afraid I do not share Mr. van Hengel's views on the importance of non-sucrose ratio for measuring performance between factories although it is a valuable figure for following changes within a factory.

Mr. Renton: Mr. Lamusse says that Empangeni's increased boiling house losses may be due to lack of experience in a new process. But the EM process system was long established and was not altered when the mills were changed for a diffuser. We are now spending more money on the back end of the factory to reduce molasses purities.

Mr. Lamusse: My tentative conclusions refer to all diffusers operating—I am not referring to a particular diffuser and do not mean to criticise EM.

I think it understandable that there was some trouble at EM because a switch was made to diffusion and no change was made in process or equipment at the back end of the factory. I unfortunately cannot say what should be done to change process and equipment but Messrs. van der Riet and Renton's paper does indicate that the steps that were taken at Empangeni, even though costing money, are proving successful.

Changes are being made in all factories to improve process and not just in diffusion factories, as Mr. Renton's comments would imply.

Mr. Buchanan: From the 1969 Factory Reports I can give the following figures for non-sucrose ratio—Malelane ,94, Entumeni ,95, Empangeni ,88 and Dalton ,88.

Mr. van Hengel: Mr. Lamusse says that the diffuser's performance was not too bad because the process was not changed. We can improve matters by having less sucrose going out in molasses and more non-sucrose.

That is why I think our results should be related to the carrier, namely, non-sucrose.

As regards the figures just given by Mr. Buchanan, had Empageni's figures been reported on spindle brix they would have been ,94 and not ,88.

Mr. Hulett: When analysing for non-sucrose in mixed juice are you compensating for the sand that is present? In the diffuser the sand is filtered.

Mr. van Hengel: No, because both factories receive the same cane. In any case, you pay for the sand.

Mr. Buchanan: In the 1969 Factory Reports it is specifically stated that brixes are determined by hydrometer.

Mr. Renton: Solids in mixed juices were measured at EM and FX and are very much the same.

Mr. Gunn: Mr. Lamusse says that the first two years of diffuser performance should be disregarded. Yet at the end of his paper, when showing improvements in diffusion, he appears to take into account these first two years, when there were many mechanical stoppages and therefore probably a lot of sucrose destruction was occurring.

Dr. Matic: I do not know why there is an impression that this paper claims there are no longer problems in connection with diffusion.

Mr. Lamusse has carried out a difficult task in putting together on paper available information and trying to analyse and assess it. He certainly has not tried to gloss over difficulties.

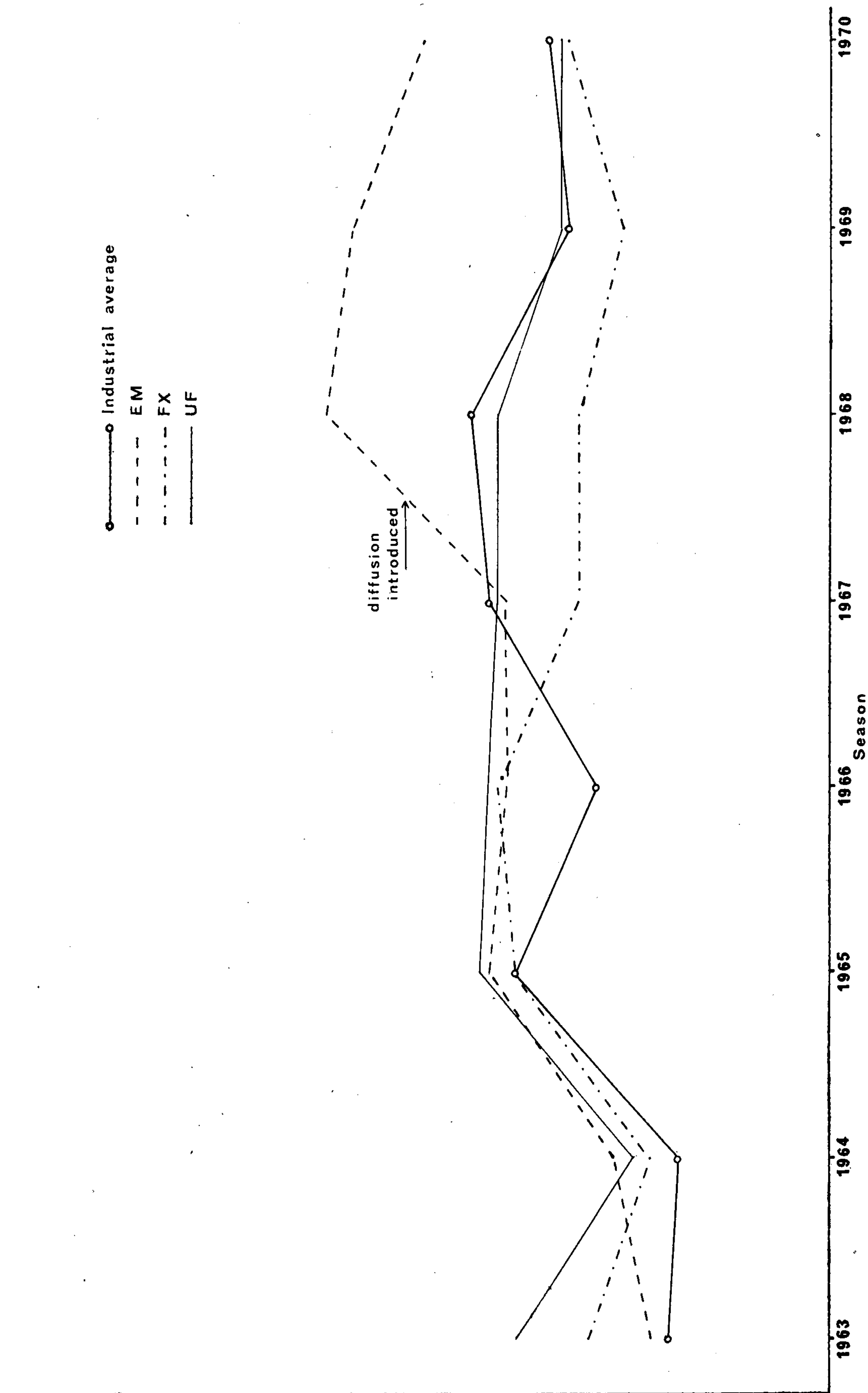

FIGURE 1: Sucrose lost in boiling house % sucrose in cane for the last 8 seasons (EM, FX, UF).

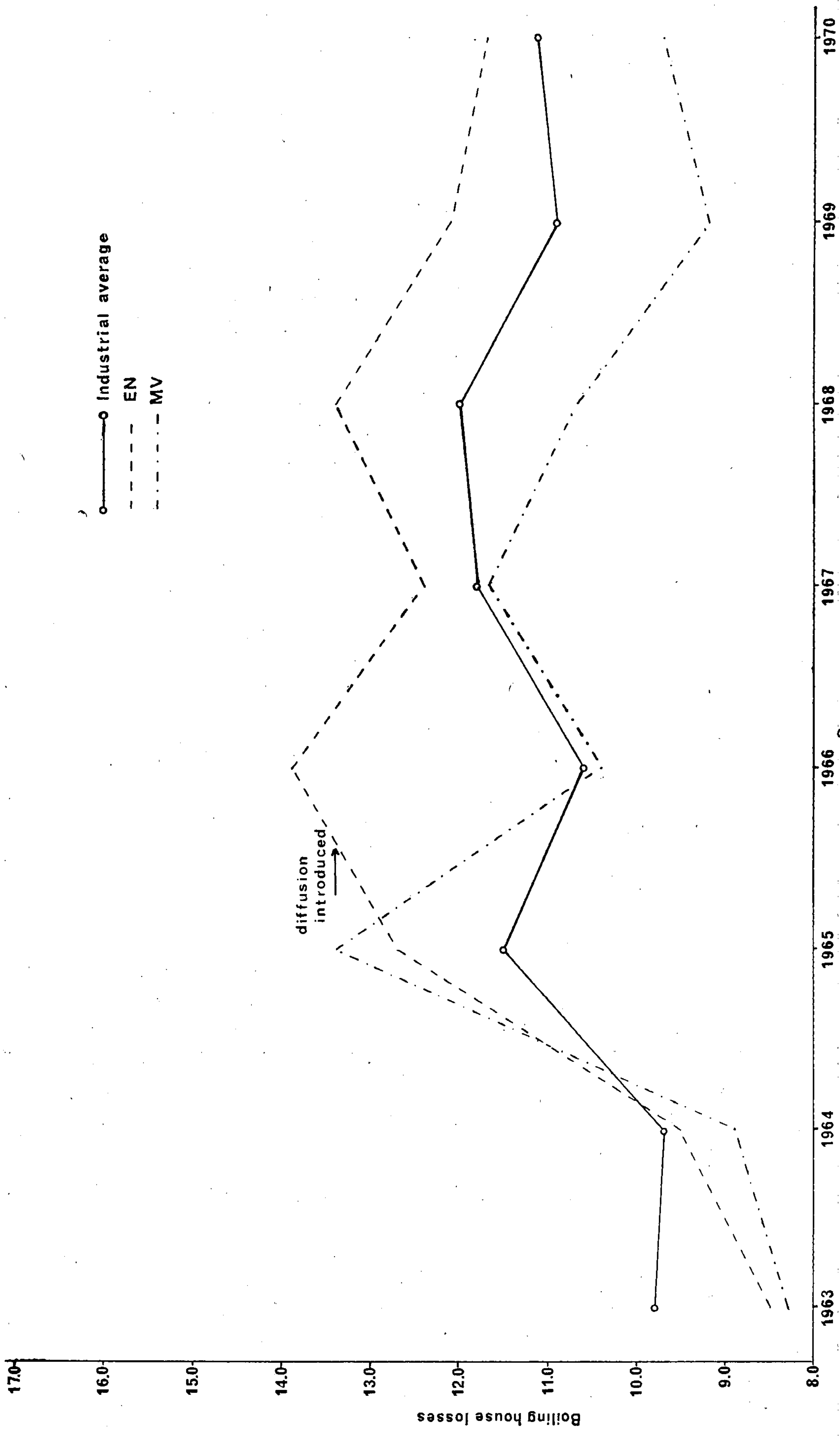

FIGURE 2: Sucrose lost in boiling house % sucrose in cane for the last 8 seasons (EN, MV).

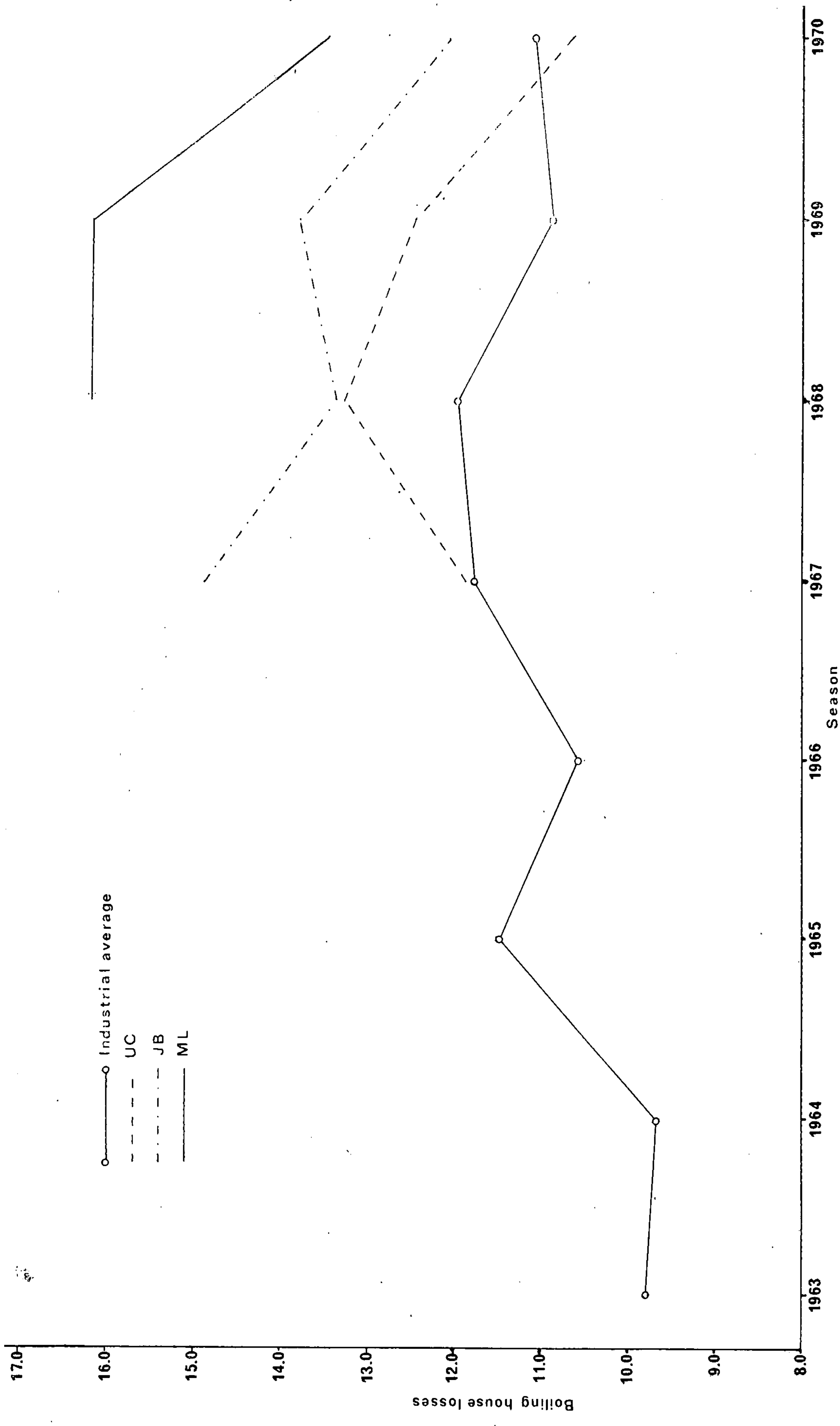

FIGURE 3: Sucrose lost in boiling house % sucrose in cane for the last 8 seasons (UC, JB, ML).

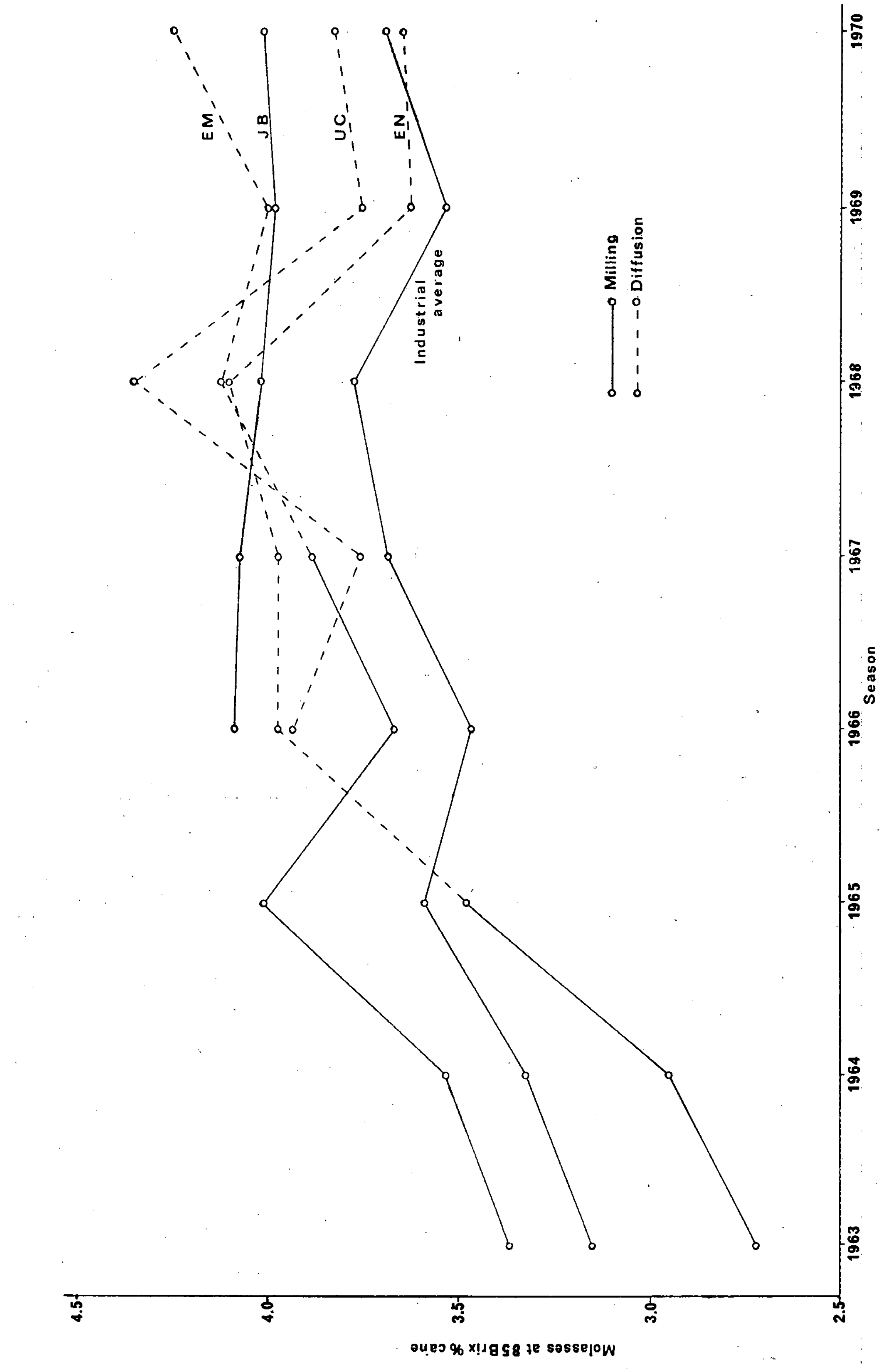

FIGURE 4: Molasses % cane for the last 8 seasons.

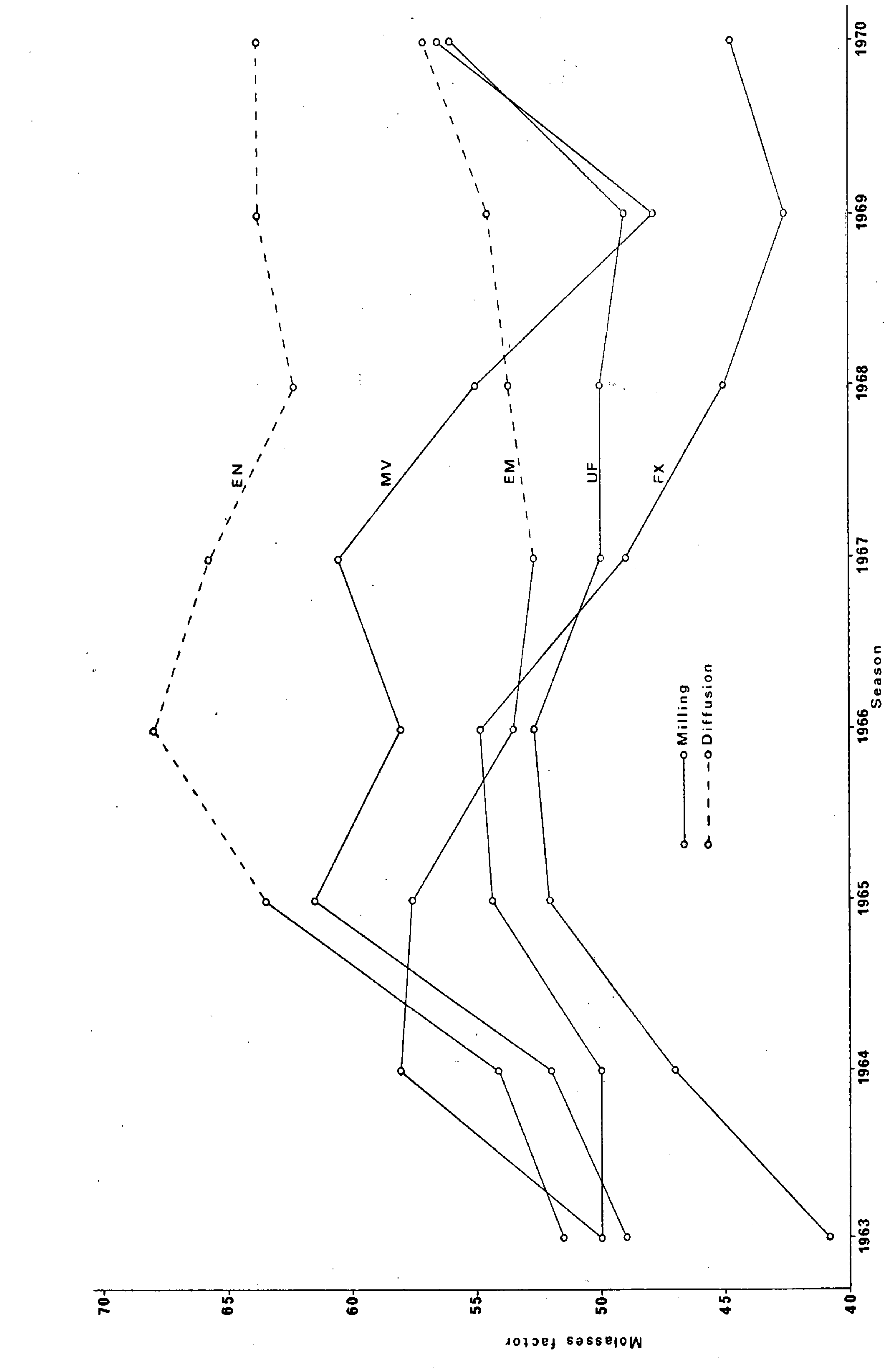

FIGURE 5: Molasses factor for the last 8 seasons (EM, EN, UF, FX, MV).

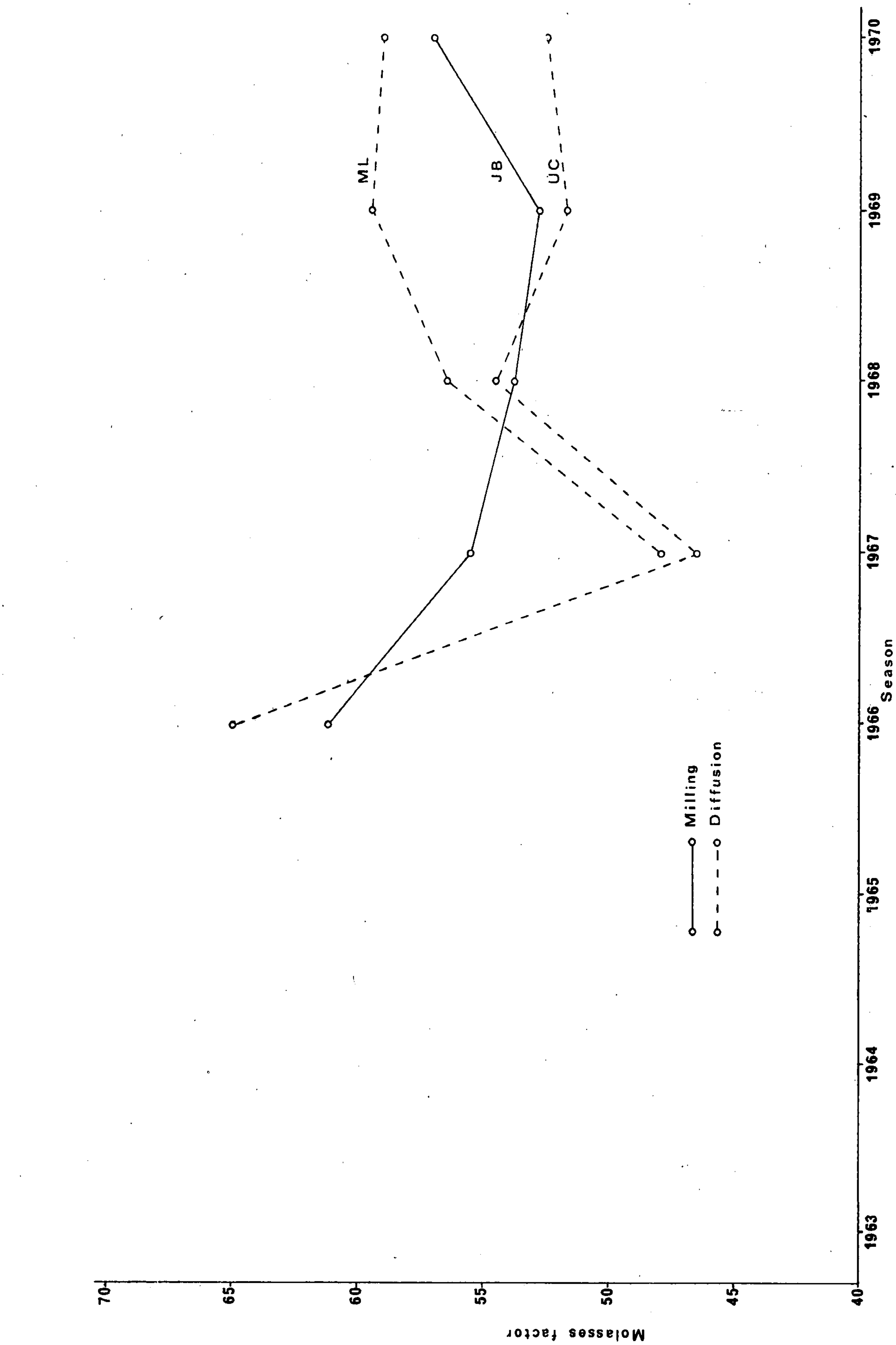

FIGURE 6: Molasses factor for ML, JB, UC.