

**PROS & CONS OF MECHANICAL HARVESTING:
A REVIEW OF EXPERIENCE ON TEA HARVESTERS TESTED BY
THE TEA RESEARCH INSTITUTE OF SRI LANKA**

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Introduction

Presently there are approximately 204,600 ha of tea lands in Sri Lanka. The total tea production in 2012 was 326 million kg recording an average yield of about 1600 kg per ha per year. Low productivity, high cost of production, declining quality of made tea and low rate of replanting are some of the key issues faced by the tea industry. These issues are greatly attributed to the lack of labour and high cost of inputs and labour. The use of labour for field operations accounts for more than 60% of the cost of production of tea. The field operation such as harvesting is highly labour intensive and warrants skill and long experience. Therefore, it has become essential to increase harvesting efficiency of available workforce by introducing suitable tea harvesters with a view to ensure sustainability of the industry. Research and development of appropriate technologies for mechanization of field practices aimed at reducing cost of production while maintaining made tea quality have thus been identified as the need of the hour. Further, introduction of tea harvesters should carefully be done taking into consideration of the terrain of tea fields, capital and running cost of machines, maneuverability and durability of machines, effects on productivity and quality of tea and worker's ability of using such technology in the field.

Plucking (Harvesting of tea)

Of tea cultivation practices, harvesting of shoots known as plucking is considered to be the most labour intensive and costliest field operation. It requires more than 70% of the workforce in a given estate and hence, contributes to more than 35% of the total cost of production. More importantly, plucking policies influence growth, yield and quality of the end product. If tea fields are not harvested correctly, the profitability of tea cultivation is greatly reduced due to loss of crop and quality of the produce. In Sri Lanka, plucking is usually done manually and some estates are presently using shears and small machines on a small scale.

Due to economic development, urbanization, better education, changes of social behaviour and opening of attractive job opportunities in many parts of the tea growing regions, estate workers and their children are moving away from tea plantations for better jobs. The majority of tea production in Sri Lanka (around 70%) comes from around 400,000 tea smallholdings. Although, it is expected that harvesting of tea in smallholdings is done by family labour, many smallholders are using hired labour, whom are taken from nearby estates in most cases. In addition, proprietary tea lands (private estate up to 50 Ac) are mostly using hired labour for harvesting. Therefore, there exist a severe shortage of labour and absenteeism of workers in many of the corporate sector tea plantations. Due to lack of workers, plucking practices have been adversely affected and as a result, yield and quality of tea have been significantly declined. Use of men pluckers or sundry workers for plucking has also contributed to higher percentage leaf damage in some of the corporate sector estates. Amidst worker shortage, increase in labour wages has aggravated the problem of rising cost of production.

The mechanization of field practices has often been identified as the sole solutions for labour shortage. With regard to harvesting of tea, shears and

motorized machines are the common mechanical devices that can be used for increasing labour productivity.

Experience on the use of shears

There are different types of tea harvesting shears used in tea growing countries. In order to assess their suitability for tea harvesting in local tea lands, different types of imported shears have been tested at the Tea Research Institute of Sri Lanka (TRI Technical/ Annual Reports, 1981-1998; Wijeratne, 1996). The shears tested were of non-selective nature with two long handles (garden shears). The harvested leaf is collected to either a bag or a tray/ box fixed to one blade. These shears weigh about 0.6-1.0 kg and the length of blades is about 25 cm. These conventional shears tested at the TRI Low country Station has given an output of 25-40 kg per man-day with 10-15% coarse leaves in excess of manually harvested leaf. Due to removal of 'arimbus' by these conventional shears plucking rounds were extended to 10-14 days. The continuous use of the non-selective shears have reduced tea yield by 25-35%. The yield losses were reduced to 10-20% by restricting shear harvesting to cropping season (rush crop) only. Although, these conventional shears are commonly used in other tea growing countries such as India and Kenya, the estate workers in Sri Lanka are often not in favour of using them due to inconvenient operation (poor maneuverability) in the field.

Taking into consideration of the above findings and industry needs, the TRI designed and tested a 'Selective Tea Harvester' (shear) that can improve harvesting efficiency by 50-100% and reduce labour requirement for plucking by more than 30%. It is lighter in weight than conventional shears (*i.e.* about 325 g) and has no prominent/ long handles. Minimum leaf damage and good maneuverability have also been added advantages of this harvester. In order to make shear harvesting more convenient and to minimize post harvest damages to harvested leaf, a light-weight tea plucking basket was also introduced by the TRI in the recent past. However, the rate of adoption of the 'TRI Selective Tea

Harvester' in Sri Lanka has not been very satisfactory. The manual operation, time taken for training and less output compared with motorized harvesters could be some of the reasons attributable for poor rate of adoption. The output of the harvester is also low during lean cropping periods and in fields nearing pruning. As discussed elsewhere in this bulletin and by Wijeratne *et al.*, (2012), some Up country estates have successfully introduced this harvester reaping the benefits of the new technology. Field observations show that at least 25% of the plucking fields of an estate can easily be brought under shear harvesting.

Experience on motorized tea harvesters

History of testing of tea harvesting machines in Sri Lanka goes back to 1940's (Fay, 1951) and mid 1960's (de Silva, 1968). The TRI undertook detailed studies on portable tea harvesting machines since late 1970's. Although, tractor mounted and self-propelled large machines are also used in other countries such as Japan, China, Indonesia *etc.*, such machines cannot be used in Sri Lanka tea plantations due to unsuitable field (ground) conditions (undulating and sloping terrains and presence of shade trees, drains/ terraces *etc.*). The common feature of these motorized machines was non-selective harvesting of shoots *i.e.* removal of all generation of shoots without leaving 'arimbus'.

Extensive investigations on mechanical harvesting were undertaken by the TRI Low country Station, Ratnapura since late 1970s. Watson *et al.*, (1982) summarized the findings of the experiments with small machines conducted by the TRI during 1970s. The results of the experiments conducted with larger machines during mid 1980 to 2000 have also been given in the TRI Technical Reports of 1980 to 1983, 1991 to 1998 and summarized by Wijeratne *et al.*, 2000. In addition to the above machines small hand-held machines (blade length of 20-30 cm) and battery operated machines was also tested in the recent past at the TRI Low country Station (TRI Annual Report, 2006).

The motorized machines have been tested under varying field and growing conditions in Sri Lanka taking into consideration of terrain (flat, undulating and sloping terrains), climatic conditions (Low, Mid and High elevations), growth stage (years from pruning), period of use (continuous use or cropping periods only), harvesting intervals (10-14 days or depending on shoot growth), planting systems (single/ hedge rows) and method of pruning (lung/ cut-across) and plucking (half-bush). Further, machines have been tested with different tea cultivars and foliar applications (high Zn and MOP, growth stimulants). Tea harvesting machines have also been modified at the TRI by fixing steps and implements (comb like structures) to leave out maintenance foliage (TRI Technical/ Annual Reports, 1980-2009).

Performance of motorized tea harvesters

Field observations and experiments conducted by the TRI have shown that the mean output of non-selective motorized machines was in the range between 50 (small machines) and 350 (large machines) kg per man day (6.5 working hours). With additional workers employed for sorting out of coarse leaves, cleaning *etc.* were considered (2-3 workers per machine per day), the actual worker out put with motorized machines was estimated to be in the range of 20-60 kg per worker per day. Although many of these portable machines tested by the TRI are originally designed for a single/ two operators, such machines required one more assistant to hold and guide the leaf collecting bag in our tea fields on sloping terrains with a full ground cover and shade trees. This has also been one of the reasons for low worker out put. The records of the investigations revealed that the extent harvested by a machine was in the range between 0.1 ha (small machine) and 0.8 ha (larger machine) per man day and the coverage was largely depended on the length of the cutter (blade length of the machine). The fuel consumption of motorized harvesters varied in the range of 4-5 L per man-day. One single charge of a battery operated machine was sufficient to work for about 5-7 hours.

Effects on growth and yield of tea

Results of the experiments conducted by the TRI have shown that use of motorized machines caused a significant crop loss of the magnitude of 30-50%, bush debilitation (poor frame development and poor recovery after pruning) and reduction of quality of the end product. These adverse consequences are brought about by non-selective harvesting and damage to maintenance foliage. Harvesting of all generations of shoots has contributed to extension of plucking rounds and shoot replacement cycle, deterioration of the sink capacity (removal of “arimbus”) low shoot population density, increased dormancy of shoots and low shoot weight. Experimental results have shown that mean weight of a mechanically harvested tea shoot was about 27% less than that of manually harvested tea shoot (Wijeratne *et al.*, 2000).

The above results were obtained when manual harvesting is done at 7 day intervals and machines are used at 2-3 week intervals depending on the availability of pluckable shoots. In contrast, some field observations in the Low country have shown that there was no significant yield difference between manual and mechanical harvesting when both were adopted at fortnight intervals, *i.e.* manual harvesting was done at extended rounds. There was an apparent labour saving of about 40% under mechanical harvesting (TRI Annual Reports, 1997 & 1998). Experimental results have also shown that use of motorized machines for a few rounds during the rush crop season, did not significantly reduce tea yields.

Results of experiments on different systems of planting (hedge row vs normal planting; TRI Annual Reports, 2000-2005) and use of high K (1.5 times recommended K in ‘U 709’) and Zn sulphate (8 applications per year) (TRI Annual Reports, 2001, 2003 & 2006) had shown that none of these measures had been effective in minimizing the crop losses with motorized machines. Half-bush harvesting aimed at preserving the source: sink balance of tea bushes has not significantly minimized the adverse impacts on yield under mechanical

harvesting. Although, it has formed a healthier plucking surface at the beginning of the experiment, such benefits faded away at the later stages. The application of fertilizers to all the experimental plots was done based on the crop (as per TRI recommendations) of manually harvested tea bushes. Hence, mechanically harvested plots always received a higher quantity of fertilizers than the requirement as the yield of mechanically harvested tea plots was significantly less than that of manually harvested plots. Hence, yield losses under mechanical harvesting cannot be attributed to lack of nutrients.

Effects of machines on product quality

Although, commercial scale tea processing was not possible with small plot experiments, the TRI Low country Station has attempted to test the quality of made tea processed from mechanically harvested leaf of large observation blocks. Results have shown that the quality of the made tea produced by mechanically harvested leaf (unsorted) was poorer than that of manually harvested leaf. Such results were attributable to higher percentage of coarse leaves, cut-leaf pieces and damaged leaves present in the mechanically harvested crop. In addition, it contained shoots of different maturity with varying moisture content. Mechanically harvested shoots produced higher refuse tea content (14%) than manually harvested shoots (5%). The made tea out-turn of mechanically and manually harvested shoots was 19% and 23% respectively (Watson, 1985). However, this outcome may be different when the manual rounds are extended to 2-3 weeks as adopted in some tea estates/ fields at present due to severe shortage of workers.

Common problems associated with motorized tea harvesters

Some of the common problems associated with motorized plucking machines are, non-selective harvesting leading to lower land productivity, adverse effects on quality due to high percentage of coarse leaves, cut pieces and broken or damaged shoots (some machines only), bush debilitation and poor recovery, need of extra workers for sorting out of coarse leaves/ mature foliage/ stalks

etc. to standardize the crop to minimize adverse effects on quality, poor maneuverability in tea fields (presence of shade trees, drains *etc.*, steep terrains and high plucking table with a dense canopy (*eg.* near pruning fields), high capital and running (fuel) cost, frequent break-downs and high wear and tare of plucking machines and lack of skilled/ trained workers for machine operations.

Conclusions

The cost of production (COP) of tea in Sri Lanka is very high due mainly to high cost of labour and low land and labour productivity. The industry still remains economically viable as a result of attractive prices fetched by “Ceylon Tea”. Hence, it is extremely important to preserve the premium quality of “Ceylon Teas”. However, maintaining its premium quality has become very difficult due to inappropriate harvesting policies and poor leaf handling. The use of expensive machines such as color sorters has been increased in factories for cleaning of made tea processed from poor quality leaf (coarse leaf/ damaged leaf *etc.*). Mechanization of plucking with the use of high output motorized machines, which is often being looked at as an alternative to manual plucking and as a solution to labour shortage has its own disadvantages such as reduction of yield and quality of made tea. Under local conditions, the prices of motorized machines and fuel and extent covered by a machine over a day have also not been very attractive for tea growers to use motorized machines. In addition, use of heavy harvesting machines will be often restricted to men workers whose population is less than 10% in the corporate sector estates. Under such situations, the ‘TRI Selective Tea Harvester’ (TRI shear) can advantageously be used as an intermediate technology to minimize labour problem related to harvesting. In addition, motorized harvesters can be used during rush crop periods for few rounds when the need for labour is very high and also to avoid abandonment of plucking fields due to severe shortage of labour.

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