CHAPTER V

SUMMARY **AND CONCLUSION**

Harvesting of turmeric rhizome is one important aspect which requires immediate attention for developing appropriate mechanical technology. Conventional method of harvesting turmeric rhizome is labour intensive, requiring skilled men labour to digout the crop. The non-availability of such skilled labour and the high wages demanded by them to harvest the crop, the higher field losses and damage to the crop by manual harvesting, necessitate the need to develop a suitable mechanical harvester for turmeric. With tractors already becoming a common feature in villages, a mechanical harvester attachment to the tractor would be the most appropriate mechanical harvesting technology. The harvester should satisfy the basic requirements of achieving maximum harvesting efficiency with minimum damage to the crop and at lesser cost. Hence an investigation was undertaken to optimize the machine parameters for mechanical harvesting and to develop a suitable tractor mounted turmeric harvester to dig and collect rhizomes.

Appropriate materials, methodologies and instrumentation were adopted for the study. The experiment was conducted in the following aspects.

The soil parameters at the time of harvest such as soil type, soil moisture, bulk density and cone index and crop parameters such as plant population, rhizome spread (vertical and lateral), rhizome weight, number of fingers/rhizome, moisture content and bulk density of rhizomes which influence the mechanical harvesting of turmeric were analysed by experimental procedures. The manual harvesting of turmeric on the row and hill spacing of 450 mm and 200 mm and performance evaluation of tractor mounted turmeric digger (TNAU model) were done for analysing field capacity and cost of manual and mechanical harvesting. The main machine parameters namely, blade geometry and conveyor characteristics were studied and optimized by experimentation. The effect of various blade geometries namely, ‘V’ shape,

trapezoidal shape, crescent shape, straight blade and straight blade with digging chisels(6nos) in front and guiding rakes(lOnos) behind the blade at different rake angles of 15, 20 and 25 deg were evaluated in terms of harvesting efficiency of tractor mounted harvester for turmeric. The width of the conveyor was fixed as 1060 mm taking into consideration with the rhizome harvesting blade as 920 mm. The effect of various conveyor lengths namely 2060 mm, 1520 mm, and 1020 mm with different screen sizes of weld mesh 50x75 mm sieve opening, weld mesh of 35x55 mm sieve opening, wire mesh 4x4 mm sieve opening and screen made of 10 mm dia freely rotating polish rods (13 numbers) made to give an opening of 15x320 mm were evaluated in terms of percentage rhizome carried using the experimental turmeric harvester. The effect of various types of conveyor-elevator strip namely, MS metal L-shape strips, wood strips, rubber strips with different conveyor speeds of 3.0, 4.5 and 6.0 kmph were evaluated in terms of percentage damage to turmeric rhizome conveyed by the experimental tractor mounted turmeric harvester. A prototype tractor mounted turmeric harvester was fabricated with the optimized design parameters. The performance of the tractor mounted turmeric harvester was evaluated and compared with manual harvesting in terms of field capacity, field efficiency, harvesting efficiency, damage caused to the rhizomes, cost of labour per unit area, and cost of labour per unit weight of harvested turmeric rhizome. The cost economics of the developed prototype turmeric harvester was analysed as per the RNAM test code and procedure for harvesters

The important findings of the study are summarised below

The soil from the experimental location namely Thondamuthur Taluk, Coimbatore, is clay loam consisting of 26.5, 32.5 and 41 per cent sand, silt and clay respectively. The mean values of soil moisture at the time of harvest after wetting the field on 3rd, 7th and 12th day was 23.55, 16.10 and 12.10 per cent (d.b) respectively. The bulk density of the soil varied from 1.65 to 1.75 g/cm^3. The mean values of cone index of the clay loam soil were 1.55, 1.91, and 2.46 kg/cm^2 at 10 cm soil depth, 3.56, 3.94 and 4.24 kg/cm^2 at 15 cm soil depth, and 4.74, 5.36, and 5.75 kg/cm^2 at 20 cm soil depth at the soil moisture levels 24,16, and 12 per cent (d.b.) respectively.

The mean plant population for the Erode variety of turmeric was 13 per m^2. The mean lateral and vertical spread was 250,5 and 175 mm respectively. The mean rhizome weight with and without soil was 665 and 235 g, respectively. The moisture content and bulk density of rhizome at the time harvest varied from 71.5 to 75.9 per cent (d.b.) and 970 to 1010 kg/m^3 respectively. The mean number of fingers per hill in mother rhizome, primary finger and secondary finger was 2, 7.7 and 16 respectively. The angle of repose of turmeric rhizome was measured as 35 deg.

As a result of manual harvesting, the average labour requirement for digging and picking up the harvested rhizomes was 27.25 man-days/ha and 131.2 women-days/ha. The average harvesting efficiency, damage caused to the rhizome by digging with fork and cost of harvesting and picking were 90.5 percent, 7.10 percent and Rs 10600 respectively. In the case of mechanical harvesting by tractor mounted turmeric harvester (TNAU model), the average labour requirement for operating the equipment and for picking up the harvested rhizome was 0.63 man days/ ha and 123 woman-days/ha. The harvesting efficiency, damage caused to the rhizome and average cost of harvesting and picking was about 97.50 per cent, 2.73 per cent and Rs. 8483 respectively.

Experiments were conducted to optimise different machine parameters, namely, shape and geometry of digging blade, blade rake angle, length of conveyor, type and size of conveyor screen, type of elevator strip and speed of conveyor for obtaining the best performance.

The lowest and highest harvesting efficiency of 82.40 per cent for 'V' shape blade with the rake angle of 15 deg and 99.00 per cent for straight blade with digging chisel with the rake angle of 20 and 25 deg were observed. This is due to higher depth of cut of the soil at higher rake angle. The maximum and least damage to turmeric rhizome of 7.60 and 0.09 per cent were recorded with the crescent blade having 15 deg and straight blade with digging chisel having rake angle of 25 deg respectively. The maximum and least undug turmeric rhizome of 17.60 and 1.0 per cent were recorded with 'V' shape blade with the rake angle of 15° and straight blade with digging chisel with the rake angle of

20 and 25 deg respectively. The highest average draft was obtained with straight blade (3537.52 N) as well as at rake angle of 25deg (3200.20 N). The lowest average draft was obtained with straight blade with digging chisel (2628.21 N) and at the rake angle of 15 deg (2897.15 N). The maximum harvesting efficiency of 99 per cent and minimum damage of 0.9 to 1.1 per cent were recorded at the depth of 198-215 mm for straight blade with digging chisel at the rake angles of 20 and 25 deg. The rake angle of 15 deg had lower draft compared to 20 deg rake angle.

The highest amount of 98.2 per cent of turmeric rhizome carried over was recorded at 2060 mm conveyor length having weld mesh screen 35x55mm and wire mesh screen 4x4 mm. The least amount of 81.61 per cent turmeric rhizome carried over was observed at conveyor length of 2060 mm having weld mesh 50x75 mm. The maximum amount of 23.0 per cent of soil carried over was recorded at 1020 mm conveyor length having wire mesh screen 4x4 mm and least amount of 2.5 per cent of soil carried over was observed at 2060 mm conveyor length having weld mesh 15x320 mm. The maximum damage to turmeric rhizome of 6.7 per cent was recorded at conveyor length of 2060 mm having weld mesh 50x75 mm. This was due to the fact that the turmeric being conveyed over the screen got entangled in the screen and during the flight got damaged. The least damage to turmeric rhizome of 1.0 per cent was observed at conveyor length of 2060 mm having weld mesh 15x320 mm.

The maximum conveying efficiency of above 97.8 per cent was observed at all levels of conveyor lengths with wire mesh type conveyor screen. In wire mesh screen, the percentage of soil carried over to the collection box ranged from 14 per cent at conveyor length of 2060 mm to 23 per cent at conveyor length of 1020 mm. The least quantity of soil carried over the conveyor was observed at conveyor length of 2060 mm and weld mesh 15x320 mm (2.5 per cent).

The conveyor-elevator strip made of rubber and conveyor speed at 6 kmph had the highest percentage of 99.1 per cent turmeric rhizome conveyed and conveyor-elevator strip made of MS metal L-shape and conveyor speed at 3 kmph had the lowest percentage of 96.2 per cent of tumeric rhizome conveyed.

The maximum soil carried over of 10 per cent was recorded at the conveyor speed of 6 kmph and conveyor-elevator strip made of wood and rubber. The minimum soil carried over of 5.5 per cent was observed at conveyor-elevator strip made of rubber at the conveyor speed of 3 kmph. The maximum damage to turmeric rhizome of 6.5 per cent was recorded at conveyor-elevator strip made of MS metal of L-shape at the conveyor speed of 6 kmph. The least damage to turmeric rhizome conveyed of 0.8 per cent was observed at conveyor-elevator strip made of rubber conveyor speed of 4.5 kmph.

MS metal L-shaped strip caused maximum damage to the turmeric rhizome (4.7 to 6.5 per cent) followed by wooden strips (2.5 to 4.8 per cent). The hardened rubber strips, having length of 820 mm, breadth of 75 mm and thickness of 15 mm gave the best conveying efficiency of 98.6 to 99.1 per cent with reduced soil accumulation and minimum damage to the turmeric rhizome. This may be due to its elastic nature which provided the cushioning effect to the rhizomes coming in contact with the strips and thus it did not break when the load was coming upon it.

Soil accumulation was more at conveyor speed of 3.0 kmph, which led to clogging of rhizomes on conveyor system. The conveyor speed at 6.0 kmph, damaged the rhizomes due to the impact force and the chances of the conveyed rhizomes getting thrown away beyond the collection box placed behind the conveyor assembly were more. The conveying efficiency of 98.8 per cent with minimum soil carried over of 6.0 per cent and minimum rhizome damage of 0.8 per cent was recorded at conveyor-elevator strip made of rubber at a speed of 4.5 kmph.

Based on the findings of experimental study on machine parameters enumerated above, the prototype tractor mounted turmeric harvester was fabricated comprising of major components like i)frame, ii) digger assembly

with the chosen blade geometry of straight blade with digging chisels (6 nos) and guide rakes (10 nos) at a rake angle of 20 deg, iii) a conveyor assembly having conveyor screen made of 13 number of 10 mm dia polished rods, length of 1520 mm mounted on a frame with 35 deg slope attached with iv) gear and sprocket-chain drive mechanism and v)collection box of semi cylindrical trough of 1100 mm length and 560 mm diameter.

The prototype was evaluated in farmer's field in Thondamuthur area of Coimbatore district at optimum speed. The effective field capacity was found to be 0.16 ha/h. The harvesting efficiency was 98.5 per cent, with damage caused to the rhizome being 2.30 per cent and leaving undug rhizome of 1.5 per cent in the soil. The conveyer efficiency was 99.50 percent. The separation index of the rhizome was 0.90. The labour required for harvesting turmeric using tractor mounted harvester was i) 6.25 man-h/ha for operating the equipment and ii) 32 women-h/ha for picking the harvested rhizome.

In manual harvesting, the harvesting efficiency was 89.9 percent with damage caused to rhizome being 7.9 percent and the percentage of rhizome left undug being 10.1 percent. This shows that an additional quantity of about 8.6 percent of the crop which otherwise would have been left undug from soil by manual method could be realized as yield by using turmeric harvested and thus the productivity could be considerably improved by mechanical harvesting of turmeric.

The cost of the harvester works out to be Rs 25000 (US $ 500). The cost economics study showed that the cost of harvesting per ha was Rs 1556 (US $ 31) with the prototype harvester while it was Rs. 10600 (US $ 212) with manual harvesting. The savings in cost was 85.32 percent by harvesting with mechanical harvester over manual harvesting. The breakeven point was 29 ha per annum and the payback period was 2.30 years for the tractor drawn turmeric harvester.

The following conclusions are drawn from this current study.

1. The turmeric harvester with the straight blade with digging chisel in front and guiding rakes behind the blade was selected based on harvesting efficiency with minimum damage.
2. The optimum conveyer length of 1060 mm x 1520 mm; screen made of Polish rod (13 no and 10mm dia) and the elevator belt made of rubber strips at a conveyor speed of 4.5 kmph were selected based on the conveying efficiency coupled with, least damage and minimum soil handling.
3. The prototype of tractor mounted turmeric harvester could be successfully operated in clay loam soil with field capacity of 0.16 hectare per hour and field efficiency of 98.5 per cent.
4. The cost of the harvester is Rs 25000 (US $ 500) and cost of harvesting per ha was Rs 1556 (US $31). The breakeven point was 29 ha per annum and payback period was 2.30 years.
5. Mechanical harvesting of turmeric is superior to manual harvesting in terms of (i) improved harvesting efficiency of about 98.50 percent over 90.50 percent; (ii) reduced damage to the crop of 2.30 percent over 7.90 percent and (iii) savings in cost by 85.32 percent. The improved harvesting efficiency would enable the farmer to realize additional 8.6 percent of the yield and reduce the extent of damage by about 5.6 percent.