



## AN INVESTIGATION OF CELLULAR FACILITY CONFIGURATION FOR TABLE GRAPE PACKING

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### ABSTRACT

Although labour unrest in export fruit industries was limited to the Western Cape, the 50% increase in the minimum wage became applicable to the industry countrywide. Table grape packhouses in particular, are finding it difficult to increase productivity as the quality of the grapes has a major influence on operational parameters. Rapid changes of grape quality upset line balancing and increases unproductiveness. Contract workers, especially in the Northern Cape, do not have a broad educational background which adds to the challenge of increasing productivity. The labour cost increase has caused several producers to move away from traditional production line Taylorism, to experiment with cellular layouts in their packhouses.

The introduction of cellular manufacturing has been successful in some industries but less so in others. Implementation and whether cellular designs are actually more productive is not clear. Cellular facilities therefore do not appear to be a guaranteed solution to recover the minimum wage increase.

The merit and the most suitable configuration of grape packaging cells are investigated. The design places an emphasis on reduced double handling for both productivity and grape quality purposes. An analysis of cellular principles and facilities in manufacturing is presented as the foundation of the work. The work is concluded with throughput measurements of different cellular configurations in the 2013/2014 packing season.

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## 1 BACKGROUND

The violent labour protests at the end of 2012 in the Western Cape initiated the implementation of a new minimum wage law. The sustainability and profitability of the farming industry is threatened by the 50% wage increase and table grape farmers specifically, are required to find alternative solutions for their labour intensive production processes [1].

In the Northern Cape, seasonal workers have had limited access to education and experience in a working environment where workers are integrated into business goal achievement. The result is that workers tend to be uncommitted to business goals against a background of limited skill with technological equipment. Supervisors are appointed to help manage the workforce and workload but struggle to promote identification with enterprise goals and worker engagement. This alongside the wage increase, the competitive international market, weather unpredictability and the constant burden of being more productive are some of the major industry challenges [2].

These factors place pressure on farmers to create and design work environments that by default promote productivity and drive. Management structures and human resource management should align in strategy to achieve the organization's objectives [3]. Trends are moving towards changing the layout design of a packing facility from the conventional production line Taylorism to that of cellular configuration alongside a system of incentives. Production Line Taylorism is the sequential processing of grapes in production line fashion. It is a labour intensive process and causes unsatisfactory productivity levels, the underutilization of resources and large amounts of WIP throughout the production line. The wage increase has been the proverbial "last straw that broke the camel's back" to precipitate a major shift towards an urgency in the table grape industry to reduce cost and increase productivity.

A sample production line that incorporates this cellular configuration approach is setup within a packing facility of an industry partner. This paper covers an investigation to determine the output capabilities of the system before implementation. Experiments are done to test the system and to determine possible loopholes, wastes, problems and risks.

## 2 INTRODUCTION

According to Wemmerlöv & Hyer [4], competition in the manufacturing industry has led companies to implement ideas that assure competitive advantage. The table grape industry in South Africa has a competitive local and international market and continuous improvement is required to maintain market share [2]. Table grape farmers wish to do this by increasing productivity and using input resources at maximum capacity.

Productivity can be defined as a measurement that indicates how well a company is utilizing its resources [5]. In quantitative terms it is achieved by dividing the outputs by the inputs and this can be done per week, per day or per hour depending on what is valuable to the user. In order to increase productivity, research has been focused on reconsidering the current processes and new alternative processing methods. Cellular facility configuration is of particular interest.

Cellular manufacturing ensures many advantages if implemented successfully. Amongst these advantages are the improvement of quality control and throughput time, the reduction of setup times, work-in-progress, finished goods inventories, material handling time and costs, space requirements and tool requirements [4, 6]. In 1989 Volvo Kalmarverken's automobile assembly plant incorporated cellular manufacturing and it achieved efficiency alongside the successful implementation of the team concept at the time [7].

The physical configuration of the facility is not the only aspect that influences productivity and [3] emphasizes the impact and advantages that cellular manufacturing has on the team

of workers. Workers become more flexible, less frustrated and experience a sense of recognition and increased security when group technology is implemented [8].

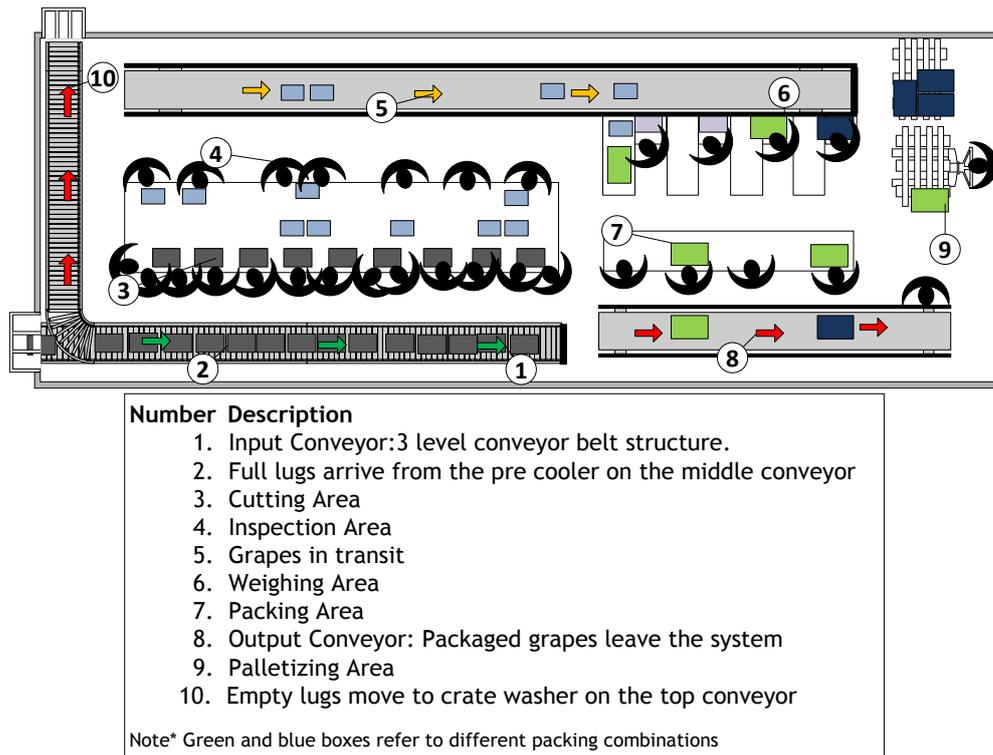
The success of cellular manufacturing and group technology is to a large degree dependent upon the relationship between the workforce and the company [3]. This relationship should be treasured for Juran states that the workforce should be involved in forming a quality culture within the company [9]. A culture of 'doing it right the first time' is non-negotiable because the productivity in the table grape industry is predominantly determined by the quality of the grapes.

Amongst other influences are the packaging program followed for the day, the bonus or rewards system and what day of the week it is. Companies need to adjust and ensure the best combination of factors discussed previously, in order to deliver maximum productivity whilst maintaining excellence in product quality.

### **3 OVERVIEW OF OPERATIONS**

#### **3.1 Conventional production line Taylorism**

The conventional method of grape packaging is a division of the work into small tasks that are organized into separate functional areas. From the vineyards grapes are transported in polymer crates, known as lugs, to the packing facility. The grapes enter the pre cooler where it gets cooled to ensure grape quality and to extend shelf life. The pre cooler also functions as a packhouse buffer. Grapes are transported from the pre cooler; using a three level conveyor belt. The middle conveyor belt transports the lugs inwards and the top level is an output conveyor belt for empty lugs. The first part of the production line is the cutting area. Berries that do not conform to specifications are cut out and the remaining good bunches are placed into smaller crates. Inspection is done on the clean cut bunches and thereafter the smaller crates are transported via a conveyor belt to the weighing area. Grapes are weighed and then placed in the appropriate packaging. Workers close the packaging and place the boxes on a different conveyor belt that leads to the palletizing area. For the purpose of this report the scope of the system ends at the palletizing area. This production line requires that workers be allocated to one of the five functional areas; cutting, inspection, weighing, packaging and palletizing. In each area, workers practice a different skill and this makes changing between areas problematic. In Figure 1 the facility layout of the conventional production can be seen.

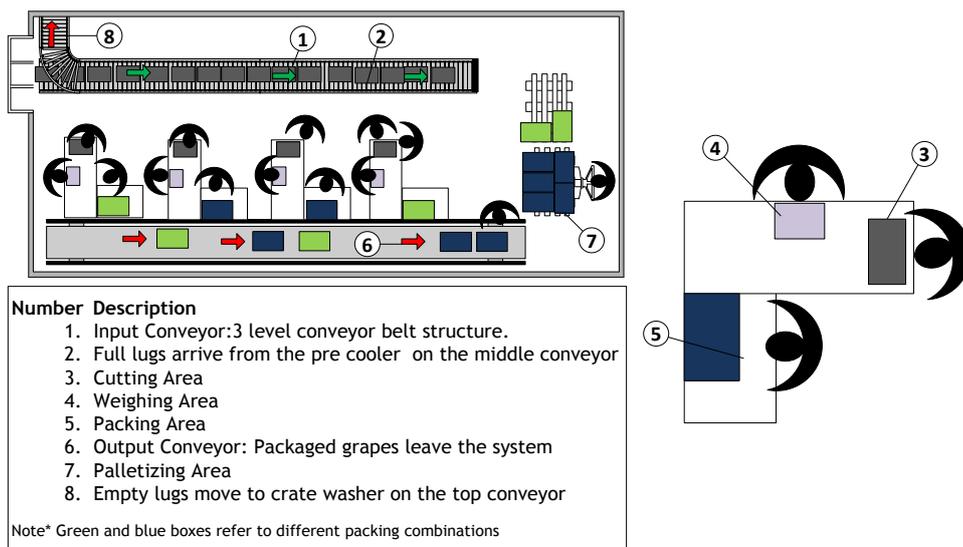


**Figure 1: Facility Layout of conventional production line**

### 3.2 Cellular facility configuration

The sample production line receives the grapes in the same way as the conventional system; from the vineyards to the pre cooler and eventually being fed to the palletizing area. Unlike cellular manufacturing that is based on grouping part families together [10]. The cellular configuration approach in the table grape industry aims to simplify the process by integrating all three required process functions (cutting, weighing and packaging) around one table. Workers are expected to do self-inspection of their work and supervisors are appointed to help in this regard. Therefore the focus is placed on the team concept that is identical to the approach in cellular manufacturing [3].

Figure 2 shows the facility layout of the production line using cell configuration. The layout shows 3 workers per work station. For the sample production line tables are placed perpendicular to the conveyor belt that feeds the lugs from the pre cooler. There is a small aisle between the table and the conveyor belt. Flush to the opposite end of the table there is a long conveyor belt that links all the tables. This conveyor belt sends the finished products to the palletizing area. Each table operates as a separate work cell and cutting, weighing and packaging are the tasks that are performed. The emphasis is placed on facilitating team work with this layout. Workers are required to share the workload and apply common sense and judgment to determine when a task on the work table needs to be treated with additional urgency or relaxed.



**Figure 2: Facility Layout of sample production line**

### 3.3 Packaging compositions

The composition of production outputs are mainly determined by the weekly packing schedule. A packing schedule is set up after considering market demands (local and international) and grape availability. There are four general packaging compositions namely; loose, loose and punnets, just punnets and stem-up's.

For the “loose” packaging composition, grapes are placed into plastic sachets and then in 4.5kg or 9kg boxes. Punnets are small, transparent plastic containers with an ideal packed weight of 500g that are placed in 5kg boxes for transport. Stem-up's are grapes, loosely placed in protected packaging in 7.5kg boxes.

## 4 METHODOLOGY

A sample production line is setup in a packing facility of an industry partner and each general packaging composition is seen as a test to be performed. Four different tests were done for 3 different cases as seen in Table 1. Time and grape availability limited the investigation of case c (4 workers per cell) to test 1. For the remainder of the document the different cases are referred to as case a, b and c.

**Table 1: Summary of the experiments performed**

Tests Performed	Case a) Two workers per cell	Case b) Three workers per cell	Case c) Four workers per cell
Test 1 : Packing Loose	X	X	X
Test 2 : Packing Loose and Punnets	X	X	
Test 3 : Packing Punnets	X	X	
Test 4 : Packing Stem-up's	X	X	

The amount of workers per cell refers to the number of workers that are occupying each work table. These workers are responsible for cutting, weighing and packaging. The weighing station at a work table has a capacity of one worker whereas the packaging and cutting station respectively can accommodate up to 3 workers simultaneously. Workers decide amongst themselves who does which task and once a station is starved the worker moves to another station to help relieve the workload

For the sample production line team a number of workers are randomly assigned and they operated independently from the other teams within the packing facility. Workers that form part of the sample production line team always operate at the same work table. Therefore the sub teams per work table generally remain the same and only vary slightly when the different cases are observed. As most of the workforce are contract workers and many of them are working in the packing facility for the first time, the training happens as the day proceeds. Not too much emphasis is placed on a formal training week before the packing season as this is costly and does not necessarily deliver results. Supervisors are appointed as permanent staff and training are focused on them during harvest season preparations. It is expected of the supervisors to pick up on quality problems and to train the workforce on the floor.

As previously stated the packing combinations followed for the day varies according to the packing schedule and grape availability. Therefore the different cases experimented with for each test (see Table 1) did not necessarily occur consecutively and were not observed for the same duration of time. We will call a production period within which a certain case is observed a sample period. These sample periods are measured and documented. When considering test 1: packing loose, for example, there were a total of 8 sample periods recorded. Of the 8 sample periods taken, 1 sample period is for case a, 4 for case b and 3 for case c. The duration of each sample period differs, being dependent on the test performed (packaging composition), the speed at which the grapes are processed as well as the quantity of grapes that need processing. All sample periods irrespective of their duration are taken into account.

Productivity measurements are calculated as a value of cartons per man per hour. The output in cartons per day is derived back to an industry standard of 4.5kg cartons per day. All workers actively involved with the production line are brought into consideration for calculations. This includes the worker that feeds the lugs from the pre-cooler, the workers in each cell (2, 3 or 4), 2 supervisors, 2 workers palletizing the outputs and a worker folding the cartons. There are 18, 24 and 30 workers active on the production line for cases a, b and c respectively.

Therefore the number of workers on the line, the number of cartons produced and the duration of a sample period is used to perform productivity measurements. Measurements are taken for each case and compared to each other to determine the relationship between the variation in workers per cell and the productivity of the production line.

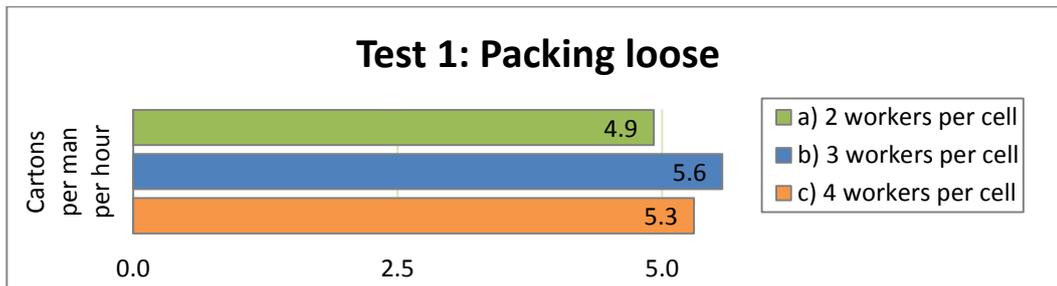
## 5 RESULTS AND DISCUSSION

For the first three tests, Prime Seedless grapes were processed. It is a green grape with relatively large berry sizes that makes it easier to handle and process. Test 4 was done with Flame Seedless grapes. Flame has small, dark, red berries that are more fragile and this makes cutting difficult.

### Test 1: Packing loose

Eight sample periods were considered. One sample period, observed for case a, was done after a pay weekend which influenced the productivity of the workforce. The productivity measurement is expected to rise if a second sample period is observed; unfortunately grape unavailability prevented this.

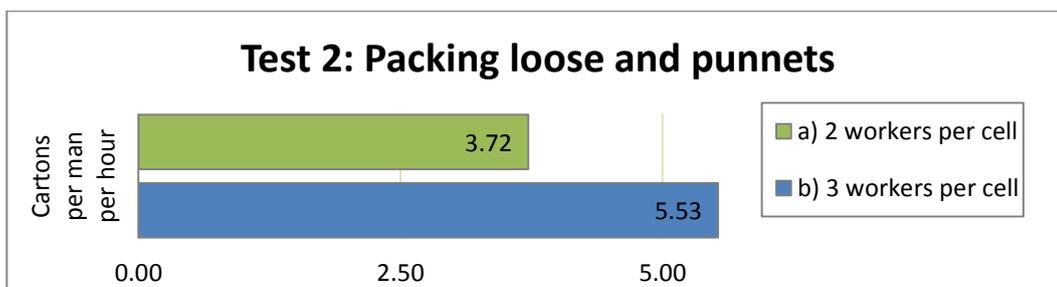
Four sample periods were observed for case b and 3 sample periods for case c. The grape quality was good and no external factors influenced the productivity of the workforce during these sample periods. **Figure 3** below compares the overall productivity of cases a, b and c.



**Figure 3: Summary productivity measurements of Test 1**

### Test 2: Packing loose and punnets

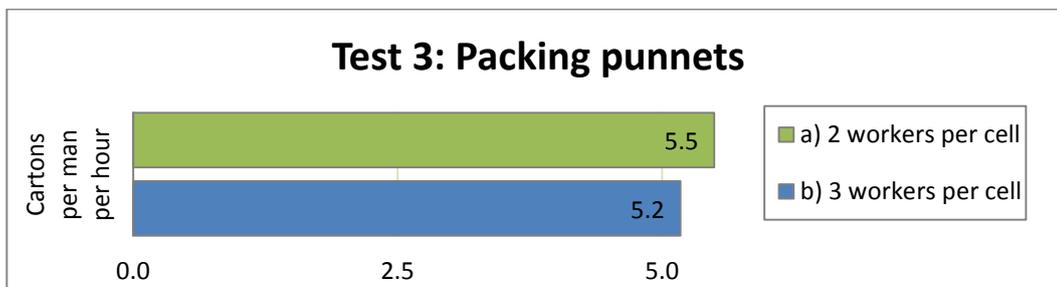
Three sample periods were considered for test 2; 1 was for case a and 2 for case b. For both cases an average grape quality was applicable and a variety of large and small berries were present. No other external factors influenced the productivity measurements. In Figure 4 a visual comparison of the results are shown.



**Figure 4: Summary productivity measurements of Test 2**

### Test 3: Packing punnets

Two sample periods were considered for both cases a and b during test 3. A substantial amount of cutting was required for case a's sample periods. The grape quality for case b was good and little cutting was required. In Figure 5 it is interesting to note that the productivity measurement for case a or two workers per cell, where more cutting was required, exceeds that of case b, or three workers per cell. This places emphasis on the necessity of cooperation and team work when considering high productivity levels. The incoming grape quality is the primary influence on productivity levels; however team work has a contributing hand in the success of the day.



**Figure 5: Summary productivity measurements of Test 3**

### Test 4: Packing stem-up's

Two sample periods were considered for case a. The grape quality ranged from good to poor (a large amount of cutting required). Rework also had to be done which suppressed the morale and therefore efficiency of the workforce. Two sample periods were considered for case b. For one of the case b sample periods the grape quality was excellent, in the other sample period average quality grapes were processed. Additionally the overall morale in the packing facility was low after disagreements between supervisors and the workforce. The productivity measurements taken for Test 4 can be seen in Figure 7

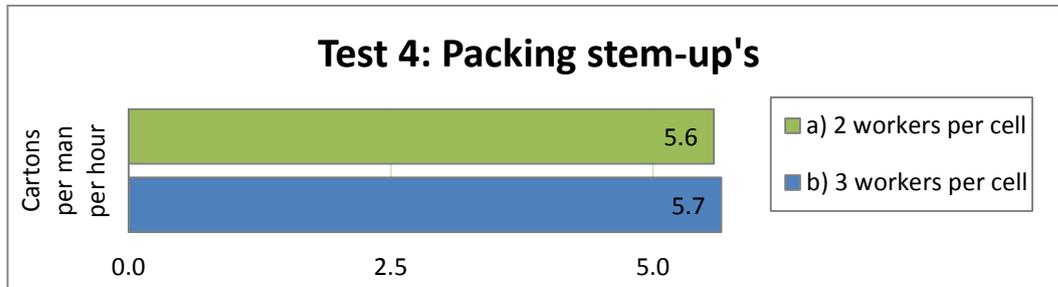


Figure 6: Summary productivity measurements of Test 4

## 6 CONCLUSION

An overview of the productivity measurements for case a, 2 workers per cell and b, 3 workers per cell for each test is shown in Figure 7. For comparative reasons the data for test 1 c is eliminated from the overview.

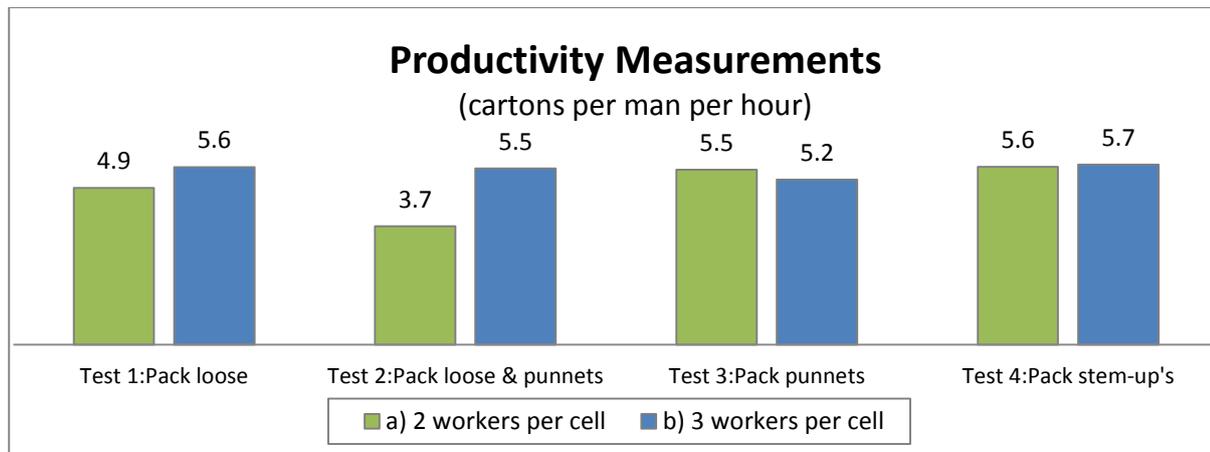


Figure 7: Productivity measurement overview

The difference in productivity measurements between case a and b, for test 4, is so small that it is disregarded in the comparison. Given the summary above it is evident that 2 workers per cell achieve a lower productivity than 3 workers per cell for test 1,2 and 4. Test 2 in particular, shows that 3 workers have a large advantage over 2 workers. However for test 3, 2 workers per cell perform better. The increase in productivity emphasizes that when packing punnets, 2 workers are able to handle the workload and that with 3 workers social loafing is present. Observations suggested that two workers make an effort to correctly size berry bunches before placing them into the punnet. This eliminates double handling and increases throughput rate. After evaluating all the information, the recommended configuration is 3 workers per cell. When packing punnets only (test 3), however, it is advised to limit the cell to 2 workers and use the remaining workers in the vineyards. Efficiency and productivity is dependent on the grape quality but also on the ability and the

morale of the workforce. Ongoing disagreements can lead to long term negative influences on productivity and worker engagement.

No comparative analysis is done on the advantages of cellular configuration as opposed to the conventional production line. However through visual inspection it is possible to conclude that the WIP and material handling time for the cellular configuration line is less than for the conventional line. The long lead times for the workers working in the weighing and packaging areas in the conventional line are eliminated with the cellular approach.

It is of the utmost importance to promote team work among the workforce and the approach of cellular configuration within the packing facility is designed to specifically do this. Further research can be focused on experimenting with different layout designs.

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