TRAINING MANUAL

Collaborative Online Refresher Training Program (RTP)

on

"Farm Mechanization for Established Agripreneurs"

(under AC&ABC Scheme MANAGE, Hyderabad)

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Custom Hiring Enterprise Development in Madhya Pradesh

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Introduction

The trend towards over-capitalisation in agriculture and the increasing cost of production are becoming the new challenges for competitive production. The basic requirement to meet this competition is to reduce the unit cost of production and maximize resource productivity which depends greatly on the availability and judicious use of mechanization means by the farmers. Custom Hiring of Agricultural Machinery is one of the best institutional innovations established in recent years as a panacea for all these problems. Pace of mechanization of agriculture in Madhya Pradesh has not been at par with the developed states like Punjab and Haryana. To increase the availability and adoption of agricultural machines and thereby increase the level of mechanization, 'Custom hiring model and skill development for improving farm mechanization level in Madhya Pradesh', in association with Directorate of Agricultural Engineering, Govt. of MP, was launched to help the farmers to raise the farm productivity through custom hiring of machines and introduction of improved farm machinery and equipment.

The Model

To ensure that the benefits of the mechanization aptly reach the farmers, it is vital to make appropriate machines accessible to the farmers along with professional services at affordable cost and time. One of the ways of doing so is creation of bank of high capacity – high efficiency machines along with suitable prime mover and then making them available to farmers with trained operator. Selection of machines vis-à-vis utility, demand, cost and market availability is vital and so is awareness about operation, adjustment, repair and maintenance for optimal performance of machinery. ICAR-CIAE, Bhopal already engaged in development of machines and protocols for different farming operations, besides a two pronged approach – developing skills in farm-machinery management and creating awareness of availability of machines across the country – was implemented in collaboration with Directorate of Agricultural Engineering, Govt. of MP.

While implementing the custom hiring model and skill development for improving farm mechanization level in Madhya Pradesh, entrepreneurs were given one-two weeks training at CIAE, Bhopal by scientists and technical officers, who educated them about the usage and benefits of advanced agricultural techniques. These trainings were provided

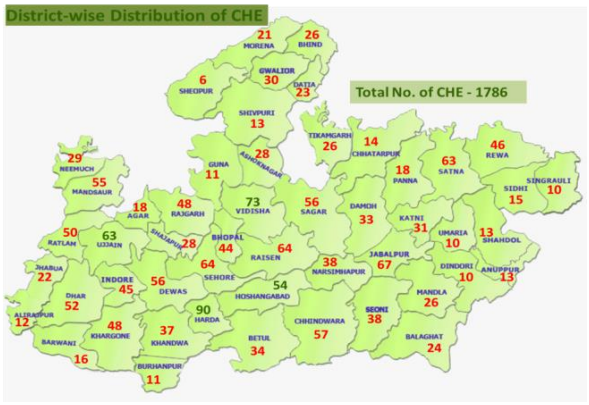
without any gender bias. The skill development programme included classroom field practical sessions (20 % classroom & 80 % practical) and exposure visits to other organizations. Each programme essentially included exposure to all the agricultural machines required for carrying out tillage operations, seedbed preparation, sowing-planting and transplanting, weeding & plant protection, harvesting, threshing, straw management and selected post-harvest operations, besides technically correct and safe operation of tractors and its maintenance. Thus a number of Technological Agents of Farm Machinery have been produced through this model.

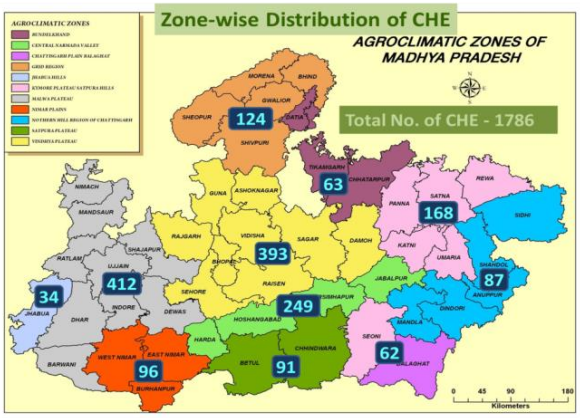
Scheme Details

The scheme has been introduced for providing mechanization solutions to small farm holders who cannot afford to have their own machines, and that way to increase the mechanization of agriculture in the state. In order to ensure the availability of complete package of farm machines to the small farmers, the scheme has been introduced with certain **measures** as following:

- Eligibility: Persons below 40 years of age belonging to all categories. An applicant must be a graduate. (Preference to Agricultural Graduates).
- Custom hiring centres costing Rs. 10 - 25 lakh
- Subsidy - 40-50 percent subsidy upto to maximum Rs. 10 lakh. Subsidy only on loans obtained from banks. "Back Ended Subsidy" (4-years lock-in period).
- Each unit should have at least one tractor, plough, rotavator, cultivator, disc harrow, seed-cum-fert drill and one thresher. Besides, selection of other suitable implements can be made on the basis of additional area and crops.
- Under the scheme tractors of 35 to 55 horsepower can be obtained.
- A centre will have to give tractor and agricultural implements on custom hiring for minimum ten years.
- Even if bank loan is repaid within this period, custom hiring services will have to be provided to farmers upto stipulated period. Sanctioned loan will be recovered in maximum 9 years.

During 2012-13 to 2016-17, 1786 enterprises have been established, out of which 55% (986 participants) were trained at ICAR-CIAE. The scenario of these enterprises across the state has been as following:





Out of those participants who have established and running there custom hiring centres for more than a year (Sample size (110 No. entrepreneurs and 330 beneficiary farmers) were surveyed through personal visit. The data collected from various custom hiring enterprises and famers broadly include the financial details of the enterprise, machines owned, crops and operations for which custom hiring services being offered, custom hiring rates etc. and feedback, future requirements and constraints faced by entrepreneurs and farmers both.

Few meaningful observations have been highlighted as following:

Availability of Machinery through Custom Hiring Entrepreneurs:

All custom hiring entrepreneurs are providing the general purpose farm machines to the small farmers and the machines available on rental basis contains complete package to serve the need of various field operations from Tillage to Threshing, as following:

Tillage: Reversible MB Plough, Rotavator, Cultivator

Sowing: Seed Drill, Seed-cum-Fertilizer Drill,

Interculture: Narrow Tyre Tractors & Small Tractors

Plant Protection: High Capacity Boom Sprayers

Harvesting: Reaper and Reaper Binder

Threshing: High Capacity Thresher

Straw management: Straw Reaper

Few custom hiring entrepreneurs are providing special purpose farm machines also to the small farmers on rental basis, as following:

- Front Dozer
- Zero-till Drill
- Rice Transplanter
- Garlic Planter
- Disk Harrow
- Raised-Bed Planter
- Potato-Planter
- Sugarcane cutter planter

Rates of custom hiring:

The rental charges of various agricultural machines have been found to be slightly varying depending on the area and demand during the season. The average custom hiring charges have been recorded as following:

Name of the equipment	Average Rate for CH (Rs./h)	Name of the equipment	Average Rate for CH (Rs./h)
Rev. MB Plough	677	Front dozer	683
Rotavator	775	Reaper Binder	1163 with rope
Cultivator	600	Straw Reaper	1252 per tank
SD/SFD/ZTD	611	Combine Harvester	1500 – 1800 per acre
Thresher	775	Spray Pump	500/h
Trolley	15-50 per km	Laser Leveller	900/h

Overall Business-Service Scenario of Custom Hiring Centres:

Data from Custom hiring service centres was also collected for profitability and the services they are providing in terms of area coverage and number of families being served, which has been summarized as following:

Particulars	Annual Profit (Rs. Lakh)	No. of Families Served	Area Covered-Annual (ha)
Average	2.50	103	153.2
Min.*	0.40	6	20.0
Max.	7.00	400	414.0

***** ***Exceptional cases***

Constraints faced by Entrepreneurs:

During survey, opinion of the entrepreneurs was also collected for the constraints being faced by them. The analysis of the same is as following:

i. **Availability of Repair-Maintenance facility:** 65.5% told that adequate repair and maintenance facility was available in their area for the machines available with them. While, 33.6% showed concern about timely availability of the facility even when adequate Repair-Maintenance facilities are available within the vicinity.

ii. Delay in Payment: This has been observed as the biggest constraint, as almost 90% entrepreneurs told that they worked on credit basis and sometimes they received the payment

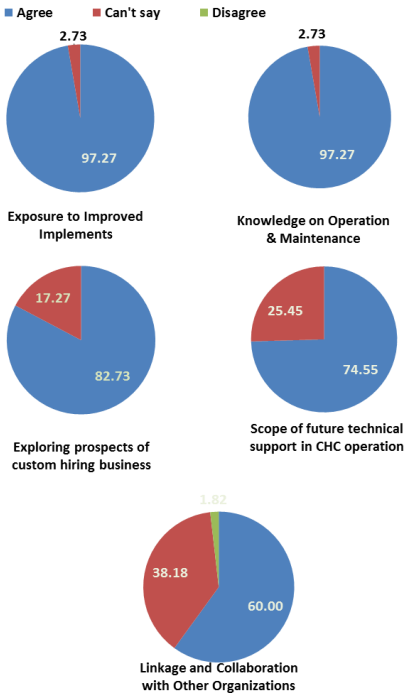
from season to season. Only 10.9% didn't have any problem related to payments from the farmers.

iii**. Availability of Driver/Operator:** Approx. 28% entrepreneurs are facing problem in availability of experienced operator. 72% didn't face any problem at all in this matter.

Benefits of Training at ICAR-CIAE, as perceived by Entrepreneurs:

The entrepreneurs trained at CIAE also shared their opinion about the way they have been benefited with training at ICAR-CIAE.

- 97% of the custom hiring entrepreneurs said that they got wide exposure to advanced agricultural machinery during the training at ICAR-CIAE which has been immensely helpful to them in selection of quality machines for their enterprise and also for future planning and expansion.
- As far as knowledge on optimal operation and maintenance of machinery is concerned, 97% said that because of the practical knowledge and tips they got during the training, they have been able to minimize the operational expenses.
- 82 % of the entrepreneurs also agreed that they learned about the further prospects in the field of custom hiring so as to maximize the annual use of machinery being owned by them and increase the profitability.
- 75 % of the entrepreneurs are willing to receive support and guidance from ICAR-CIAE, in future too on technical aspects.
- 60 % of the entrepreneurs realized that the training at ICAR-CIAE has also been helpful for them in developing linkages and collaboration.



Benefits to Farmers:

Besides survey of entrepreneurs, the associated/client farmers, who have been availing the custom hiring services form the entrepreneurs were also surveyed for the benefits realized from them. A total of 330 farmers (3-4 farmers associated with each entrepreneur) were interviewed and it was observed that the small farmers have been getting the machines for various operations timely from these entrepreneurs, which has precisely been the objective of the scheme i.e. to ensure the availability of complete package of farm machines to the small farmers. 32% of the farmers availing the facility are those who have a loan holding of 1-2 ha

only. Land holding wise distribution of farmers availing custom hiring services is tabulated as following:

Land holding wise Client Farmers	
Marginal (< 1 ha)	10.8 %
Small (1-2 ha)	21.0 %
Semi-medium (2-4 ha)	26.9 %
Medium (4 - 10 ha)	28.7 %
Large (> 10 ha)	12.6 %

Client Farmers' Opinion about benefits: The opinion of farmers was collected about the following:

- Increase in Production
- Saving in Input
- Saving in Time
- Reduction in Losses
- Reduction in Cost of Production

Data collected from client farmers during survey have been analysed and tabulated as following:

Values (%)	Production	Losses	Input	Time	Cost
AVG	26.1	21.1	28.4	51.0	33.2
Max	40.0	50.0	60.0	80.0	50.0
Min	10.0	0.0	5.0	15.0	15.0

Due to increased mechanization level and easy availability of improved machinery through custom hiring entrepreneurship, even small farmers are now getting encouraged to replace their traditional and time consuming farming practices with improved and mechanized protocols.

Comparison of farming practices before and after introduction of Custom Hiring Facility

Due to increased mechanization level and easy availability of improved machinery through custom hiring entrepreneurship, even small farmers are now getting encouraged to replace their traditional and time consuming farming practices with improved and mechanized protocols. The table below gives a snapshot of change in various farming practices before and after increase in the mechanization level:

Farming/ Agricultural Operation	Old Practice	New Practice
Ploughing and seedbed preparation	B/D ploughs and T/D cultivators were used. It ploughs the land to shallow depth only did not pulverize and invert the soil that well. The land retained less water & land was not flattened after sowing.	T/D reversible MB ploughs and rotavators are used for ploughing and seedbed preparation, which ploughs the land deep, mixes the soil better, allowing it to retain more water and give smooth and flattened seedbed facilitating higher germination.
Seed grading	Infected or spoilt seeds were not separated and sown along with Good quality seeds.	Seeds are properly separated using graders and only good quality seeds are used for sowing.
Seed treatment	Treatment of seeds and mixing with fertilizers were done by hands.	Seed treatment drums are used for chemical treatment and proper mixing of seeds with fertilizer.
Sowing	Manual broadcasting of seed and fertilizer or B/D, T/D seed drills (with fertilizer mixed) were used.	Sowing is done using seed cum fertilizer drill, allowing separate placement of seed and fertilizer. Modern techniques like raised bed planting & ridge-furrow sowing are also used.
Weeding & intercultural	Manual weeding with hand held khurpi or chemical weeding with shoulder mounted sprayer, which is highly time consuming because of very low field capacity.	Chemical weeding is done using Tractor mounted sprayer pumps which gives very high field capacity. Small tractors (15-20 hp) having narrow tyres are used for mechanical weeding.
Harvesting	Manual harvesting. Highly labour intensive, time and cost consuming.	Self-propelled reapers and reaper-binders cuts and bundles crops. It saves time and there is less wastage.
Threshing	Manual threshing devices and Small power threshers. Much dependency on availability of electricity and weather uncertainty too. Also labour intensive, time and cost consuming.	Tractor drawn Mechanized multi crop threshers are used. It reduces time and cost and also reduces dependency on availability of electricity and weather uncertainty is also minimized with timeliness in threshing operation. Accidents have also reduced due to use of safe and automatic feeding type threshers.

Farming/ Agricultural Operation	Old Practice	New Practice
Straw management	Crop/Straw stubbles were burnt to prepare the field for subsequent crops and operations	Straw is fully recovered from the field using straw reapers which fetches extra income to the farmers. Instead of burning, crop stubbles, it is buried well into the soil using rotavator, which improves the soil health

B/D – Bullock drawn; T/D – Tractor Drawn

Outcome

Until so far, the growth of these custom hiring centres has not only contributed in increasing farm productivity but also in improving rural employment generation. It is raising the self-esteem of the youths associated with it and discouraging the rural migration as well. On the basis of a survey of farmers hiring various machines, major impact of "Custom Hiring Entrepreneurship Development" scheme on farmers and farming practices in Madhya Pradesh are as following:

- Increase in average productivity of major crops

Major Crops for which Custom Hiring Services Utilized	Average Yield of crop before intervention (kg/ha)#	Average yield / Expected yield after intervention (kg/ha)#
Soybean Wheat Gram Paddy Pulses & Lentil*	Soybean – 1450 Wheat – 2800 Gram – 1110 Paddy – 1950 Lentil – 620	Soybean – 2580 Wheat – 4600 Gram – 2025 Paddy – 3500 Lentil – 1460
*Contributed to significant increase in **Cropping Intensity** as Pulses family crops (Black gram, Green Gram etc.) are being taken as **Third Crop** in Many areas, which could become possible only because of ***Increase in Mechanization Level.***		

 # Source: *Data made available by Directorate of Ag. Engg., Govt. of MP*

- Increased availability of improved agricultural machines.
- Easy availability of machinery at affordable rates, especially to small and marginal farmers unable to own machine(s).
- Increase in cropping intensity.
- Increase (25-35 %) in overall production due to high productivity and higher cropping intensity, as reported by farmers.
- Timely completion of operations, thus reducing losses.
- Saving in costly inputs.
- Saving in time.
- Reduced cost of cultivation (25-45% as reported by farmers)
- Empowerment of the farming community.

Suggested Strategic Interventions for further Improvement of Scheme:

- New Custom hiring centres be opened in areas, having less number of CH centres.
- Income slab and land limit ceiling be introduced to extend the benefit to real needy and to fulfil the scheme objectives.
- Technical scrutiny of Tractor & Implement combination and approval by a competent committee, involving Scientists from CIAE, before sanction.
- Training be conducted before preparing and submitting the project proposal to the bank for financing.
- Uniform Interest rates, repayment plan and other Terms & Conditions across various banks.
- Project proposals with min 80% investment only be considered, so as to ensure availability of complete package of agricultural machinery.
- Preference is given to those residing in rural area.
- The improved prototypes developed by ICAR Institutes and SAUs, despite being efficient in performance, have not become common among the farmers. Few improved farm equipment which have done well in the field may be included in the list of options in the future.

Case Study-1:

Shri Anil Pratap Singh is a resident of village Semariya of Rewa district. His family owns about 2 ha land in Rewa district. To augment his net income, he became interested in custom hiring business of agricultural machinery in his village and received training from ICAR-CIAE, Bhopal after enrolling in entrepreneurship development programme of Directorate of Agricultural Engineering, Government of M.P. which is funded by Department of Agriculture, Cooperation and Farmers' Welfare, Government of India. After successfully completing the training, he established his custom hiring business centre at Semariya village naming it as 'Shiv Mahima Custom Hiring Centre', with an investment of Rs. 21 lakhs in March 2014. His venture was financed by Allahabad Bank, Rewa. In the beginning, he bought two tractors (48 and 55 hp) along with one reversible MB plough (2 bottom), front dozer (width 8 feet), two rotavators (1.8 and 2 m) two cultivators (both 11 tynes), seed-cum-fertilizer drill (11 rows), and tractor operated paddy thresher. He already had one 35 hp tractor, one 11-rows zero till drill and one self-propelled walk behind reaper under his possession. Gradually, he expanded his business by purchasing raised bed maker-cum-seeder (6 rows on 3 beds), self-propelled walk-behind type paddy transplanter (4 rows) and straw

reaper. With his entrepreneurial skill, zeal to adopt new technology and wide range of farm machinery inventory, he specialized in complete mechanization of paddy-wheat cropping system for the farmers in his area and also promoting raised bed cultivation for kharif crops. He rents out these machines to many farmers of his village and also surrounding villages of Rewa block for cultivation of field crops like paddy, soybean, wheat, and chickpea. He generated gross revenue of around 11 lakhs with a net profit of about Rs. 5 lakhs in 2015-16. With technical guidance from CIAE scientists, He is also planning to procure LASER guided land leveller to offer the complete mechanization package starting from land preparation and levelling to residue management to his clients for paddy-wheat cropping system.

Case Study-2:

M/s Renu Tomar D/o Shri Shakti Singh Tomar is a resident of village Sayar, block Vidisha of Vidisha district. After completion of her post-graduation in chemistry, she became interested in custom hiring business of agricultural machinery in her village and enrolled in entrepreneurship development programme. She received training from CIAE, Bhopal in January 2013. After successfully completing the training, she established her custom hiring business centre in April 2013 naming it as 'Renu Custom Hiring Centre', with an investment of Rs. 18.0 lakhs out of which Rs. 9 lakhs was given to her as subsidy from Government. In the beginning, she bought a tractor of 55 hp along with one reversible MB plough (2 bottoms), front dozer blade (6 feet), rotavator (1.2 m) cultivator (7 tynes), seed drill (11 rows), multi-crop thresher (25 hp), straw reaper, spray pump (700 l) and trolley (2 wheels). With active help from her father Mr. Shakti Singh Tomar in running day-to-day business of the custom hiring centre, she rented out these machines to many farmers for 1030 hours in 2013-14 and 1320 hours in 2014-15 hrs of his village and also surrounding villages for cultivation of field crops like soybean, wheat, gram as well as vegetable crops. The custom hiring centre generated an annual net profit of about Rs. 5 lakhs in 2013-14 and Rs. 7.87 lakhs in 2014-15. Gradually, a

few more machines were added to her inventory like bhusa shifting pump, winnower, spiral grader etc. with the surplus profit made from custom hiring centre and two small tractors of 15 & 18 hp for horticultural works with 50% subsidy provided by Department of Horticulture, Government of Madhya Pradesh.

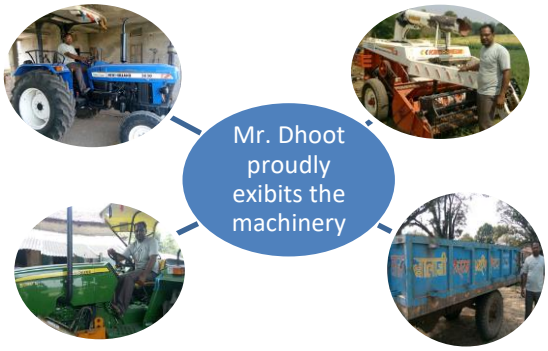
Case Study-3: Shri Anil Pratap Singh is a resident of village Semariya of Rewa district. His family owns about 2 ha land in Betul district. To augment his net income, he became interested in custom hiring business of agricultural machinery in his village and received training from ICAR-CIAE, Bhopal in August 2013. After successfully completing the training, he established his custom hiring business centre at Bajpur Chakora village naming it as 'Devendra Rathore Custom Hiring Centre', with an investment of Rs. 18 lakhs in December 2013. In the beginning, he bought one tractor of 60 hp along with one reversible MB plough (2 bottom), front dozer, rotavator (2.1 m) cultivator (9 tynes), seed-cum-fertilizer drill (13 rows), raised bed maker-cum-seeder (4 rows – 2 beds), multi-crop hadamba thresher (35 hp), sugarcane cutter planter (2 rows) and hydraulic trolley (4 wheel). With his entrepreneurial skill and zeal to adopt new technology, he procured the sugarcane cutter planter from Shahabad in Haryana for providing service to sugarcane farmers in his area and also promoting raised bed cultivation for kharif crops. He rents out these machines to many farmers of his village and also surrounding villages of Betul block for cultivation of field crops like soybean, wheat, maize, chickpea and sugarcane. He generated income of around 6.5 lakhs in a year with a net profit of about Rs. 3 lakhs. With technical guidance from CIAE scientists,

He is planning to add two more machines in his inventory in near future namely, reaper-cum-binder and sugarcane bud chipping machine for growing sugarcane settlings in portray to further diversify the business of his custom hiring centre.

Case Study-4:

Shri Rahul Dhoot is a resident of village Berkheda Hassan, tehsil Shyampur of Sehore district. He owns only 1.25 ha land. To augment his net income, he became interested in custom hiring business of agricultural machinery in his village and received training from CIAE, Bhopal in January 2014. After successfully completing the training, he established his custom hiring business centre in April 2014 naming it as 'Balaji Custom Hiring Centre', with

an investment of Rs. 21.50 lakhs. In the beginning, ha bought two tractors of 50 & 55 hp along with one reversible MB plough (2 bottom), front dozer, rotavator (1.8 m) cultivator (9 tynes), seed drill (11 rows), multi-crop *hadamba* thresher (35 hp), straw reaper (56") and trolley (2 wheel). With active help from his father and elder brother in running day-to-day business of the custom hiring centre, he rented out these machines to around 100 farmers for about 1100 hrs of his village and also surrounding villages for cultivation of field crops like soybean, wheat, chickpea as well as vegetables like onion, garlic, chilli etc. He generated income of around 8.0 lakhs in a year with a net profit of about Rs. 2.5 lakhs. He added two more machines in his inventory in April 2015 namely combine harvester and *bhusa* shifting pump with the surplus profit made from custom hiring centre.



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Selection, operation and safety of intercultural, plant protection equipment including Drones

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Introduction

The aim of interculture and plant protection operation is to provide the best opportunity to crop to establish and grow vigorously up to time of maturity. All the lighter and finer operations carried out on the soil, between sowing and harvesting are termed as intercultural operations. They include weeding, fertilizer application, mulching, etc. The machineries and implements used for this purpose are called as inter cultural equipments. Pests and disease incident on the crops / plants are to be overcome by the application of poisonous chemicals. As the technology advances and newer crop varieties are introduced newer insects, pests and diseases are also growing up and methods are deviced to control them. The main objectives of weed control are to improve the soil conditions by reducing evaporation from the soil surface, improve infiltration of rain or surface water, reduce runoff to maintain ridges or beds on which the crop is grown and to reduce competition of weeds for light, nutrients and water. Mechanical methods of weed control are simple and easily understood by farmers. The tools and implements for mechanical weed control are mostly manual and animal operated. Manual method is most effective but is slow. It is popular in regions where labour wages are low and labour is easily available during the season. The additional cost of weeding using implements is comparatively less than the gains due to extra yields obtained. First weeding operation is mostly done between and along the rows. Remaining operations are done mostly between the rows. Hand hoes are generally used for removing weeds between plants in a row.

Many chemicals used for plant protection cannot be handled by human operators directly. Also, that needs to be applied in fine particles. This necessitates the use of suitable machines. Chemicals are widely used for controlling disease, insects and weeds in the crops. They are able to save a crop from pest attack only when applied in time. They need to be applied on plants and soil in the form of spray, dust or mist. The chemicals are costly. Therefore, equipment for uniform and effective application is essential. Dusters and sprayers are generally used for applying chemicals. Dusting, the simpler method of applying chemical, is best suited to portable machinery and it usually requires simple equipment. But it is less efficient than spraying, because of the low retention of the dust. High volume spraying is usually effective and reliable but is expensive. Low volume spraying to some extent

overcomes the failings of each of the above two methods while retaining the good points of both.

1. Interculture operation

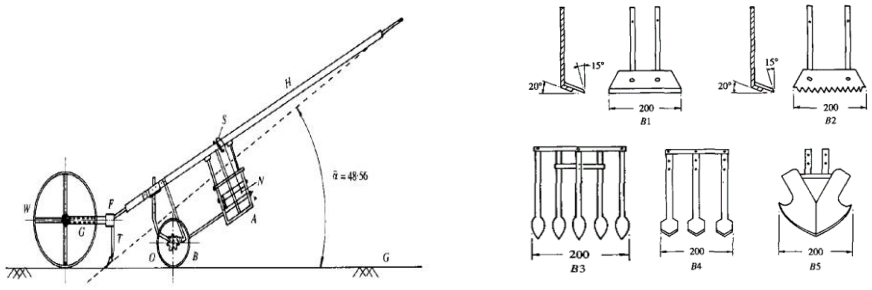
The aim of weeding and intercultivation operation is to provide best opportunity to crop to establish and grow vigorously up to time of maturity. The main objectives of weed control are to improve the soil onditions by reducing evaporation from the soil surface, improve infiltration of rain or surface water, reduce runoff to maintain ridges or beds on which the crop is grown and to reduce competition of weeds for light, nutrients and water. Mechanical methods of weed control are simple and easily understood by farmers. The tools and implements for mechanical weed control are mostly manual and animal operated. Manual method is most effective but is slow. It is popular in regions where labour wages are low and labour is easily available during the season. The additional cost of weeding using implements is comparatively less than the gains due to extra yields obtained. First weeding operation is mostly done between and along the rows. Remaining operations are done mostly between the rows. Hand hoes are generally used for removing weeds between plants in a row.

Types of Weeding Tools

The weeding tools and equipment are categorized based on their power source i.e manual, animal drawn and power or tractor operated.

(a) Manual weeding tools

Small weeding tools or aids are traditional hand held type hoes like "Khurpi" used by the farmers. These tools are operated in squatting posture and have very low work output. Different designs of these tools are being used by the farmers of different regions. These tools are suitable for removing the weeds between plants in both row-sown and broadcast fields and are quite efficient. Spades or chopping hoes weeders work on the principle of impact and have straight, curved or pronged blades.



(a) Push-Pull weeder (b) Different type of weeding tools

Fig. 1: Manual operated weeder

Weeds are removed by digging, cutting and uprooting. These are operated in the bending posture. The operation is normally slow and tiring. Long handle tools have a soil working tool mounted at the end of a 1.5 to 2 metre long wooden/bamboo handle. These tools are operated in push or push-pull or pull mode and in standing posture. The common shapes of blades on these weeders are straight, convex, V -shape, sweep, serrated, etc. These are designed to work under friable soil moisture conditions and give high work output at the early stages of crop growth when weeds are small.

(b) Animal drawn weeding tools

Fig. 2: Animal drawn weed control

In oilseedc crops, interculture and weeding operations could be done quickly and efficiently by using improved animal drawn implements. It is essential to provide wider row spacing (above 30 cm), for movement of animals and implement, if animal drawn weeders are to be used. Accurate row spacing and straight rows are a must for successful weeding. Animal drawn tools reduce the cost of operation and time. Animal drawn single row hoes are most widely used by the farmers of different states. The three tine cultivator or "Triphali ", "Akola" hoe,"Bardoli" hoe and animal drawn sweeps of different designs are some of the new designs of animal drawn weeders.

(c) Power operated weeding tools

Some designs of small engine operated tools have been developed for inter-row cultivation, however, the cost of operation on small farms with a power operated weeder is higher than that with push-pull type weeder. Therefore, their usefulness is limited. Tractor operated implements can be used for intercultivation but these require wider row spacing and leaving of space at the headlands for allowing the tractor to operate and turn before entering into the rows.

(a) Power weeder

(b) Tractor operated rotary weeder

Fig. 3: Power weeder and tractor operated rotary weeder (Anonymous, 2018)

(d) Mechanical inter and intra row weeder for wide-spaced deep rooted field crops

Mechanical intra and inter-row weeder for wide-spaced deep-rooted field crops have been developed by CIAE Bhopal (Chandel et al., 2021). The weeding system consisted of sweep for inter-row weeding and spike tines for Intra row weeding. The developed mechanism was preliminarily tested in soil bin for working accuracy. The forward speed of weeder, peripheral speed of rotor, moisture content, cone index and u/v ratio are the main factors affecting depth of cut, tilling pitch and number of pitch. The weeding machine was tested at soil dynamic laboratory for the optimization of operating parameters of intra row mechanism. Tractor operated inter and intra row weeder is shown in Fig. 4. The weeder includes combinations of active and passive tools for weeding. The weeding operation of inter-row is performed by sweep and intra row by spring tines. Intra row rotary shaft is operated with help of hydraulic motor with flow control valve by tractor hydraulic. The guidance of the developed intra-row weeding tine follows the principle of its synchronized rotational speed as per the forward speed of operation in real-time. In the case of inter-row weeding, both cutting and uprooting likely resulted in weeds uprooted about 90% in maize and pigeon pea crop. Total buried and intact weeds were about 10-12% for both crops. Average burial depth was range 4 -14 mm by sweep type inter-row mechanism. In the case of intra row weeding, both cutting and uprooting likely resulted in weeds uprooted of weeds in intra row about 64 and 66% in maize and pigeon pea crop, respectively. Total intact weeds were about 23 and 19% in maize and pigeon pea crop, respectively. Burial weeding rates were lower as compared to intact weeding.

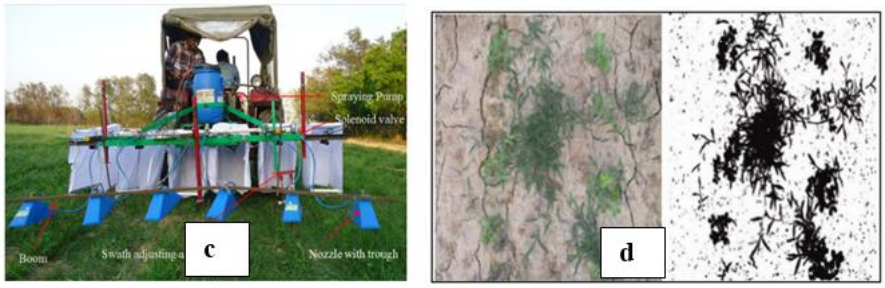
Fig.4: Prototype of three row inter and intra row weeder and field test of weeder in maize field

(e) Automation in weed control

Automation is a technique of operating and controlling a mechanical device by an automotive mode without intervention of human. It helps to reduce the operator stress and restricts operators from continuous steering of agricultural equipment. This allows for focusing on

implement performance. It has a leading role to optimize machine performance and reduce resources through use of electronic hardware, sensors, actuators and software. Weed control can overcome the limitation in manual and mechanical methods through automation. This will help in differentiating between crop plants and weeds and remove the weeds precisely without causing plant damage. Automation incorporates major innovations, for example, guidance, detection and identification, in-row precise weed control and mapping. A three-row contact type microcontroller-based herbicides applicator was developed to control the weeds population from the inter-row crop (IIT Kharagpur). The system was based on real-time image processing and manually operated. The system automatically computes and applies the amount of herbicide through contact sponge rollers depending on the amount of weed estimated by real-time image processing (Fig.4a). Field experiments demonstrated that there was a 40% herbicides reduction having an application efficiency of 90%. A tractor-operated six-row contact type weed eradicator was developed using a microcontroller-based position sensing and digital image processing embedded system for row crops (Fig.4 b & c).

(a) Manual drawn (b) Tractor drawn roller based herbicides applicator



(c) Herbicideds applicator (d) Image processing of weeds

Fig.5: Image processing and microcontroller based herbicide applicators

An image analyzer was developed in Visual Studio Open computer vision platform to detect the weed density within the crop rows, which was used under different illumination levels. Additionally, for parametric adjustments of the image analyzer, a graphic user interface was also developed for parametric adjustments. The micro-controller acquires the data from the image analyzer, processes the data, and sends the signal to the solenoid valve to release the

chemical over the contacting roller (Fig.5). They reported an average weeding efficiency of 90% in maize and groundnut crops with plant damage of 5 and 8%, respectively. They observed a saving of 79.5% of herbicides by using the digitally developed embedded system. The chemical herbicides application in the field causes increasing health hazards, environmental concerns, herbicide-resistant weed species that demand low cost and chemical-free production.

2. Plant Protection

Chemicals are widely used for controlling disease, insects and weeds in the crops. They are able to save a crop from pest attack only when applied in time. They need to be applied on plants and soil in the form of spray, dust or mist. The chemicals are costly. Therefore, equipment for uniform and effective application is essential. Dusters and sprayers are generally used for applying chemicals. Dusting, the simpler method of applying chemical, is best suited to portable machinery and it usually requires simple equipment. But it is less efficient than spraying, because of the low retention of the dust. High volume spraying is usually effective and reliable but is expensive. Low volume spraying to some extent overcomes the failings of each of the above two methods while retaining the good points of both.

Hand sprayer

Hand compression low volume sprayer

Knapsack sprayer

Rocker sprayer

Air assisted sprayer

Tractor-operated spinning disc type sprayer

Fig. 6: Different type of spraying system

Spraying is employed for a variety of purposes such as application of:

i. Herbicides in order to reduce competition from weeds
ii. Protective fungicides to minimize the effects of fungal diseases
iii. Insecticides to control various kinds of insects pests
iv. Micro-nutrients such as manganese or boron,

The main function of a sprayer is to break the liquid into droplets of effective size and distribute them uniformly over the surface or space to be protected. Another function is to regulate the amount of insecticide to avoid excessive application that might prove harmful or wasteful. A sprayer that delivers droplets large enough to wet the surface readily should be used for proper application. Extremely fine droplets of less than 100 micron size tend to be diverted by air currents and get wasted. Crops should, as far as possible, be treated in regular swaths. By use of a boom, uniform application can be obtained with constant output of the machine and uniform forward travel.

Classification of Spraying Technologies

Spraying techniques are classified as high volume (HV), low volume (LV) and ultra-low volume (ULV), according to the total volume of liquid applied per unit of ground area. Initially high volume spraying technique was used for pesticide application but with the advent of new pesticides the trend is to use least amount of carrier or diluent's liquid. In spraying, the optimum droplet size differs for different types of application. Fine droplets are required to control insects, pests or diseases and bigger size droplets for application of herbicides, etc. The greater the number of fine droplets produced by the device better will be deposition on target area. The size of droplet is important as it affects drift and penetration distance of droplets towards the target. Hence a compromise is to be made to prevent drift, achieve wide coverage of plant or target area and more penetration. The optimum droplet sizes are indicated in below:

Table 1: Optimum Droplet Sizes for Different Targets

Target group	**Droplet size (microns)**
Flying insects (drift)	10-15
Crawling and sucking insect (drift)	30-50
Plants urfaces(limited drift)	60-150
Soil application (no drift) as in case of herbicide application	250-500

Table 2: Classification of spray according to volume rates

Spray application technology	**Application volume, l/ha**	
	Field crops	**Orchard crops**
High volume	600	1000
Medium volume	200 – 600	500 – 1000
Low volume	50 – 200	200 – 500
Very low volume	5 – 50	50 – 200
Ultra low volume	0.5	50

Drones in agriculture:

1. Unmanned Aerial Vehicle (Drone)

Drones are flying robots, which include unmanned aerial vehicles (UAVs) capable of flying thousands of kilometres and mini drones that can fly in confined spaces (Krijnen *et al.*, 2014; Cavoukian *et al.*, 2012). Prominent alternative terms commonly used in various parts of the world and different contexts include Remotely Piloted Aircraft (RPA), Unmanned Aerial Vehicle (UAV) and Unmanned Aircraft Systems (UAS). Drones were classified by Australian researchers (Brooke-Holland, 2012); the categorization procedure was initially based on the minimal take-off weight, as well as how and where the drones are planned to be used. Generally, drones are classified into three categories based on their aerodynamic characteristics: a) fixed-wing, b) rotary-wing and c) hybrid (Vergouw *et al.*, 2016; Mogili *et al.*, 2018). During the previous two decades, various types of drone models have been deployed. Depending on the number of rotors, a rotary-wing drone can be categorized as tricopters, quadcopters, hexacopters and octocopters that are lifted and propelled by three, four, six and eight rotors, respectively (Gonzalez-Jorge *et al.*, 2017).

In India, drones are classified into five categories based on their weight i.e. nano (<0.25 kg), micro (0.25-2.0 kg), small (2.0-25 kg), medium (25-150 kg) and large (>150 kg).The operating the drone in stable form and process the image data some hardware and software are used. The main hardware of drone is flight controller, motor/speed controllers, sensors and camera, communication system, drone airframe. Drone analytics tools enable visualization, consumption and analysis of aerial data captured by drones. Some of the most commonly used tools for drone data mapping and management include: DroneDeploy, Pix4D, ArcGIS, Drone2Map, DJI Terra, AgisoftMetashape

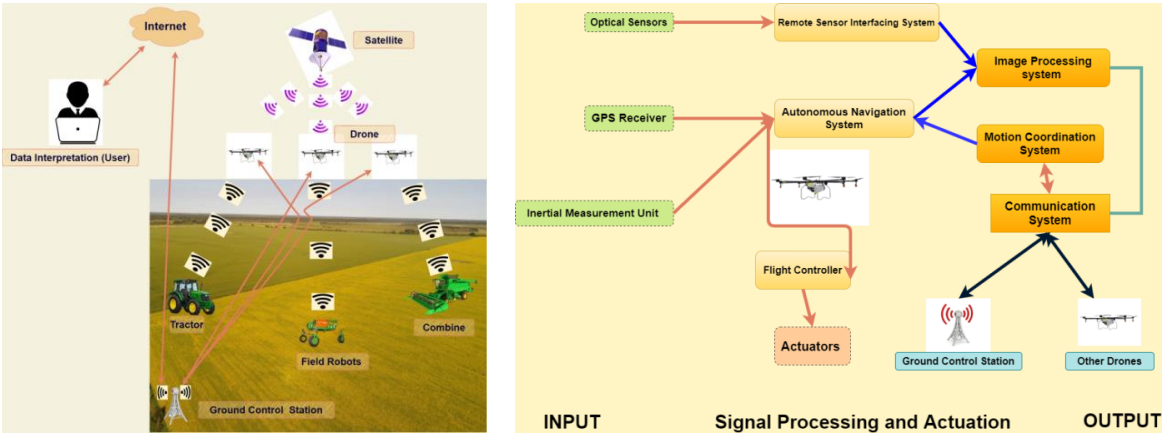
2. Status of drones use in agriculture

Agricultural drones are considered a promising technology in precision agriculture and have a great potential to address the age-old problem of acquiring real-time agricultural data for real-time monitoring in agricultural fields. Drones are now commonly used in different applications for precise application of agricultural inputs along with growth monitoring, plant health management, and yield estimation. Drones offer an enormous possibility for wider adaptability in agriculture by data acquisition, processing and enhancing the performance of monitoring systems. A drone equipped with a high temporal resolution monitoring system can fly at low altitudes to acquire images with ultra-high spatial resolution. A drone provides a non-destructive way to cover a larger field in a short time compared to ground-based

systems. There is a broad range of potential civil and commercial applications for which drones are attractive platforms. Drones are more popular in agriculture and allied sector for performing different tasks such as crop scouting, weed mapping, spraying, yield estimation, crop and water source identification, estimation of vegetation indices, crop insurance, soil analysis, health and vigour in crops, irrigation and nutrient management. Moreover, it also finds its application in forestry, fisheries, livestock management and wildlife conservation.

2.1 Working of Agricultural Drones

Drones used in agriculture collect data from geographical positioning system (GPS) and sensor-equipped farm equipment and transmit it to a ground control station (GCS) via satellite. Data is then transferred to the users over the internet for data analysis and regulation of farm implements. The working concept and real-time implementation of UAV in agriculture is shown in Fig. 1. Drones can also be used as standalone input applicator for site-specific management.



(a) (b)

Fig.1: (a) The working concept (b) Real-time implementation of UAV in agriculture

2.2 Application of Drones in Agriculture

(a) Analysis of soil, health and vigour in crops

Drones can collect data and monitor crops, giving farmers new options for monitoring crop growth and recording variations in a variety of field variables.Many recent studies have focused on crop biomass and nitrogen status, as well as yield estimation. The most frequent crop characteristic is biomass, which, when combined with information on nitrogen content, can be used to predict whether extra fertilizer or other activities are required. Furthermore, the data collected by the drones can be used to create field maps of the crop, as well as to measure various factors such as crop height, distance between rows or between plants, and Leaf Area Index (LAI). Drones have the potential to collect crop data in a consistent manner,

allowing farmers to plan crop management, input utilization (e.g., fertilizers), harvesting timetables, soil and yield illnesses, and identify any management flaws in a controlled manner. Disease detection is possible because infections cause changes in the crops' biophysical and biochemical features. Crop imaging data is used by drone-based data processing tools to assess variation in biomass and health of plants. As a result, infections can be recognized early, allowing farmers to respond to minimize losses.

(b) Irrigation and nutrient management

Drone technology can be utilized in precision agriculture to manage crop irrigation. Crop irrigation consumes 70% of the world's water, emphasizing the significance of precision irrigation. Farmers can save time and water resources by identifying regions that require extensive irrigation. At the same time, precision farming techniques can increase crop yield and quality.The field is divided into multiple irrigation zones in precision agriculture to accurately manage the resources. Using drones outfitted with the necessary sensor types, it is possible to identify areas of a crop with water and nutrient stress that demand more fertigation. Simultaneously, the aforementioned technologies enable the creation of specific maps that depict the real-time soil moisture content for efficient planning of irrigation.

(c) Remote sensing and field mapping

Drones that can fly at low altitudes be utilized in crop phenotyping and field mapping using various remote sensing approaches. Studies have established that aerial remote sensing using drone can acquire plant canopy temperature and NDVI of breeding plots effectively. Moreover, drones are becoming increasingly useful in agricultural phenotyping for high yield and real-time phenotyping of large number of test plots. Aerial-based remote sensing platforms like drones are outfitted with multispectral cameras, digital cameras, infrared thermal imagers, hyperspectral sensors and light detection and ranging (LIDAR). Drone equipped with remote sensing equipment allows growers to gather, visualize, and analyse crop and soil health conditions at various stages of production in a simple and cost-effective manner.

(d) Precision agriculture

Drones can assist PA by performing a variety of agricultural tasks including soil health scanning, irrigation schedule planning, seed planting, fertilizer application, and weather analysis. Drones provide a number of advantages over other aerial-based remote sensing platforms, including the following:

- Possibility of combining 3D canopy height and ortho-photo data

- Rapid data collection with excellent quality, range and resolution
- Capacity to acquire multi-angular data (particularly from snapshot cameras)
- Capacity to run many sensors at the same time

(e) Survey of farm lands and land use mapping

A drone can inspect a bigger area of agricultural land with much higher spatial and temporal details. Drones have been used in agriculture to produce high-resolution photographs that can distinguish individual crops and weeds on a miniature scale. Surveying the nutritional condition of soil at different soil types, nutrient ranges, and nutrient requirements within and between fields is another area where drones can be used. Drones can be used to reduce unlawful stubble burning in agricultural fields in India, where it is a big issue and a threat to the environment. Pests, insects, locusts, and army worms can all be controlled using multispectral imagery acquired through drones.

(f) Weed and pest management

Weed mapping is one of the most prominent uses of drones in precision agriculture. Weeds can cause complications during harvesting, in addition to causing problems with crop growth. To solve the aforementioned concerns, drones can be used for Site-Specific Weed Management (SSWM). Drones have previously been used to spray herbicides spatially based on weed density assessed by drone-collected hyperspectral images. Because weed plants usually grow in a few regions of the field, the field is divided into management zones, each of which receives its own treatment. Spraying drones can help reduce operator exposure while also improving the capacity to distribute chemicals in a timely and spatially resolved manner.

(g) Flood risk and environment risk assessment

Drone platforms have recently seen a rapid surge in their use for environmental monitoring. Drones produce observations in a wide range of air conditions, and their revisit time is completely configurable. Drone technology is rapidly advancing, allowing for quantitative estimation of hydraulic data such as inundated zones and surface flow measurements. Drone-borne observations have also been used to predict hydrological variables such as evaporation and evapotranspiration utilizing energy balance models using drone-borne data input of soil and vegetation. Drone-borne pictures of geomorphological variables and sediment suspension have also been researched, and surface water velocity in a river reach has been evaluated using drones.

(h) Forestry

Drones have been utilized in forestry to create an integrated information system for forest conservation. Drone technology is being used to improve forest management and operations planning, as well as to monitor illegal activity and encroachment. It also helps collect forest

metrics such as carbon sequestration, tree canopy analysis, conservation characteristics, native species tracking, biodiversity monitoring, and ecological landscape elements.

(i) Fisheries

The governments of a number of countries, including the Republic of Palau, Belize, Jamaica, and the Republic of Costa Rica, are currently using drones to detect illegal fishing and aid in the prosecution of fisheries criminals. The Belizean government is employing drones to police fishing regulations in the Glover's Reef Marine Reserve and other marine protected areas off the Belizean coast.

(j) Livestock management and wildlife conservation

Drones have been in great demand in livestock management for sanitization of farm areas as well as inside the animal sheds by spraying the sanitizers, conducting behaviour studies/phenomics and onsite delivery of semen/vaccines/medicaments/fertile eggs. Additionally, it can be utilized for animal/poultry population enumerations particularly for the nomadic/pastoralist populations, tracking the home tract as well as migration of livestock population and mapping feed and fodder grasses areas. Drones equipped with high-definition thermal cameras are also used to remotely track, check, and monitor livestock for wildlife protection. Even if poachers are hiding in thick forests, drones equipped with thermal cameras can detect their heat signatures and identify them.

3. Challenges with the use of drones in agriculture:

- **Battery life:** UAVs available today can only fly for a limited time (15-30 min) and for the uninterrupted operation of the drone, frequent charging is required.
- **Cost:** Developing UAVs are quite expensive due to the training and integration of various components, technical and deployment expertise, *etc*. This makes drones unaffordable to small and marginal farmers for agricultural purposes.
- **Licensing and legislations:** Before UAV deployment, proper licensing and legislation are necessary. The drone operators must be alert about the flight restrictions, restricted airspaces and presence of other small planes in the vicinity.
- **Balancing and stability:** UAV applications such as spraying require a change in payload continuously and this affects the balancing of the drone.
- **Weather conditions:** Weather conditions such as strong winds, precipitation, temperature, *etc.* can hinder the operation of drones. High temperature reduces the performance of the drones because of the density altitude and low-temperature causes a reduction in battery efficiency.
- **Failure-free operation:** The development of failure-free system is critical as there are possibilities of component failures due to poor quality of motors, rotors and controllers.
- **Safety and security:** Accidents, air collisions, safety and security risks are always associated with drone usage. Also, fault offset delivery in case of critical operations like the application of hazardous pesticides may cause a threat to human life.

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Selection, Operation & Cost calculation of Harvesting and Threshing Equipment

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Factors in favor of farm mechanization: -

- Timeliness of farm operations
- Increased cropping intensity
- Increased area under crop production.
- Increased productivity
- Increased labour productivity and employment generation.
- Reduced cost of production.
- Commercialization and diversification of agriculture.
- Drudgery reduction
- Improved quality of life and rural upliftment.
- Quality improvement and value addition.

Selection of Tractor:-

- Land holding - 1 hp for every 2 ha of land
- Cropping pattern - more than one crop 1.5 ha/hp
- Soil - less wheelbase, higher ground clearance, and low overall weight in light soil
- Repair facilities - Has dealer nearby
- Running Cost - Less SFC so mining cost is less.
- Initial cost and resale value - keep resale value in mind, initial cost should not be high.
- Test report - Released from farm machinery testing stations should be consulted for guidance.

Selection criteria for the machines:-

- Trademark: We cannot judge the machine by its appearance. Choose equipment of well-known and reputed trademark. It is distinguished by the mark of a trader to his goods to distinguish from other traders.
- Model: Buy the latest model with better features.
- Whether or not the machine is an approved design: BIS or ISO mark (International standard organization) (Beauro of Indian Standards).
- Repair facilities: To see whether the machine is repairable or not, how far is the service station or existence of repair shop, how easily the repair can be done?
- Availability of spare parts: Whether components of machine are easily available?
- Design features:
    - Points of wear i.e. type of bearing etc. provision for lubrication
    - Ease of adjustments i.e. disc angle, tilt angle
    - Safety provisions i.e. shielding of rotary members
    - Appearance of the machine (eye appeal, aesthetics)
    - Vibrations and noise in the machine should be low

- Ease of operation: It should not require unnecessary amount of power and labour to operate. Ease of operation may depend upon correct adjustment. Modern machines are equipped with power and hydraulic lifts and once adjusted properly they would require little effort to operate expecting steering and turning.
- Ease of adjustment: Methods and provisions for adjustments of various parts, and adjustment should be easy to make and less time consuming. Discourage the "I am in hurry attitude" to make correct adjustments.
- Adaptability of machine to work and working conditions (environment and versatility): Select the machine or tool which can work under a wide range of conditions. It must be easy to adopt the equipment to different soil, crop and environmental conditions.
- Quick change of units: For machines which are one built in unit packages and design to change them like from plough to cultivator or like multi crop planter, the time required for the changeover must be minimum.
- Maneuverability: See if the equipment is a trailed or mounted type. Mounted equipments are easy to lift and easy to turn. Trail equipment which are attached to the draw bar of a tractor cannot make sharp turns. Extended and swinging drawbars are one aid for short turning. (Articulated frames are provided in some equipment). Choose a machine with a proper size of wheels. A small wheel sinks into loose soil, drops into shallow ditches and furrows and for the tractor turning is difficult.
- Human comfort: Human comfort is an important factor in the selection and operation of equipment. The seat must be comfortable, stable and adjustable to suit different sized individuals. There should be proper operator safety provisions.

Some other factors are:

- Power requirement: Power required for operating the equipment. It determines the size of the equipment.
- Cost of operation: Initial cost and operational cost of m/c i.e. economical viability of the machine.
- Availability on custom hiring
- Years of services expected
- Economics of the equipment in relation to size of farm and work to be performed
- If possible purchase multipurpose machines with minimum adjustments for example wheel hand hoe, till planter, ridger seeder.

Selection based on performance of machine:-

Measures of performance of farm equipment are the rate and quality with which the operations are accomplished. This is generally expressed in terms of capacity as well as efficiency.

Capacity: Calculations of machine capacity involve measuring of area covered, weight of material and time. The machine capacity is normally expressed in three ways:

a. Field capacity

b. Material capacity
c. Throughput capacity

Field capacity: It is the rate of field coverage. It is also expressed in two ways:

a. Theoretical field capacity
b. Effective field capacity

Harvesting:

- ✓ It is the process of cutting and collecting the mature crop from the field. The goal of good harvesting methods is to maximize grain yield, and to minimize grain damage and quality deterioration.
- ✓ Harvesting of cereal crops, Cotton, fruit crop especially is a serious problem.
- ✓ There is a tremendous crop loss when untimely rain is experienced. Delayed harvesting causes grain shattering due to over maturity.
- ✓ The standing crop in the field can be harvested with the use of harvesting equipment may be manually operated, animal-drawn or power operated.

<u>Manual cutting and hauling:</u>

- Sickle is the most widely used harvesting tool for various crops.
- Sickle used may be plain or serrated edged and both types are found effective in cutting plants
- Capacity: 0.07 ha/person day

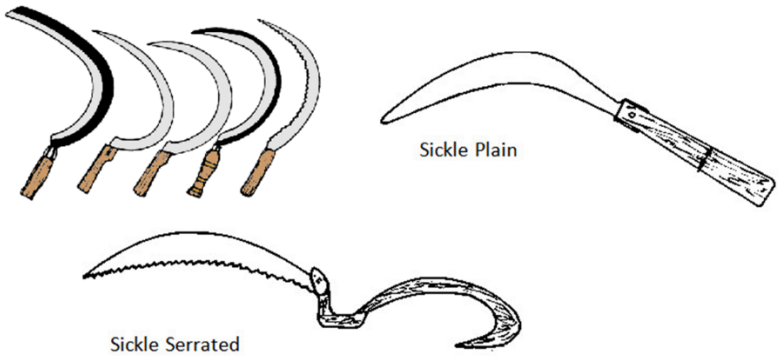

Fig: Types of sickles

Advantages-

- Effective in lodged crop
- Less weather dependent

Problems-

- ✓ High labor cost
- ✓ Labor dependent, competes with other operations in peak season

- ✓ Winnowing/cleaning necessary

Reaper:

- A front mounted vertical conveyor reaper is the most common reaper, to harvest wheat and paddy crops. It can also be used for harvesting of soybean and other similar crops.
- Engine operated reaper can be operated with a 5-6 hp engine, whereas, tractor operated reapers can be operated with 25-35 hp tractor.
- Width of cut is about 1.6 m in power tiller reaper, and about 2.05 m in tractor operated reapers.
- Power tiller and tractor-front mounted vertical conveyer reaper windrower can cover about 0.2 ha/h and 0.4 ha/h, respectively.

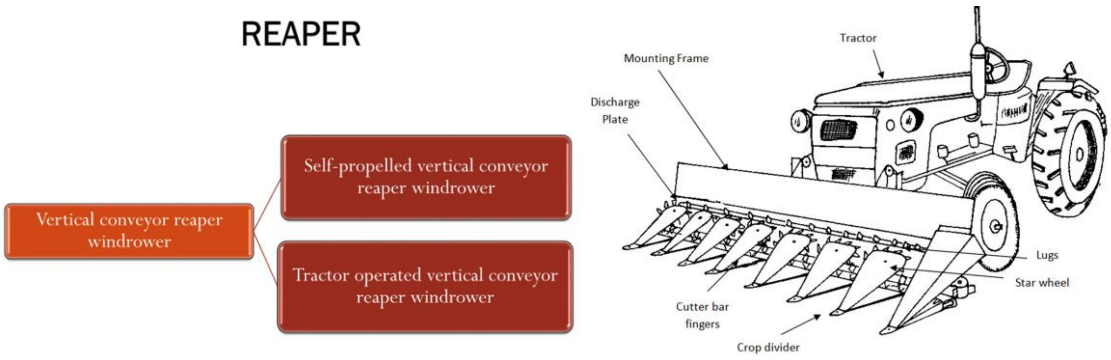

Fig: Tractor front-mounted vertical conveyor reaper-cum-windrower

<u>Self-propelled Reaper cum Binder</u>:-

The Self-propelled reaper binder is a very use full machine to complete the harvesting of wheat timely. Self-propelled reaper binder. It is suitable for harvesting cereals crops. It has a cutter bar of 1.2 m wide and is operated by 10.5 hp diesel engine. Four forward and one reverse gear are provided in the machine. Timely harvest of crops is vital to achieving better quality and higher yield of the crop. The shortages of labour during wheat harvesting season and vagaries of weather cause losses in yield. Harvesting by locally available tools causes a delay in the harvest and has a direct effect on the yield. The field capacity of the reaper is 0.3 ha/h with a field efficiency of 68%. The fuel consumption was 1.0 l/h. The labour requirement could be saved by more than 90% with the reaper.

Fig: Self-propelled Reaper cum Binder

Reaper problems and adjustments:-

Sr. No.	Part	Problem	Adjustment
1.	Reel	i) Does not rotate ii)Improper gathering of crop	i) Check tension of reel belt. Reel by hand to ensure that the drive pulley key and belt are secured. ii) Adjust height according to height of crop
2.	Cutter bar	Unsatisfactory cutting	i) Reduce forward speed ii) Correct the registration iii) Sharpen the knife sections or replace if worn out. iv) Check drive belt tension. If loose, tighten
3.	Binding & tying mechanism	i) Broken or torn twine ii) Loose or untied knot iii) Frequent untied bundles iv) Improper cutting of twine	i) Remove twine and clean needle eyelet and pliers. Reduce tension on twine under the tension plate through fly-nut ii) Tighten the twine disc with the help of spring loaded screw-bolt provided for the purpose iii) Adjust spring tension and smooth face of pliers by emmary paper. Use twine of uniform thiclmen
4.	Conveyor	i) Bundles keep collecting on conveyor ii) Conveyor slackened & bundles not conveyed at regular internal	i) Check the tension or the v-belt over the conveyor roller pulley. ii) Tighten the convas conveyor with help of the sum buckles provided
5.	Bundle size		Increase or decrease the size of bundles by increasing or decreasing the tension of trigger. For this the trigger spring is hooked on to different holes provided

Threshing: -

- The operation of detaching the grains from the ear head, cob or pod is called threshing.
- The traditional method of threshing using manual labours requires 150-230 man-h/ha. ear
- Threshing can be achieved by three methods namely rubbing, impact and stripping.
- It is basically the removal of grains from the plant by striking, treading or rupturing.

In various parts of world, threshing is accomplished by-

1. Treading the grains under the feet of animals or under the tractor tyres.
2. Striking the grains with sticks, pegs or loops and removing the grains by rubbing between stone or wooden rollers.
3. Threshing floor or between the rasp bar and a concave of combine.

Fig: Types of threshing Methods

Power thresher:-

Power thresher is a machine, which thresh the crops and performs several other functions such as:

- Feed the harvest crop to the threshing cylinder
- Thresh the grain out of the ear head
- Separate the grain from the straw
- Clean the grain
- Make 'bhusa' suitable of animal feeding

Principle-

- Based on the principle that when Impact is given on crops, the grains are separated.
- The crop mass passes through a gap between drum and concave, wearing or rubbing action takes place-separates grain from panicle.

Rupture of the bond between grains and ears is due to-

- Impact of beaters or spikes over grains
- Wearing or rubbing action

Strength of the bond between grain and panicles depends upon-

- Type of crop
- Variety of crop
- Moisture content of grain
- Ripening phase of grain

Types of Power Threshers:-

1. According to crops being threshed

- Single Crop
- Multi-crop

2. According to functional components

- Drummy
- Regular (Through-put)
- Axial flow

3. According to types of threshing cylinder

- Syndicator
- Hammer Mill or Beater type
- Spike tooth type
- Rasp bar type

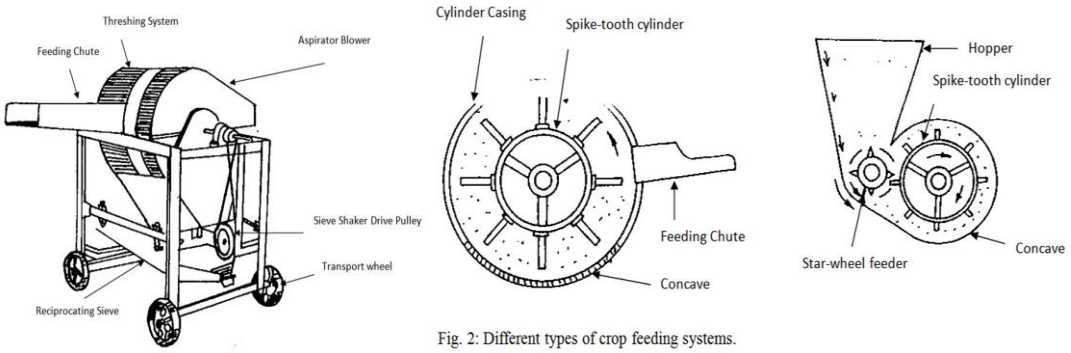

Fig. 2: Different types of crop feeding systems.

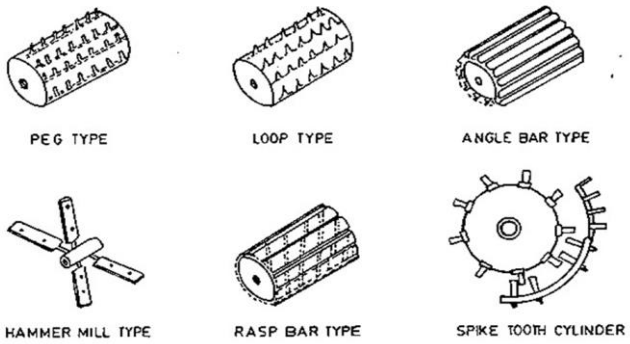

Fig. 3: Different types of threshing cylinders.

Fig: Conceptual view of Thresher

Table 1: Permissible limits of performance parameters:

Performance parameters	Permissible limits
Capacity, kg (grain)/ kW/h	>85
Threshing efficiency (%)	>99
Cleaning efficiency (%)	>98
Total losses (%)	<3
Cracked grain (%)	<2

Table 2: Recommended speeds of threshing cylinder for selected crops

Crop	Cylinder speed (m/s)
Wheat	20-30
Paddy	15-25
Jowar	12-20
Bajra	10-16
Gram	12-22
Pea	13-22
Barley	20-26

Replacement of farm machinery:

Good guidelines are available for making management decisions on when to replace the farm equipment. Important reasons for replacing a machine are:

i. Accidents have damaged the implement beyond repair
ii. Field capacity of the machine is inadequate
iii. A new machine or farm practice has made the old machine obsolete
iv. Performance of a new machine is significantly superior
v. Anticipated costs for operating the old machine exceed those for a replacement machine, and
vi. The machine is worn out.

The time of replacement decisions depends on the accumulated costs over a period of years. The annual cost curve as well as the accumulated average cost curve for a machine is shown in Fig. Both curves intersect at a point. Theoretically, the time to replace a machine is when the annual cost starts to exceed the average accumulated cost. However, machine repair rate really determines the time of replacement. One method of establishing the time of replacement is to determine that the cost per unit of use has reached its lowest value.

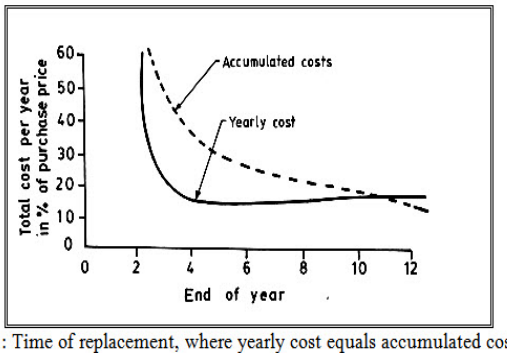

Fig. 1: Time of replacement, where yearly cost equals accumulated cost

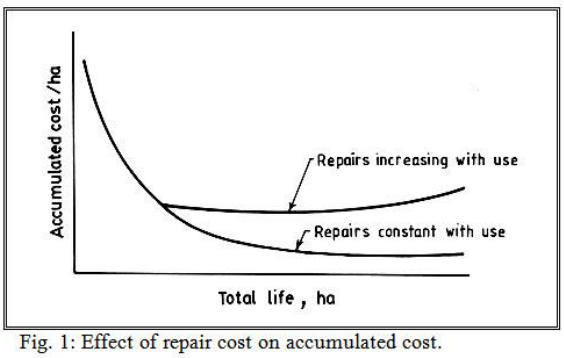

Fig. 1: Effect of repair cost on accumulated cost.

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Improved Tools and Equipment for Custom Hiring for small farms

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Introduction

Custom Hiring Centre (CHC) are basically a unit comprising a set of farm machinery, implements and equipment meant for custom hiring by farmers. The main objective of CHC is to supply of farm implements to small, marginal and poor farmers at subsidized rates on hire. This enables the small and the marginal farmers to timely carry out the farm operations by providing access to the costly farm machines at subsidized rate on hiring basis. It has been advantageous in drudgery reduction, minimizing the cost of cultivation and also creating opportunities for skilled labour. Custom hiring has facilitated efficient use of resources and applied inputs. In spite of its importance and need, farm mechanization is still beyond the reach and acceptance of many farmers in India due to various constraints perceived by them. Lack of knowledge about custom hiring centres and non-availability of machineries during peak season are the maximum constraints faced by the farmers. There is lot of tools and machinery has been developed and being utilized by custom hiring centres which are mostly tractor operated. But for small farms, Power tiller with its matching equipment are more suitable and there are machines and tools available which are operated by power tiller and suitable for small farms. Power Tiller is a tractor usually fitted with two wheels (pneumatic or steel) in which operator walking behind it or riding performs direction of travel and its control for field operations. It is also known as hand or walking or garden tractor. Power tillers are especially designed and developed for use on small and medium farm and under farming conditions where conventional four-wheel tractors are either difficult or uneconomical to use.

Features of Power Tillers

Advantages

(i) Power tillers are compact in construction and have good trafficability and suitable to go through the narrow path in the countryside. The power tillers can be conveniently operated between rows of plants in orchards.

(ii) The power tillers are light in weight and therefore, their sinkage is low on soft soils. The lightness and low centre of gravity facilitate easy operation on sloping fields and in forest areas and hills. It is not likely to overturn on hills and casualties are rare.

(iii) The power tillers have good maneuverability. Due to absence of two front wheels (as in case of four wheel tractors) and narrow wheel tread, power tillers have short turning radius. Thus less land is left untilled during field operations.

(iv) The provision for adjustment of wheel tread and narrow width of tyres of power tiller make it suitable for interculture, spraying and dusting in crops having row spacing of 30 cm or more.

(v) The power tillers are simple in construction as there are no front wheels, hydraulic system etc. In small size power tillers, the transmission system is very simple. The power tillers are easy to assemble, dismantle and maintain.

(vi) The simplicity in the construction facilitates its manufacturing even in small scale sector and thus costs less.

(vii) The power tillers are capable of performing various operations with different matching attachments like puddling, upland seedbed preparation, sowing and fertilizer application, interculture, spraying, dusting, weeding, harvesting, pit digging, transportation and various stationary jobs like water pumping, threshing, winnowing, grading, sugarcane crushing, oil expelling and grain milling etc.

Limitations:

(i) The power tillers have low horsepower thus not suited to large farms and deep tillage.

(ii) Power tillers have low tractive efficiency. The drawbar power is usually 15 to 20% of brake horsepower and thus there is high-energy requirement per unit area for tractive work.

(iii) Power tillers have high cost per drawbar power.

(iv) Lack of seating arrangement in most power tillers available in the country causes considerable fatigue to the operator.

Construction of Power Tiller

A power tiller normally comprises of an engine, power transmission, brakes, ground drive components, handles, controls and chassis. Manufacturers supply counter weights and ballast weights also as optional accessories for balancing the power tiller using operation and increasing the drawbar power, respectively.

Engine

A lightweight diesel of petrol engine of small to medium size and medium speed range is used in power tillers to generate necessary power. Most of the engines used in power tillers are water-cooled and have splash system of lubrication. Pressure type radiator working on

thermo-siphon principle achieves the cooling of engine. The power tillers equipped with air cooled engines are suitable under cold climate, where the temperature of the engine does not go very high and engine is mainly cooled because of the cold climate. Being light in weight, air cooled engines are fitted in power tillers used in hilly regions. Another reason of using air-cooled engine in hilly region is that there is no risk of freezing of cooling water due to very low temperature. However, the power tillers equipped with water-cooled engines can also be used in hilly regions depending upon the climate of particular region.

Power Tiller Matching Equipment

In an effort to enhance the utility of the power tillers number of matching equipment have been developed by various organizations in India. The brief description of few selected matching equipment is given below:

Seedbed preparation

Rotary Tiller

Generally, rotary tiller is considered as an integral part of the power tiller. The rotary tiller is an excellent equipment to prepare land for wet and dry cultivation and interculture in garden and crops with large row spacing (Fig 1). Rotary tillers have proved an ideal device for uprooting, shredding and mixing of sugarcane stumps and interculture in forest plantation. The rotary tiller consists of a transverse shaft on which knives or tynes are mounted to cut the trash and soil. Normally two shapes of tynes or knives are use on power tillers. The hook or pointed tynes are suitable for deep tillage in relatively clean ground, but clogging and wrapping of trashes on the tynes and shafts of rotary tiller are likely to occur when heavy cover crops are encountered. The L-shaped knives are better for trashy conditions for weed control and where deep penetration is not required. The effective field capacity of the rotary tiller during seedbed preparation if 0.10 ha/h. The depth of seddbed preparation is about 10 cm.

Fig 1.CIAE light weight power tiller during rotatilling operation

CIAE Light Weight Power Tiller

One lightweight power tiller has been developed at Central Institute of Agricultural Engineering, Bhopal. The light weight power tiller is provided with petrol start kerosene run engine of 3.75kW, friction clutch to facilitate engagement and disengagement of power from engine to gear box, two speed gear

Fig 2. CIAE light weight power tiller during puddling operation

box, power transmission system and rotary tilling unit of 30 cm width having fourteen L-shaped tines and two pneumatic lugged wheels. Slat type steel wheels of 4.5" x10" size can be used for puddling operation for better traction in saturated soils. The power tiller is equipped with two handles, speed control lever, main clutch lever and two levers fitted on handles for turning the power tiller on either side, one rotary engaging lever and tail wheel for depth adjustment during operation. Height of handles can be adjusted according to the requirement of the operator.

Seedbed preparation for paddy crop

The light weight power tiller was used for puddling operation for transplanting of the paddy crop. The average bulk density of saturated soil before and after puddling operations was 0.91 g /cc and 0.66 g/cc, respectively. The weed intensity before puddling operation was 44.97 g/m^2 (dry weight basis) with average height of weed plants of 41.75 cm. No weeds were found after two operations of power tiller rotary tiller. The power tiller was operated at the forward speed of 2.41 km/h. The effective field capacity was 0.096 and 0.11 ha/h during first and second operation of the power tiller rotary tiller. Thus total time required to complete two puddling operations was 19.51h/ha. The puddling index was 54.45%. The average depth of puddle land was 139.1 mm. The fuel consumption was 1.55 l/h (kerosene).

Sowing and planting equipment

Till - plant machine

The power tiller till-plant system can perform the job of rotatilling as well as sowing of seeds of wheat, bengalgram, soybean, sorghum, paddy, safflower, sunflower and similar seeds and application of fertilizer simultaneously (Fig 3). The operator can sit on the seed box without any inconvenience. The till plant machine was tested in the laboratory and field for sowing wheat, bengalgram and soybean crops. The depth of seed placement varied from 7.0 to 9.0 cm for sowing of wheat, bengalgram and soybean crops, the effective field capacity of the till-plant system varies from 0.085 to 0.120 ha/h depending upon the row spacing of the crop. The average fuel consumption was recorded as 1.25 l/h.

Fig 3: Power tiller operated till-plant machine

Seed-cum-fertilizer drill

The CIAE seed-cum-fertilizer drill can sow the seeds of wheat, paddy, bengalgram, greengram, blackgram, pigeonpea, soybean, sorghum, safflower, sunflower and similar seeds

(Fig 4). The machine can be operated in heavy and light soils. The machine can drill the seeds with reasonably good accuracy.

Fig 4: Power tiller operated seed cum fertilizer drill

Plant protection equipment

Boom sprayer

Boom sprayer attachment mounted in the front part of the power tiller can be used for spraying chemicals in the field crops. It consists of a reciprocating pump mounted in the central part of the power tiller above the clutch pulley. Power is derived from the clutch pulley of the power tiller. Chemical tank is kept on power tiller below the handles by removing rotavator. Nine to twelve nozzles can be fitted on 5 m long boom depending upon the row spacing of the crop. The effective field capacity of the boom sprayer is 0.31 ha/h at a forward speed of 1.5 kmph.

Fig 5: Power tiller operated boom sprayer

Tall tree sprayer

Tall tree sprayer consists of ASPEE triplex pump, pressure gauge and by-pass valve-cum-pressure regulator (Fig 6). The spraying system is mounted in the front part of the power tiller. The storage tank of 200-litre capacity is placed in the trailer of the power tiller. Spraying is performed by hand with 18 m long three aluminum pipes fitted with spray lance and nozzles. The machine can be used for spraying chemical in orchards. Capacity of the sprayer varies from 10 to 15 trees/hour for trees of medium canopy. The maximum height of reach of the chemical is 7.0 m. The average fuel consumption is about 1.00 l/h. Approximate cost of the sprayer with pump is about Rs. 15000/-.

Fig 6: Power tiller operated tall tree sprayer

Orchard sprayer for small trees

This orchard sprayer can be mounted in the rear part of the power tiller. The machine is suitable for spraying of chemicals in orchards like grapes, pomegranate and citrus etc). The machine consists of two elliptically shaped booms of 1350 mm length. The boom covers half of the tree canopy on either side of the sprayer. Each elliptically shaped boom consists of four hollow cone nozzles. The machine has the provision to adjust the boom

length of 1000 mm for grapes and 1300 mm for citrus and pomegranate orchards. The sprayer can be adjusted for working width of 2000 mm for grapes and 3500 mm for citrus and pomegranate orchards depending upon the row spacing and canopy condition. The machine can be operated easily at the forward speed of 0.8 kmph and at liquid pressure of 15 to 20 kg/cm^2.The effective field capacity of the machine is 1.0 ha/h for grapes and 0.5 ha/h for citrus and pomegranate. Average fuel consumption is 1.10 l/h. Labour requirement is 2 man-h/ha for grape orchards and 4 man-h/ha for pomegranate and citrus orchards. Approximate cost of the sprayer with pump is Rs. 20,000/-.

Harvesting and threshing equipment

Vertical conveyer reaper

The vertical conveyor reaper can be mounted in the front part of the power tiller (Fig 7). It consists of 1.6 m size cutter bar, crop row divider with star wheels, conveyor belt with lugs and crop retaining springs. Power is taken from the engine of the power tiller for operating various mechanisms. There is provision of power cut off to stop the reaper cutter bar without stopping the engine. The machine is suitable for harvesting of the cereal crops. The effective field capacity of the machine varies from 0.225 to 0.300 ha/h at the operating speed of 2.50 to 3.00 kmph. The variation in the field capacity depends upon the speed of operation and skill of the operator. About 35 to 40 man- h/ha are required for harvesting and collection of the crop. Average fuel consumption of 1.00 l/h was measured during field-testing. Approximate cost of the machine is Rs. 30,000/-.

Fig 7: Power tiller operated vertical conveyor reaper

Potato digger

The potato digger developed at TNAU, Coimbatore can be mounted in the rear part of the power tiller. The unit consists of a ridger type digger bottom of 38.5 cm size. The digger bottom can be attached to plough shank by replacing mould board unit. The effective field capacity of the digger is 0.40 ha/day when operated at the forward speed of 1.40 kmph. The working depth and working width of the digger are 21.0 cm and 40.0 cm with approximate damage to the potato of about 1.40%. The percentage of undug potato are 14.0% approximately. The average fuel consumption of 1.0 l/h was recorded during evaluation of the machine. The cost of the potato digger is about Rs. 6000/-

Paddy thresher

The hold-on type paddy thresher consists of one threshing cylinder with wire loops (Fig 8). The shaft of threshing cylinder gets power from the clutch pulley of the power tiller. The threshing is done by holding the butts of the plants and exposing the ear heads to the rotating cylinder. Speed of threshing cylinder can be controlled by power tiller throttle. The capacity of the thresher is about 3.00 q/h with threshing efficiency of 98.5%. Four labourers are required to operate the thresher.

Fig 8: Power tiller operated hold on type thresher

Agro-forestry/ social forestry equipment

Auger digger

The auger digger attachment is mounted in the rear part of the power tiller is used to dig pits for transplanting forest and orchard seedlings (Fig 9). Power is transmitted from the engine pulley to rotate the digger at speed of 110 rev/min. The auger digger has rack and pinion arrangement for up and down movement of spiral auger to dig pits. The rotating auger is moved up and down by means of an auxiliary handle. The cutting edge mounted on the lower most part of the spiral unit is replaceable .The cutting edge is projected 4.0 cm outside the surface of the spiral for the reduction of the friction between the outer surface and walls of the pits. The auger digger has the capacity to dig 50 to 60 pits of 30.0 cm diameter and 45.0 cm depth in one hour. Fuel consumption is approximately 0.800 l/h.

Fig 9: Power tiller operated auger digger

Tree felling machine

The tree-felling machine consisted of 45 cm serrated disc saw, sliding mechanism, two gearboxes and lead screw (Fig 10). The machine is mounted in the front part of the power tiller. The saw is rotated at the speed of 2100 rev/min. During operation rotating saw can be moved forward and back ward with the help of lead screw and wheel handle. It can harvest 30 to 40 trees in one hour with a stem diameter of 20.0 cm. The fuel consumption is about 1.20 l/h.

Fig 10: Power tiller operated tree felling machine

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Web-based Software for cost calculation of farm machinery package

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Custom Hiring Business Model

Day by day farm machinery not only becoming costlier but also it is difficult to maintain the purchased machinery. Therefore, the trend of purchasing the farm machinery by individual farmer is moving towards package of machinery by group of people or who have the money and resources. The selection of package of farm machinery to establish a farm machinery custom hiring centre is not only difficult but also an intelligent decision which depends not only on cost but also on other parameters. The cost involved in owning and operating any farm machinery can be divided in three parts- the initial cost when the machine is first purchased, the repair costs necessary to maintain it in efficient running order and the running costs which comprise fuel servicing costs. The other parameters are – region, area covered, soil type and crops grown in that area.The major problem of selection of farm machinery based on various parameters has been addressed developing suitable software for various calculations and selections. The developed software can take the inputs in the form of – name of state and agro-climatic region. On selection of these two parameters, districts covered as well as soil and crops grown are linked. Based these inputs, a complete package of machinery is recommended by the software for the selected region. If the recommended package seems to be correct the no problem other wise a customized package can be formed. Once the package is finalized, calculations for fixed cost, variable cost and custom hiring rates are calculated. If the calculated custom hiring rates are more than prevailing marketing rates than software warns the user and also suggest the remedy how the custom hiring rates can be brought to prevailing market rates.

As soon as the custom hiring rates are finalized, values of payback period, break even point and net return are calculated. These calculated values are further utilized to get the economic analysis and annual recurring cost of selected package. Getting these values, critical economic terms – net present worth, cost benefit ratio and internal rate of return are calculated to decide the feasibility of the selected package. Finally, calculations for repayment of bank loan in terms of period and debt service coverage ratio are calculated. The developed software is found to be very useful in calculation of various economic values and decision making for establishment of custom hiring centre for farm machinery.

Design of the Software

A long discussion was held with farm machinery expert, economist and interested peoples who are willing to establish the Farm Machinery Custom Hiring Centre. The broad guide

lines were formed and on the basis of this, a logical and physical design of the software was finalized. Once the design of the software was completed, basic assumptions were framed on which software needs to be developed.

Basic Assumptions

Though the basic assumptions were formulated but it is kept in mind that assumptions can get change with time, therefore, provision for changing these has been made. The following basic assumptions were considered for development of software:

A. Fixed cost:

1. Method: Straight line
2. Interest rate: 9-14% of purchased price
3. Taxes: 1% of purchased price
4. Insurance: 0.25% of purchased price
5. Shelter: 0.75% of purchased price

B. Variable cost:

1. Repair & maintenance: 1-4% of purchased price
2. Diesel consumption: 4.5 l/h for tractor & 10 l/h in combine, Diesel cost Rs. 54/l
3. Engine oil, filter & lubricant: 20% of diesel cost
4. Operator's cost: Rs. 25/h
5. Labour cost: Rs. 20/h

C. Managerial/supervision cost: 10% of (A+B)

D. Total cost: (A+B+C)

Development of Software

The software is developed using .NET plate form and MySQL as backend and ASP/Java as front end.

The .NET Framework is a technology that supports building and running the next generation of applications and XML Web services. The .NET Framework is designed to fulfill the following objectives:

- To provide a consistent object-oriented programming environment whether object code is stored and executed locally, executed locally but Internet-distributed, or executed remotely.
- To provide a code-execution environment that minimizes software deployment and versioning conflicts.

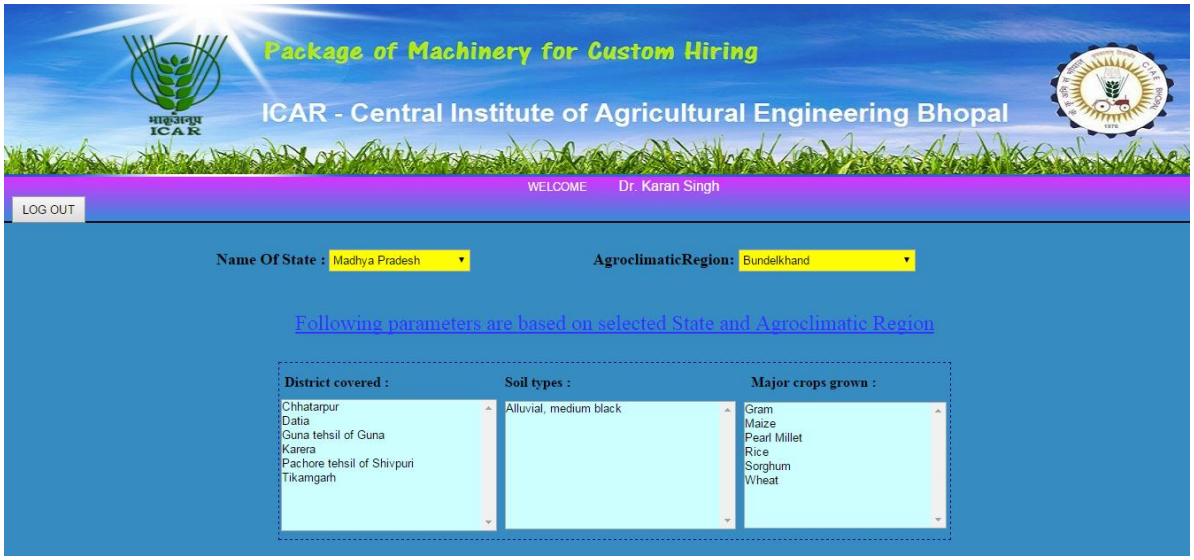
- To provide a code-execution environment that promotes safe execution of code, including code created by an unknown or semi-trusted third party.
- To provide a code-execution environment that eliminates the performance problems of scripted or interpreted environments.
- To make the developer experience consistent across widely varying types of applications, such as Windows-based applications and Web-based applications.
- To build all communication on industry standards to ensure that code based on the .NET Framework can integrate with any other code.

The link for the software is available on CIAE Website. By clicking on the link following home page is displayed. The user needs to be registered on this website by clicking on Login button. Once the user gets registered, the user name and password is sent on the registered e-mail ID. After Login, user can access the all the screens and options available in the software.

The main screen has different options such as name of state, agro-climatic region, districts covered, major crops grown and soil types. To operate the software following steps need to be followed:

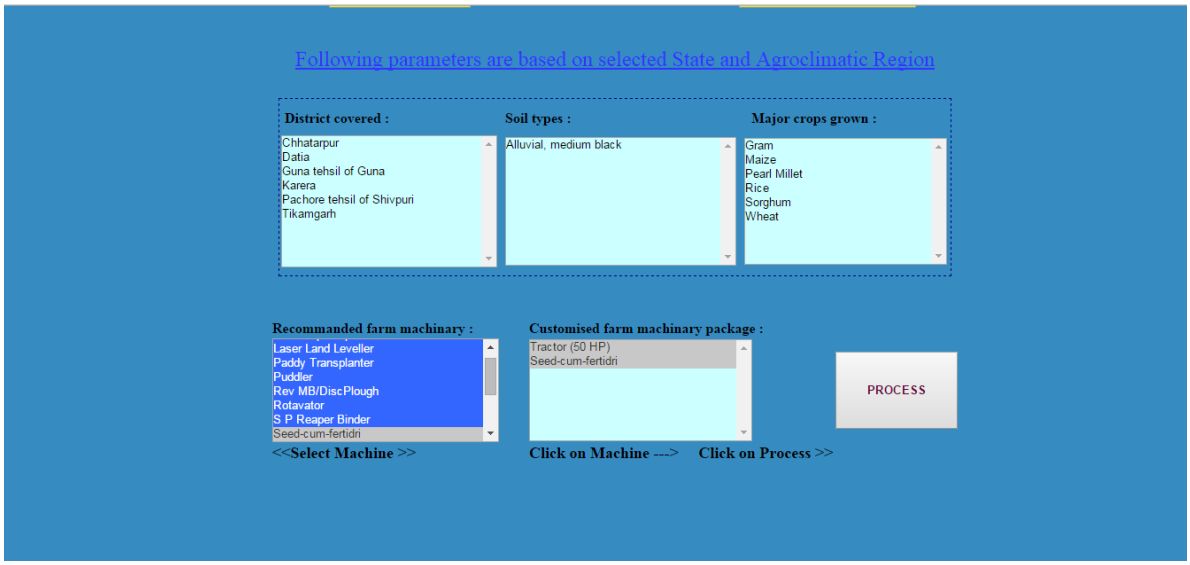
1) Select Name of State
2) Select agro-climatic region

Once these two parameters are selected; districts covered, major crops grown and soil types in the selected area appears and a recommended Farm Machinery Package also appears in the list box “Recommended Farm Machinery Package”.



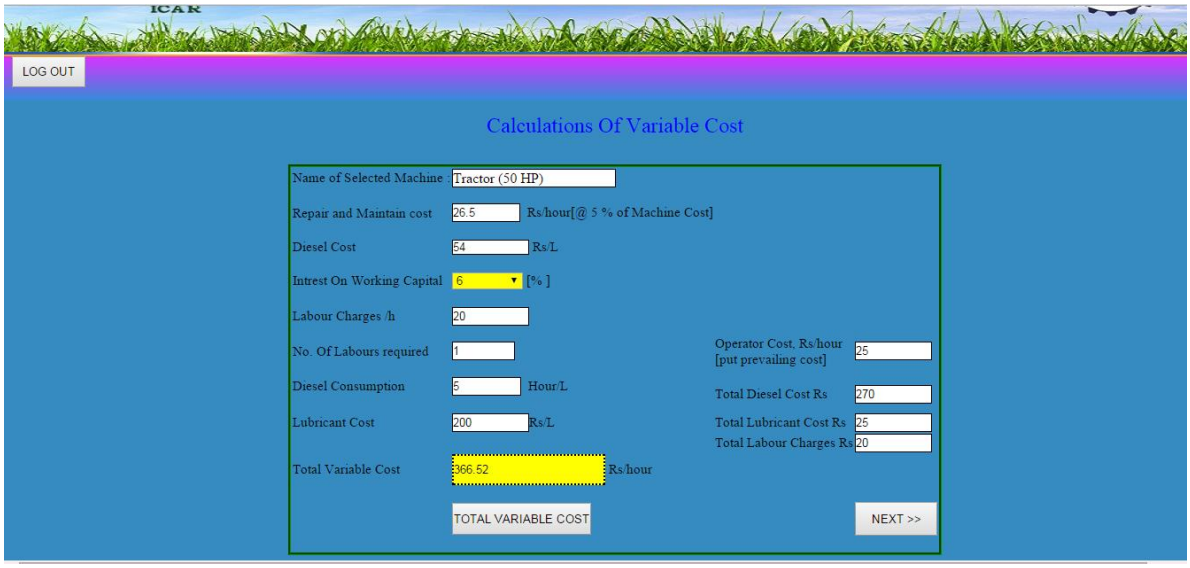
Machines form this box can be shifted to the "Customised Farm Machinery Package" by clicking one by one. Once the machine selection process is completed, calculation process for different parameters starts by clicking any machine.

The calculations are required to be done for each and every machine appearing in the box "Customised Farm Machinery Package".



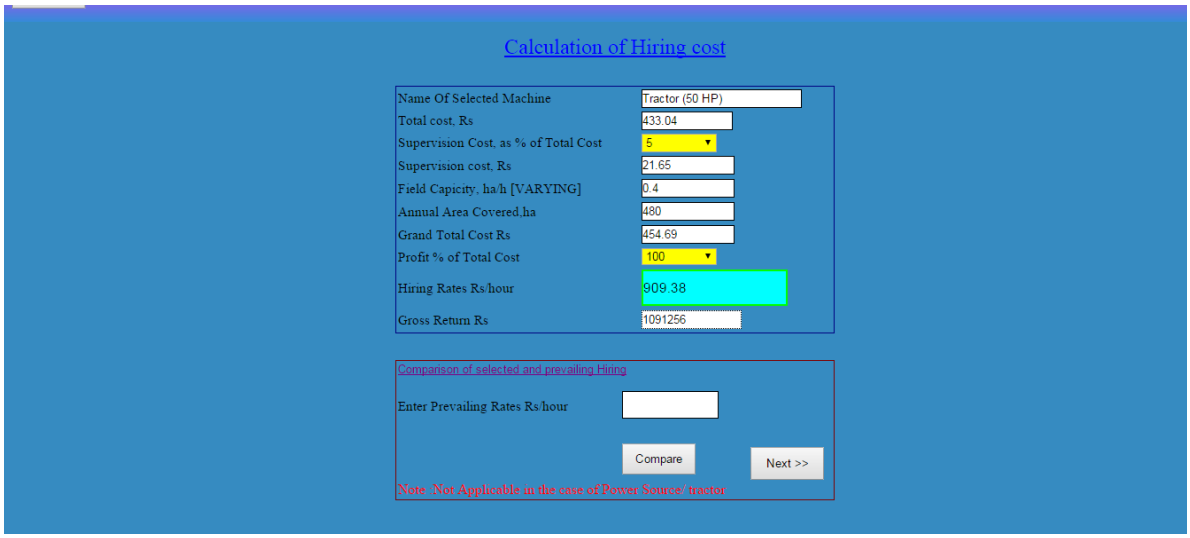
By clicking on any machine, screen for "Fixed cost calculation" appears as shown below. Some of the values such as Name of selected machine, Cost of machine, Annual use and Life of machine appear which are taken form database. As soon as Rate of interest is selected from Combo box, Depreciation is calculated. By clicking on "Total Fixed Cost", Total fixed cost in Rupees per hour is calculated. After calculating the fixed cost, click on "Next" button to get "Variable cost calculation" screen.

The "Variable cost calculation" screen appears as shown below. Some of the values such as Name of selected machine, repair and maintenance cost, diesel consumption, diesel cost, operator cost, lubricant cost, labour required, labour charges appear which are taken from database. At most of the places, the option for changing the values appearing from database has been provided. By clicking on "Variable Cost Calculation" button, Variable cost in Rupees per hour is calculated. By clicking on "Next" button, screen for calculation of hiring rate appears.

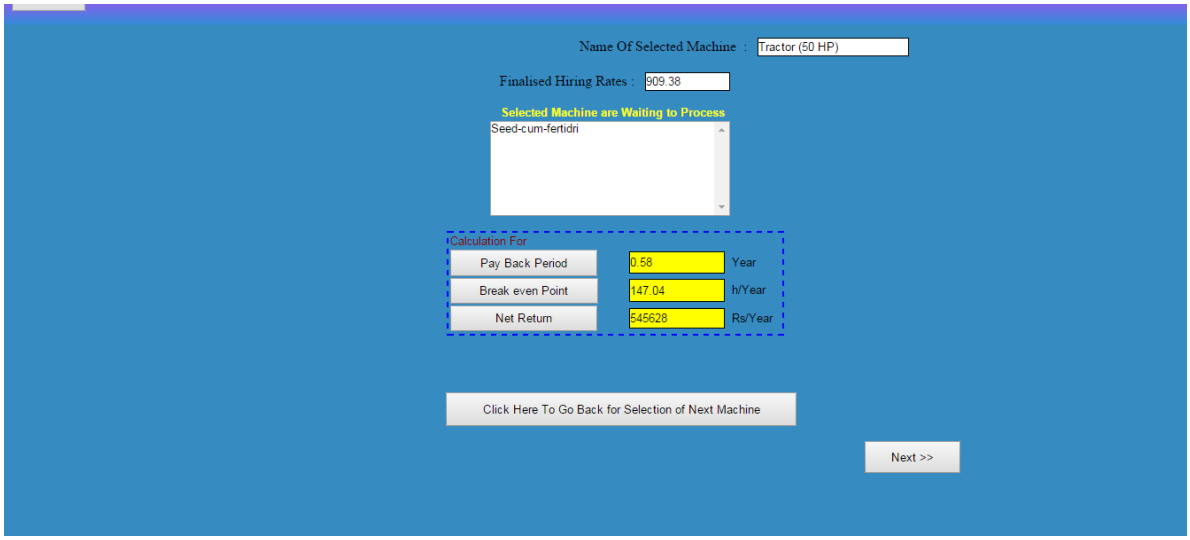


The "Calculation for hiring rates" screen appears as shown below. Some of the values such as Name of selected machine, total cost, field capacity, annual area covered appear which are calculated/taken from database. There are two combo boxes provided for calculation of Supervision cost and profit percentage of total cost, values can be selected from these boxes. On selection of Profit percentage, hiring rates are calculated. The option

for comparing the calculated and prevailing hiring rates has been provided. If calculated hiring rates are less than prevailing market rates, message "You may proceed" appears otherwise the message "Please reduce the profit percentage or increase the annual use hours of machine" appears. By clicking on "Next" button, screen for calculation of Payback period, Break even point and Net return appears.

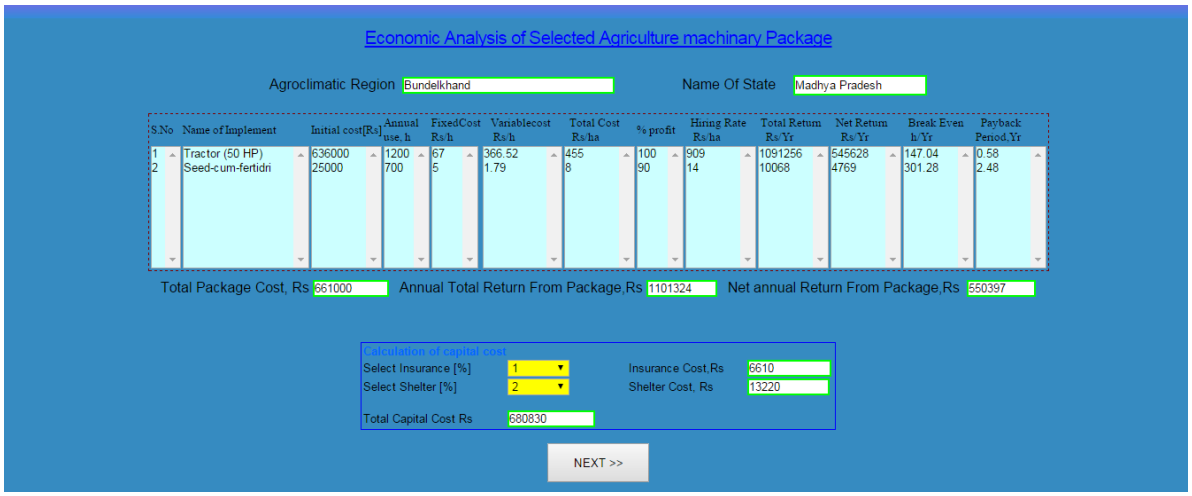


The "Calculation for PBP, BEP, Net Return" screen appears as shown below. Some of the values such as Name of selected machine, finalized hiring rates from previous screens appear. By clicking on "Pay Back Period", "Break Even Point" and "Net Return", the values for PBP, BEP, Net Return are calculated.



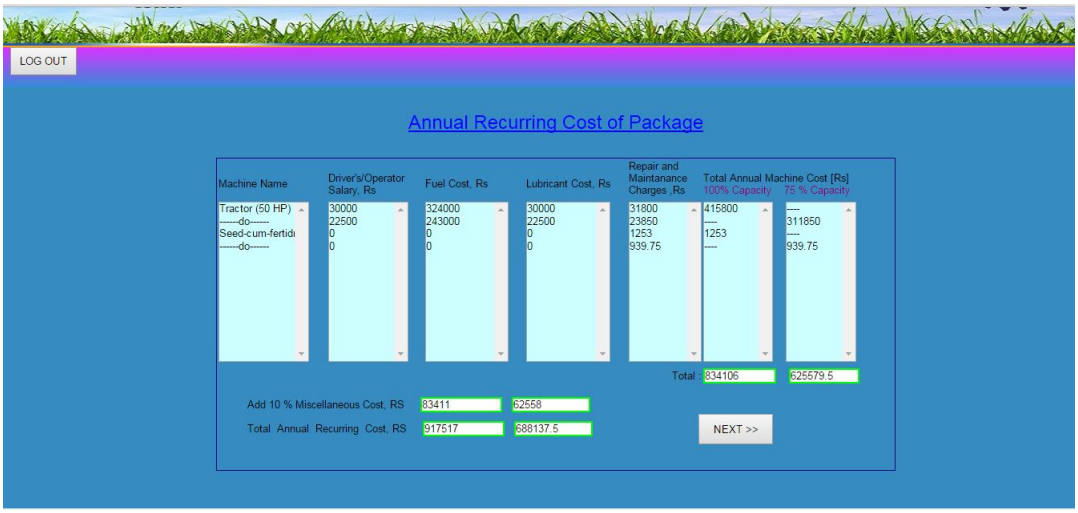
Coming up to this screen, calculations for one selected machine is over. The option for "Selection of another machine" has been provided, by clicking on this button control moves to the main screen from where you can start calculations for another machine. By repeating

the same process calculations for all the machines are required to be completed. By clicking on “Next” button, screen for calculation of complete package cost and economic analysis appears.

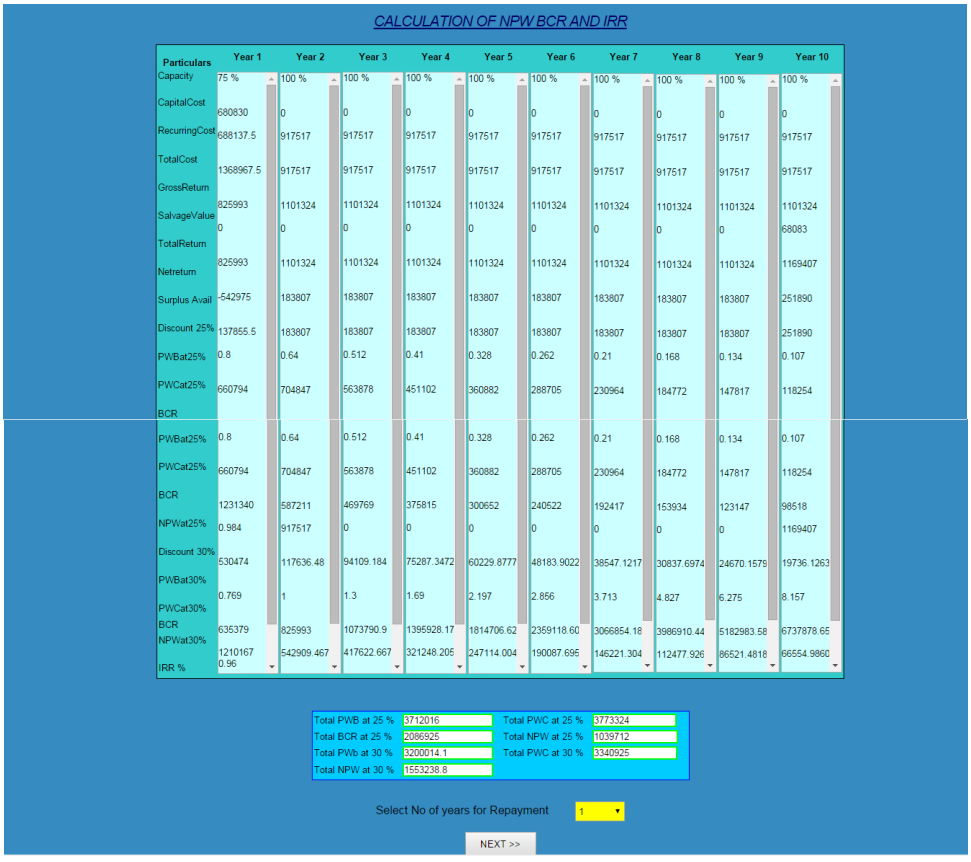


The “Economic Analysis of Selected Agricultural Machinery Package” screen shows details about name of state, agroclimatic region, name of implements, intial cost, annual use, fixed and variable cost, percentage of profit, hiring rate, total return, net return, break even and payback period. The values of all these variables are displayed for all the selected machineries, finally the total package cost along with annual total return from package and net annual return from package is calculated. The values of insurance percentage and shelter cost percentage are required to be selected from the available combo boxes to get the Total Capital Cost of the package. By clicking on “Next” button, screen for calculation of “Annual recurring cost of package” appears.

The “Annual recurring cost of package” screen shows details about name of implements, driver/operator salary, fuel cost, lubricant cost and repair and maintenance cost. Once these costs are calculated, total annual machine cost at 100% and 75% capacity for all the selected machineries are calculated. The 10% miscellaneous cost is added to total annual machine cost to get Total Annual Recurring Cost. By clicking on “Next” button, screen for calculation of “NPW, BCR and IRR” appears.

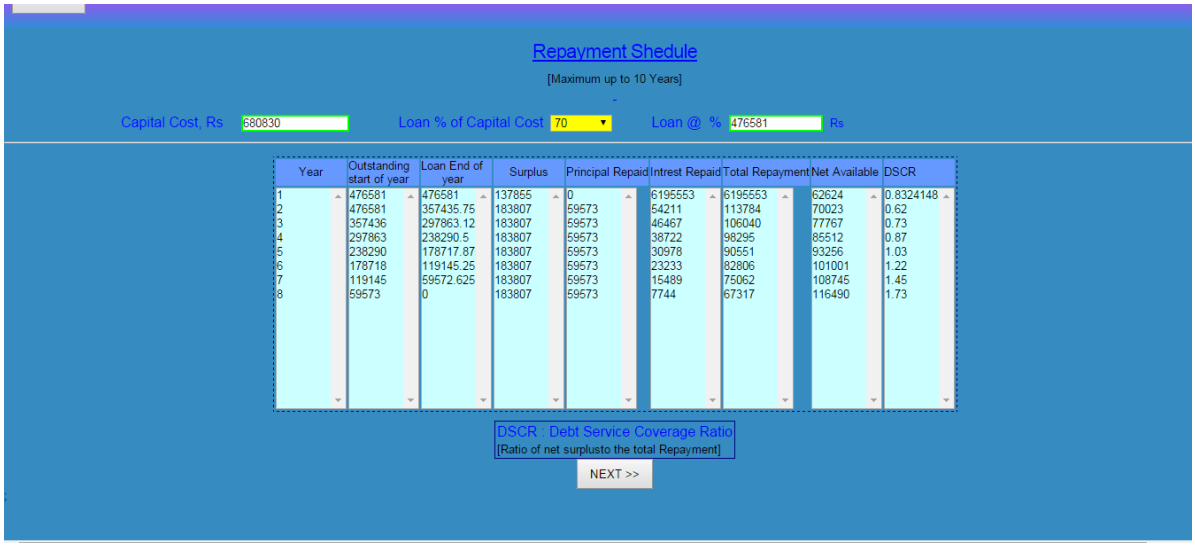


The "NPW, BCR and IRR" screen shows details about year-wise details of capacity, capital cost, recurring cost, total cost, gross return, salvage value, total return, net return, surplus available, discounting values of PWB, PWC at 25% and 30%, BCR and IRR. The various critical values of parameters appear on this screen which helps in decision making. Normally, banks provide loan maximum up to 10 years, therefore, option for selection of years for payment has been provided on this screen.



By clicking on "Next" button, screen for calculation of "Repayment schedule" appears.

The “Repayment schedule” screen shows capital cost and details about year-wise outstanding loan, surplus, principal repaid, interest repaid, total repayment, net available and debt service coverage ratio. The option for selection of loan percentage of capital cost can be selected to get the value of loan.



By clicking on “Next” button, screen for calculation of “Feasibility report of the project” appears.

The “Feasibility report of the project” screen shows details about BC Ratio, IRR, NPW and finally feasibility report of the machinery package is generated using calculated parameters.

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Business Planning and Licensing Procedure

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What is Business planning

The planning means making decision in advance for onward action to accomplish the assigned task. Planning is an important function of management; it tells the manager where the organization should be headed. It also helps the organization reduce uncertainty. Planning requires innovation, creativity and multi-tasking from the managers. Planning is a function that managers of all levels must perform, i.e upper, middle and lower management. Following are the important functions of the planning :

1. Planning provides a sense of direction

Planning means coming up with a predetermined action plan for the organization. It actually states in advance what and how the work is to be done. This helps provide the workers and the managers with a sense of direction, guidance in a way. Without planning managerial actions would be uncoordinated and unorganized.

2. Planning reduces uncertainty

Planning not only sets objectives but also anticipates any future changes in the industry or the organization. So it allows the managers to prepare for these changes, and allow them to deal with the uncertainties. Planning takes into consideration past events and trends and prepares the managers to deal with any uncertain events.

3. Planning reduces Wastefulness

The detailed plans made keep in mind the needs of all the departments. This ensures that all the departments are on the same page about the plan and that all their activities are coordinated. There is clarity in thought, which leads to clarity in action. All work is carried out without interruptions or waste of time or resources.

4. Planning invokes Innovation

Planning actually involves a lot of innovation on the part of the managers. Being the first function of management it is a very difficult activity. It encourages the manager to broaden their horizons and forces them to think differently. So the managers have to be creative, perceptive and innovative.

5. Decision making becomes easier

In business planning the goals of the organization have been set, an action plan developed and even predictions have been made for future events. This makes it easier for all managers across all levels to make decisions with some ease. The decision-making process also becomes faster.

6. Establishes standards

Once the business planning is done, the managers now have set goals and standards. This provides the manager's standards against which they can measure actual performances. This will help the organization measure if the goals have been met or not. So planning is a prerequisite to organizing, coordinating, communicating and controlling the business factors.

How to prepare a good business plan

A good business plan has ten key components, all of which are necessary if proprietor wants his business plan to be a success. The first five components of a business plan provide an overview of the business opportunity and market research to support it. The remaining five components of the plan focus mainly on strategy, primarily the marketing, operational, financial and management strategies that that firm will employ.

The key components include the following:

- A description of the company's desired strategic positioning
- Detailed descriptions of the company's product and service offerings and potential product extensions
- Descriptions of the company's desired image and branding strategy
- Descriptions of the company's promotional strategies
- An overview of the company's pricing strategies
- A description of current and potential strategic marketing partnerships/ alliances

Marketing Plan. The marketing plan details one's strategy for penetrating the target markets.

Importance of Marketing Mix

The marketing mix is a remarkable tool for creating the right marketing strategy and its implementation through effective tactics. The assessment of the roles of your product, promotion, price, and place plays a vital part in your overall marketing approach. Whereas the marketing mix strategy goes hand in hand with positioning, targeting, and segmentation. And at last, all the elements, included in the marketing mix and the extended marketing mix, have an interaction with one another.

Marketing Mix is a set of marketing tool or tactics, used to promote a product or services in the market and sell it. It is about positioning a product and deciding it to sell in the right place, at the right price and right time. The product will then be sold, according to marketing and promotional strategy. The components of the marketing mix consist of 4Ps Product, Price, Place, and Promotion. In the business sector, the marketing managers plan a marketing strategy taking into consideration all the 4Ps. However, nowadays, in the marketing mix 3 more Ps have been introduced which are – i) People who are knowledge workers, experienced and skilful ii) Process to be well structured and timely verified business process to avoid mistakes to ensure cost reduction and competitiveness iii) Physical evidence of the product or service may be identified by trademark/service mark etc.

The 4 Ps of Marketing

Product in Marketing Mix:

A product is a commodity, produced or built to satisfy the need of an individual or a group. The product can be intangible or tangible as it can be in the form of services or goods. It is important to do extensive research before developing a product as it has a fluctuating life cycle, from the growth phase to the maturity phase to the sales decline phase.

A product has a certain life cycle that includes the growth phase, the maturity phase, and the sales decline phase. It is important for marketers to reinvent their products to stimulate more demand once it reaches the sales decline phase. It should create an impact in the mind of the customers, which is exclusive and different from the competitor's product. There is an old saying stating for marketers, "what can I do to offer a better product to this group of people than my competitors". This strategy also helps the company to build brand value.

Price in Marketing Mix:

Price is a very important component of the marketing mix definition. The price of the product is basically the amount that a customer pays for to enjoy it. Price is the most critical element of a marketing plan because it dictates a company's survival and profit. Adjusting the price of the product, even a little bit has a big impact on the entire marketing strategy as well as greatly affecting the sales and demand of the product in the market. Things to keep on mind while determining the cost of the product are, the competitor's price, list price, customer location, discount, terms of sale, etc.,

Place in Marketing Mix:

Placement or distribution is a very important part of the marketing mix strategy. We should position and distribute our product in a place that is easily accessible to potential buyers/customers.

Promotion in Marketing Mix:

It is a marketing communication process that helps the company to publicize the product and its features to the public. It is the most expensive and essential components of the marketing mix, that helps to grab the attention of the customers and influence them to buy the product. Most of the marketers use promotion tactics to promote their product and reach out to the public or the target audience. The promotion might include direct marketing, advertising, personal branding, sales promotion, etc.

Operations / Design and Development Plan. These sections detail the internal strategies for building the venture from concept to reality, and include answers to the following questions:

- What functions will be required to run the business?
- What milestones must be reached before the venture can be launched?
- How will quality be controlled?

Management Team. The management team section demonstrates that the company has the required human resources to be successful. The business plan must answer questions including:

- Who are the key management personnel and what are their backgrounds? What management additions will be required to make the business a success?
- Who are the other investors and/or shareholders, if any?
- Who comprises the Board of Directors and/or Board of Advisors?
- Who are the professional advisors (e.g., lawyer, accounting firm)?

Financial Plan. The Financial Plan involves the development of the company's revenue and profitability model. It includes detailed explanations of the key assumptions used in building the model, sensitivity analysis on key revenue and cost variables, and description of comparable valuations for existing companies with similar business models.

In addition, the financial plan assesses the amount of capital the firm needs, the proposed use of these funds, and the expected future earnings. It includes Projected Income Statements, Balance Sheets and Cash Flow Statements, broken out quarterly for the first two years, and annually for years 1-5. Importantly, all of the assumptions and projections in the financial plan must flow from and be supported by the descriptions and explanations offered in the other sections of the plan. The Financial Plan is where the entrepreneur communicates how he/she plans to "monetize" the overall vision for the new venture.

Ancillary Plan under Appendix. The Appendix is used to support the rest of the business plan. Every business plan should have a full set of financial projections in the appendix, with the summary of these financials in the executive summary and the financial plan. Other

documentation that could appear in the appendix includes technical drawings, partnership and/or customer letters, expanded competitor reviews, customer lists as ancillary plans.

Further, the remaining five elements are as follows:

1. Executive Summary. It provides a succinct synopsis of the business plan, and highlights the key points raised within. The executive summary must communicate to the prospective investor the size and scope of the market opportunity, the venture's business and profitability model, and how the resources/skills/strategic positioning of the company's management team make it uniquely qualified to execute the plan. The executive summary must be compelling, easy-to-read, and no longer than 2-4 pages.

2. Company Analysis. This section provides a strategic overview of the company and describes how the company is organized, what products and services it offers/will offer, and goes into further detail on the company's unique qualifications in serving its target markets.

3. Industry Analysis. This section evaluates the playing field in which the company will be competing, and includes well-structured answers to key market research questions such as the following:

What are the sizes of the target market segments?

What are the trends for the industry as a whole?

With what other industries do one's firm services compete?

4. Analysis of Customers. The Customer Analysis section assesses the customer segment(s) that the company serves. In this section, the company must convey the needs of its target customers. It must then show how its products and services satisfy these needs to an extent that the customer will pay for them

5. Analysis of Competition. This section defines the competitive landscape of one's business. It identifies who the direct and indirect competitors are, assesses their strengths and weaknesses and delineates one's company's competitive advantages.

Business planning under agri business (AC and ABC) ventures

As far as agri clinic and agri business (AC and ABC) ventures under business planning are concerned, the scheme is to create gainful self-employment opportunities to unemployed agricultural graduates, agricultural diploma holders, intermediate in agriculture and biological science graduates with PG in agri-related courses. However, under such scheme there could be number of good business proposals for aspiring entrepreneurs to incubate in association with CIAE who can venture in to variety of business opportunities. These are classified under four categories (A to D).

A. Agricultural Machinery based Business Incubation Centre

A-1. Agricultural Machinery Manufacturing

- Incubation of new/existing agricultural equipment manufacturers by providing/ sharing CIAE workshop machines & facilities on nominal payment basis.
- Support on CAD & CNC based manufacturing.
- Training support in skill upgradation for manufacturers & entrepreneurs in CAD/CAM.
- Manufacturing technology covering Tooling development, operation of CNC machines, heat treatment techniques etc.
- Scientific and technical support to the manufacturers in development/ improvement of machines based on their own novel ideas.

A-2. Custom Hiring of Agricultural Machines

- Entrepreneurship development for custom hiring of agricultural machines selected as per the local demands.

B. Agro-Produce Processing & Value Addition based Business Incubation Units

B-1 Enterprises based on products such as soy flour, soy-milk, soy-paneer, soy-butter, soynuts, bakery products, extruded soy products etc.

B-2 Modern dal mill (0.5 tonnes per hour capacity).

B-3 Agro processing centre for milling of cereal, pulses, oilseeds, spices etc.

B-4 Livestock feed plant for production of animal, poultry and aqua feed.

C. Biomass Based business incubation unit

C-1 Briquetting plant for crop residues for direct fuel or producer gas generation.

C-2 Biomass based power generation unit (20-50 kW).

D. Covered Cultivation for Horticultural Crops

D-1 Advanced controlled based poly-house/greenhouse for covered cultivation of vegetables, flowers, selected fruits & their nurseries to fetch higher market price during off-seasons.

Industrial Liasioning and Technology Management and Licensing Procedure

The ICAR-CIAE aims to share agricultural engineering technologies demand with local, national and global world developed by ICAR-CIAE through their transfer and commercialization, while protecting and managing the Intellectual Property (IP) issues and interests. Under the IP and technology management following are the mode of technology and service support rendered by ICAR-CIAE for Industrial liasioning and support to agri

business ventures. It works for strong linkages and liaisoning with industry for technologies commercialization, formulation of policy and roadmap for mechanization, sharing of resources, collaborative and consultancy projects, identification of research gap, direction and projections of market demands.

As and when the industry as business firm approaches to ICAR Institute with the proposal to take up the joint undertaking on Intellectual Property and Technology Management and Commercialization. The proposal would have been examined by the Institute Technology Management Committee for possible public-private partnership as per following modes:

License Agreement (LA)

The ICAR-CIAE develops several agricultural tools, implements and equipment to be manufactured and adopted by the manufacturers by charging License fee through License Agreement, so as to make available CIAE technology / equipment to the farming community.

Firstly prior to preparation of license agreement, the technology needs to be developed through research project by the scientist as researcher of the Institute, ICAR-CIAE Bhopal.

If the developed technology is patentable or developed software has intellectual property input, then it may be filed either for Patent Grant/ Copyright registration

The developed technology may be licensed under the Public Private Partnership mode (PPP)

Now, the cost of research and development on machine and its business as market potential is assessed for determining the license fee of the technology.

One's the license fee is finalized then technology information and license fee + 18 % GST information is provided for payment to be made by the firm for taking license of the technology ready for commercialization.

The next step onward is to prepare the license agreement, which would be valid for 03 years in general and after expiry it would again require to renew further with all necessary terms and conditions. However, in some special cases license agreement may be valid up to 05 years

There has been a set procedure / mechanism of dispute resolution to be amicably solved between ICAR-CIAE as licensor and business firm as manufacturer. Else there would be arbitration, but the jurisdiction for dispute settlement would be Bhopal or may be New Delhi

Memorandum of Understanding (MoU) for Collaborative Projects

Memorandum of Understanding [MOU] is executed mainly for partnership projects for taking up a joint Research & Development (R&D), promotion and commercialization of technology / farm equipment between ICAR-CIAE and the Industry for further development.

Consultancy Services

The technical advice in the form of one time assistance to help in trouble shooting or problem solving, including pilot plant / up-scaling trials for technology validation and commercialization. Preparation of feasibility of project/technology design & forecasting/ evaluation reports.

Contract Research

Contract research undertaken should results in terms of new knowledge, skills or technologies. The contracting party could be government departments, public or private sector, autonomous organization, international organizations/institutions, for mutual short- or long-term benefits.

Contract Service

Contract Service would mean services rendered to the external organizations /clients/ customers, or assistance of minor nature based on available knowledge, expertise, skills and facilities of the Institute; it involves only routine laboratory testing and would not require any technical advice.

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