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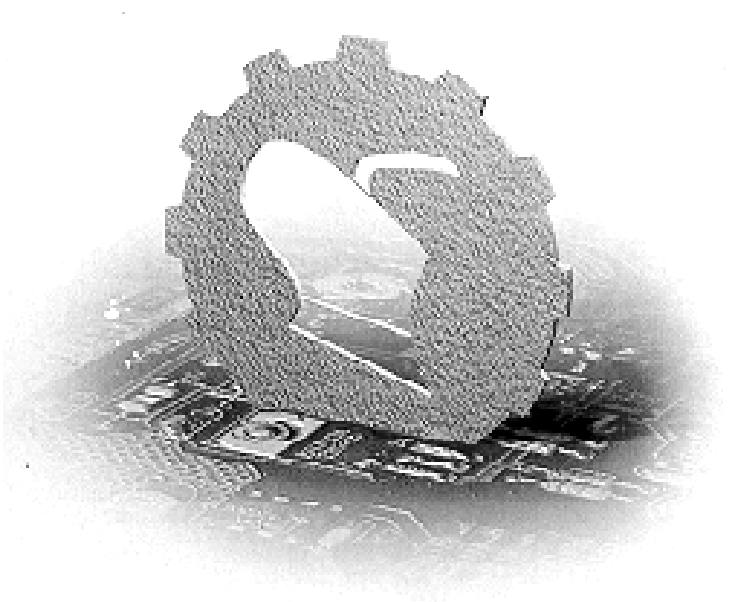

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THE IMPORTANCE OF OPERATING AGRICULTURAL EQUIPMENT IN USE BY FAIR VALUE FROM THE MANAGEMENT SITUATION IN SMALL AND MEDIUM-SIZED ENTERPRISES IN THE TRANSITIONAL COUNTRY, -EXAMPLE OF THE REPUBLIC OF SERBIA

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Summary: This study highlights the importance of using real-life values of agricultural equipment in real financial statements in medium-sized enterprises. The authors have adopted the essence of nature related to the estimation of agricultural equipment, that is, he has stated that in the agricultural production of transition countries, agricultural equipment has been used for more than five decades. This was a key assumption adopted by the authors of this study. In addition, the presentation of realistic financial statements should include an account of the real value of agricultural equipment, which essentially leads to a periodic fair valuation of agricultural equipment available to agricultural producers in transition countries.

Key words: *agricultural equipment, fair valuation, enterprise.*

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INTRODUCTION

In the literature dealing with fair valuation of agricultural equipment, an analysis of the importance of the use of fair value in the presentation of agricultural equipment in company books is increasingly encountered. Dominantly, fair valuation of agricultural equipment is analyzed in the SMEs of transition countries [1], [2], [3], [4], [5].

Another important feature that accompanies fair value of agricultural equipment and its fair value in the financial statements of an enterprise is the application of a number of standard methods [6], [7], [8], [9], [10] that are introduced in the process self evaluation of agricultural equipment.

Thus, the current principle related to standardization of accounting observation is substantially changing in favor of fair valuation of the said equipment in enterprises.
Over the last 20 years, there has been a growing interest from a number of authors who have pointed to possible improvements in structural management in companies if they improve financial reporting in companies [11], [12], [13], [14], [15].

Only financial reporting in companies is focused on the increasing application [16], [17], [18], [19], [20] of the introduction of fair value of all assets in the books of account, and therefore of agricultural equipment.

MATERIALS AND METHODS

The study was started with a SWOT analysis because the author wanted to start the research with a presentation of initial knowledge about the use of fair value of agricultural equipment, which in the region that once covered the territory of the former Yugoslavia is mainly in business in small and medium-sized enterprises.

Therefore, this analysis serves to ensure that the results obtained can be compared and applied in further research activities, primarily in the field of agriculture.

The research included obtaining valid information from top management that was done in 20 medium-sized enterprises in the Republic of Serbia. Agricultural equipment by age is analyzed in the intervals 1965-1975, 1975-1985, 1985-1995, 1995-2005, 2005-2015, 2015-2019. The interval of observed equipment used in use covered the period from 1965 to 2019, that is, at that age the equipment was still in use and shown in the books of account at fair value.

The agricultural equipment of enterprises in terms of measuring their performance in terms of value refers to equipment used on a daily basis. The expression of equipment at fair value should be the standard to which the author points out in the study below.

The research presented in the study relies on an analysis of top management behavior in corporate governance, and the primary objective of the judge's author was to show the importance of determining the actual measured fair value of the agricultural equipment used in the enterprises in use.

RESULTS

Initial study results are based on the application of SWOT analysis, i.e.

The author presented: available options, perceived weaknesses, opportunities and threats to the agricultural enterprise. So the first goal is fulfilled.

In other words, the main attributes have been identified that relate to the importance of measuring agricultural equipment used at fair value mainly in small and medium-sized enterprises in the country in transition, and in this case the survey was dominantly conducted and relates to the territory of the Republic of Serbia.

Table 1. SWOT analysis illustrating the fair value situation of agricultural equipment in the books of predominantly medium-sized enterprises in the Republic of Serbia

Available options	*Weaknesses*
• application of the IAS adopted at the national level in the process of EU accession; *• unqualified opinion of external auditors for enterprises that already measured agricultural equipment in use at fair value;* *• presenting agricultural equipment in use at fair value encourages application of standardization by top management in enterprise governance*	*• lack of information on strengths in fair valuation of agricultural equipment in use by enterprises;* *• lack of prescribed procedures relating to top management bonuses for improved performance of enterprises they are in charge of;* *• inadequate policy of punishment due to inappropriate managerial decisions and poor management by top executives of enterprises*
Opportunities	*Threats*
• increase in compatibility with positive business practice of the EU and developed countries; *• greater reliability of financial reporting of top management, owners and shareholders;* *• providing safety of operations of international companies in the Republic of Serbia;* *• increase in general certainty of doing business and corporate governance;* *• fair valuation of agricultural equipment in use by enterprises facilitates borrowing from business banks;* *• facilitated decision-making on joint investments with foreign companies*	*• non-harmonized legal regulations with those of developed countries;* *• slow transformation of state-owned enterprises into private companies or joint stock companies;* *• increase in tax on assets based on the increase in the value of agricultural equipment measured at fair value*

Table 2. Display of fair value of equipment at observation intervals by age of the agricultural holding equipment and significance ranges per enterprise

Observation of equipment age interval	*Age agricultural equipment observed at intervals within the year*	*Valued agricultural equipment at fair value*	
		Number of individually evaluated equipment	*Description of the significance of the expression of the equipment*
1	*1965-1975*	*2*	*little*
2	*1975-1985*	*8*	*little*
3	*1985-1995*	*14*	*middle*
4	*1995-2005*	*20*	*high character*
5	*2005-2015*	*30*	*high character*
6	*2015-2019*	*5*	*little*

DISCUSSION

Based on the results of the study, the study shows that agricultural equipment is used over a large interval of its age (the year in which it was produced). The interval at which the equipment was still in use covered the survey period 1965-2019.

The interval by age criterion of the used equipment used included the observation period 1965-2019, that is, at that age the equipment was still in use and shown in the books of account at fair value.

The large interval of expression of the fair value of agricultural equipment essentially indicates that it is in use even though it is old, but it is used for performing agricultural production work.

The last column required the top management to outline their observations regarding the equipment used and, depending on its importance, to indicate three degrees of graduation of importance to the company (small, medium and significant levels of enterprise management).

CONCLUSIONS

Through this research, the author of the study presented several important characteristics of agricultural equipment, which is still practically used in the ordinary course of business, and which is kept in the books of account “Fair-values”.

First there is a small number of agricultural equipment that is extremely old but still used in the production process in an agricultural enterprise.

Dominantly the largest number of individually reported equipment kept in the books of the company is of age in the interval 1995-2015, which indicates which equipment is the most represented in real exploitation in the enterprises.

This attitude was also strengthened by people who rated the importance of these equipment with descriptive ratings, that is, the top management of the enterprises run by the aforementioned medium-sized agricultural enterprises.

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ZNAČAJ EVIDENCIJE POLJOPRIVREDNE OPREME U UPOTREBI PREMA FER VREDNOSTI SA STANOVIŠTA UPRAVLJANJA U MALIM I SREDNJIM PREDUZEĆIMA U TRANZICIONOJ DRŽAVI, -PRIMER REPUBLIKE SRBIJE

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Sažetak: Ova studija ukazuje na važnost korišćenja realno prikazanih vrednosti poljoprivredne opreme u stvarnim finansijskim izveštajima u srednjim preduzećima. Autori su usvojili suštinu prirode koja se vezuje za procenu poljoprivredne opreme, odnosno, da se u poljoprivrednoj proizvodnji tranzicionih zemalja poljoprivredna oprema koristi i više od pet decenija. To je bila ključna pretpostavka usvojena od autora ovog rada. Osim toga, prikaz realnih finansijskih izveštaja treba da uključi prikaz realne vrednosti poljoprivredne opreme, što suštinski vodi u periodično fer vrednovanje poljoprivredne opreme sa kojom raspolažu nosioci poljoprivredne proizvodnje u tranzicionim državama.

Ključne reči: *poljoprivredna oprema, fer vrednovanje, preduzeće.*

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TECHNICAL AND FIELD EVALUATION OF TRACTOR OPERATED FRONTAL PRE-PRUNER FOR KINNOW MANDARIN (*Citrus reticulata)* AND GUAVA (*Myrtaceae*) ORCHARD

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Abstract: Fruit tree pruning is the cutting and removing of selected parts of a fruit tree. It spans through quite a number of horticultural techniques. Pruning includes cutting branches back, sometimes removing smaller limbs entirely and more so the removal of young shoots, buds and leaves. Established orchard practice of both organic and nonorganic types typically includes pruning. Pruning can control growth, remove dead or diseased wood, and stimulate the formation of flowers and fruit buds. Pruning and training young trees improves their later productivity and longevity and can also prevent later injury from weak crotches or forks (where a tree trunk splits into two or more branches) that break from the weight of fruit, snow, or ice on the branches. However, the efficiency of pruning methods is also important. Manual pruning has constraints like lower field Capacity and incomplete pruning in case of tall trees. Therefore, a tractor operated 1-row frontal pre pruner with electro hydraulic control was tested for Kinnow Mandarin and Guava orchards. The time involved for top and side pruning was 23.30 and 46.80 min/acre, respectively and there was 99.32 - 99.38 % saving in time as compared to manual pruning.

Key words*: Hydraulic, vertical, disc, horizontal, automatic, 1-row, Kinnow Mandarin, Guava, Pre Pruner, top pruning, side pruning.*

INTRODUCTION

Mandarin orange (*Citrus reticulata*) is the most common citrus fruits grown in India. It occupies nearly 40% of the total area under citrus cultivation in India.

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The most important commercial citrus species in India are the mandarin (*Citrus reticulata*), sweet orange (*Citrus sinensis*) and lime lemon (*Citrus limon*) sharing 41, 23 and 23%, respectively of all citrus fruits produced in the country with an area of 0.428, 0.185, 0.286 million ha and production rate of 5.1, 3.27 and 3.15 million metric tons, respectively (Anonumous, 2018). Citrus (*Citrus sp., Rutaceae*) is cultivated in the states of Maharashtra, Andhra Pradesh, Punjab, Himachal Pradesh, Uttar Pradesh, Madhya Pradesh, Karnataka, Jammu and Kashmir, Orissa, Gujarat, Assam, Meghalaya, Rajasthan, Sikkim and Tamil Nadu. It is an evergreen medium to tall erected tree. It grows to a maximum height of 25 m (Anonumous[a], 2020). In India, Guava (*Psidium guajava*, *Myrtaceae*) is successfully grown in Uttar Pradesh, Bihar, Madhya Pradesh, Maharashtra, West Bengal, Orissa and Tripura. Uttar Pradesh is considered as the most important guava producing state in India, and the Allahabad-Varanasi region has the reputation of growing the best quality guava in the country as well as in the world. It is a hardy and tall tree with height of more than 2.5 m (Anonumous[b], 2020). In most developing countries, manual pruning are used whereas in developed countries mechanical pruner are used. Pruning is at the heart of arboriculture, one of the most important services arborists provide (Clark and Matheny, 2010). In the next future it is expected that greater use of wireless and lightweight equipment will be done to assess worker exposure to musculoskeletal disorders not only in pruning but in all farming operations (Elio et al., 2014) . The results suggested that maintaining a live crown ratio of 55% would minimize effects of pruning on diameter growth. The effect of severe pruning on diameter increment was greater for subdominant trees than for dominant stems (Neilsen and Pinkard, 2011). In economic terms, if the rows are 400 m long, then the surface area suitable for mechanical pruning is 10 to 11 ha for all three varieties. There was no visible damage to the fruit branches with the mechanical pruner, but some damage occurred to wires with a diameter of less than 1.8 mm. (Gambella and Sartori, 2014). Canopy management system labour operation cost estimates indicated a labour saving of 62% and 80% with mechanical prepruning with hand shoot thinning (MPDHT) and mechanical box-pruning with mechanical shoot thinning (MPDMT) treatments, respectively when compared with hand pruning (HP) for 'Cabernet sauvignon' grape (Vitis vinifera). All treatments had similar yield, total soluble solids (TSS), juice pH, and titratable acidity (TA), Berry skin total phenolics, anthocyanins, and tannins at harvest. All treatments tested were within acceptable Ravaz index limits of 5 to 10 lb/lb. However, only MPDMT treatment reached a near optimum leaf area to fruit ratio of 1.2 $m^2 \cdot kg^{-1}$ and pruning weight of 1.0 $kg.m^{-1}$ for warm climate viticulture. (Kurtural et al.,2012). Sanding and pruning are two practices used in the cranberry (Vaccinium macrocarpon) industry for vine management and yield stimulation. Cumulative yield and net returns were higher in light severity treatments compared to those in the moderate and heavy treatments. Moderate and heavy sanding treatments were associated with lower yields and net returns than those for the untreated controls (Suhayda et al., 2009). Chancellor cited in Persson, (1987), Kempe (1967) and John-ston (1968a and b) also reported that the cutting force required when pruning a range of herbaceous *(Phleum pratense)* and woody *(Picea glauca, Pinus resinosa, Pinus banksiana, Pinus taeda, Pinus radiata, Abies balsamea*) up to 18 cm thick materials was greatly affected by the knife thickness. In some cases, doubling the knife thickness resulted in 50% increase in the cutting force.

Mattson and Sturos (1996) on the other hand, found that knife thickness did not affect cutting force required to shear sugar maple *(Acer sacharum)* branches. This may have been due to lower cutting speeds *(>600* mm/sec compared with <10 mm/sec) in the earlier study. Little agreement exists about the effect of cutting edge angle ***(A)*** on force and energy requirements. Kempe (1967) reported that a 45º cutting edge angle require 20 to 30% less force to shear spruce logs than what was needed with a 60º angle. Mattson and Sturos (1996) found that reducing the cutting edge angle *(A)* from 45º to 30º resulted in a 55% reduction in peak force necessary for shearing sugar maple branches. Koch (1971) reported that a 9.5 mm thick blade with a 22.5º cutting edge required 45% less total energy and 25% less peak force for shearing 130 mm diameter Southern Pine logs than was required when using a 45º cutting edge *(A).* The counteredge angle has also been shown to affect peak force requirements. Chancellor (1957) stated that a "fine" counteredge requires approximately 25% less force than a "blunt" counteredge. Kempe (1967) reported that knives with recessed sides required 20% less peak force for the same cutting edge angle and thickness than parallel-sided knives. Koch (1971) found that tapered knives with a thin root also required less force. Koch (1971) and Johnston (1968b) both commented that small reductions in the necessary force could be achieved if the friction co-efficient between the blade and the wood was lowered. Greasing the blade has been found to have no appreciable effect but teflon coating of the blade surface is effective. The manner in which the force is applied has also been shown to have an effect. Mattson and Sturos (1996) demonstrated that an oblique cutting angle **(**β**)** requires greater peak force. They also examined the effect of cutting speed (600 vs 1100 mm/sec) on required force but found no significant difference at these high speeds. In summary, there performance may possibly be improved by tuning such design features as knife thickness, cutting edge angle ***(A),*** knife shape, knife friction, oblique cutting angle (13) and counteredge angle. Total energy and peak force required for cutting radiate pine and Douglas-fir branches were measured. Branch sizes ranged from 9 to 65 mm. Under one set of standard conditions some shears required over 50% more energy and peak force than others. Douglas-fir required more energy and force than radiate pine. Total energy and force requirements tends to increase with cutting edge angle and with blade thickness (Crossland et al., 1997). The selection of pruner machine is also dependent on type of orchard. In general intensive/high density orchards (HD system) are characterized by densities between 250 and 700 trees per ha, super-high-density systems (SHD system) orchards can present densities over 1500 trees/ha (the hedgerow system). The average full yield in high density systems ranges between 6000-10000 kg/ha for rainfed and irrigated orchards. However the economic life of the SHD is shorter (around 15 years, while in intensive system it can be more than 30 years) due to the lack of space and the competition among trees for light and ventilation inside the canopies(Freixa et.al., 2011). Intensive tree orchard with narrow tree canopy or even 2D planar fruiting wall would be suitable for fully autonomous pruning system in the future. With the adoption of intensive tree architecture as well as the improvement of cutting end-effector, tree branch identification and reconstruction, it is very promising to have a robotic pruning system for tree fruit crops (He and Schupp, 2018). A remote operated system may be an operating alternative for pruning equipment although there are remote control systems developed in the United States, Canada and Israel (Castellanos et al., 2017). A study was done to determine the input requirements for both the hydraulic circuit and the mechanical pruner designs.

Then a description of an adapted inter-axle carrier used for the experimental model of the hop mechanical pruner and of the effected field measurement follows, along with interpretation of the measured data.

These data are depicted in clearly arranged graphs showing the dependency of pressure and hydraulic oil flow on the cutting disc rotational frequency (Hoffmann et al., 2015).

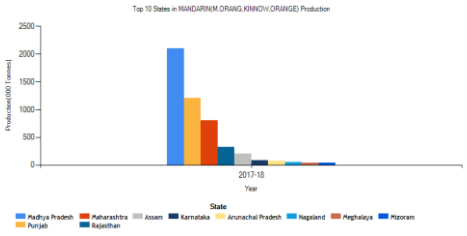

*Fig. 1.The Mandarin producing states of India**

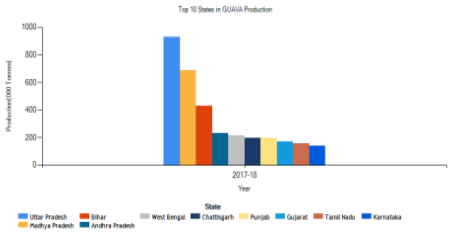

*Fig. 2. The Guava producing states of India***

Major kinnow and Guava producing states in India are shown in Figs. 1 and 2., source
** http://apeda.in/agriexchange/India%20Production/India_Productions.aspx?cat=fruit&hscode=1064;*
***http://agriexchange.apeda.gov.in/India%20Production/India_Productions.aspx?cat=fruit&hscode=1046*

The total area under Kinnow crop was around 53,045 ha which accounts for 60 % of the total area under fruits in Punjab. The production of Kinnow was 1,246,821 MT. The area under Guava was 9142 ha with a production of 206106 MT (Thind and Mahal, 2019). Manual pruning has constraints like lower field capacity and incomplete pruning in case of tall trees. Therefore a mechanical pruner can overcome both of these constraints. Therefore, a Pre Pruner was tested for Kinnow and Guava orchards in Indian conditions.

MATERIAL AND METHODS

Experimental site detail

In 2017, a Pre Pruner machine was operated at Kinnow and Guava Orchards at Punjab Agricultural University, Ludhiana. The field evaluation of tractor operated pruner was done for Kinnow and Guava orchard at a spacing of 5 m by 7.5 m (plant spacing x row spacing) and height of Kinnow Mandarin and Guava tree varied from 3.66 m to 4.27 m with an average plant population of 275.ha^{-1} (intensive/high density system). A view of Kinnow Mandarin Orchard is shown in Fig. 3.

Fig.3: A view of Kinnow Mandarin Orchard

General description of Pre Pruner

Pre Pruner (Fig. 4) machine is equipped as standard with hydraulic motors facilitated with safety system against stresses, cutting module (discs) of low maintenance without pulleys or belts, mechanical regulation of the angle of incidence of the cut, saws

disks (Fig. 5), inclination and hydraulic positioning of the cutting plane, hydraulic lifting, hydraulic lateral displacement, hydraulic power station and chiller. Its design is especially indicated for work in orchard traditional crops where the space between plants is reduced. . Saw blades are 600 mm in diameter, with the availability of special discs for very thin branches or pruning in green. It requires a minimum power of 40 hp tractor. The table is rotating to position the cutting module to the right or left of the tractor. It has a maximum cutting diameter up to 12 cm with a maximum cutting height in horizontal position of 4 m and minimum of 1.6 m. The maximum height of vertical cut up is 7.15 m and 3.7 m down (pendulum). The machine high performance is due to its ease of operation and cutting positions with more than 250° of travel in the position of the cutting module. . On the PFS-5 (Reinforced Orchard disc pruner compact) models the coupling to the tractor is front with number of hydraulic functions of 3 + 1 and 4 + 1. Discs RPM are 1650 rpm but it also depend on the branches to be cut and the discs mounted on the machine. Different kind of discs can be used to cut different diameter of branches.

Fig. 4. A view of Pre Pruner

Fig. 5.A view of cutting discs

The Pre Pruner is very high-tech fully hydraulic equipment and is equipped with individual hydraulic motors in each of the discs, therefore with total absence of pulleys or belts. Moreover its independent motor in each disc equipped with a safety valve and automatic reset in case of blocking, gives a great power of cut with a very reduced maintenance. It can be adapted to the front of the orchard's tractors allowing cutting both on the sides and at the top of the tree. Its design is especially indicated for work in orchard traditional crops. It is equipped with a turning frame which facilitates to work with the cutting bar positioned to the right or left of the tractor, being able to determine the cutting direction and the place of evacuation of the branches. Due to its high speed of turning, it gives a high cutting quality and correct evacuation of branches outside the tree**.** High quality of work and safety both in its handling as in the mechanical and hydraulic integrity of the same since it has individual systems of protection of the motors and rest of the hydraulic components.

- *Lift inclination and hydraulic extension.*
- *Electric controls in cabin.*
- *1 Motor + safety valve on each disc.*
- *Hydraulic lifting.*
- *Additional modules for cutting skirts.*
- *Special module for pruning on the sides of the tree.*
- *Electronic speed control of the discs (Fig. 5) in both directions.*

- *Hydraulic sideshift.*
- *Hydraulic inclination.*
- *Manual turning central frame (cutting left/right and branches discharge).*
- *Hardened steel 86 teeth-disc. 150L Hydraulic power unit with oil cooler and lateral counterweight box (C16).*
- *Power supply by independent hydraulic power station to tdf.*
- *Front coupling to tractor.*
- *Reverse hydraulic device of the cutting module. Other cutting heights on demand.*
- *Integrated automatic control of cutting functions with programming in work position memories.*
- *Different types of cutting discs.*
- *Safety system with automatic reset.*

Storage foot includes:

- *Adaptable standard plate to tractor (frontal).*
- *Lateral support rods.*

Main technical characteristics of Standard equipment:

The tilt adjustment of the disc module is by electric control installed in a cab (Fig. 6, 7 & 8), and has a mechanical adjustment of the angle of incidence. It is a very high-tech integral hydraulic drive machine. The standard dimensions of linkages of Pre Pruner machine in various positions is shown in Fig. 9.

Fig.6*. A Schematic view of various components of Pre Pruner*

Fig. 7. A view of tractor operated pre pruner lab experiment and field

Fig. 8. Pressure gauge for checking hydraulic oil pressure

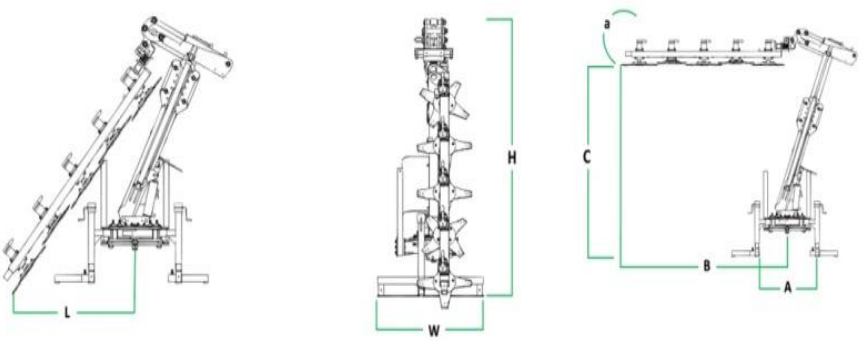

Fig. 9. Various linkage dimensions of Pre Pruner

Table 1. Various technical specifications of Pre Pruner

Particulars	*Symbols*	*Detail*
Tractor HP required		*≥ 44.76 KW*
Battery power and current required to operate distributor (driving various hydraulic mototrs)		*12V, 6 A*
Switches for horizontal positioning of pre-pruner		*One*
Switches for multiple positioning in horizontal mode		*three*
Switches for vertical positioning of pre pruner		*One*
Switches for multiple positioning in horizontal mode		*Three*
Model		*PFS-V5XX-2750, Compact XXL Frontal Pre-Pruner*
Type		*Frontal Pre-Pruner*
Movement		*Cut, lifting movement, tilting module*
Diameter Discs N°/mm		*5, ϕ600mm (86 toothed)*
Cutting Disc Tours/minute or revolutions per minute(rpm)		*1650 t/m*
Cutting length		*2750 mm*
Hydraulic functions		*4*
Movements N°		*3*
Weight, kg		*920*
A, mm		*770*
B, mm		*Min 2700, Max 4150*
C, mm		*Min 2700 Max 4200*
H, mm		*2900*
W, mm		*1170*
L, mm		*2600*

To make the machine functional it was necessary to develop the control box indigenously. Material required to develop control box included switches, switch boards, ICB, hydraulic pipes, wires etc and this indigenous control box was designed and developed with the support of local industry. Electro hydraulic control has been made by electro valves connected through a control box.

Estimation of Field capacity

The effective field capacity was determined by measuring all the time elements involved while harvesting. The total time was categorized into the productive and non-productive time. The productive time is the actual time used for harvesting the grains while the non-productive time consisted of the turning time, repair and adjustment time and other time losses. The area covered divided by the total time gave the effective field capacity. The effective field capacity of combine was calculated using the following formula (Kepner et al., 1978) :

$$C = \frac{SW}{10} \times \frac{E_f}{100} \quad \text{.....(1)}$$

C - effective field capacity, $ha.h^{-1}$.
S - speed of travel, $km.h^{-1}$
W- rated width of implement, m
E_f – Field efficiency, in percent

$$E_f = 100\frac{T_0}{T_e + T_h + T_a} \quad \text{.....(2)}$$

T_o – theoretical time per hectare (per acre)
T_e – effective operating time = T_o *x 100/K*
K – percent of implement width actually utilized
T_h – time lost per acre due to interruptions that are not proportional to area. At least part of T_h usually tends to be proportional to Te
T_a- time lost per acre due to interruptions that tend to be proportional to area.

2.6. *Estimation of fuel consumption*

Before starting the test, the engine's fuel tank was completely filled. The quantity of fuel required to fill the tank after harvesting the test field was measured using a 1 *l* graduated cylinder. Thus, the fuel consumed during the test was determined.

$$F = \frac{L}{A} \quad \text{.....(3)}$$

where *F* is the fuel consumption in $l.ha^{-1}$; *A* is the area harvested in ha; and L is the quantity of fuel required to

fill the tank after harvesting the test field in *l*.

Economics

For economics calculations labour cost, diesel cost, repair cost etc. were considered. The economics was worked out for comparing the tractor operated pre pruner savings as compared to manual pruning operation.

RESULTS AND DISCUSSION

Field evaluation of Pre Pruning machine was done for Kinnow at New Orchard, PAU, (Ludhiana, 2017). Other orchard specifications and operational parameters are shown in Table 2.

Fig. 10. Sequential view of Tractor operated Pre pruner in vertical cutting position and view of cut branches

Table 2: Orchard specifications and operational parameters of pruner for Kinnow Mandarin and Guava orchard

Particulars	*Range/Mean*
Average forward speed of Pruner, Km.h^{-1}	*2.73*
Fuel Consumption, l.h^{-1}	*5.0-6.0*
Canopy width between pruning, m	*2.52*
Canopy width after pruning, m	*1.94*
Canopy height before pruning, m	*4.11*
Canopy height after pruning, m	*3.00*
Uncut lower branch height, cm	*63-78*
Cut branch diameter/thickness, mm	*5-25*

The field layout was prepared prior to each operation in orchard for maximizing field efficiency and minimizing time lost in turnings. The time of travel for each straight row and time involved in turnings were recorded for each orchard field capacity calculations. The speed of cutting discs and inclination of cutting bar was controlled by electronic panel, distributor and hydraulic mototrs provided for each saw blade.

The machine was operated on side and top and side of Kinnow Mandarin and Gauava plants (Fig. 10 & 11) and time of operation for both kinds was recorded and is shown in Table 3.

Fig. 11. Top Pruning in Guava and Kinnow Mandarin Orchard and view of cut branches in Guava orchards

The time involved in pruning for kinnow orchard was 40.86 and 23.30 min/acre for side and top pruning. The pruning time involved per tree for side and top pruning was 19.46 seconds and 11.10 seconds respectively.

Table 3. Mean time for side and top pruning of Kinnow Mandarin and Guava Orchards

Method of pruning	*Mean time for pruning/tree*		*Mean time forpruning/acre*		*Saving in time, %*
	Side	*Top*	*Side*	*Top*	
Tree Pruner	*19.46 sec.*	*11.10 sec.*	*40.86 min.*	*23.30 min.*	*99.32-99.38*
Manual pruning	*60-90 min.*	*Not possible*	*126-189 h*	*Not possible*	---

The saving of time for pre pruner as compared to manual pruning varied between 99.32-99.38 %.

Some authors, such as Kallsen (2005), compared several types and intensities of mechanical pruning, such as topping at several heights and some hand-pruning intensities, with non-pruning. He noticed that, in all cases, the higher the pruning intensity was, the lower the yield was, regardless of the type of pruning used.

In the same way, Joubert et al. (2000), working in South Africa, tested the effect of light and severe prepruning followed up by hand pruning in 'Valencia'and 'Navel' oranges and 'Star Ruby' grapefruits.

After three years'experimentation, they were able to confirm that all the systems tested produced a higher yield than the unpruned control, with the best choice being hedging with an inclination of 10-20° combined with hand pruning once or twice a year. Pre-pruning in which a tilted plane is produced facilitates lighting of the bottom of the tree and also favours the concentration of fruits in the lower part of the tree, which makes manual harvesting easier. Spanish citrus farmers like to leave the trees with large skirts because this is a highly productive part of the tree. However, skirting tests performed with prepruners have shown that the overall production of the tree is not affected, while mechanical harvesting is facilitated, problems with soil fungus are reduced and tree microclimate is affected (El-Zeftawi, 1976; Morales et. al.,, 2000; Sauls, 2008).

Nowadays, mechanical pruning, either alone or combined with hand pruning, is used by some Spanish farmers. It is, however, not a technique that is widely accepted by growers, among other reasons due to a lack of experience. Pruning citrus trees must be a general canopy management strategy based on the understanding of specific pruning and regrowth management practices that must be combined with cost-effective methods adapted to each orchard period, growth, full production and old trees decline due to age and/or shading (Krajewski & Krajewski, 2011).

So economics part was also calculated for the pre pruner operation keeping in view its future scope.

Economics

The economics calculation was also done for pre pruner and manual pruning method. The operational cost for pre pruner and manual pre pruner were calculated taking into account their field capacities.

The field capacity was calculated using all the time involved in involved in pruning operation for manual method.

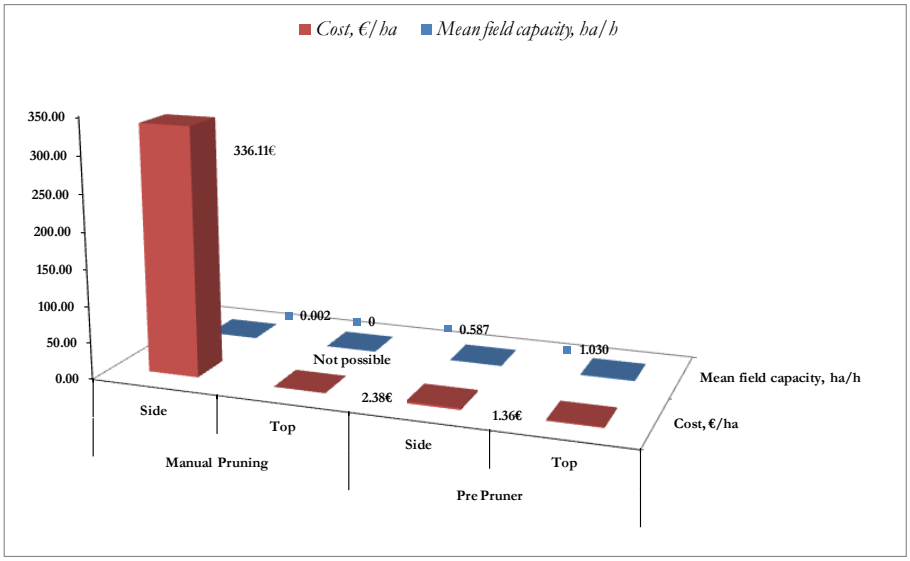

Fig. 12. A graphical representation of field capacity and cost of pruning operation for pre pruner and manual pruning pruning operation for manual method

For pre pruner machine time lost in turnings, breakdowns etc were taken into account. The labour cost (0.61 $€.h^{-1}$), diesel cost (0.79 $€.L^{-1}$), repair costs were considered for calculations. The cost of operation for side pruning operation for pre pruner and manual pruning were calculated as 2.38€/ha and 336.11 €/ha respectively (Fig. 12). (*1€=82.19 INR*). The cost of top pruning for manual method was not worked out as it was not possible for this method. The cost of top pruning in case of pre pruner was worked out as 1.36 €/ha.

The saving in cost with pre pruner machine for side pruning was 99.29 % with added advantage of complete top pruning.

CONCLUSIONS

The mean field capacity of manual pruning was calculated as 0.002 $ha.h^{-1}$ for side pruning and for top pruning the manual efficiency was very low and unable to complete the pruning due to reach problem. Whereas in case of tractor operated pre pruner the mean field capacity was higher for side and top pruning as 0.587 $ha.h^{-1}$ and 1.030 $ha.h^{-1}$ respectively along with benefits of efficient and complete pruning.

Orchard planting geometry should be such as to facilitate easy, quick and balanced movement of tractor in between rows and at headlands i.e. orchards should have minimum of ridges, undulation as well as weeds/grasses to avoid slippage of tractor during operation and for maximizing field capacity of machine.

The irrigation planning of orchard should be done keeping in view the date of next pruning operation or should be well in advance before pruning operation so that during pruning field is in dry conditions this so to provide good traction condition for tractor during operation. The operator should be fully aware about controls of pre pruning machine and equipped with good driving skills which are very important for field operation and road movement of pre pruning machine.

Tractor with cabin should be preferred for pre pruning machine for safety of operator as during pruning of trees small wooden pieces may hit and cause injury to the tractor operator. For plants having height more than 10 feet high clearance tractor may be used for enhancing visibility of operator during field operation. The pruning of tree sides should be done before start of top pruning. The choking may occur in pre pruning machine for the case when machine is lowered to increase cutting height of top portion greater than overall height of cutting unit. Therefore cutting height for top portion should be selected accordingly.

Before starting operation operator should check these points daily

- The oil level in the reservoir should be checked for marked level and if found less should be filled up to marked level first.
- Nuts of all the rotating blades and other units should be checked and tightened if needed.
- The free movement of pre pruning machine should be checked in all planes.
- The rotary blades should be checked by running them ideally.
- All the hose pipes should be checked for any leakage and if found should be repaired or replaced before operation.
- The support system of should be checked thoroughly for any loose nuts and if found any should be tightened.
- The wearing of cutting discs also depend on the branches diameter but normally they need sharpening before starting a new season.

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TEHNIČKO I EKSPLOATACIONO ISPITIVANJE TRAKTORSKIH FRONTALNIH MAŠINA ZA OREZIVANJE U VOĆNJAKU MANDARINA (*Citrus reticulata*) I GUAVA (*Mirtaceae*)

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Sažetak: Rezidba voćke je sečenje i uklanjanje odabranih delova voćki. Može se primeniti sa priličnim brojem tehnika u hortikulturi kod proizvodnje voća. Rezidba uključuje rezanje određenih grana ili ponekad potpuno uklanjanje manjih delova stabla, a pre svega uklanjanje mladih izdanaka, pupoljaka i lišća prema određenim pravilima. Utvrđena voćarska praksa organskih i neorganskih vrsta voćki obično uključuje redovnu primenu tehnike orezivanja određenih grana stabala.

Rezidbom se može kontrolisati rast, ukloniti suvi ili bolesni delovi stabla voćke i znatno podstaknuti produkcija pupoljaka, odnosno kasnije cvetova i plodova.

Rezidba i priprema mladih stabala poboljšava njihovu produktivnost i dugovečnost, a takođe može sprečiti kasnije oštećenja slabijih delova stabla voćke (gde se stablo cepa na dve ili više grana) koje mogu da se polome od težine plodova voća, snega ili leda na granama.

Međutim, efikasnost metoda orezivanja voćki je takođe važna. Ručna rezidba ima mnogobrojna ograničenja, pre svega manji učinak i efikasnost, ili nepotpuna rezidba grana krošnje-stabala u slučaju visokih tipova pojedinih vrsta.

Zbog toga su traktorski agregati sa frontalnim jednorednim predrezačem i elektro hidrauličkom kontrolom testirani u uslovima voćnjaka (Indija, države Maharashtra, Andhra Pradesh, Punjab, Himachal Pradesh, Uttar Pradesh, Madhya Pradesh, Karnataka, Jammu and Kashmir, Orissa, Gujarat, Assam, Meghalaya, Rajasthan, Sikkim and Tamil Nadu.) Kinnov Mandarin (*Citrus reticulata)* i Guava (*Myrtaceae*).

U eksploataciji mašina utvrđeno je da vreme za vršno i bočno orezivanje određenih grana stabala voćki bilo 23,30 odnosno 46,80 min/acr, a uštede vremena od 99,32 - 99,38% u poređenju sa ručnim orezivanjem stabala u voćnjacima.

Ključne reči: *hidraulično, vertikalno, disk, horizontalno, automatski, jednoredna mašina*

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EFFECT OF SOIL MOISTURE CONTENT, DYNAMIC LOAD AND WHEEL SLIPPAGE IN MEASURING TRACTION IN AN INDOOR TRACTION BED

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Abstract: A study was conducted to determine the effect of soil moisture content, dynamic load and wheel slippage in measuring traction. A single wheel test rig was developed to enable fundamental research on traction studies on tropical soil at the department of Agricultural and Environmental Engineering of Federal University of Technology, Akure. This facility consists of a moving carriage with a trolley that moves in either forward or reverse directions on rails well above a soil bin powered by 2.2 kW, three phase induction motor. The present facility set up was able to operate in either towing test mode for tire motion resistance studies or driving test mode for tire net traction and tractive efficiency studies. The test tire on the moving carriage was powered to rotate by a motor with additional pull provided by a cable-pulley mechanism connected to a tower with hanging dead weights. All controls on the moving carriage were activated from the main control console. The developed facility was successfully tested to determine tractive efficiency for narrow wheels at a particular inflation pressure on clay soil. The single wheel test rig facility worked well and the research indicates that wheel load, wheel slippage, soil moisture content and inflation pressure has great effect on traction efficiency. Traction efficiency decreased as the wheel load and wheel slippage increased. The developed single wheel testing facility can perform traction tests in controlled soil conditions to study the effect of soil, tire and moisture parameters on the performance of the system.

Key words*: Soil moisture content, dynamic load, wheel slippage, traction, inflation pressure*

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INTRODUCTION

Traction is an important study in the behavior of tractive devices (wheels or tracks) in which pneumatic tire is for off road vehicles and hence the study of test rig for single wheel to study traction is of fundamental importance. Research studies indicate that about 20-55% of the energy developed to the drive tractor wheels is wasted on the tire soil interaction [1]. This energy is not only wasted but the resulting soil compaction created by a portion of this energy may be detrimental to crop production as well [2]. Due to the enormous problems of interaction between the vehicle's running gears (wheel, tract etc.) and various soil conditions and terrain surfaces, there have been rigorous research efforts to obtain a better understanding of traction studies. Tractive performance is influenced by tire parameters, soil condition etc. [3]. Traction properties of a wheel vehicle largely depend on the interaction between the wheel and the ground. Thus, it is essential to analyze this interaction with a view of attaining the best possible use of wheels and tracks under given conditions. The optimal use of a wheel (depending on a criterion we choose) consists of ensuring maximum efficiency of a wheel, not exceeding the permissible values of wheel slip, and obtaining the maximum tractive effort [4]. It is also noted that traction performance of tractors has been a challenging problem for many engineers especially in Nigeria.

More so, the globally increasing demand for food production magnifies the importance of crop yield of farmlands. Consequently, soil-tool interactions should be evaluated comprehensively to achieve this aim since crop yield is a function of farm condition. In the countries with mechanized agriculture, the intensive application of heavier tractors due to increasing farm operations endangers the soil condition of farm through all the forces applied to the ground. Determination of contact area between tire and soil plays an important role on both the intensity of soil compaction and also in the soil-wheel interactions [5]. Tests are conducted either on soil bin found in indoor testing facilities or by performing real field tire testing. Situations where the soil is brought to the tester, have been used to acquire a significant amount of data worldwide [6]

Traction Parameters

Five dimensionless parameters are used to describe tractive performance [7]:

i. Travel Reduction Ration (TRR), commonly called "slip" and expressed in percent.
ii. Net Traction Ration (NTR), sometimes called/weight ration.
iii. Tractive Efficiency (TE)
iv. Gross Traction Ration (GTR)
v. Motion Resistance Ration (MRR).

Travel Reduction Ration (TRR)

$$TRR = 1 - \frac{Actual\ Velocity}{Theoretical\ Velocity} = 1 - \frac{V_a}{V_t} \quad (1)$$

Travel reduction has traditionally been called "slip" or "% slip", but technically this is incorrect. Slip occurs between surfaces.

Net Traction Ration (NTR)

$$NTR = \frac{Net\ Traction}{Dynamic\ reaction\ force} = \frac{NT}{Wd} \quad (2)$$

The net traction ratio is sometimes referred to as pull/weight, P.W, dynamic traction ratio, or coefficient of traction. The dynamic reaction force of dynamic weight (Wd) includes the effects of ballast and any weight transfer that may occur in the testing process

Tractive Efficiency (TE)

$$TE_{(ratio)} = \frac{Output\ Power}{Input\ Power} = \frac{NT\ x\ Va}{Axle\ Power} \quad (3)$$

$$= \frac{NT}{GT}\frac{Va}{Vt} = \frac{{}^{NT}/_{Wd}}{{}^{GT}/_{Wd}}\frac{Va}{Vt} = (\frac{NTR}{GTR})(\frac{Va}{Vt}) \quad (4)$$

Tractive "inefficiency" is caused by both velocity losses and pull losses. The loss in travel speed is commonly referred to as "slip", although it is more accurately referred to as "travel reduction". Travel reduction is the result of the theoretical travel speed (Vt) not being entirely converted to forward progress (Va) due to losses within the soil, between the soil surface and the traction device and within the traction device (hysteresis and tire windup or belt slippage). Travel reduction losses are visible, that is, the operator can see it happening. The other component of tractive "inefficiency", which is less visible and often overlooked, is a loss of pull (net traction) when motion resistance reduced the amount of gross traction that is converted to useful output (net traction). This is part of what happens when a tractor is over ballasted. Travel reduction is reduced, but motion resistance is increased. Motion resistance losses are especially relevant to belts, as internal losses within the belt drive mechanism, rollers and bending of the belt are normally greater than those within a tire. On soft soils, the internal losses of belts are generally compensated for by lower external motion resistance than that of tires.

Gross Traction Ration (GTR)

$$GTR = \frac{GT}{W_d} = \frac{T}{rt\ x\ W_d} \quad (5)$$

Gross traction (GT) is sometimes referred to as rim pull, design drawbar pull, or theoretical pull. It is the axle torque input converted to a pull force. It is the pull you would develop if there were no motion resistance loss.

Gross traction (GT) itself cannot be measured directly and is usually calculated from the axle torque and radius of the wheel or tractive device. The problem is that the correct radius to use is not well defined or directly measurable.

There is no general agreement among traction researchers as to what radius to use and an alternate method of calculating gross traction ratio is preferred using energy or power considerations.

From the equations above

$$GTR = \left(\frac{NTR}{TE}\right)\left(\frac{V_a}{V_t}\right) = \left(\frac{NTR}{TE}\right)(1 - TRR) \quad (6)$$

Having thus determined the gross traction ratio (GTR), since

$$GTR = \frac{GT}{W_d} = \frac{T}{rt\ x\ W_d} \quad (7)$$

The effective torque radius (rt) can be calculated by:

$$rt = \frac{T}{(GTR)(Wd)} \quad (8)$$

Motion Resistance Ratio (MRR)

$$MRR = GTR - NTR \quad (9)$$

The motion resistance ratio (MRR), sometimes referred to as rolling resistance, includes internal losses within the tractive device (for example, losses within a belt drive or a tire) and soil forces. All "force" losses beyond where the torque is measured are included in motion resistance, for example, gear losses if the torque is not measured directly at the input to the tractive device. An example of this might be use of input drive shaft torque when testing tires using a mechanical front wheel drive mechanism. Rolling losses of bogie wheels of a belt drive mechanism would be another example, as well as the torque required to overcome the bending of a belt.

MATERIAL AND METHODS

Characteristics of the Soil that was studied

The soil used for soil tire interaction in this research work was clay. The physical properties of clay are of extreme importance in soil science. The soil was gotten in Step B area of Federal University of Technology Akure. The soil was tested in the laboratory and confirmed to be clay.

Characteristics of the wheels that was studied

Brand	-	IRC (INOUE RUBBER COMPANY)
Front/Rear	-	Front, rear
Tire size	-	90/90-10
Bias/Radial	-	Bias Ply
Rim size	-	10
Tube/Tubeless	-	Tubeless

Design of the Tool Carriage

The tool carriage is fabricated using steel and is supported on four pairs of wheel mounting brackets.

The arrangement of the wheels were designed to run on the side railings of the soil bin.

The tool carriage and the soil processing carriage are placed on top of the soil bin for the operations. The tool carriage and soil processing carriage is pulled in either direction by means of rope. The rope is driven by the drive system positioned at one end of the bin. The bin provides rigid support for soil and the carriages. Tool carriage provides mounting and positioning for tools.

Design of the Implement Carriage

The implement carriage was fabricated using rectangular steel and is attached to the tool carriage. The carriage has a coupling recess to enhance the rigid coupling of the wheel. The function of the carriage is twofold;

For mounting traction devices such as traction or towed wheels for testing
For mounting carriage subsystem which in turn carries the toolbar.

Experiment conducted to investigate effect of wheel load and wheel slippage on Traction

Load of various sizes 15, 20, 30 and 40 kg were varied on the test rig to study the traction. Two conditions of wheel (inflation 380 kPa and 276 kPa) were used to study its effect on traction and varying conditions of soil 10% and 8% moisture content respectively.

Fig. 1. Single wheel test rig

Fig.2. Fabricated tool Carriage

Fig.3. Fabricated single wheel test

RESULTS AND DISCUSSION

The Preliminary tests indicated that the test rig facility worked well. The processing of the soil was carried out by a trolley powered by 2.2 kW, 3 phase induction motor with reduction gear and the test rig was powered by another 2.2 kW, 3 phase induction motor with reduction gear. The variables recorded for traction test were;

(i) Normal load on the wheel axle
(ii) Tire inflation pressure
(iii) Soil moisture content
(iv) Speed of the wheel

References should be numbered in brackets in the order of appearance in the text, e. g. [1], [3, 4], [7-11], etc. The full references should be listed at the end of the paper in numerical order of citation in the text.
All equations, formulas, and expressions should be numbered in parentheses e. g. [1], with right alignment, in the order of appearance in the text, and must be centered with one line left above and below.

Result at inflation pressure of 380 kPa and 8% moisture content

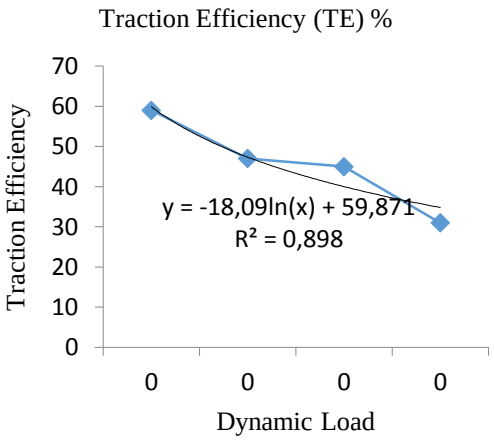

Fig. 4. Effect of slippage on tractive efficiency

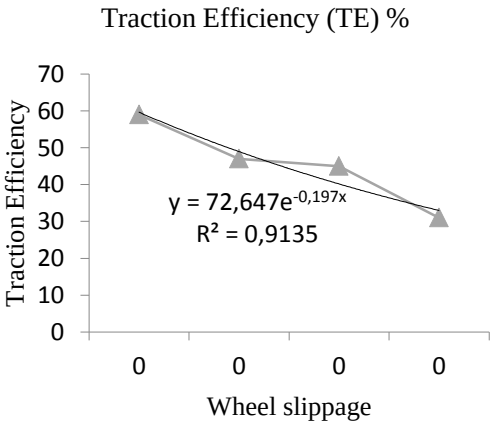

Fig.5. Effect of dynamic load on tractive efficiency

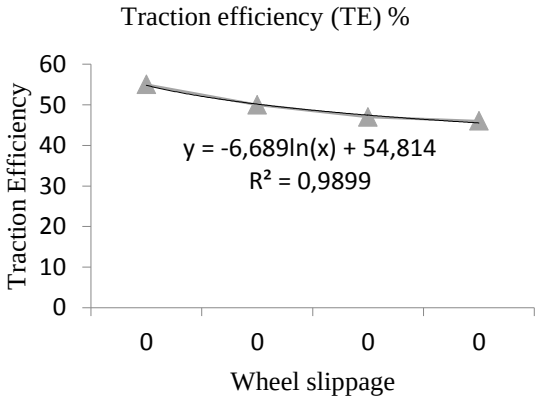

Fig. 6. Effect of wheel slippage on traction efficiency

Result At Inflation Pressure of 276 kPa, and 10% Moisture Content

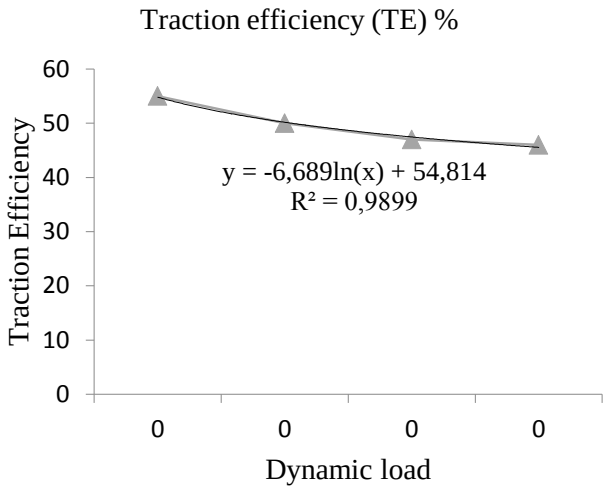

Fig. 7. Effect of dynamic load on traction performance

Figures 4 and 5 show the result at wheel inflation pressure of 380 kPa and 8% moisture content.Traction efficiency decreases as wheel slippage and dynamic load increases.

Also, Figures 6 and 7 show the result at inflation pressure of 276 kPa and 10% soil moisture content traction efficiency decreases as wheel slippage and dynamic load increases.

Similarly, reports concerned with tractive performance parameters in the literatures confirm the discovered trends in the investigations of [8],[9], and [10] respectively.

CONCLUSIONS

1. An indoor test rig for single wheel to study traction has been developed.
2. The developed single wheel testing facility is able to perform traction tests in controlled soil conditions to study the effect of soil, tire and system parameters on the performance of the tires.
3. The test rig has ease of maneuverability because of its simplicity in construction.
4. The developed test rig is a simple wheeled device, capable of testing of tires 500 mm in diameter and dynamic weight 400 N.

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UTICAJ SADRŽAJA VLAGE ZEMLJIŠTA, DINAMIČKOG OPTEREĆENJA, KLIZANJA TOČKOVA KOD ODREĐIVANJA SILE VUČE U USLOVIMA LABORATORIJE

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Sažetak: Studija je urađena kako bi se utvrdio uticaj sadržaja vlage u zemljištu, dinamičkog opterećenja i proklizavanja točkova na merenje sile vuče.
Ispitni uređaj sa jednim točkom razvijen je kako bi se omogućilo osnovno istraživanje studija vuče na tropskom zemljištu na Odeljenju za poljoprivredno inženjerstvo i zaštitu životne sredine federalnog Tehnološkog Univerziteta, Akure, Nigerija.
Ovaj uređaj ima pokretna kolica koja se kreću u pravcu napred ili unazad na šinama iznad posude (kade) sa uzorkom zemljišta.
Kolica dobijaju pogon od trofaznog asinhronog motora snage od 2,2 kW. Sadašnje postavljeno postrojenje može da radi u bilo kojem režimu ispitivanja vuče za studije otpora kretanja pneumatika ili u ispitivanja režima kretanja za studije vuče i efikasnosti točkova uređaja.
Testiran točak (pneumatik) na pokretnim kolicima dobija pogon preko remenice i povezan je sa dodatnim mehanizmom za moguću promenu vertikalnog opterećenja sa tegovima.
Sve komande na pokretnim kolicima aktiviraju se sa glavne kontrolne konzole.

Razvijeno postrojenje (uređaj) u laboratoriji uspešno je testirano za utvrđivanje vrednosti vučne sile uskih tipova točkova pri određenom pritisku u pneumatiku za uslove glinovitih tipova zemljišta.
Postrojenje u laboratorijskim uslovima za ispitivanje sa jednim točkom je dobro funkcionisalo i istraživanje pokazuje da opterećenje točkova, proklizavanje točkova, sadržaj vlage u zemljištu i pritisak u pneumatiku, imaju veliki uticaj na vrednost sile vuče. Efikasnost sile vuče se smanjivala kako se povećavalo opterećenje točkova i klizanje točkova.
Razvijeno laboratorijsko postrojenje za ispitivanje sa jednim točkom može da simulira testove vuče u kontrolisanim uslovima zemljišta kako bi se proučio uticaj različitih parametara zemljišta, pneumatika i vlage na performanse sistema.

Ključne reči: *sadržaj vlage u zemljištu, dinamičko opterećenje, proklizavanje točkova, vuča, pritisak u pneumatiku*

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POSTHARVEST PROCESSING, PACKAGING AND STORAGE OF AFRICAN OIL BEAN SEED

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Abstract: The underutilization of African oil bean seed necessitated the study of its post-harvest operations. This work reviews the status of research on postharvest processes of African Oil Bean (AOB) seed. Information was sought through a search query with African oil bean post-harvest processing, packaging and storage as keywords on Google Scholar, internet, publishers' website, textbooks and oral interview with local processors. The results showed that researchers have focused on the fermentation, proximate, phytochemical, mineral and vitamins composition of AOB seeds. This study also revealed the dearth of research on characterization, improved variety, packaging, storage, value addition and oil extraction from AOB seeds. Research on postharvest handling, storage, packaging and processing of AOB seed is imperative for optimal utilization of the seed, and to prevent the prevalent post-harvest losses.

Key words*: African oil bean seed, packaging, processing, storage, value addition*

INTRODUCTION

The African oil bean (*Pentaclethra macrophylla Benth*.) is a tropical tree crop treasured for the multipurpose usefulness of its seed, pod, timber, bark, root and leaf.

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The crop is native to Africa, with the distribution cutting across the Cameroon, Cote d'Ivoire, Democratic Republic of Congo, Ghana, Niger, Nigeria and Togo rain forest zones [1].

The AOB is known in Nigeria as *ugba* or *ukpaka*, *apara* and *ukana* among the Igbo, Yoruba and Efik tribes, respectively. The crop belongs to the family of *Leguminosae* (*Mimosoideae*) with no recognized varietal characterization [1-3].

The crop flowers and produce green dicotyledon pods that changes to brown on maturity. Each pod contains up to 10 seeds that are glossy brown, and at maturity, the pod splits open explosively scattering its seeds up to a distance of 20 m from the tree [2]. After the explosion, the pods usually curl up. The seeds of African oil bean are flat in shape, hard, but smooth in texture and have an average length of 56.18 mm and width of 37.89 mm [4-5]. The seed is a good source of minerals, vitamins (Table 2), protein, carbohydrate, crude fibre, oil (Table 3), and contain many phytochemicals (Table 4). These researchers [6] found that AOB seeds protein content is greater than those of high animal protein sources like beef, oyster, pork and fishes.

Table 1. Importance of various parts of African oil bean tree (Adapted from [1])

Tree part	*Uses*	*Description*
Fruit pod	*Fuel*	*Empty dry pods are used as firewood for cooking, and charcoal production*
Timber	*Wood work*	*The wood is used in carving household utensils in Ghana and Nigeria*
Pod ash	*Tannin or dyestuff*	*Ashes of burnt pods are used made into mordant dyes*
Seed	*Food*	*Seeds are processed into ugba which is eaten as a snack or used as a condiment for soup, salad and many local sauces*
	Lipids	*The seed is good source of seed oil*
	Decoration	*Seeds are used for making beads, necklaces and rosaries*
Stem	*Medicine*	*For treating diarrhea*
Leaves	*Soil improver*	*Improves soil fertility; for herbal medicine in treating wound and diarrhea.*
Tree	*Ornamental*	*The tree is planted as ornamental plant*

In other to maximize the protein constituent, a texturized vegetable protein from AOB seed that will serve as a meat analogue at optimal parameters of 92.45^{o}C barrel temperature, 101.48 rpm screw speed, 59.63 % feed moisture, and 1% AOB seed protein concentrations was developed [7].

A work by [8] posits that the seed is a good source of lipase. AOB seed improves metabolism and possess anti-atherogenic property [9]. Some researchers [10] recommended the use of the seed in the treatment of diabetes because of the hypolipidemic activities it exhibited.

According to [11], AOB seed could help to improve kidney functionality. The seed, also, contains anti-inflammatory and analgesic properties and is used to treat gonorrhoea and convulsions in Cameroon [12]. Besides, it is an excellent raw material for the manufacturing of cosmetics, oil paints, varnishes, edible oil for cooking, and margarine production [13]. The oil of AOB seed is relatively high in viscosity compared to other under-exploited seeds in Africa like Baobab, African pear, African nutmeg and fluted pumpkin seed [14]. Investigation by [15] suggests that the oil of AOB seed is a good raw material for pharmaceutical industries because the extract from the seeds can inhibit the growth of micro-organisms such as *B. cereus, B. lichemiformis, L. species, E. coli and C. albican*.

The stem, bark, root, hull and pod of AOB are equally important to man (Table 1).

Table 2. The nutritional contents of African oil bean seed

Minerals	*Compositions*				
	(ppm)	*(mg $100g^{-1}$)*	*(mg $100g^{-1}$)*	*(µg g^{-1})*	*(mg $100g^{-1}$)*
Calcium	*104.5*	*1.10*	-	*8.16*	*2.89*
Copper	-	*0.98*	-	*0.05*	-
Iron	*34.8*	*4.23*	-	*1.60*	*0.13*
Lead	-	-	-	*3.94*	-
Magnesium	-	*0.30*	-	*4.86*	*11.10*
Manganese	-	-	-	*0.72*	-
Phosphorous	*101.6*	*1.51*	-	*0.06*	-
Potassium	*181.3*	*0.65*	-	-	*4.95*
Sodium	*236.2*	*0.18*	-	-	*5.28*
Zinc	-	*1.31*	-	-	*3.31*
Vitamins					
Ascorbic acid	-	*10.56*	-	-	-
Niacin	-	*2.10*	*2.00*	-	-
Riboflavin	-	*0.18*	*0.11*	-	-
Thiamine	-	*0.25*	*1.10*	-	-
References	*[13]*	*[16]*	*[17]*	*[18]*	*[19]*

In their work, [19] found that AOB seed contains high levels of some anti-nutritional and toxic factors which are eliminated during cooking and fermentation. The fermented AOB seed sliced or shreds are commonly known as *ugba*. The *ugba* is prevalent in Eastern Nigeria, and is usually consumed as a snack or a condiment for preparing African salad, soup, porridge yam, cocoyam, meat (*nkwobi*), among others delicacies.

Fermentation improves the amino acids and nutritional contents of *ugba* [20, 21]. Also, fermentation increases the proximate composition and reduces the phytochemical content of the seed [16, 19, 22]. The kinetics of AOB fermentation is influenced by boiling time and slice thickness [23].

The bacteria responsible for fermenting of AOB, according to [24], are *Bacillus pumilus* and *Bacillus sphaericus*, apart from *Bacillus licheniformis* and *Bacillus subtilis.*

In their study, [25] discovered that the starter culture fermented *ugba* is rated higher by the consumers in terms of consistency, aroma and taste than those obtained from the markets. It has been found that African oil bean seeds fermented with oil palm inflorescence ash have better chemical and microbial composition than the one processed without the oil palm ash [26]. The fermentation of AOB seed enhances its oil extraction [27]. Though fermentation is necessary for processing AOB seed into *ugba*, [28] found a high prevalence and co-contamination of different potentially toxigenic fungi on *ugba* and other fermented foods in Nigeria. Extract from the seed, as suggested by [29] could be used for bio-preservation of condiments against pathogens that spoil food.

Table 3. Proximate composition of raw, boiled and fermented African oil bean seeds (Adapted from, [16])

Constituents	*Raw*	*Boiled*	*Fermented*
Crude Protein (N x 6.25)	24.06 ± 0.22^b	25.59 ± 0.11^b	28.25 ± 0.20^a
Crude fiber	2.80 ± 0.11^b	2.66 ± 0.10^b	3.76 ± 0.22^a
Lipids	52.50 ± 0.20^b	51.40 ± 0.30^b	44.20 ± 0.10^a
Ash	2.70 ± 0.20^b	3.04 ± 0.22^b	1.86 ± 0.30^a
Carbohydrates	17.94 ± 0.10^b	17.31 ± 0.11^b	21.93 ± 0.22^a
Calorific value (Cal g^{-1})	640.50^b	634.20^b	598.52^a

Values with superscript that are the same not significantly different at $p < 0.05$.

Though not listed among the 101 orphaned crops in Africa [30], the African oil bean can be regarded as an orphaned crop because of inadequate research on the crop. This implies that African plant breeders, sociologists, anthropologists, nutritionists, policy-makers, scientists, farmers, government representatives, universities and various other stakeholders that compiled the list did not consider the crop for inclusion in the neglected African crops. This reality poses a serious danger for the survival of the crop in a few decades, if nothing is done to boost research on the crop.

Table 4. Phytochemical compositions of African oil bean seed

Components($mg100g^{-1}$)	*[16]*	*[31]*
Alkaloid	*1.88-8.96*	*11.24+0.01*
Flavonoid	*0.28-0.90*	-
Oxalate	-	*1.39+0.01*
Phenol	*0.02-0.75*	-
Phylate	-	*1.17+0.01*
Saponin	*0.22-4.96*	*3.20+0.01*
Tannin	*$3.0x10^{-3}$-0.49*	*0.95+0.01*

Hence, this study is aimed at reviewing the importance of African oil bean seed, the status of postharvest research on the seeds' processing, handling, storage, value addition, and to highlight the research needs of the crop.

PRODUCTION AND PROPERTIES

Production of African oil bean seed

The African oil bean trees grow in the wild until recently when the domestication has started. However, the wild still makes up a higher percentage of total production. Currently, there is neither any empirical data on the quantity produced annually nor any known commercial plantation. It was showed by [12] that the seeds and stem cuttings are used in propagating the crop. The seeds are dispersed naturally (during the splitting of the pods) or manually after harvest. It can also be propagated by air-layering or budding. The budded trees start fruiting after 3 years whereas the stem-cuttings may produce seeds after four years [32].

Engineering properties of African oil bean seeds

Engineering properties of biomaterials are essential in designing their postharvest processing machines, storage facilities and handling equipment [33, 34]. The average major, intermediate and minor diameters of African oil bean seed at 14.5%, moisture content were 65.332 mm, 60.269 mm and 59.584 mm, respectively [35]. At the moisture content of 8.73% dry basis, [5] obtained values for these properties the major, intermediate and minor diameters of the seeds averaged 56.18mm, 37.89mm, 12.01m with standard deviations 8.46, 3.82 and 1.66 mm respectively. They, also, got the equivalent diameter, sphericity and porosity as 32.51 mm, 0.523 mm and 51.56 mm, respectively. The seed dimensions are relatively larger than many oil seeds. The gravimetric properties show that the seed is heavier than water [5, 35]. In addition, [36] found the angle of repose and friction coefficient to be 17.20^{o} and 0.31, respectively. In their own work, [3] investigated the mechanical properties of the seed at moisture content range of 15.76 to 34.43% wet basis and loading rate of 25 mm/min., and they found the values of rupture force, toughness, rupture stress, yield force and modulus of stiffness of the seeds to decreased linearly from 362.04 to 168.82 N, 1.783 to 0.623 J, 7.4 to 3.15 N/mm^2, 213.42 to 89.68 N and 39.6 to 21.97 N with moisture increase in transverse axis. Whereas for longitudinal loading, the values decreased from 276.64 to 195.26 N, 1.355 to 0.641 J, 16.12 to 6.23 N/mm^2, 211.58 to 124.72 N and 38.74 to 24.77 N with an increase in moisture content. The seeds' physical and mechanical properties were affected by moisture content [3, 35]. However, it was observed that adequate work had not been done on the thermal properties of the seeds despite the fact that heat treatment is essential for its processing.

POSTHARVEST AND STORAGE

Processing of African oil bean seed

It has been stated [37] that *Ugba* contains some anti-nutritional factors like undigestible oligosaccharides and phytate in its natural state, and this make processing inevitable. The processing of the seed into *Ugba* involves boiling or roasting, dehulling, shredding / slicing, soaking, washing, packaging, and fermenting (Table 5).

However, the processing method affects the nutrients and phytochemical properties of AOB seeds *Ugba* [10, 38, 39, 40, 41]. This revelation makes optimization of the processing method imperative to get the optimal variables for *Ugba* processing. A study [42] is of the opinion that *Ugba* should be handled properly during processing in order to take care of the *Micrococcus spp* and to inhibit the enzyme production responsible for spoilage. Processors can save up to 2 days by using a rapid technique for *Ugba* processing proposed by [43]. The apparent simple process achieved the same quality of *Ugba* after fermentation as the much more cumbersome, fuel-wasting and time-consuming.

Fermentation of African oil bean seed shreds/slices (*ugba*)

Some foods are probiotics and must have to undergo fermentation before they are ready to be consumed. Examples of such foods to include wine, yogurt, cheese, alcohol, vinegar and bread [22]. The shreds and slices of cooked African oil bean is fermented before they are consumed.

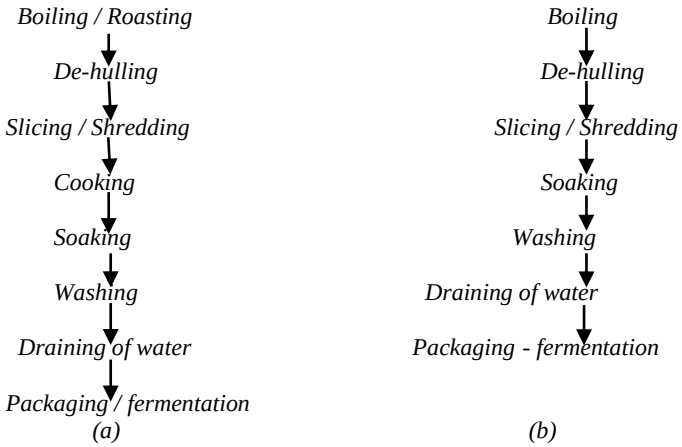

Fig. 2. Flowchart of Ugba processing

Unfermented shreds/slices are bitter and not tasty. The first stage in the processing is cleaning to remove damaged seeds. After cleaning, the traditional processing operations follows (Figure 2).

However, [44] recommended 2-3 days of fermentation and reported that fermentation for 4 days increased cholesterol levels which could pose a problem for patients of cardiovascular disease-related to cholesterol.

Different processors adopt varying sequence of the processing methods (Table 5), however, there are two main methods of processing African oil bean seeds into *Ugba* (Figure 2) prevalent within the Southeastern part of Nigeria as reported by local processors.

Packaging of the shreds/slices of African oil bean seeds

African oil bean seed shreds and slices are traditionally packaged by wrapping a handful with different kinds of leaves (Figure 1). The wrapping of the seeds with leaves is believed to aid the fermentation process. The leaves wrapping and the poor measures during handling contaminates the product [45]. Also, leaves-wrapping creates openings for microbes to enter the product resulting to rapid deterioration. The leaves-wrapped product has a low shelf life of not more than 5 days under tropical ambient conditions of 31 -32^{o}C.

(a)
Fig.1a. AOB shreds

(b)
1b. AOB slices

(c)
1c. Wrapped AOB shreds/slices

The type and the number of leaves varies from one processor to another, and they are determined by the processor's discretion and experience. The effect of the type and number of leaves on the quality of wrapping African oil bean shreds was evaluated by [46]. Their study showed that the leaves of plantain (*Musa paradisiaca*), cocoyam (*Xanthosoma sagittifolium*) and *Okpopia* (*Alchornea laxifora Benth*) did not affect the proximate composition of the product so also the number of leaves used. However, they recommended five leaves of *Okpopia* (*Alchornea laxiflora Benth*) for wrapping African oil bean seed slices and shreds because of the high storage quality observed.

Other researchers have studied alternative ways to package and extend the shelf life of African bean seed shreds/slices. The use of canning method of packaging was studied by [47]. They used brine, groundnut and tomato sauce as various media to extend the shelf of African oil bean slices. They observed that canning with media led to softening and colour darkening of the samples over prolonged storage time. Apart from these problems detected, another challenge would be the acceptability of those media with African oil bean slices in dish preparations. This is because the foods prepared with African oil bean does not go with any of those media as an ingredient. In their work, [48] evaluated bottle/cup packaging with locally adapted pasteurization technique as an alternative storage method.

They used starter culture of washed cells of Bacillus subtilis and Bacillus megaterium to ferment the sliced and sterilized slices of African oil bean seeds for 48 hours at room temperature (30±2^{o}C). Although they observed no microbial growth on the product at the end of 6 weeks of storage, they did not indicate whether or not the intrinsic properties of the product were affected.

Some other researchers [49] studied the possibility of using polyethene bags and foil wraps with the aid of preservatives to package and extend the storage duration of African oil bean seeds. Their method was able to keep the product for only eight days after which the product quality was found to degrade.

Besides, some preservatives can alter the organoleptic properties of food, and carrying out tests such as Hedonic, could have been useful in evaluating the effects of the preservatives and storage methods on the organoleptic characteristics of the product.

Notably, the various methods evaluated, when compared to leaves wrapping, have the advantage of reducing or preventing the entrance of microbes that leads to product spoilage. Nonetheless, none of the methods is satisfactory in solving the packaging and storage problems of African oil bean shreds/slices.

Table 5. Processing methods for fermented African oil bean seed

S/N	*Processing method*	*Reference*
1	*Boil the seeds for 4 hours, dehull, slice, boil for another two hours, drain and soak in water for two hours, wash and package in leaves for fermentation*	*[22])*
2	*Boil at 121^{o}C for 1 hour, dehull, wash kernel, drain, rewash kernel several times in cold water, slice, mix with salt, wrap with leaves and place in a basket to ferment for 3-5 days.*	*[50]*
3	*Boil for 3 hours, dehull, slice, wash and boil for 2 hours, cool and soak for 10 hours, wash, drain water and keep in a basket lined with banana leaves to ferment*	*[51]*
4	*Boil for 12 hours, slice, boil for 24 hours, wash, drain and allow to ferment*	*[52]*
5	*Boil for 12 hours, dehull, slice, boil for 2 hours, wash, wrap in banana leaves and packaged in the basket for fermentation*	*[16]*
6	*Toast in hot (100^{o}C) sand and hold for a further 30 min at 100^{o}C, slice to 1 mm, boil for 30 mins and soak for 2 hours.*	*[43]*
7	*Boil for 12 hours, dehull, slice, boil for 30 mins, drain, cool, wash and ferment at room temperature in wraps of heat-blanched banana leaves*	*[53]*

Seed storage

The information obtained from local processors and farmers showed that the seeds of African oil bean are stored in their pods until they are taken to the market or processed.

Farmers do harvest the pods early because of their susceptibility to explode under the intense heat of the sun. The maturity index of the pod is taken as a change in their colour, from green to brown. Some farmers see the maturity index as when any of the pods start to explode.

Harvested pods are kept in shade or room where sunlight does not touch them. Another way to store the seeds is to remove them from the pods and store in a jute bag or multilayer black polyethene bags. The seeds are removed from matured pods by breaking the pods through their longitudinal axis using a machete or by smashing it on a hard object. Otherwise, the seeds are collected from the farm where they are dispersed after splitting of the pod while still on the tree.

Fig. 3(a). Deteriorated AOB seeds

Fig. 3.(b). AOB seeds

The information obtained from local processors showed that the shelf life of the seeds stored in their pods could be up to 6 months, depending on the prevalent ambient conditions, whereas, the jute bag or multilayer black polyethene bag storage shelf life is within three months. However, none of these methods proved to be effective in storing AOB seeds, since some of the products were spoilt over time as shown in Figure 3.

OIL PROSPECTS OF AFRICAN OIL BEAN SEEDS

The African oil bean seed is rich in oil content (53.98%) and oleic acid (29.0%) [54, 55]. The AOB seed oil yield is greater than that of castor bean (42.2%) and locust bean (20.68%) [56]. This high oil content of the seed indicates that processing of the seeds for oil would be economically viable [18]. However, there is no grocery shelve where oil from African oil bean seed is displayed. Such neglect has limited the potential of the crop to date.

The influence of moisture content and seed dimension on the mechanical expression of oil from African oil bean seeds has been evaluated [57]. The research showed an oil yield of 47.7% and oil expression efficiency of 78.96% using mechanical oil expression. Also found was that the higher the moisture content and seed dimensions, the lower the quantity of oil expressed by the machine from the seeds.

Mechanical expression of oil seeds does leave some fractions of the oil in the cake, which will require the use of solvent, like food grade n-Hexane, to extract. It implies that solvent extraction will give oil yield higher than 47.7% obtained by [57].

POSTHARVEST CHALLENGES

Postharvest losses

Postharvest losses, which refer to losses in quality and quantity, are usually preceded by physical or physiological damage of agricultural produce. Physical damage occurs during harvest, transportation, handling, packaging and in storage for most agricultural products, while physiological damage results from physiological changes that take place after harvest. The African oil bean seeds are hard and are not susceptible to physical damage during postharvest handling. Many post-harvest losses of the seeds are mostly due to physiological damage, pests attack and diseases. The physiological changes are made possible because of high the moisture contents of the seeds at harvest. It was stated by [58] that the two significant factors affecting physiological deterioration of products are pre-harvest factors (temperature, moisture status, mineral nutrition and cultural practices) and postharvest factors (temperature, chilling injury, light, gases such as carbohydrate, oxygen, ethylene). *Ugba* has a very low shelf life, and whenever the product is not marketed within days of processing, the product will be lost to spoilage.

Dearth of research

There is a decline in the production of African oil bean seeds because of afforestation, urbanization and lack of planting new trees [59]. Majority of the tree still grows in wild and there is no known plantation for the crop. The seed has only a mono bye-product (*ugba*) in Nigeria despite its potential for other products. Researchers have focused their attention of the proximate, organoleptic, chemical, nutritional, functional properties, fermentation, phytochemical and health benefits of African oil bean seed [16, 18, 31, 54, 55, 60-70]. The problem of lack of research input from agronomy and engineering disciplines has led to the absence of improved variety and many postharvest challenges, respectively. As a result, the crop could be termed an orphan and endangered species.

RESEARCH NEEDS OF AFRICAN OIL BEAN SEED

In order to maximize the potential of African oil bean research, there is an urgent need for researchers to look into the following research areas for the crop:

- Development of improved varieties of African oil bean seed
- Optimization of the oil yield of African oil seed
- Characterization of the oil from African oil bean seed
- Evaluation of the drying kinetic of African oil bean shreds/slices for improved shelf life
- Effects of drying on the proximate, phytochemical, mineral and vitamins contents of the African oil bean seed
- Technological development of a proper packaging method for African oil bean seed
- Process optimization of *Ugba* preparation

CONCLUSIONS

The growing population of developing nations has put enormous pressure on the staple food availability of the people, and imported foods are relatively expensive and unaffordable to the majority of the populace due to poverty. To ensure food security in these regions, research on nutritious but neglected crops that grow and flourish with little or no special care, like AOB, should be encouraged. Considering the nutrient attribute, the phytochemical, proximate, mineral and vitamin constituents of African oil bean; the crop could be regarded as a great complementary food for household nourishment and an essential raw material for food and pharmaceutical industries. AOB seed has great prospect of improving the economy of households and the nation through value addition. The exploration of the oil potentials of AOB seed could see the crop compete in world oil-seed trade. Moreover, it brings a high return to investors. Improving the postharvest operations of AOB seed through research could help to tackle food insecurity. Furthermore, there is need to get improved varieties for increased production, and improved research on the postharvest challenges of the crop. So, any value addition on the AOB seed could possibly create wealth and jobs for the teeming youth population of these regions.

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OBRADA POSLE ŽETVE, PAKOVANJE I SKLADIŠTENJE AFRIČKOG SEMENA (ZRNA) ZA ULJE

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Sažetak: Nedovoljna upotreba Afričkog zrna (semena) (*Pentaclethra macrophilla* Benth.) za ulje, zahteva proučavanje operacija posležetvenih postupaka. Ovaj rad daje pregled stanja i situacije istraživanja procesa žetve Afričkog semena (zrna) za ulje (AUS). Informacije su dobijene putem upita za pretragu, obradu, pakovanje i skladištenje afričkog zrna (semena) posle berbe, kao ključne reči na Google Scholar info sistemu, internetu, veb lokaciji izdavača, udžbenicima i usmenim intervjuima sa lokalnim proizvođačima ove kulture. Rezultati su pokazali da su straživači fokusirani na fermentacioni, fitohemijski, mineralni i vitaminski sastav afričkog zrna –semena za ulje (AUS). Ova studija je takođe otkrila nedostatak istraživanja o karakterizaciji, poboljšanoj sorti, pakovanju, skladištenju, dodavanju vrednosti i ekstrakciji ulja iz zrna (semena).

Istraživanje rukovanja, skladištenja, pakovanja i prerade AUS semena (zrna) nakon berbe neophodno je za optimalno korišćenje semena i za sprečavanje raširenih gubitaka posle berbe.

Ključne reči: *Afričko seme (zrno) za ulje, pakovanje, prerada, skladištenje, dodate vrednosti.*

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MOVEMENT OF DOCUMENTATION AS A PART OF THE AUDIT REPORTING OF TOP AGRICULTURAL COMPANY MANAGEMENT

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Summary*:* The movement of documentation as part of an implemented audit in the operations and management of an agricultural enterprise can contribute to improving the operation and management of an agricultural enterprise. This generally reduces the risk to the business of the agricultural enterprise. The movement of documentation within the company is done constantly. In this movement it is possible to make mistakes and omissions that will lead to worse business results of the company, which are essentially a consequence of poor internal factors of organization of work and business of top management. Therefore, the authors draw attention to the importance of establishing audit mechanisms that will contribute to improving the overall management of the agricultural enterprise, through better organization of the flow of documentation in the agricultural enterprise. The authors point out that their contribution in this paper is primarily focused on highlighting the importance of the movement of documentation within the company, which is the basis of audit monitoring and giving recommendations to the top management, who will then have the opportunity to make valid business decisions.

Key words: *Documentation, audit, process management, agriculture*

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INTRODUCTION

The management of an agricultural company should make valid business decisions based on the received valid information based on valid documentation of information within the enterprise [1], [2], which generally ensures the creation of numerous benefits [3] in the regular business of agricultural enterprises.

Agricultural businesses should have in their regular operations a documented circulation system [4], which will enable real business operations [5], [6], [7], that is, businesses that will succeed in the market.

The audit of an agricultural enterprise is based on documents describing individual events in the enterprise [8], [9], that is, the documentation monitors the functioning of the agricultural enterprise, and without its real appreciation the performance of the enterprise cannot be improved [10], [11], [12], and audit reporting is neither valid nor timely.

Substantial audit processes should be based on timely documentation that will respect the standardization of top management reporting [13], which in a way is a socio-economic phenomenon and socio-economic behavior in the economy as a whole [14].

On this basis, it can be observed that the audit work is being carried out with continuous monitoring of the documentation of the agricultural company for a long period [16], [17], [18].

MATERIAL AND METHODS

In designing this study, the authors used generally accepted management models in an agricultural enterprise based on the use of top management reporting and the use of document tracking that is constantly circulating in the enterprise and represents the basic flow of information within the enterprise.

Accordingly, the documentation is the basis for the audit, and it is also the basis that helps the top management in the work or in making valid business decisions in the work of agricultural enterprises.

Documentation used in the work of top management, as well as in the work of auditors is of great importance for continuous and successful management of the company.

In relation to the above, the authors presented a possible model of decision making based on the consideration of documentation as part of making valid business decisions, which is illustrated in Figure 1 of this study, which emphasizes the importance of documentation in making audit reports.

Contemporary business requires management that incorporates innovative approaches from top management through the use of new approaches, which cannot be accomplished without the proper information provided by the business records, on the one hand, and on the other hand provides the implementation of audit recommendations addressed to top management.

In this paper, the authors emphasize the importance of conducting audit reporting that is based on valid documentation.

RESULTS AND DISCUSSION

The authors emphasize that the audit must be based on the use of documentation as a basis for passing the audit certificates and recommendations that they submit to top management after the work has been done.

At the same time, an appreciation of what is being said can contribute to improving the performance of an agricultural enterprise, thus raising the importance of respecting the audit profession in the continued operation of the agricultural enterprise itself.

The authors gave the general model of appreciation and / or appreciation of the movement of documentation in the company in Figure 1.

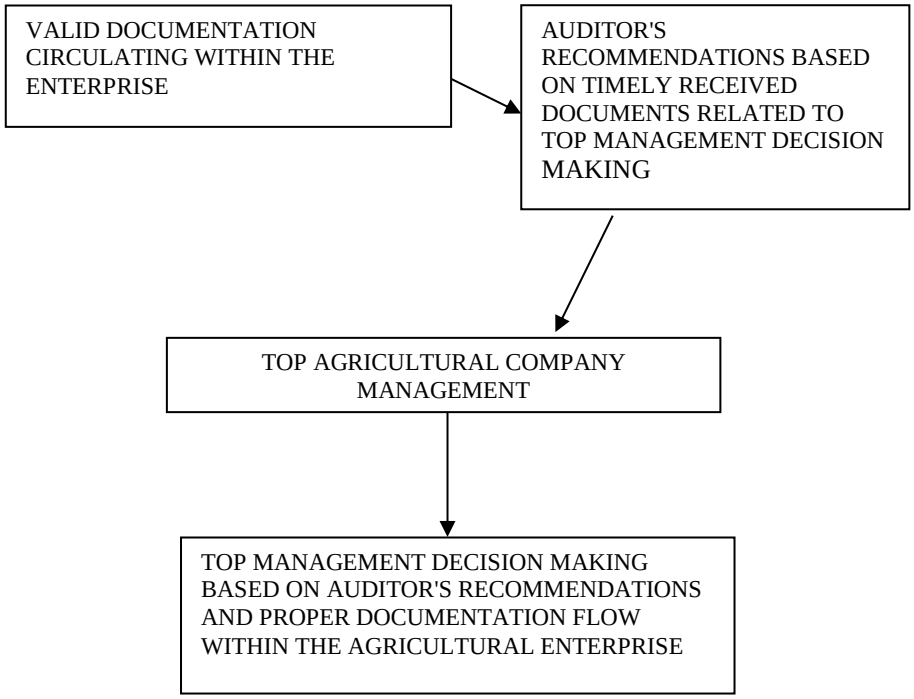

Fig. 1 Model of a well-established audit model in an agricultural enterprise based on management decision-making in accordance with the recommendations of the audit profession based on the appreciation of documentation that is constantly circulating in the enterprise

The authors of Tab white 1 show a model of possible provision of conditions for safe movement of documentation during the functioning of top management and audit as part of making valid business decisions based on the real functioning of agricultural enterprises and interview conducted in 14 companies in the period from 01.01.2019 to 30.09.2019., in the Republic of Serbia.

The authors gave an example of the presentation method in Table 1.

Table 1: Provide conditions for safe movement of documentation during the functioning of top management and audit as part of making valid business decisions

Serial num.	Provide conditions for safe movement of documentation	Exists		Note
		Yes	No	
1.	Review the existence of an obligation to keep a control book of the Managing Director.		X	There is no obligation to keep a control book of the managing body or the director of the company.
2.	Review to confirm that the responsible person of the sector makes the order to initiate the procedure.	X		
3.	Review the existence of a document to initiate the defined name procurement process.		X	The name of the order indicating the predominant procurement object at the time of initiation of the procedure has not been defined.
4.	Review to confirm the existence in the title of the document for initiating the procurement process of the printed procurement number in the current year.		X	The number of orders to initiate proceedings has not been defined, nor in which business years has been initiated.
5.	Review to confirm that the procurement initiation order has been signed by the Assistant Director.	X		
6.	Review to confirm that the order initiating the procurement process was first signed by the Assistant Director of the Procurement Sector, then by the Assistant Director for Economic and Financial Affairs and then by the Director of the company.	X		
7.	Review to confirm that the order for initiating the procurement procedure was first signed by the Assistant Director of the Sector who initiated the procedure, then by the Assistant Director for Economic and Financial Affairs, and then by the Director of the company and then recorded at the company office		No	The order to initiate the procedure was first filed at the office of the company and then signed by the assistant director of the sector who initiated the procedure, then by the assistant director for economic and financial affairs, and finally by the director of the company whose signature was stamped with the company seal.
8.	Inspect to confirm that the employees in the procurement department performed the tasks of analyzing the procurement orders received.	X		
9.	Review to confirm that the decision to initiate the procedure was made in writing with the prescribed parts.	X		
10.	Review to confirm that the decision to initiate the procedure is numbered by the procurement number in the current year.	X		

CONCLUSIONS

In this paper, the authors emphasized the importance of respecting the movement of documentation within an agricultural enterprise in two respects.

The first aspect of observation involves the immediate appreciation of the documentation flow by top management as it is important to make valid current business decisions.

The second aspect of observation is relevant from the point of view of making the recommendations of the auditor, which is intended for top management. Audit certificates are obtained here on the basis of realistic indicators that are visible in the documentation of the agricultural enterprise.

The overall objective of both activities is to prepare an audit report in the ordinary course of business of an agricultural enterprise, which should apply top management of the enterprise in order to achieve better business results.

The contribution of the author is reflected in highlighting a possible model of behavior of top management and auditors in the business decision-making process of an agricultural company, which is managed with respect for the auditing profession, but also with respect for realistic documentation.

In addition, the authors highlighted the basis for possible proper reporting to the top management of an agricultural enterprise, which essentially accepts the real movement of documentation, followed by the recommendations of the auditor, and then the decision-making of the top management of the agricultural enterprise.

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KRETANJE DOKUMENTACIJE U SKLOPU REVIZIJSKOG IZVEŠTAVANJA TOP MENADŽMENTA POLJOPRIVREDNOG PREDUZEĆA

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Sažetak: Kretanje dokumentacije u sklopu implementirane revizije u poslovanju i upravljanju poljoprivrednog preduzeća može da doprinese poboljšanju rada i upravljanja poljoprivrednog preduzeća. Time se generalno smanjuje rizik po poslovanje poljoprivrednog preduzeća. Kretanje dokumentacije unutar preduzeća se obavlja konstantno.

U tom kretanju moguće su greške i poropusti koji će dovesti do lošijih poslovnih rezultata preduzeća, koji su suštinski posledica loših internih faktora organizacije rada i poslovanja top menadžmenta.

Zato, autori rada skreću pažnju na značaj uspostavljanja revizijskih mehanizmama koji će doprineti poboljšanju ukupnog upravljanja poljoprivrednog preduzeća, putem bolje organizacije toka kretanja dokumentacije u poljoprivrednom preduzeću.

Autori ističu da je njihov doprinos u ovom radu pre svega usmeren na isticanju značaja kretanja dokumentacije unutar preduzeća, koje se nalazi u osnovi revizijskog praćenja i davanja preporuka revizora top menadžmentu, koji će nakon toga imati priliku da donese validne poslovne odluke.

***Ključne reči**: dokumentacije, revizija, upravljanje procesima, poljoprivreda*

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THE MOBILE GRAPE TRELLISES

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Abstract: The amount of the work in the vineyard, its yield greatly depends on what type of grape trellis is used in the vineyard.The most common is the Vertical Shoot Position.The advantages of the Vertical Shoot Position is the simplicity of the device and the use of inexpensive building materials. It is less time consuming and easily accessible for vineyard care.The disadvantages are that the maximum area of the green mass and the maximum yield cannot be obtained.The horizontal grape trellis system - pergola - allows to get the maximum area of green mass, the maximum assimilation of solar energy takes place, that increase yields by 2-3 times and provide the best quality of grapes.The disadvantages is that the care of vines grown on horizontal trellis is very time-consuming. Because the vintner is forced to work with his head constantly pulled back and his arms raised high.The authors have developed a new type of grape trellis - a mobile pergola - which during the vegetation - during the development of green mass and fruit ripening are placed horizontally, and during the green operations - pruning, spraying, harvesting - in a vertical position. As a result, we get a high yield typical for the pergola, which is 2-3 times higher than the yield obtained on the vertical grape trellis, and its maintenance is just as convenient and simplified as that of the vertical grape trellis.

Key words*: grape trellis system, vertical shoot positioning support system, mobile trellis, two plane vertical grape trellis, pergola, yields*

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INTRODUCTION

In viticulture, as well as in all fields of agriculture, one of the main tasks is to increase productivity and product quality, reduce its cost, which depends on many factors, including the quality performance of vine care, vine formation, vine training - green operations pruning; spraying, mechanical and chemical tillage, fertilizer, irrigation, grape variety, etc.

In all these directions, scientific-research works are being carried out to increase the quality of the grape and yields.

The laboriousness (labor intensity) of working in the vineyard, its yield also greatly depends on what type of grape trellis is used in the vineyard.

Grape trellis is characterized by a number of positive characteristics:

1. Grape trellises allow us to properly form the frame of a vine in the first years and then maintain its shape;
2. Distribute the vine buds evenly over the flatness of the trellis, so that all the leaves get as much sunlight as possible;
3. Convenient construction of trellises makes it easier for the viticulturist to take care of the vines and harvest;
4. At the expense of good lighting, raising the plane of leaves at a certain distance from the soil, good air circulation in the area where the leaves planes placed, decrease the probability of fungal diseases.

MATERIAL AND METHODS

Various grape trellises that exist today were taken as material. As methods - studying these trellises, their pros and cons; analysis, creation - invention of a new type of grape trellis.

There are many ways to cultivate a vineyard in the world, many types of grape trellis have been developed.

The most common and widely used grape trellis is the Vertical Shoot Position Trellis (Негруль, 1952); (Смирнов К.В., et.al., 1987), also known as VSP invented by the famous Austrian viticulturist Lenz Moser in the 1930s (Fig. 1).

Fig. 1. VerticalShoot Position

The disadvantages are that the maximum area of the green mass and the maximum energy assimilation of the sun's rays cannot be obtained, as a result, the maximum yield cannot be obtained.

The horizontal grape trellis system or pergola has been used by mankind since ancient times (Goldammer, 2018), (Klewir et.al., 2000), (Fig. 2).

Fig.2 Horizontal Trellis system the Pergola

This system of vineyard cultivation has a number of advantages. First of all, we get the maximum area of green mass, the energy is assimilated throughout the day and the vine gets the maximum energy of the sun. Grapes are protected from sunburn by leaves. Such farming techniques increase yields by 2-3 times and provide the best quality of grapes (Goldammer, 2018), (Reynolds, VandenHeuvel, 2009).

But the horizontal trellis system - the pergola - has a significant disadvantage, the care of vines grown on a horizontal trellis is very time-consuming (Girly, 2009). The vintner is forced to work with his head constantly pulled back and his arms raised high. Therefore, this method of vineyard cultivation is not often used in large areas, on an industrial scale (commercial grape growing). In such vineyards, the use of mechanization, the tractor is limited, cause the pergola in the vineyard cultivated on an industrial scale should be at human height.

It is more accepted as a decorative element of landscape design of private houses - the pergola gives a special beauty and coziness to the gardens and yards of private houses. In the yard of private houses, a pergola is usually placed above to save space - under the pergola (or alley) can be placed a table, chairs, or this space can be used for other useful purposes. When caring for a vine on such an alley, a ladder or its replacement device is used, which the viticulturist can not touch due to engaging in green hand operations while working, and there is a risk of its fall - trauma.

In viticulture also is used T-shaped pergola (trellis system): (Негруль, 1952); (Смирнов К.В., et.al., 1987); (Goldammer, 2018.), consisting of a vertical pole and shoulders mounted horizontally on it (Fig.3) (T-shaped horizontal trellises).

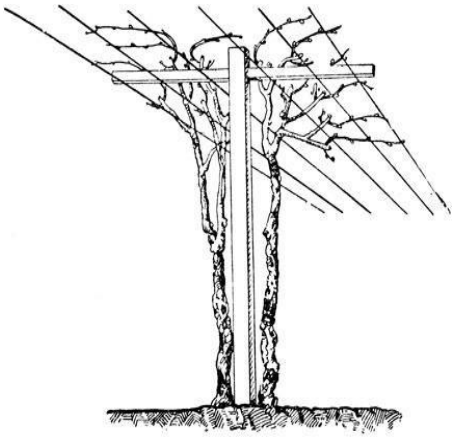

Fig.3. T-shaped pergola (trellis system)

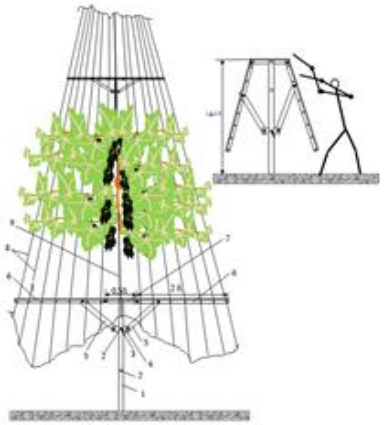

Fig.4. T-shaped Mobile Trellis

We propose a T-shaped trellis system - a mobile trellis (Kharibegashvili, et.al., 2020), the shoulders of which are movably attached to the poles by the hinges with the possibility of mounting them vertically and horizontally (Fig. 4). Only one-year-old branches take part in the bending, which are replaced with new ones every year (they have enough flexibility and elasticity to participate in bending-unfolding).

During the vegetation period - the development of green mass and fruit ripening - the shoulders are placed horizontally, and during the green operations - during pruning, spraying, harvesting - in a vertical position. Figures 5, 6 show a technical drawings of the T-shape trellis system - a mobile trellis with folding shoulders (Fig. 5) and an axonometric view of two adjacent rows of the trellis (Fig. 6). Figs. 5, 6 show trellises with both folded and outstretched shoulders.

As a result of the stretching of hawser 13 (stretching can be done with a winch), the shoulders 5 are raised and placed horizontally in the whole row. When releasing the hawser13, the shoulders 5 gradually lower and stand upright.

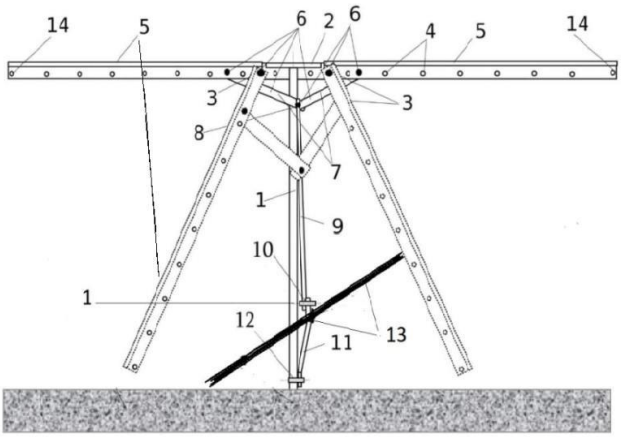

Fig.5. Technical drawing of the T-shaped Mobile Trellis

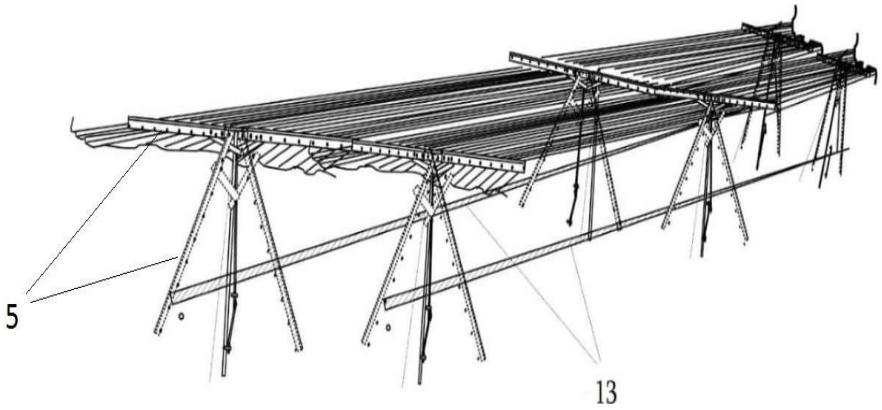

Fig.6. Axonometric views of two adjacent rows of the T-shaped Mobile Trerllis

Today (although less) also is used two plane vertical trellis (Fig. 7), which are two vertical rows located close to each other (60-100 cm) (Радчевский П.П., et.al., 2010). It is difficult to understand what the viticulturists are guided by when they install such trellis for grapes. When even the technical varieties of grapes grown on a single row vertical grape trellis – VSP (vertical shoot position system), if the summer does not turn out quite sunny, can not collect enough sugar. It is clear that the adjacent rows of these two plane trellis will overshadow each other and will not give us a large crop, while the sugar content of the grapes will not be high.

Fig.7. Two-plane trellis

But if the upper part of such trellis will be articulated (movably connected) to the lower part and we will provide them with a mechanism to change the position of the upper part of the trellis, then it will be possible to place the rows horizontally or close to the horizontal during vegetation. We get a two-plane mobile trellis (Fig. 8).

For such Two plane mobile trellis, we have developed a simple mechanism for mounting the rows vertically and horizontally, which will allow the owners of such trellis to easily upgrade it.

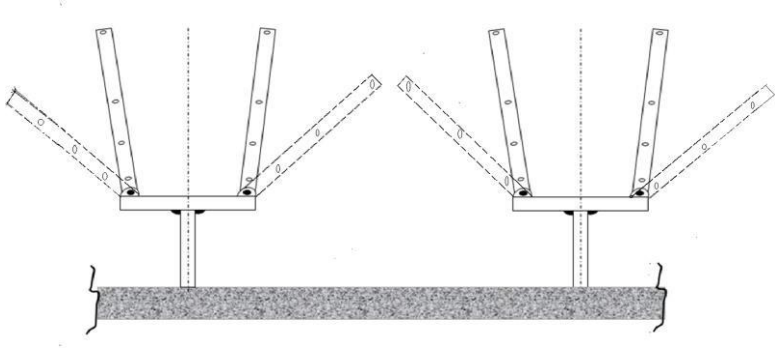

Fig. 8 Two-plane Mobile Trellis

We have also developed a T-shaped Balanced Mobile Trellis (Figure. 9), the upper part of which rotates around an axis located in its center. The symmetry of the weights of the trellis shoulders (more or less balanced of the torques) about the stake (pillar) - the axis is placed on it - does not require large loads from the service personnel when placing this trellis in a horizontal or vertical position.

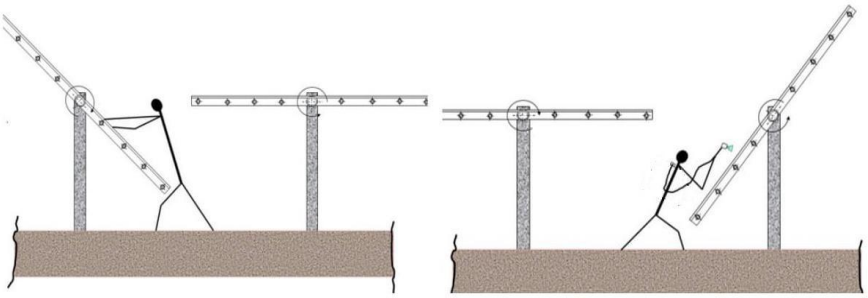

Fig. 9 Balanced T-shaped Mobile Trellis

RESULTS

The proposed types of grape trellis – mobile pergola trellises - allow us to combine the advantages of horizontal and vertical trellises - to obtain a high yield characteristic of the pergola, which is 2-3 times higher than of the vertical trellis, and its maintenance is as convenient and simple as for the vertical trellis. Vertical installation of the trellis allows the use of mechanization, the tractor.

Raising the plane of leaves at a certain distance from the soil decrease the probability of fungal diseases. Reducing labor time reduces the cost of grapes.

We have submitted an application for the proposed grape trellis project to Sakpatenti, the State Patent Office of Georgia. It is recognized as an invention and published in the Official Bulletin of Industrial Property of SAKPATENTI, THE NATIONAL CENTER OF INTELLECTUAL PROPERTY OF GEORGIA [7].

DISCUSSION

The disadvantage of the presented mobile grape trellis is its cost, it will be 3-4 times more expensive than vertical grape trellises, and not much more expensive than a T-shaped trellis (immobile). But if we take into account that its yield is 2-3 times higher than the vertical grape trellis, in 2-3 years it will compensate the costs incurred on it, and then we will get a net profit.

CONCLUSIONS

Today the world is characterized by a sharp, rapid increase in population and urbanization, a reduction in areas suitable for agricultural land.

If we also take into account that the area suitable for viticulture is limited by agro-climatic conditions, it becomes especially important to develop viticulture in an intensive type - to increase the grape yield in the same area of the vineyard – i.e. without increasing the area of the vineyard. The presented project meets this requirement, it is an ecologically clean solution to the problem of increasing grape yield - not associated with environmental pollution by chemicals.

The modern level of development of technologies and technics freely allows to introduce and spread the proposed project of grape trellises - a Mobile Trellises.

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POKRETNI NASLONI ZA VINOVU LOZU

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Sažetak: Količina i obim rada u vinogradu, njegov prinos u velikoj meri zavisi od toga koja se vrsta naslona (rešetki) koristi u vinogradu. Najčešći je vertikalni položaj naslona rešetki. Prednosti vertikalnog položaja rešetki (naslona) za vinovu lozu je jednostavna konstrukcija kao i upotreba relativno jeftinog materijala za izradu.

Ali ovakav tip naslona ima manju dugotrajanost i ako je lako dostupan za postavljenje i negu vinograda.

Nedostaci ovakvih (vertikalnih) konstrukcija naslona su što se ne može dobiti maksimalna površina zelene mase i maksimalan prinos vinove loze.

Horizontalni sistem naslona (pergola) za vinovu lozu omogućava da se dobije maksimalna površina zelene mase, dobija se maksimalna asimilacija zbog izloženosti suncu, što povećava prinose za 2-3 puta i obezbeđuje najbolji kvalitet grožđa.

Nedostaci ovog načina je briga o vinovoj lozi podignutoj na horizontalnim naslonima postoje, jer vinogradar je primoran da radi u pojedinim opracijama nege vinograda sa neprestano pognutom glavom i visoko podignutim rukama (zbog ograničene visine horizontalnih naslona).

Autori ovog rada su razvili novu tip naslona za vinovu lozu i grožđe, pokretnu pergolu, koja se tokom vegetacije i razvoja zelene mase i sazrevanja grožđa postavlja u horizontalni položaj. U toku zelenih operacija orezivanja, zaštite vinove loze, a zatim berbe grožđa, naslon (rešetka) se nalazi u vertikalnom položaju, kada je bolji pristup svim operacijam nege vinograda.

Kao rezultat, dobijen je visok prinos tipičan za pergolu, koji je 2-3 puta veći od prinosa dobijenog na isključivo vertikalnim naslonima (rešetkama) za vinovu lozu, dok je održavanje ovog tipa naslona jednako prikladno i pojednostavljeno kao i kod vertikalnih naslona za grožđa.

Ključne reči: *Rešetkasti sistem naslona grožđa, vertikalni sistem podrške za pozicioniranje izdanaka, pokretni nasloni za grožđe, pergola, prinosi*

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MATLAB OPTIMIZATION OF PRODUCTION UNIT OF A MANUFACTURING FIRM

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Abstract: This research work focused on how to maximize the profit of a mechanical manufacturing firm by optimizing the production units using MATLAB. This numerical analysis was manually done through the Simplex Method to model the production units into a linear mathematical equation that produces four major units which include standard aluminium spoon, bowl, pot and plates. Thereafter, a mathematical model was simulated using MATLAB2013b computational tool based on the previous input data of the mechanical firm and subjected to constraint equations based on the time required to finish each of the three products denoted p, q, r and s. The profit function was subsequently analysed to obtain the quantity of each product that will give maximum profit. The results of the manually calculated linear model corresponded with the MATLAB simulation that revealed that approximately <1 units, 17 units, 10 and 8 units of spoon, bowl, grinding teeth plate and pot respectively will have to be produced per day in order to obtain a maximum daily and monthly profit of #6,120.00 and #134,640.00. Businesses can thus be optimized and made more lucrative when resources and time available are allocated properly.

Keywords*: Optimization, production units, profit, mechanical firm*

INTRODUCTION

Engineering firms involving production where the objectives of a firm are centred on the increment in profit and reduction in the cost of production, it becomes imperative to evaluate the equivalent units of production that favours the company's goal.

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Mathematical programming is a technique for solving certain kinds of problems (notably maximizing the profits and minimizing costs) subject to constraints on resources, capacities, supplies, demand and the like (Bender, 2000). The mathematical tools for attaining profitability index are of varying forms such as economic order quantity, break even method, and optimization techniques to mention but a few from several. The data obtained with respect to the formulated model will determine the technique to be utilized (Ejiko *et al.*, 2015). The application of linear programming techniques into the production of Aluminium components through casting will go a long way in the expansion of the workshop activities (Champion Blacksmith Ltd. Foundry Workshop) knowing very much that Aluminium is one of the most abundant metals on earth (Abass, 2000). The basic processes such as mould preparation, pouring and solidification and finishing were considered against the time for varying products such as aluminium spoon, 5 litre bowl, aluminium grinding teeth and 5 litre pot with respect to the available time per day.

The case study of foundry shop largely depends on Aluminium alloy for casting which has properties such as compressive strength, corrosion resistance, fatigue strength, creep strength to mention but a few is used in metal casting (Abass, 2000).

This is a liquid shaping process in which the liquid is made to conform to a desired geometry in a mould and then allowed to transform into a solid (Degarmo *et al.*, 2003; American Foundry society, 2010). The case of solidification as treated by which implies that the transport mechanism, kinetics of heat, fluid and mass flow during liquid to solid transformation of the alloy directly control the resultant cast structure which dictates the properties and performance of the cast components (Beeley, 2001; American Foundry Society, 2010). At the end of simulation process, the numbers of component obtained will go a long way in optimizing the objectives of the company. This tool is not limited to production process only; it can also be applied to other social function in life provided the initial modelling conditions are met. Linear programming (L.P.) is a tool for solving optimization problems. It is a mathematical tool (model) for determining the optimal (maximum or minimum) value of a given function called the objective function, subject to a set of stated restrictions, or constraints, placed on the variable concerned (Joglekar & Ford, 2005). Also, optimization can be referred to as the act of obtaining the best result under given circumstances. Again, it can be defined as a process of finding the conditions that give the maximum or minimum value of a given function (Bender, 2000).

In the World War II, when the war operations had to be planned to economise expenditure, maximise damage to the enemy, linear programming problems came to the forefront. The first problem in linear programming was formulated in 1941 by the Russian mathematician, L. Kantorovich and the American economist, F. L. Hitchcock, both of whom worked at it independently of each other. This was the well-known *transportation problem*. In 1945, an English economist, G. Stigler, described yet another linear programming problem – that of determining an *optimal diet*. In 1947, the American economist, G. B. Dantzig suggested an efficient method known as the Simplex method which is an iterative procedure to solve any linear programming problem in a finite number of steps. With the advent of computers and the necessary software, it has become possible to apply linear programming model to increasingly complex problems in many areas (Joglekar & Ford, 2005). The method is simple and very powerful algorithm in solving real world problems relating to linear programming.

The L.P. is a tool for project evaluation and selection which we adopt for decision aiding model. There are various project selection model for deriving varying solutions such as that of economic-batch/lot size, payback period and regression analysis (Adejuyigbe, 2002).

Firms must develop strategies for reassessing the use of their resources in other to survive. Every allocation of resources is an investment in the future. Old techniques such as arithmetic forecast technique (manual calculations), oral guess and unplanned forecast used in the allocation of limited resources in the company are becoming redundant, less efficient, time consuming, obsolete and very lax.

This techniques had slowed down engineering production in the Company as the manual forecast technique must first be carried out before actual production at some points, they do not engage in caring out a forecast to ensuring that limited resources are not wasted or underutilized, thereby increasing production cost, wasting human energy, overstaffing of a particular department and importantly, decrease in monthly profit.

Limited-resource allocation algorithms deal with a difficult problem that mathematicians refer to as a large combinatorial problem. Various approaches have been formulated to solve the problem optimally, including Integer Programming, branch-and-bound, and Dynamic Programming. However, none of these were computationally tractable for any real-life problem size, rendering them impractical. The application of linear optimization tool will go a long way in evaluating the economic viability of the company. Linear Optimization/Programming with MATLAB as applied to a Mechanical Industry does not only help in the allocation of limited resources such as to determine the number of components to be produced but also, be employed to determine the number of workers to be employed and the capacity of equipment to be purchased. Thus, the aim of this Project is the MATLAB Optimization of Production Units of a Mechanical firm so as to maximize profit. The objective of the research work is to Optimize the Production Unit of a Manufacturing Firm using MATLAB.

MATERIALS AND METHODS

The Foundry mechanical Firm selected as the case study produces three major units/components which include aluminium spoon, 5 litre bowl, grinding teeth plate and 5 litre pot by casting. Data were collected during the workshop operation. Time of varying operations were determined by the use of stop watch through observation and monitoring of the product processes which includes moulding, casting and finishing. The data gathered, as shown in Table 1, gives the average moulding time of 20 minutes, 30 minutes, 20 minutes and 30 minutes; casting time of 10, 10, 40 and 30 minutes; and finishing time of 10, 20, 10 and 10 minutes for the aluminium spoon, 5 litre bowl, aluminium grinding teeth and 5 litre pot respectively.

Table 1: Input data of the production operations in mechanical firm

	Avg.Intial units	*Moulding (mins)*	*Casting (mins)*	*Finishing (mins)*	*Product per(min)*	*Profit per Component #*
Aluminium spoon	*10*	*20*	*10*	*10*	*0.25*	*15*
5 litre bowl	*15*	*30*	*10*	*20*	*0.25*	*160*
Grinding teeth Plate	*10*	*20*	*40*	*10*	*0.14*	*180*
5 litre pot	*7*	*30*	*30*	*10*	*0.1*	*200*
Available time per day		*950*	*810*	*520*		

Formation of the mathematical model of the production unit

The tabulated data presented in Table 1 was formulated in linear equation to optimize the production unit and increase profit made by the mechanical firm.
Hence, let the decision variables be represented as p, q, r and s; these are they units to be optimized stated as follows:

p = number of aluminium spoon produced in a day
q = number of 5 litre bowl produced in a day
r = number of aluminium grinding teeth plate produced in a day
s = number of 5 litre pot produced in a day
Z = Profit of the Company to be maximized (to be set as the objective function)

The target is to maximize the company profit. 950, 810 and 520 minutes is the available time per day for moulding, casting and finishing. Hence, all parameters needed to formulate the inequalities of the linear programming problem.
The mathematical equations were established as follow:

$$20p + 30q + 20r + 30s \leq 950 \text{ (moulding time)} \quad \ldots\ldots \quad (1)$$
$$10p + 10q + 40r + 30s \leq 810 \text{ (casting time)} \quad \ldots\ldots\ldots \quad (2)$$
$$10p + 20q + 10r + 10s \leq 520 \text{ (finishing time)} \quad \ldots\ldots\ldots \quad (3)$$

Hence the above equation is subject to the objective function below:
$$Z = 15p + 160q + 180r + 200s \quad \ldots\ldots\ldots\ldots \quad (4)$$

$These\ are\ the\ constraints, with\ p, q, r\ and\ s\ as\ unknowns. p, q, r, s \geq 0$; r, s 0;
Z is the profit function to be optimized.

Subsequently, after the manual analysis of the linear equation, the model was mathematically simulated in MATLAB R2013b model, by utilizing the linprog syntax for the system of linear equations expressed in an explicit manner. This method has been successfully implemented for solving a system of four linear equations with three unknowns (variables) and three slack variables (Ejiko, S. O. *et al.,* 2015).

Therefore, as a logical extension, this study will test the appropriateness of linprog developed codes for a system of four linear equations with four unknowns (variables) and three slack variables on MATLAB to determine the number of Production units (p, q, r and s variables) to be produced in a day and the maximum profit (Z) made in a day. This system of linear equations can be expressed in a matrix form shown in eqn (5).

$$Z = \begin{bmatrix} a_{41} \\ a_{42} \\ a_{43} \\ a_{44} \\ 0 \\ 0 \\ 0 \end{bmatrix}^T \begin{bmatrix} p \\ q \\ r \\ s \\ w_1 \\ w_2 \\ w_3 \end{bmatrix} \qquad \ldots\ldots\ldots\ldots \qquad (5)$$

Where p, q, r and s are the production units and Z is the maximum profit.
T indicates e the production units and Z is the maximum profit. This was solved using linear programming as applied in the mathematically modelling as seen as a function file developed in MATLAB R2013b Interphase shown in Fig 1. This Syntax form the linear equations were used to compare and validate the results of the developed MATLAB simulation model.

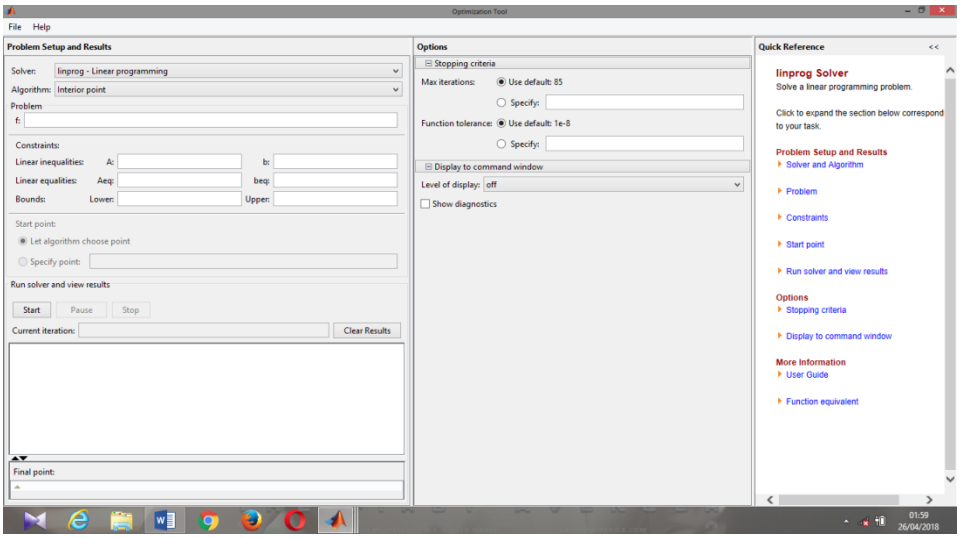

Fig. 1: Interface of Optimization Tool Interphase

RESULTS AND DISCUSSION

The results of the manual evaluated linear equation Simplex method shown in Table 2; and the that of the MATLAB model simulation of the production units shown in Table 3, were developed by establishing the four constraints and seven variables: p, q, r, s, w_1, w_2 and w_3. If we start by letting p, q, r and s to be zero, then we have the temporary solutions: w_1 = 95, , w_2 = 81 and w_3 = 52.

The columns with the slack variable form a unit matrix. The objective function (Z) is moved across the equal sign so as to obtain a function that corresponds to the manual evaluated linear equation.

Table 2: Linear Equation Optimized Results

Basis	*P*	*Q*	*R*	*S*	w_1	w_2	w_3	*b*	*Check*
w_1	*2*	*3*	*2*	*3*	*1*	*0*	*0*	*95*	*106*
w_2	*1*	*1*	*4*	*3*	*0*	*1*	*0*	*81*	*91*
w_3	*1*	*2*	*1*	*1*	*0*	*0*	*1*	*52*	*58*
Z	$^{-3}/_{2}$	-16	-18	-20	*0*	*0*	*0*	*0*	$^{-111}/_{2}$
w_1	*2*	*3*	*2*	*3*	*1*	*0*	*0*	*95*	*106*
~~w_2~~ *s*	$^{1}/_{3}$	$^{1}/_{3}$	$^{4}/_{3}$	*1*	*0*	$^{1}/_{3}$	*0*	*27*	$^{91}/_{3}$
w_3	*1*	*2*	*1*	*1*	*0*	*0*	*1*	*52*	*58*
Z	$^{-3}/_{2}$	-16	-18	-20	*0*	*0*	*0*	*0*	$^{-111}/_{2}$
w_1	*1*	*2*	-2	*0*	*1*	-1	*0*	*14*	*15*
~~w_2~~ *s*	$^{1}/_{3}$	$^{1}/_{3}$	$^{4}/_{3}$	*1*	*0*	$^{1}/_{3}$	*0*	*27*	$^{91}/_{3}$
w_3	$^{2}/_{3}$	$^{5}/_{3}$	$^{-1}/_{3}$	*0*	*0*	$^{-1}/_{3}$	*1*	*25*	$^{83}/_{3}$
Z	$^{31}/_{6}$	$_{-}{}^{28}/_{3}$	$^{26}/_{3}$	0	*0*	$^{20}/_{3}$	*0*	*540*	$^{3307}/_{6}$
Basis	***p***	***Q***	***R***	***S***	w_1	w_2	w_3	***b***	***Check***
~~w_1~~ *q*	$^{1}/_{2}$	1	-1	*0*	$^{1}/_{2}$	$^{-1}/_{2}$	*0*	*7*	$^{15}/_{2}$
~~w_2~~ *s*	$^{1}/_{3}$	$^{1}/_{3}$	$^{4}/_{3}$	*1*	*0*	$^{1}/_{3}$	*0*	*27*	$^{91}/_{3}$
w_3	$^{2}/_{3}$	$^{5}/_{3}$	$^{-1}/_{3}$	*0*	*0*	$^{-1}/_{3}$	*1*	*25*	$^{83}/_{3}$
Z	$^{31}/_{6}$	$_{-}{}^{28}/_{3}$	$^{26}/_{3}$	0	*0*	$^{20}/_{3}$	*0*	*540*	$^{3307}/_{6}$
~~w_1~~ *q*	$^{1}/_{2}$	1	-1	*0*	$^{1}/_{2}$	$^{-1}/_{2}$	*0*	*7*	$^{15}/_{2}$
~~w_2~~ *s*	$^{1}/_{6}$	*0*	$^{5}/_{3}$	*1*	$^{-1}/_{6}$	$^{1}/_{2}$	*0*	$^{74}/_{3}$	$^{167}/_{6}$
w_3	$^{-1}/_{6}$	0	$^{4}/_{3}$	*0*	$^{-5}/_{6}$	$^{1}/_{2}$	*1*	$^{40}/_{3}$	$^{91}/_{6}$
Z	$^{59}/_{6}$	0	$^{-2}/_{3}$	0	$^{14}/_{3}$	2	*0*	$^{1816}/_{3}$	$^{3727}/_{6}$
~~w_1~~ *q*	$^{1}/_{2}$	1	-1	*0*	$^{1}/_{2}$	$^{-1}/_{2}$	*0*	*7*	$^{15}/_{2}$
~~w_2~~ *s*	$^{1}/_{6}$	*0*	$^{5}/_{3}$	*1*	$^{-1}/_{6}$	$^{1}/_{2}$	*0*	$^{74}/_{3}$	$^{167}/_{6}$
~~w_3~~ *r*	$^{-1}/_{8}$	0	1	*0*	$^{-5}/_{8}$	$^{3}/_{8}$	$^{3}/_{4}$	100	$^{91}/_{8}$
Z	$^{59}/_{6}$	0	$^{-2}/_{3}$	0	$^{14}/_{3}$	2	*0*	$^{1816}/_{3}$	$^{3727}/_{6}$
~~w_1~~ *q*	$^{3}/_{8}$	1	0	*0*	$^{-1}/_{8}$	$^{-1}/_{8}$	$^{3}/_{4}$	*17*	$^{151}/_{8}$
~~w_3~~ *r*	$^{-1}/_{8}$	0	1	*0*	$^{-5}/_{8}$	$^{3}/_{8}$	$^{3}/_{4}$	10	$^{91}/_{8}$
~~w_2~~ *s*	$^{3}/_{8}$	*0*	*0*	*1*	$^{7}/_{8}$	$^{-1}/_{8}$	$^{-5}/_{4}$	8	$^{71}/_{8}$
Z	$^{39}/_{4}$	0	0	0	$^{17}/_{4}$	$^{9}/_{4}$	$^{1}/_{2}$	612	$^{119537}/_{192}$

The profit function (Z) is calculated manually in order to obtain the quantity of each product that will give maximum profit above.

The result obtained in Table 2 show that p – number of spoon is 0; q – number of bowl is 18 units; r – number of teeth plate is 12 units and s – number of pot is 10 units will have to be produced per day in order to obtain a maximum profit of #6,120.00 in a day.

```
% MATLAB Optimization of Production Units of a Foundry Firm using MATLAB:
Case Study % Of Champion Blacksmith Ltd., Rivers State
% ---------- the linprog Syntax is used here in MATLAB
% In solution, any of the following linprog syntax can be used
% x = linprog(f,A,b)
% x = linprog(f,A,b,Aeq,beq)
% x = linprog(f,A,b,Aeq,beq,lb,ub) when specifying the boundaries
% x = linprog(f,A,b,Aeq,beq,lb,ub,options)
% x = linprog(problem)
% [x,fval] = linprog(___)
% [x,fval,exitflag,output] = linprog(___)
% [x,fval,exitflag,output,lambda] = linprog(___)
f = [-15 -160 -180 -200]; % function to be minimized
A = [20 30 20 30; 10 10 40 30; 10 20 10 10]; % left hand side of the constraint equations
b = [950; 810; 520]; % right hand side of the constraint equations
Aeq = [0 0 0 0; 0 0 0 0; 0 0 0 0; 0 0 0 0];
beq = [0; 0; 0; 0];
lb = [0; 0; 0; 0];
ub = [inf; inf; inf; inf];
% The first five syntax can be used; the third syntax were boundaries are being
% specified is simply employed here.
R = linprog (f,A,b,Aeq,beq,lb,ub) % perform optimization
Z = -f * R % compute the maximum profit
```

```
Optimization terminated at the followiong:
R =     0.0000,    18.0000,    12.0000,    10.0000
Z =     6.1200e+03
```

Hence the results indicated show that R and Z represent the quantity of each production units in a day and the maximum profit per day, respectively. That implies that, for the firm to achieve an optimal daily profit of #6,120.00K, it should produce no aluminium spoon, 18 units of 5 litre bowl, 12 units of aluminium grinding teeth plate and 10 units of 5 litre pots.

Subsequently, the results got from the manual computations were the same as that of the manually computed results when the program in Appendix I is run.

The results shown in shown in Table 3 were gotten from the designed MATLAB program.

P = 0.0000 (<1.0000); q = 18.0000;r =12.0000 and s = 10.0000
The maximum profit z = #6120.00

Table 3: MATLAB model simulation

Basis	*P*	*Q*	*R*	*S*	w_1	w_2	w_3	*B*	*Check*
w_1	*2*	*3*	*2*	*3*	*1*	*0*	*0*	*95*	*106*
w_2	*1*	*1*	*4*	*3*	*0*	*1*	*0*	*81*	*91*
w_3	*1*	*2*	*1*	*1*	*0*	*0*	*1*	*52*	*58*
Z	*-1.5*	*-16*	*18*	*-20*	*0*	*0*	*0*	*0*	*-55.5*

Comparative Analysis of Results

As seen in Table 2 and Table 3, the results of the manually solve linear equation and that of the MATLAB simulated model are in agreement, where the results show the optimized quantity of product to be produced in order to achieve the maximum profit. The products quantity as estimated includes approximately no units of aluminium spoon (p) per day, 18units of bowl (q) per day and 12 units of aluminium teeth plate (r) per day and 10 units of pot (s) per day with a maximum profit of #6,120.00. However, the results showed that greater attention should be given to production of bowl because of its volume and profit generated that is almost half of the entire profit and that the company could cease the production of aluminium spoon since no much profit (below 1%) is got from it as shown in the Pie Chart of Fig. 3. The chart subsequently revealed that the production of 5 litre bowl contributes to 49% of the Company's viability (growth), grinding teeth plate contributes 29%; 5 litre pot contributes 23% to obtain an optimal profit of #6120.00. Therefore, the company should focus more attention on bowl while also considering the teeth plate and pot as they are more viable than the production of spoon that yields little or no profit.

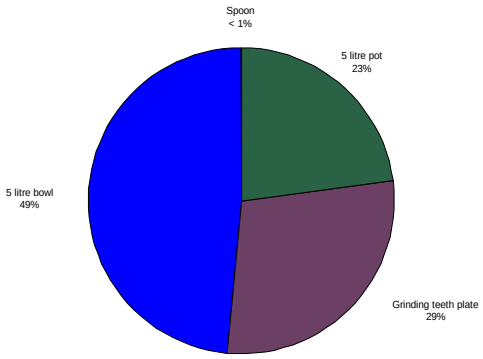

Fig.2. Optimal units of items needed to be produced in a day

Hence, from the numerical analysis done using MATLAB R2013b, the shaded area shown in Fig. 3 revealed the optimal values of p, q, r, s that yields the optimal profit at the points that are joined linearly to yield a total monthly profit of #134,640.00.

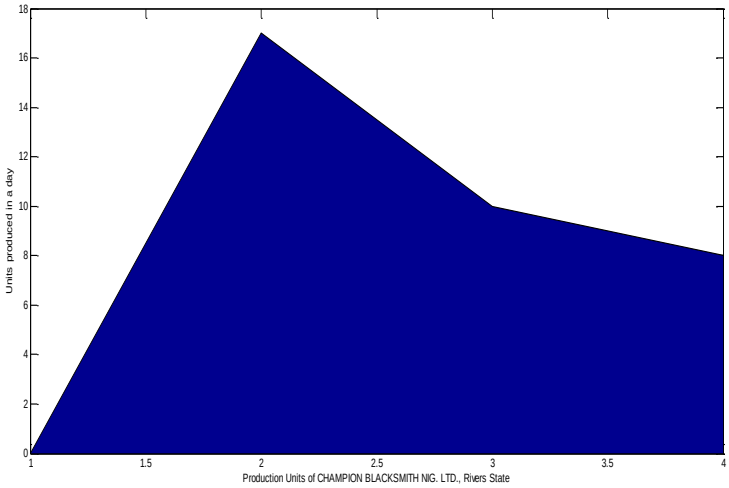

Fig.3. The Area of the Optimal Solution

CONCLUSION

The Project hence, discusses the possibility of maximizing the profit of the company by optimizing the production units using linear programming under varying constraints in a MATLAB simulation tool.

Produced Units at the Firm include aluminium spoon, 5 litre bowl, grinding teeth plate of aluminium and 5 litre pot respectively, all by casting. Time for varying operations such as moulding, casting (pouring and solidifying) and finishing were collected for each product. The result obtained from the analysed profit function, both manually and by MATLAB simulation program, obtained the quantity of each product that will give maximum profit. These were revealed at approximately <1 units, 17 units, 10 units and 8 units of spoon, bowl, grinding teeth plate and pot respectively; should be produced per day in order to obtain a maximum profit of #6,120.00 in a day for both methods.

The matrix developed is useful in explaining differences in project performance and developing an intuitive understanding of the characteristics and impacts of different allocation policies and techniques. Resource allocation policies were then used in a system dynamics model of the system to test performance. Our results show that and how foresighted policies can improve Production planning performance, without increasing the total amount of resources. While preliminary, our results could have far reaching impacts on resource management through allocation policies because the schedule improvements are essentially free, requiring no additional resources.

However, not all projects benefit from foresight but these results suggest that an improved understanding for the design of foresighted resource allocation policies are needed to use foresight to improve product development project planning performance.

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MATLAB OPTIMIZACIJA PROIZVODNE JEDINICE ZA PREDUZEĆE

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Sažetak: Ovaj istraživački rad prikazuje kako postići najveći profit proizvodne firme optimizacijom proizvodnih jedinica pomoću programa MATLAB.

Ova numerička analiza je rađena metodom Simplex kako bi se proizvodne jedinice modelirale kao linearna matematička jednačina koja daje četiri glavne jedinice koje uključuju proizvode kao elemente : standardna aluminijumska kašika, činija, lonac i tanjire.

Nakon toga, matematički model je simuliran upotrebom računarskog alata MATLAB2013b na osnovu prethodnih ulaznih podataka proizvodnog preduzeća i podvrgnut jednačinama ograničenja na osnovu vremena potrebnog za završetak svakog proizvoda označenih sa: p, q, r, s.

Funkcija profita naknadno je analizirana kako bi se dobila količina svakog proizvoda koja donosi najveći profit.

Rezultati ručno izračunatog linearnog modela korespondiraju sa simulacijom programom MATLAB koja je otkrila da treba dnevno proizvesti približno <1 jedinica, 17 jedinica, 10 i 8 jedinica aluminijskih kašika, posuda od 5 lit, ploče, ili lonca od 5 lit., dnevno, kako bi se dobio najveći dnevni i mesečni profit od #6.120,00 i #134.640,00.

Na osnovu prikazanog modela optimizacije, preduzeća se mogu optimizirati i učiniti profitabilnijim, kada se raspoloživi resursi i vreme proizvodnje pravilno rasporede.

Ključne reči: *Optimizacija, proizvodna jedinice, profit, mašinsko preduzeće.*

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