Oil palm (*Elaeis guineensis Jacq*.) Block Sex Ratio

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***Abstract*- Block Sex Ratio (BSR) is an operational or commercial measure of the number of palms producing fruit relative to palm planting density for any given period. It is different to the oil palm sex ratio which is a biological measure that calculates the number of female inflorescences relative to the total number of inflorescences. Three blocks were assessed and compared; two younger, adjacent blocks (A and B) and one older block (C). Block A had a BSR average of 29.9 (40 bunches) calculated over four years, BSR maximum of 48 (65 bunches), and BSR minimum of 14 (19 bunches). Block B had a BSR average of 19 (26 bunches) also calculated over four years, BSR maximum of 32 (44 bunches), and BSR minimum of 13 (18 bunches). Block C had a BSR average 10.3 (14 bunches) calculated over 21 years, BSR maximum of 13.4 (18 bunches) and BSR minimum of 6.6 (9 bunches). Effectively this means that for block C on average only 14 palms per hectare out of a possible 136 palms were productive during a harvest round. The differences between blocks A/B and C are likely due to improved breeding; however their different ages, planting material and locations will be contributing factors and must be considered carefully. While increases in BSR are significant, in general they fall well short of theoretical. Maintaining a BSR48 could theoretically produce 57.29 t/ha, at least in block A. These results highlight the degree of variation within and between blocks. It is therefore important that managers, researchers and breeders are aware of, and understand palm growth and development from a commercial perspective. Increasing BSR and minimising fluctuations in yield have distinct commercial and logistical advantages.**

***Index Terms*— Block Efficiency Indicator (BEI), Bunch harvesting, Frond production rate, Harvest rounds, Improving agronomic performance, Increasing yield, Palms per hectare**

I. Introduction

Oil palm produces inflorescences in the axil of every leaf, however it is sex ratio that ultimately defines the number of bunches produced. Palm sex ratio is defined as the number of female inflorescences relative to the total number of inflorescences produced (Corley and Tinker 2003). To calculate palm sex ratio requires monitoring of individual palms over an extended period of time.

A simple alternative is to calculate a Block Sex Ratio (BSR). BSR uses basic data to calculate the number of palms producing fruit at any given point in time. It is important to understand that BSR does not provide data regarding the individual palm sex ratio. BSR was originally developed as part of the oil palm Block Efficiency Indicator (BEI) (Henderson, et al. 2014) where it is combined with yield, planting density, average bunch weight and frond production data to monitor block efficiency. BSR provides managers, researchers and breeders with an additional tool with which to monitor block performance and continue improvement.

The objective is to produce a simple, reliable and repeatable block based sex ratio (BSR) that can provide valuable data and insight into the differences between actual and theoretical yield.

A. Materials and Methods

To determine a BSR for a block Equation 1 is used:

$$BSR = \frac{Tot.\,bunches\ harvested}{Tot.\,harvest\ rounds} \div Tot.\,No.\,palms \qquad (Eq.1)$$

Total bunches harvested is divided by the total number of harvest rounds. This is then divided by the total number of palms in the block to give the ratio of palms producing fruit, effectively the Block Sex Ratio. Multiplying this ratio by 100 produces a percentage that may be easier to understand. For this reason all BSR values will be presented as percentages, except when calculating the BSR numbers of bunches. For this calculation the ratio will be used. If for example a 35 ha block planted at 136 palms/ha produces 65,000 bunches in a year, harvested over 50 harvest rounds then the BSR is 0.273 or 27.3 % (Equation 2).

$$\frac{65{,}000}{50} = 1{,}300 \div 4{,}760 = 0.273 \times 100 = 27.3 \qquad (Eq.2)$$

The BSR means that only 0.273 or 27.3 % of the block was productive during any one harvest round. The number of productive palms per hectare (producing fruit bunches) can be calculated using Equation 3. Note that this calculation uses the BSR ratio, not the percentage value.

$$No.\,bunches = 136\,palms \times 0.273 = 37.1 \qquad (Eq.3)$$

The number of productive palms per hectare is therefore 37.1. It is also possible to calculate a simple correlation between BSR and yield once the BSR is known. If the average yield is 25 t/ha and the BSR27.3, then for every change in BSR by a factor of 1, the corresponding change in yield will be 0.92 t/ha. Increasing the BSR to 35 would therefore result in a yield increase of 7.2 t/h.

Three blocks are presented as examples. Blocks A and B, which are adjacent to one another, for a period of four years, and block C with data representing a period of 21 years. Blocks A and B have the same genetic planting material and were planted at the same time and are located in an area not affected by seasonal water deficit. Block performance is therefore expected to be relatively uniform. Block C has different planting material to blocks A and B and is located in an area subject to seasonal water deficit so some performance variation is to be expected.

BSR is plotted over time and comparisons made with yield and average bunch weight. BSR makes the assumption that each palm only produces one bunch per harvest round. While occurrences of multiple bunches have been observed at the end of periods of water deficit their effect can be minimised by recording data over a longer period of time. If multiple bunches are being produced regularly then this would indicate a high frond production rate, and may be of research or breeding interest. Often high frond production rates are associated with low bunch weight; however this is not always the case. BSR can be calculated per harvest round, or on a monthly or yearly basis as required. Monthly and yearly calculations will allow for comparisons with rainfall. Data for the total number of bunches harvested and the number of harvest rounds should be readily available as it is normally recorded by estate managers. Data were log transformed (log (x+1)) to remove heteroscedasticity using SAS 9.3 (SAS Institute Inc., Cary, NC, USA). Data are presented in logarithm value.

B. Results and Discussion

In Figure 1 the BSR and yields for two adjacent blocks (A and B) are presented. BSR is similar for 2008 and 2009; however block B does not match the increase observed in block A for 2010 to 2011. Information provided by the estate manager indicated that this was the result of a rat infestation which affected pollination and subsequently reduced yields. While this result is due to management and not genetic or environmental influences it does highlight the need for caution and understanding when interpreting BSR, although it is really no different to interpreting any reduction in yield.

Figure 2 shows the monthly relationship between BSR, average bunch weight, and yield for blocks A and B over the four year period. In block A two areas of interest are highlighted. In September 2009, BSR decreased and there was a corresponding decrease in yield and a very slight increase in average bunch weight, although not sufficient to counter act the decrease in yield. In April 2011 BSR showed a slight increase, however yield decreased. What is interesting is that while average bunch weight increased significantly, yield still declined. In block B two areas of interest are also highlighted. In June 2008 average bunch weight decreases dramatically, BSR increases and yield remains constant. The degree of change observed in June 2008 is outside the normal range and may simply be a management issue. In September 2010 BSR increases, average bunch weight decreases and yield remains constant. In general there is a negative correlation between BSR and average bunch weight. This is to be expected given the technique for calculating BSR; however the inconsistencies highlighted may warrant further investigation.

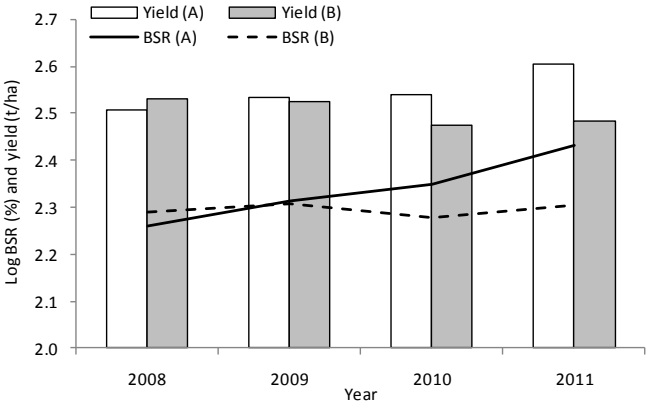

Fig 1. Comparison of BSR and yield for two adjacent blocks, A and B planted at the same time and with the same genetic planting material over a four year period

In block A, BSR reached a maximum of 48 (65 bunches) in November 2011, a minimum of 14 (19 bunches) in September 2009, with an average of 29.9 (40 bunches). Block B on the other hand reached a maximum BSR of 32 (44 bunches), a minimum of 13 (18 bunches) with an average of 19 (26 bunches). The maximum of 65 bunches/ha (BSR48) observed in block A when combined with an average bunch weight of 22.6 kg and 39 harvest rounds, means a potential yield of 57.29 t/ha might be theoretically possible if BSR could be maintained at 48. The BSR observed in blocks A and B are significantly better than the BSR of 10.3 observed for block C

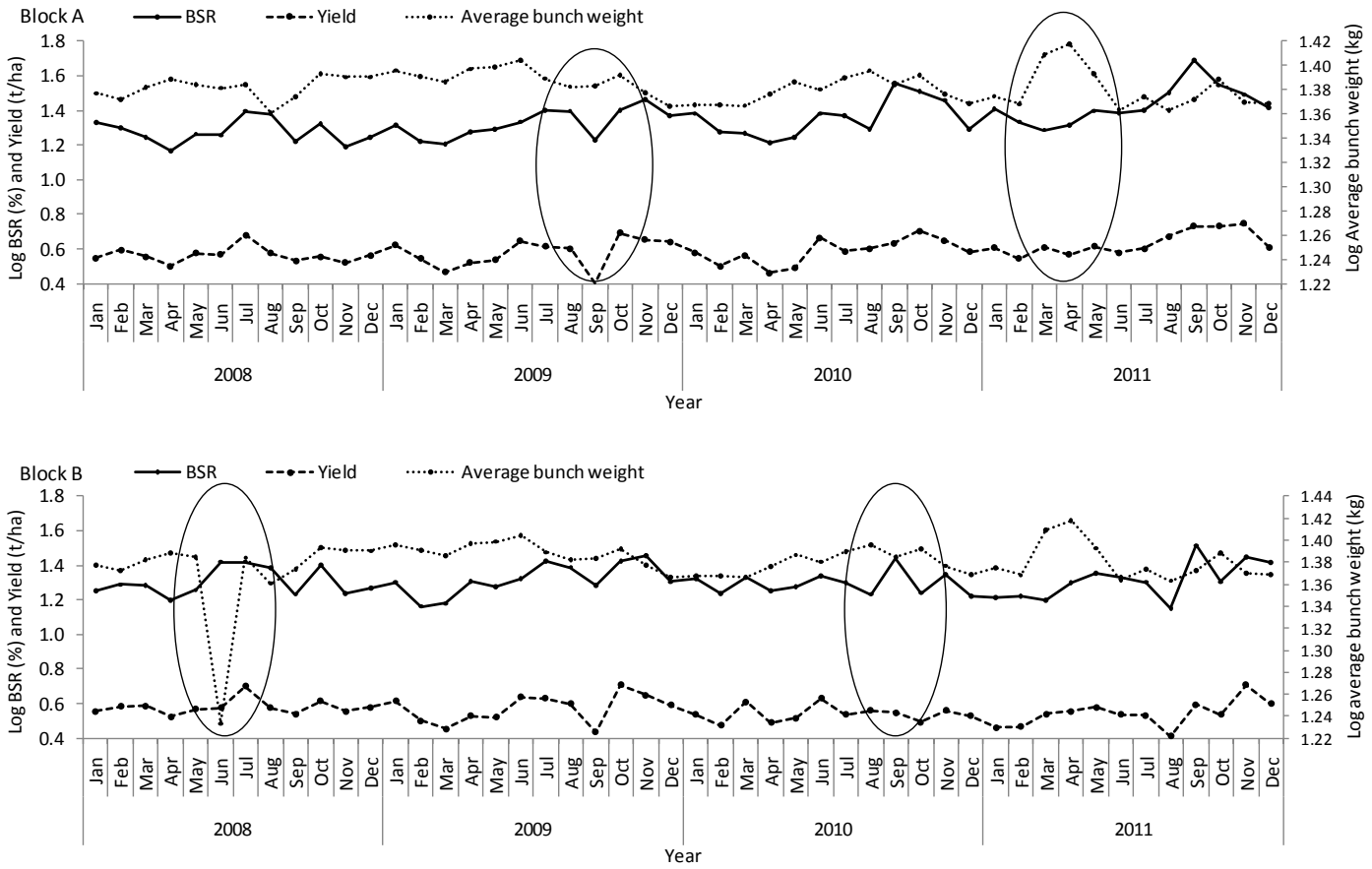

Fig 2. Block A (top) and Block (B) bottom - BSR and yield are plotted on the primary axis, while average bunch weight is plotted on the secondary axis. Areas of interest are marked using ovals.

Figure 3 compares BSR with yield for block C over 21 years (1992 - 2012). BSR average is 10.3 (14 bunches) with a maximum and minimum of 13.4 (18 bunches) and 6.6 (9 bunches) respectively. The BSR value is very low and even if the number of available palms was over estimated and was in fact only 110/ha, BSR average would still only be 12.8. Two interesting anomalies have been highlighted. The first is in 2000 where BSR remains constant, but yield has increased significantly. This means that bunch weight has increased and not the numbers of bunches produced. The second is 2009 where BSR has decreased significantly, but yield has remained relatively constant. In this situation not only has the number of bunches decreased, there has been a corresponding decrease in bunch weight that has maintained yield at a constant. This shows a positive correlation between BSR and average bunch weight which is unusual. The opposite nature of these two anomalies highlights the value of BSR in a multiple comparison analysis. A positive correlation (data not presented) was observed with rainfall in block C as would be expected given that periods of water deficit are reported to influence sex ratio as well as palm growth and development (Corley and Tinker 2003).

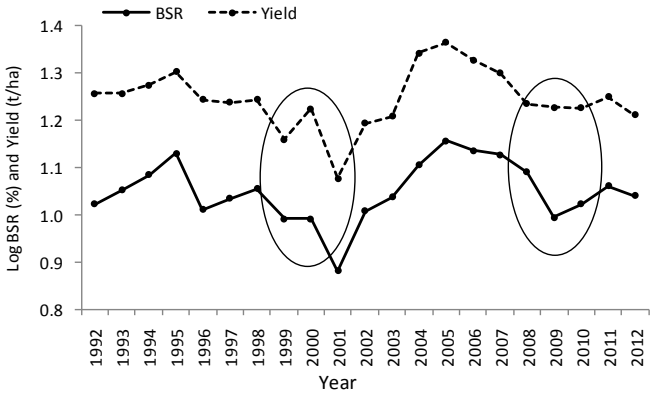

Fig 3. Block C - Yearly BSR with yield comparison calculated for one block over 21 years – Areas of interest are marked using ovals.

It is interesting to observe the differences between the average bunch weight and BSR as these two factors sometimes appear to be working independently of one another. Increases in yield it seems may be more a function of changes in BSR than bunch weight. This aspect highlights the importance of evaluating palms on bunch number, which in turn raises the issues of high frond production rate. High frond production rate should not be confused with a high biological sex ratio.

Log BSR LS-Mean is presented for all blocks in Figure 4. The differences observed may be the result of gains achieved through improved breeding, however the effects associated with different palm age, planting material and location must also be considered.

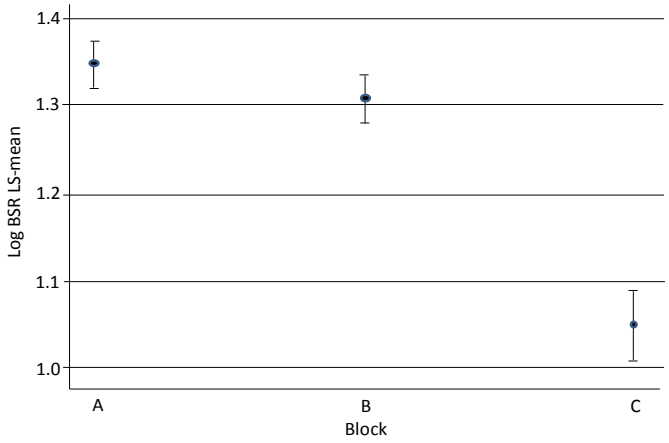

Fig 4. Log BSR LS-Means for blocks A, B and C with 95% confidence limits

In this regard BSR can be very effective in making assessments of the suitability of different planting materials from different sources. It is important to understand that a block might be high yielding, but still have a low BSR. This simply means that the bunch weight is high. It would be possible to develop coefficients that factor age, planting material or location into the BSR equation; however the primary objective was to keep BSR simple. While the differences in BSR are significant they are still a long way short of what might be considered desirable or even theoretically possible.

The fact that BSR does vary over time provides researchers with valuable data for the development of improved cultivars, especially if BSR can be increased and/or yearly fluctuations minimised. Using BSR to help minimise yield fluctuations has distinct commercial and logistical advantages. While analysis of BSR data over a longer period of time is useful, short term analysis can also provide valuable data. It is however important to remember that BSR is a measure of bunches harvested, not bunches produced. It is therefore an operational or commercial sex ratio as opposed to a biological one.

II. Conclusion

The objective of the Block Sex Ratio (BSR) is to provide managers, researchers and breeders with a simple, reliable and repeatable technique to determine the number of palms producing bunches in a block at a given point in time. While BSR forms an integral part of the oil palm Block Efficiency Indicator (BEI), it is also an effective tool for the identifying palms with the potential for increasing yield and/or improving agronomic performance.

Differences in the BSR between older and more recent plantings may be due to improvements in plant breeding. However it is important to understand that oil palm productivity is not constant and changes over the life of the palm. In this respect care is needed when making comparisons between blocks of different ages, planting material and locations. This is no different to the care required when making comparisons between blocks based purely on yield.

Variations between blocks can be used to compare planting materials and performance, and to highlight potential problems within the block that might otherwise be missed. If BSR is calculated for individual harvest areas, it will allow a much deeper and more productive analysis. If the BSR maximum recorded in each of the blocks assessed could be maintained throughout the year, significant increases in yield would result. It is therefore important that managers, researchers and breeders are aware of, and understand palm growth and development from a commercial perspective. In particular the fact that frond production rate as well as the biological sex ratio is a key component of yield. Increasing BSR and minimising fluctuations in yield has distinct commercial and logistical advantages, and while the increases observed in BSR are significant, they fall well short of theoretical.

References

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