NO-TILL FARMING EQUIPMENT FOR SMALL FARM HOLDERS

In Partial Fulfillment
of the Requirements for the Degree of

B.S.M.E. – Bachelor of Science in Mechanical Engineering

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This thesis research hereto entitled:

**NO-TILL FARMING EQUIPMENT
FOR SMALL-SCALE FARMERS**

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ABSTRACT

The No-till system of farming is one of the farming techniques that, many scientists believe, should be adopted by large and small farm holders alike, in order to minimize the gradual damage caused by tilling. Likewise, their studies showed that the quality of life of farmers may be improved by using this method. Several countries have already adopted this method, while in the Philippines; it seemed that tilling was still most popular among farmers as evidenced by the interviews done in this study. The interview also showed that the farmers, in Baranggay Palola in Lucban Quezon, have no or very little knowledge about the no-till farming system.

This study aimed to develop and evaluate a first generation animal drawn no-till farming equipment for small farm holders in the Philippines. The study included the design, fabrication and testing of an animal-drawn equipment, a dibbler, and a residue roller. The data gathering and testing were done in Barangay Palola and the fabrication was done in the mechanical shops of Don Bosco Technical College.

Data gathering started with the baseline survey regarding the conventional method of farming. Design and fabrication then proceeded. Testing was done both in the laboratory and in the field. In the initial field tests, the equipment was pulled by one and sometimes two persons at an average speed of 0.5 m/s. The pulling force, depth and width, seed spacing and dispensing rate of fertilizer were measured in the tests. In the final field test, an animal was used to pull the equipment at a rate of 1 m/s. Observations were made regarding the function and ease of operation of the equipment while it was being pulled by the carabao. Comparison between labor requirements and projected annual costs were compared afterwards. Recommendations were also made regarding the design of the equipment and some future directives were also stated.

The study revealed that a significant reduction in labor requirements would be possible when the equipment would be used. Also, the study showed that it would be economically viable to use no-till farming system using the equipment with the assumption that productivity is the same for both conventional and conservative system. Regarding adaptability, this study showed that the equipment worked in both wet and dry soil and at a slope of 7 degrees.

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Chapter 1

INTRODUCTION

This chapter introduces the no-till farming system and states the problem, objective, and scope and limitation of the study. It also discusses the economic, social, environmental, and technical significance of the study.

1.1 Background of the Study

Farming systems can be classified into two: the conventional farming systems (with intensive tillage) and the conservational farming systems. The conventional farming system consists of slashing, burning, harrowing, furrowing, pre-emerging herbicides, planting, post-emerging herbicides, and hand weeding or hoeing. While conservation tillage consists of slashing, application of herbicides, planting, re-application of herbicides, and hand weeding or hoeing.

Many farmers and scientists have realized that conventional farming causes several negative effects on the soil productivity, environment, and profitability. These farmers have tried and adopted some of the conservation farming techniques and have documented their benefits. Among the conservation farming system being adopted now by farmers all over the world is the no-till farming system.

Dr. Rolf Derpsch defines no-tillage as the process of planting crops in previously unprepared soil by cutting through the soil covered with crop residues and opening a narrow slot for the seed to be planted on a proper depth. [4] No-tillage is based on three principles; (1) the minimal disturbance of the soil, (2) covering the soil with plant residues as long as possible, and (3) crop rotation. [7] No-till is a farming system that is growing in popularity among many farmers around the world.

Studies have found that no-till farming systems can have many benefits to the farmers and the environment. Less work, more money, more erosion control and more environmentally friendly and improved quality of life are among the main benefits of no-till farming. Because of these benefits, no-till farming has been gaining popularity all over the world.[2] Other benefits of no-till farming that intensive tillage cannot contest are reduced labor requirement, time savings, reduced machinery wear, fuel savings, improved long-term productivity, improved surface water quality, reduced soil erosion, greater soil moisture retention, improved water infiltration, decreased soil compaction, improved soil tilth, reduced release of carbon gases, and reduced air pollution. [2] Because of these, the land area under this farming system has been increasing in some parts of the world.

The biggest area under no-tillage is the USA with 19.3 million hectares followed by Brazil with 11.2 million hectares, Argentina with 7.3 million hectares, Canada with 4.1 million hectares, Australia with 1 million hectares and Paraguay with 790 hectares. [3] An economic evaluation was made on small farms 1998 in Paraguay of generally less than 20 hectares without tractors. The total economic benefits from the adaptation of the system on 480 hectares have been computed to be US$ 941 million. [3] In the Latin America, 14 million hectares had adopted this system without any subsidies.

The development and spread of no-tillage have been achieved in medium and large-sized farms. However, in most parts of the world, no study had been done yet for small farms aside from Brazil. [4]

In Asian countries, like Bangladesh, India, Nepal and Pakistan, more than 3 million hectares were under zero-till or reduced till farming in the year 2005. This helped in the production of more food at lower cost, and at the same time provided remarkable environmental benefits. The Rice-Wheat Consortium (RWC) in Asia is perfecting double no-till system for flat and sloped lands. [5]

In the Philippines, some farmers practice conservation farming technologies such as alley cropping, bench terracing, and minimum tillage. These processes had helped the farmers to protect the land from environmental degradation while having an adequate livelihood. In addition to this, farmers had observed improvements in the fertility of the soil and the formation of the natural terrace. However, despite the benefits of conservation farming, many Filipino farmers had not yet adopted the conservational system and most still practice conventional farming involving intensive tillage.

Although no-till farming system is one of the best farming systems identified by many farmers and scientists around the world, again many farmers, especially the small scale farmers, have not attempted to even try it for some reasons. Literatures say that scientists have identified some constraints in the adoption of no-till farming. First is the lack of knowledge of farmers on the farming system. According to a survey conducted in Brazil, lack of technical knowledge and the knowledge of the farming technique itself are the top two (2) reasons why farmers don't adopt the no-till farming system. Second is the doubt on the farming system. Farmers are afraid to try it because they may not implement the technique correctly. Third is the lack of available no-till farming equipment especially for the small scale farmers. [6]

This study aimed to address these constraints by developing simple and economically viable no-till equipment for small scale farmers and by demonstrating to the farmers how to use the equipment.

1.2 Statement of the Problem

Most of the farmers in the Philippines till the soil when they plant crops. Tilling can cause detrimental effects to the environment such as soil erosion and tilling releases carbon dioxide from the soil which can contribute to global warming. As suggested by several studies, no-till is one of the farming techniques that the farmers should adopt to minimize the gradual damage caused by tilling and to improve the quality of life of farmers. In the Philippines, however, most farmers, especially the small farm holders, have little or no knowledge about no-till farming. Because of this, introduction of this farming system to the small farmers has become important. This study, with the introduction of the no-till farming system in mind, aimed to develop and evaluate a first generation no-till farming equipment for small farm holders in the Philippines.

1.3 Objective of the Study

The objective of the study was to develop and evaluate a first generation animal drawn no-till farming equipment for small holders in the Philippines.

The study specifically aimed to:

1. Design and fabricate a simple and easy to manufacture no-till farming equipment prototype that would allow the study to generate data needed in the development of a commercial no-till equipment for small farm holders
2. Determine the reduction of labor in the use of the no-till farming equipment developed
3. Determine the economic viability of implementing no-till farming
4. Determine the performance of the equipment developed on wet soil and dry soil and in sloping lands

1.4 Significance of the Study

Social impact

The adoption of no-till farming would reduce farm labor time, thus, increasing the time spent for families and the community. With easy to use equipment, most family members could participate in the farming activities. Also less physical work would be required in no-till farming, thus, farmer would have more energy left after farming to do other social activities.

Economic Impact

With the development of better no-till equipment, the operating cost would be reduced while increasing profitability. In no-till farming, less physical work was required, thus larger areas could be planted with the same amount of labor and machinery.

Environmental Impact

With the paradigm shift to conservation farming systems, the farmers would contribute in the solution of problems regarding soil erosion, global warming and soil degradation.

Technical Impact

The technical data, positive and negative features of the design should serve as a basis for developing better no-till farming equipment for small holders.

1.5 Scope and Limitations

The study covered the following:

1. The design and fabrication of an animal-drawn farming equipment
2. Baseline survey and final survey were done to gather data that were used as a basis of comparison for the study.

3. The design and fabrication of the following was done:
    a. Driller and planter
        a.1. Coulter
        a.2. Opener
        a.3. Frame
        a.4. Handle
        a.5. Soil Compactor
    b. Seeder Mechanism
    c. Fertilizer Dispenser
    d. Residue Roller
    e. Dibbler
4. Functionality test of the parts as well as the whole equipment was done. Data were gathered during trials such as downward force pulling force, depth, width, and time.
5. On farm trial was done in Barangay Palola, in Lucban, Quezon with the presence of randomly selected farmers
6. Reduction in man-hour and animal-hour were used as a basis in determining reduction in labor.
7. Annual cost method were used to determine the economic viability of the no-till equipment
8. The pulling force, depth and width of soil opening was used as a basis to determine the performance of the equipment on wet soil and dry soil.
9. The equipment was tested on a maximum slope of 7 degrees.

1.6 Assumptions

The following were assumed in the study:

1. Conventional farming and no-till farming system have same yield (refer to Table 2.1).
2. Maneuvering period of the equipment was assumed to be 25% of the duration of applying the no-till drill and planter.
3. The farmers were planting 3 times a year
4. Property and insurance taxes were exempted.
5. The minimum required rate of return was 15%
6. The estimated life of the farming equipment would be 10 years.
7. Two (2) liters of Round-up herbicides were consumed per hectare.

Chapter 2

THEORETICAL FRAMEWORK

This chapter discusses the related literature and study, and concept of the research.

2.1 Review of Related Literature

No-till farming is a farming process which is performed by managing fertility of the soil by means of un-disturbing the soil and having it covered by killed mulches which are needed for seeding/transplanting. The main process is done by preparation of the cover crops followed by the planting procedure, no other process is done.

According to the Conservation Technology Information Center (CTIC) and the National Association of Conservation Districts (NACD), no-till is a farming system in which at least 30 percent residue is left after planting and two-thirds of the row is left undisturbed from harvest through seeding.[7]

Weed control is achieved with herbicides. Soil disturbance is limited to planters or drills that can cut through residue, though certain disturbances such as row cleaners, injection knives, row-crop cultivators, rotary hoes or harrows may also be allowed. No-till farming practices were developed to protect the soil surface from sealing by rainfall, to achieve and maintain an open internal soil structure, to enhance biological processes in the soil, and to develop a means for safe disposal of any surface runoff that nevertheless will occur.[7]

Preston Sullivan (NCAT agriculture specialist) stated no-till systems, based on what is it called, do not use tillage for creating a seedbed. Crops are simply planted into the previous year's crop residue. No-till planters are equipped with mechanisms like coulters that slice the soil, allowing a double disc opener to place the seed at a proper depth. The slot is closed with a press wheel. Herbicides are typically used as the sole means for weed control in no-till systems.[8]

In no-till system, differences in the procedures are dramatically noticeable because of the numbers of procedures that are disregarded. To have more sense, a comparison can be a good method in identifying these differences. By comparing both conventional and conservational tillage, conservational tillage appears to reduce the procedures and yet improving the efficiency of the plantation.

2.1.1 Benefits of No-till farming

No-tillage presents several agronomic benefits compared to conventional tillage. No till significantly increases water infiltration, thus limiting soil erosion and improving water conservation. Also, condition of the soil improves because of increased organic matter content and improved soil structure. No-till also increases soil moisture content enabling farmers to plant in the optimal dates.[6]

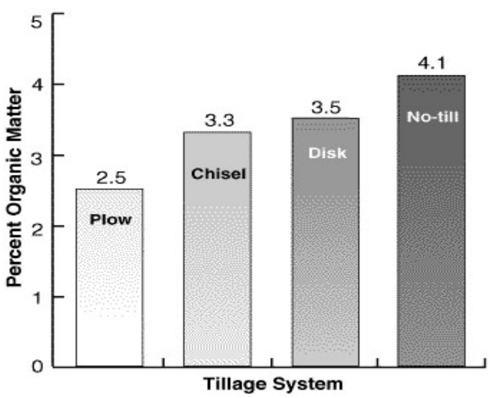


Figure 2.1. Amount of organic matter per tillage system (Missouri No-Till Planting Systems Manual)[19]

There are also several economic advantages in no-till farming. Even for small-scale farmers, no-till lessens cost since expensive labor is replaced with herbicides. Investment in agricultural machinery and labor requirements are reduced because fewer implements are required in no-till. Less labor demand will allow farmers to venture to other revenue generating activities. Further, there are less physical work in no-till; so, larger areas can be planted with the same amount of machinery and labor. [6]

Table 2.1
Tillage system cost of production and profitability.
Pennsylvania Five Acre Corn Club, 1990-94
(Economics of Conservation Tillage)

Item	Conventional tillage ($/A)	Reduced tillage ($/A)	No-till ($/A)
Selected variable costs			
Seed	$23.30	$23.06	$24.41
Fertilizer	$44.22	$45.99	$40.03
Lime	$9.77	$8.37	$9.27
Herbicides	$18.16	$18.81	$26.67
Insecticides	$4.97	$6.90	$4.71
Machinery operating	$21.20	$21.50	$13.61
Custom hire	$6.65	$7.29	$13.30
Total variable costs	$154.13	$162.63	$158.39
Fixed costs			
Machinery ownership	$43.99	$40.69	$23.89
Total costs	$198.13	$203.32	$182.27
Returns to land and management	$186.77	$187.12	$208.51
Yield (bu/A)	149.5	147.8	149.8

Table 2.2
Fuel used in growing corn and soybeans in Illinois under conventional and no-till systems (No-Till Solutions)[18]

	Diesel Fuel Use (US gallons / acre)			
	Corn		Soybeans	
	Conventional	No-Till	Conventional	No-Till
Cultivate	0.7	0	2.4	0
Plant	0.4	0.5	0.4	0.5
Spray	0.3	0.5	0.3	0.5
Fertilize	0.8	0.7	0.2	0.2
Combine	1.5	1.5	1	1
Total	**3.7**	**3.2**	**4.3**	**2.2**

Small-scale farmers in several countries had said that they have more stable and better income in no-till. Because of this, the need for family labor is reduced, hence children can attend school, and the quality of life had improved. [6]

No-till also has significant benefits on the environment. Soil covers limits soil erosion and increases water infiltration, reducing mudslides and pollution of waterways with agrochemicals. Emissions of greenhouse gases are reduce because of lesser consumption of fossil fuels, and fewer amount of organic matter are transformed into carbon dioxide. Also, formation of nitrous oxide is diminished, because of fertilizer efficiency. And, less energy is needed because of less use of fertilizer. [6]

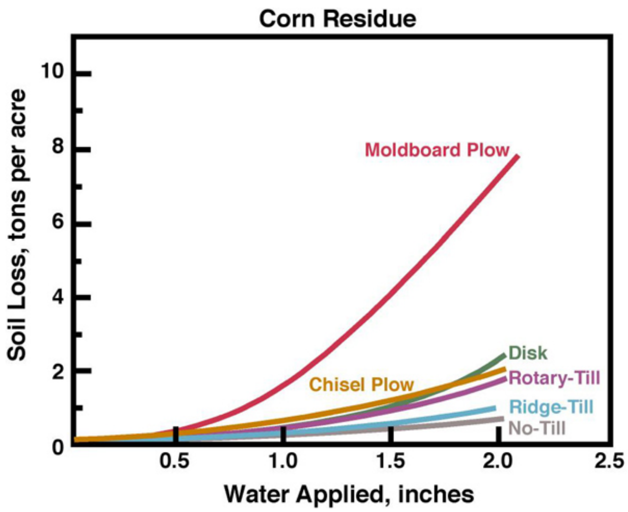


Figure 2.2
Soil loss to water erosion as affected by tillage system
(Choosing the Right Tillage System for Row Crop Production)[20]

2.1.2 Adoption of No-till in the Globe

A grower bought a farm in 1982; the land still has the unfertile form of soil typical of Brazil's vast central savannas. The grower was discouraged by the rugged terrain, purchasing 620 acres, or 250 hectares planting soybeans. The area was said to be historically considered unproductive. Then the wet season came, flooding much of his first crop. Subsequent years brought more rain, time and again washing away topsoil, seedlings and most of the new farm's promise. The grower lost a lot and so turned farming on its head. Instead of plowing before each planting, they leveled the previous crop, let the residue decompose and seeded the following year's crop directly in the mulch remains which is basically no-till system.[13]

The runoff stopped, and within a decade the farm had a layer of topsoil. The land initially then produced surprising increase in production such as crops including corn, sunflowers and pineapples.[7]

The most important crop being raised using no-till system in Brazil is the soybean. After adopting no-till system, savings in soybean crop is doubled because of the increase in the amount of nitrogen, increasing the fertility. It is obvious that soybean is not specific for no-till, but it is this system that guarantees both the production sustainability and the subsequent double cropping, in that way increasing profits and avoiding serious problems of soil degradation that occur under conventional tillage.

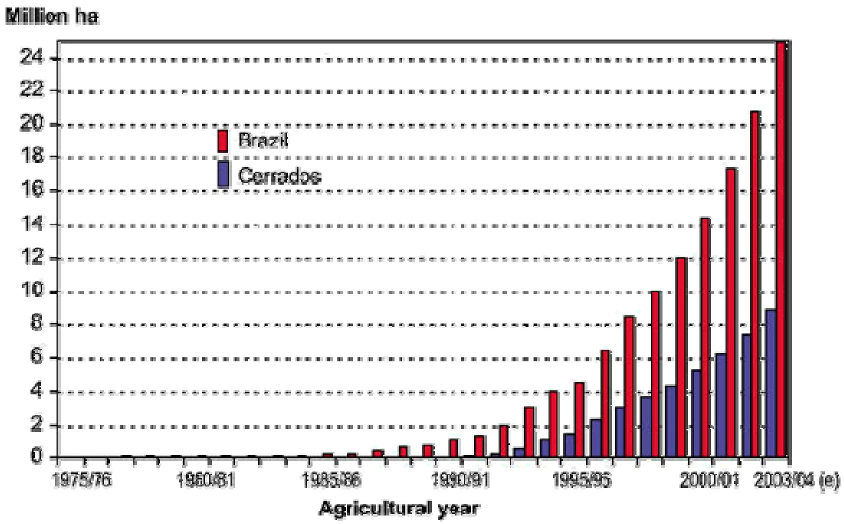


Figure 2.3
Hectares under No-Till in Brazil and Cerrados
(Fertilizer use by crop in Brazil)[21]

Brazil has great accomplishments in agriculture and it seeks through no-till farming for agriculture on most of the cultivated area to be conducted in a sustainable way. Thus no-till is the central component of sustainable agriculture condition for responsible agriculture. It is a part of a success story that points to a better future, an accomplishment that Brazilians willingly share with other tropical areas, thus contributing to a more sustainable and happier world.[12]

Adoption in the United States has been slower. Though many farmers in the Great Plains use no-till planting – over plowing and drought created the Dust Bowl of the 1930s

- other growers have been reluctant to alter conventional methods. No-till plots now account for 23 percent of U.S. farmland, according to the Conservation Technology Information Center in West Lafayette, Indiana.[7]

As to the general situation in the world, countries with the largest area under no-tillage are the U.S. with 19.3 million hectares, Brazil with 11.2 million ha, Argentina with 7.3 million ha, Canada with about 4.1 million ha, Australia with 1 million ha and Paraguay with 790,000 ha. In Paraguay, no-tillage was practiced on only 20,000 ha in 1992 but grew to 790,000 ha in 1999. [14]

Admitting that there may be many gaps in information it is estimated that no-tillage is practiced on about 45 million hectares worldwide. Approximately 96% of the technology is practiced in the Americas (North and South) and probably less than 4% in the rest of the world. About 52% of no-tillage is practiced in the U.S. and Canada, 44% in Latin America, 2% in Australia and 2% in the rest of the world, including Europe, Africa and Asia.

There is a very big potential to bring this soil conserving technology to these parts of the world, although limiting climatic and socio-economic factors have to be taken into account. The East European countries seem to have the biggest potential for a fast growth of this technology. In order to overcome the information gaps relating mainly to the East European countries as well as Africa and Asia, the author would welcome any information about the area of no-tillage and conservation tillage being applied in those parts of the world.[14]

Table 2.3
Total area under no-tillage in different countries (hectares)
(Frontiers in Conservation Tillage and Advances in Conservation Practice)[14]

COUNTRY	2000/ 2001
U.S.A.	21.120.000 1)
Brazil	13.470.000 2)
Argentina	9.250.000 3)
Australia	8.640.000 4)
Canada	4.080.000 5)
Paraguay	960.000 6)
México	650.000 7)
Bolivia	350.000 8)
Venezuela	150.000 9)
Chile	100.000 10)
Colombia	70.000 11)
Uruguay	50.000 12)
Others	1.000.000 13)
Total	**59.890.000 .**

Quelle: 1) Dan Towery, CTIC, 2001; 2) FEBRAPDP, 2000; 3) AAPRESID, 2000; 4) Bill Crabtree, WANTFA; 5) Hebblethwaite, CTIC, 1997; 6) MAG - GTZ Soil Conservation Project, 1999; 7) Ramón Claverán, CENAPROS, 1999; 8) Carlito Los, 2000; 9)Carlos Bravo, 2000; 10) Carlos Crovetto, 1999; 11) Roberto Tisnes, Armenia, 1999; 12) AUSID, 1999; 13) Schätzungen.

No-tillage is a dynamic system, so farmers should be prepared to learn constantly and stay up to date with new developments. New, cheaper and better herbicides and machines appear continually, new cover crops are introduced, new research results on fertilization, liming, varieties, management, diseases and pest control, etc., are constantly published. No-tillage facilitates biological pest control. The no-tillage system still has room for improvements and organic farmers have a lot to do with these improvements. There is great opportunity for every farmer to be creative and to develop the system further. [14]

Finally, farmers all over the world adapt these technologies because they are economically and financially capable. Therefore an economic evaluation of the system under the different agro-ecological and socio-economic conditions is essential. It is misleading to analyze the results of only one or two cropping seasons. Instead an evaluation of the whole system, with all its components has to be made, putting value to timeliness, wear and tear on equipment, improvement of soil fertility, reduced costs for fertilizers and pesticides, environmental benefits, etc. [14]

2.1.3 Adoption of No-Till in Asia

With the socio-economic constraints in Africa and Asia, it is recommended to promote no-till system in these areas to provide aid to their economical crisis. No-till system has been adopted on about 10-15% (2 million out of 13.5 millions hectares) of the wheat planted after rice in the rice-wheat cropping system in the Indo- India and Pakistan.[10] These countries are in tropical condition, proving that no-till farming system is really applicable in tropical areas such as Philippines only if performed correctly. It is very applicable throughout Asia wherein vast production of rice is prominent. There is currently research being initiated and undertaken in some parts of South Asia on direct-seeded or zero-tilled rice.

Actually, there is little or no prior research on how to zero-till rice under monsoon conditions. In South Asia, they are developing a process of zero tilling rice, which is commonly seen in tropical regions in the world. Through the research and development of researcher *Fatima Ribeiro, Scott E. Justic, Peter R. Hobbs and C. John Baker,* they encountered series of hindrances of the adoption of zero tilling rice. These troubles consist of problem in seasonal plantation, irrigation system and weed control. The problem in monsoon condition is over the moisture of the soil. Once the soil became too moist, serious compaction of soil will occur. Though there are possible resolutions to these issues like in the moisture problem, the grower can plant as early as possible when proper soil moisture is reached. Another solution is to use lighter machinery or to shift in plantation into dry season irrigated rice.[9] Other issues are as follows:

Table 2.4
Other Issues in No-Till Farming
(No-tillage drill and planter design- small scale machines)[9]

Problems	Possible solutions
1) Majority of rice is rain-fed. Major problems is changing monsoon and therefore problems of entering fields for seeding operations	1) Planting needs to be done as quickly as possible when the proper soil moisture is reached. Once the field is too wet serious compaction will occur. 2) Use smaller, lighter machinery. 3) Farmers may want to have the option of transplanting by hand or machine into zero till fields if direct seeding is impossible. 4) Move to early dry season irrigated rice.
2) Lack of drainage and flooding kills off emerging seedlings after a heavy downpour of monsoon rain	1) Permanent beds and introduction of some drainage capability. 2) Flood tolerant rice varieties are also possible. 3) Transplanted zero till rice.
3) Problems of weed control when soils are not kept flooded (more serious on research stations than farmer fields).	1) Integrated weed management will be the key using competitive varieties, mulching, preventing seed set of weeds, rotation, and various herbicide strategies. Untilled seed beds where the first flush of weeds are allowed to germinate and then controlled with herbicide are another strategy. In this system avoiding plowing will avoid a new flush of weeds germinating. 2) Planting of a cover crop after wheat and killing the cover crop and weeds with herbicide before zero-tilling rice.

Resource Conserving Technologies (RCTs) have revolutionized irrigated agriculture in South Asia. The practice that has most widely adopted is the no-till system applied to rice fields. Area under this technology now exceeds 2 million ha, up from virtually zero in the late 1990s. The rapid adoption of this system is an indication of its very high levels of profitability to farmers that is achieved through improvement in cost reductions as well as the increase in their yield.[11]

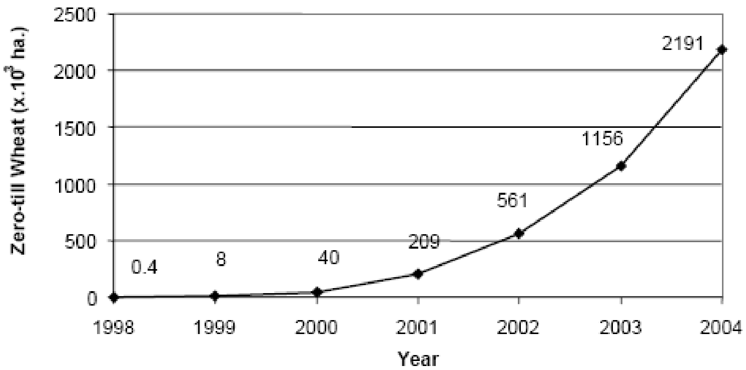


Figure 2.4
Adoption of wheat zero-till after puddled rice in the Indo-Gangetic Plains, 1998- 99 to 2004-05 (m ha)
(The Asian Platform, Conservation Agriculture in the Asian agroecosystems)[11]

No-till revolution research featured a good partnership among national public-sector research programs, local universities, international research centers, private sector implement manufacturers, state-level extension agencies, NGOs, and farmer groups to continually increase the adoption of no-till system in other regions. The development of conservation agriculture practices is just beginning in the intensively-cropped rice-based lowland agro-ecosystems in river valleys in northern Vietnam. As in South Asia, the search for ways to construct the principles of conservation agriculture is complicated by the prevalence of puddled rice culture. Direct dry seeding of rice and co-culturing techniques of rice with green manure crops are practices that result in unacceptably low rice yields.[11]

2.1.4 No-Till Farming Equipment

No-till farming equipment have several advantages on conventional farming equipment; (1) it is heavier to guarantee penetration in firm soil, (2) it has the ability to through stalks, straws, and growing cover, (3) it can be adjusted to plant seeds at proper depths, and (4) it covers and firms soils around the seed to have a good contact between the seed and the soil.

No till farming equipment have coulters to slice the cover crops and to loosen a small part of the soil, an opener to set the proper depth of the seed, seed metering device for a precise spacing between the seeds, and the press wheel to close the opened slot after planting the seed.

Some no-till planter includes residue cleaners to remove residue in the row area, seed firmer to press the seed at the bottom of the seed furrow, and insecticide applicator to apply insecticide on top of the seed slot.

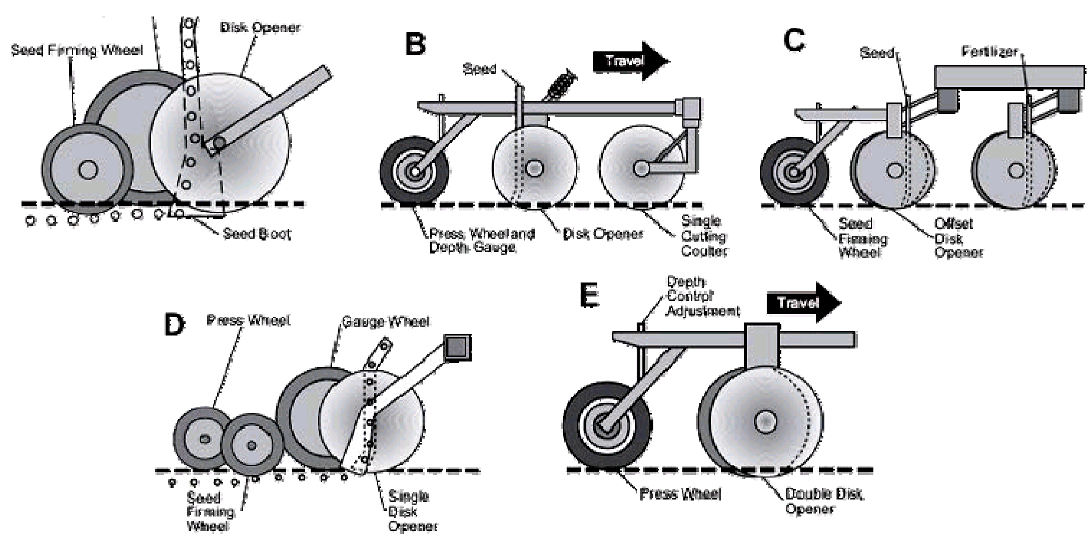


Figure 3. Diagram of typical seeding mechanisms: A) single-disk opener, B) single-disk opener with add-on coulter unit, C) offset double-disk openers with fertilizer opener mounted midway between seed openers, D) gauge wheel mounted beside the seed-opener disk to maintain depth control, E) press wheel mounted on the furrow-opener frame member to maintain depth control.

Figure 2.5
Diagram of No-Till Equipment
(Equipment Considerations for No-till Soybean Seeding)[24]

Today, manufacturers had developed wide variety no-till equipment including planters, adapted sprayers, and harvesters to spread the residues evenly over the cutting width. In Brazil, more than 30 companies are producing no-till equipment and they have pioneered the animal drawn and manual no-till equipment.[10]

Small scale no-tillage equipment is usually characterized by small field sizes and limited availability of energy, often also accompanied by limited financial resources. Operation of large-scale tractor-drawn implements is neither practical nor possible for many farmers on small properties. Because of that reasons, most small-scale farmers use smaller and maneuverable equipment like hand-operating jabbing devices or drills and planters with one or two rows. Some triple-row planters are also available but are reasonably rare.[9]

The limited number of rows influences some of the functions of no-till equipment, including opener design. Some of these influences are beneficial. Others are not. For example, many of the more advanced opener designs require large amount of power per opener, which is often beyond the resources of small farmers. Also, non-symmetrical openers, such as angled discs, are rarely regarded as an option on single-row machines because the side forces are too difficult to counter-act while keeping the machine heading in a straight line. [9]

There is a large variety of small-scale no-tillage seeding equipment available, each suited to different sources of power and field conditions. The range includes hand jabbing, animal-drawn planters, power tillers and planters for limited-powered tractors. Despite the differences in power requirements, the designers of most small machines recognize the need to be able to handle residues, open an appropriate slot, meter seed and perhaps fertilizer, distribute this to the opener(s), place it in the soil in an acceptable pattern, and cover and pack the seed and the fertilizer.[9]

2.1.4.1 The Hand-jab planters (dibblers)

Hand-jab planters are popular amongst small-scale farmers. Some form the primary means of sowing seeds under no-tillage. Others are kept in reserve for filling in spaces in crops otherwise sown with openers in rows. Since the residue-handling ability of small drills and planters is often limited, spaces occur if and when residues-handling suffers along the row. Hand-jabbers may have either separate hoppers for seed and fertilizer or one hopper for seed only.[9]

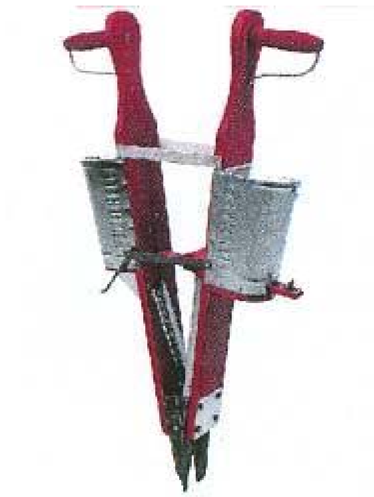


Figure 2.6
Hand-jab Planter
(No-tillage drill and planter design - small scale machines)[9]

A common seed metering device used on hand-jabbers is a rectangular plate placed inside the hopper. When the handles are pulled apart, the seeds drop into the holes, which are delivered to the outlet and the discharge tube. Plates with different hole sizes are available according to the seed size. Seeding rates can be adjusted according to the number of holes in the seed plate that are exposed in the outlet. [9]

Part of the attraction of hand-jab planters is that they do not require access to animal or tractor power, are low cost, light and easy to operate, although some skill is required. For these reasons they are often used by women, which increases the available labor pool for small farmers, although no-tillage itself reduces labor demands significantly anyway. [9]

By planting seeds in pockets, there is minimal soil disturbance so weed seed germination is minimized, resulting in easy hand hoeing between plants. The small size of the device makes it suitable for operation on hilly, stony and stumpy areas and for intercropping and for planting in fallow areas. [9]

Their use is most suited to light soils since penetration is sometimes too difficult in harder soils in the absence of some form of tillage.[9]

The main components of a no-till equipment typically composed of disc which cuts straw, seed metering devices that are positioned at the bases of the seed, fertilizer feeder, openers that open slots for placement of fertilizer and seed respectively. Usually the fertilizer opener operates deeper or off-line compared with the seed opener in the same manner as bigger machines, and the packing wheel which controls the depth of seeding and firms the soil over the slot. The effectiveness of packer wheels operating on the soil over the slot, compared with operating in the base of the slot before covering. [9]

Duiker and Myers identified the criteria that should be considered in designing no-till equipment. These were as follows: [16]

1. They should be heavy enough to guarantee penetration in firm soil.
2. They should have the ability to cut through stalks, straw, and growing cover and allow residue to flow through the machine.

3. They should be allowed to be adjusted to plant seeds at appropriate depths for the crop-soil condition, although crop residue is present at the surface. They include both down pressure and depth control settings.
4. They should cover and firm soil around the seed for complete seed coverage and protection against rodent and bird.

2.1.4.2 Discs

All of the principles of discs and residue handling apply equally to small-scale machines as they do to large-scale machines, except that with single-row small-scale machines there is greater clearance around the opener for random residues to fall away without blocking the machine. [9]

Most small-scale no-tillage planters have discs, the effectiveness of which are dependant upon the disc diameter and design, soil conditions, residue conditions and adjustments provided on the planter. There are varieties of disc designs to prefer from such as plain, notched, wavy, flat or dished. [9]

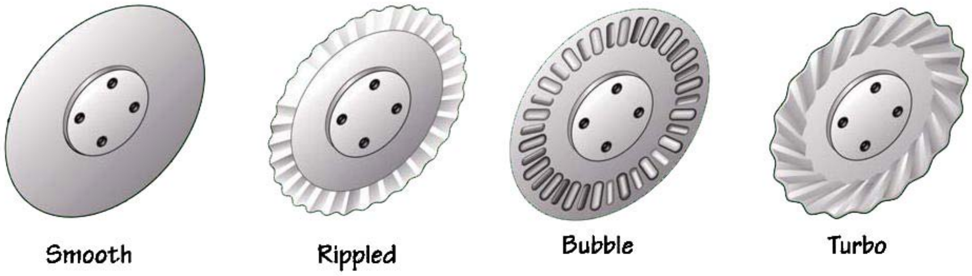


Figure 2.7
Variety of disc design
(Equipment Considerations for No-till Soybean Seeding)[24]

Ineffective residue cutting results in clogging of straw on the seed components, which in turn results in problems for seed and fertilizer placement and coverage, and even seed and/or fertilizer metering.[9]

2.1.4.3 Openers

The functions of openers for small-scale no-tillage are no different than their functions for larger-scale. On small-scale planters with tined openers, there should be independent adjustment of the fertilizer opener so that fertilizer can be placed deeper than the seed. Although placing fertilizer beneath the seed in no-tillage does not always result in the best crop yield, with small-scale drills and planters it is a more realistic option than placing fertilizer beside the seed because the latter option requires the fertilizer opener to be operating in new ground, which requires more energy than when both openers (seed and fertilizer) operate at different depths in a common slot. In any case, placed fertilizer within the seed zone is far superior to surface broadcasting causing slow crop access and increased weed growth. As with larger machines, there are advantages for slots with minimal disturbance**.** While the choice of opener type might depend on soil resistance to penetration amount and resistance to cutting of residues, it is no more feasible for small-scale no-tillage farmers to possess more than one no-tillage machine in order to handle with varying conditions than is the case for large scale farmers.

Double disc openers (V-shaped slots with Grade I cover) are commonly used on small scale drills and planters. The slots are narrow at the surface and may be compacted at their bases and sides, but are less power-demanding than tine-disc openers that have less compacting tendencies. With unequal diameter double disc openers, because the smaller disc rotates faster than the larger disc a degree of cutting, or ‘guillotine’, effect is created.

Generally, tines require less down force than double disc openers, which contributes to maintaining a uniform seeding depth if a suitable depth control mechanism is included.[9]

2.1.4.4 Seed Metering Device

One of the important factors in designing the seed metering device is the importance of seed spacing along the row with row crops. More recent evidence has shown that uniform plant emergence along the row may be more important than plant spacing to reduce plant competition of smaller plants by larger plants. But the fact remains that if ‘perfect spacing’ has become the accepted norm in conventionally tilled seedbeds, no-tillage exponents need to match this norm in untilled seed beds in order to avoid introducing an unnecessary negative factor against no-tillage.[9]

Seed metering devices are responsible for governing seed rate (number of seeds/m) and seed spacing (consistency of spacing between seeds in the row), thus their accuracy must be assured.

Most crops sown by small farmers are in wide rows. Singulation of seeds is very important, so emphasis is placed on seeding mechanisms and power requirements as priority design criteria. This contrasts with larger no-tillage planters where slot microenvironment, residue management and fertilizer banding assume at least equal importance to seed spacing and energy requirements.

No-tillage farming in Brazil provides an interesting comparison and contrast of small scale machines and tractor-drawn machines. Both systems are practiced widely in a country that spans many climatic and socio-economic zones, often in relatively close proximity to one another.

Seed metering devices used on animal-drawn no-tillage planters in Brazil all feature the same gravity seed plates that are used on local tractor-mounted planters, namely plastic or cast-iron horizontal plates.[9]

To be most effective, horizontal plate singulators require the seed to be graded into uniform sizes and the holes or cups in the plates to be matched to the chosen seed size. This requires having several plate sizes and some experimentation when seed lines or batches are changed. But with limited numbers of rows and small quantities of seed, this is not a difficult undertaking compared with multi-row machines. But it does highlight the importance of being able to change plates without emptying the entire seed hopper. [9]

2.1.4.5 Fertilizer Metering Device

The types of fertilizer-metering devices found on small scale no-tillage machines include rotating-bottom, auger-type, edge-cell and star-wheels. The discharge rate for star-wheel and rotating bottom types, is controlled by adjustable outlets, while auger and edge-cell types are controlled by changing their speed of rotation relative to the ground speed.[9]

2.1.4.6 Packing Wheels / Soil Compactor

While seed row packing wheels vary in design, most are of either steel or plastic construction. V-shaped wheels are used where soil disturbed by tined openers needs to be collected and thrown into the open slots. Good coverage/compaction depends on the depth of seed placement, the type of seed compaction wheel and soil moisture. Open-centered wheels are better for soils with a tendency towards crusting as they press the soil laterally towards the seed.[9]

2.1.4.7 Adjustment and Maintenance

All models offer adjustments of both seed and fertilizer sowing rates. But some models do not offer many adjustments either for seed and fertilizer sowing depth or for residue handling. On the other hand, the most sophisticated openers do not require adjustments to handle a wide range of residue types, but these are seldom used on small drills or planters. In general, tined openers have the poorest residue handling characteristics and disc openers the best. But certain disc openers (e.g. double disc) have a tendency to hairpin pliable straw into the slot where it interferes with seed germination in both wet and dry soils. These disadvantages apply equally to small planters as to larger equipment.[9]

For this reason, several small planters with tined openers provide adjustments that affect their residue-cutting ability. The two main adjustments are the hitching point and the front ground wheel. Adjustments made to the disc will also affect the depth of the fertilizer slot. For the same depth of the fertilizer, different depths for seeds are possible through adjustments to the rear ground wheel.

In the simplest models, seed rates are adjusted by changing to different seed plates, while multiple-row models often provide sets of gears to change the plate speed. Other models that do not sow widely spaced rows provide geared adjustment of the speed of bulk seeders. [9]

2.1.4.8 Roller-Crimper Drum

Water-filled drum rollers modified with horizontal welded blunt steel blades or metal strips have been used in Brazil and other locations to roll-crimp cover crops, thus facilitating killing yet leaving plant stems intact.[9]

2.1.4.9 Annual Cost Method [17]

Applying this method is used to compare alternatives on which has the lesser annual cost. The interest on the investment is also determined. This method is applied to alternatives which has consistent cost data for each year and a single investment of capital at the beginning of the first year of the alternative.

Annual cost method is computed by having the following parameters:

1. First Cost
2. Annual Operating Cost
3. Annual Labor Cost
4. Rate of Return
5. Estimated Life of Equipment

Annual cost is the sum of the Annual Depreciation of the equipment, annual operating and labor cost and the interest in the capital invested.

$$Depreciation = \frac{First\ Cost}{F/_{A},i,L}$$

Where:

$$F/A = \left[\frac{(1+i)^{L}-1}{i}\right]$$

$$L = Estimated\ Life$$

$$i = Rate\ of\ Return$$

$$Interest\ on\ Capital\ Invested = First\ Cost\ (Rate\ of\ Return)$$

Salvage value refers to the value at the end of life of any equipment. It is computed to add to the additional investment for a new set of equipment. To solve for salvage value (C_L):

$$d = \frac{C_0 - C_L}{L}$$ Where: d = Depreciation

C_o = Original Cost / First Cost

C_L = Salvage Value

L = Estimated Life

Therefore:

$$C_L = C_0 - \left(L \times d\right)$$

2.1.4.10 Pulling Force of Carabao

According to the Forestry Department of FAO (Corporate Document Repository) maximum pulling capacity of a prime carabao bull ranges between 150 and 450 kg, depending on the weight of the animal itself. The maximum continuous pulling power of the carabao/sled combination is 100-120 kg. In comparison, a carabao with a harness/four-wheel trailer can average 250 kg (measured max. 350 kg). The best solution for wood transport in southeastern Philippines therefore appears to be a combination of full harness for the carabao together with a four-wheeled or six-wheeled log trailer.[22]

2.1.4.11 Useful Life of Equipment

Figure 2.8
Useful Life of Various Equipment
(Table of Estimated useful Life of Property, Plant and Equipment)[23]

Machineries and Equipment	Life (years)
Machineries	10
Agricultural, Fishery and Forestry	10
Airport Equipment	10
Communication Equipment	10
Construction and Heavy Equipment	10
Firefighting Equipment and Accessories	7
Hospital Equipment	10
Medical, Dental and Laboratory Equipment	10
Military and Police Equipment	10

2.2 Conceptual Framework

The idea of this study was to develop and evaluate first generation animal drawn no-till farming equipment for small farm holders in the Philippines. The study included the design and fabrication of a simple and easy to manufacture no-till farming equipment that would encourage small-scale farmers and local fabricators in the Philippines to adopt the no-till farming system. The study began with a baseline survey. It determined the requirements of the equipment developed. Also, the data from this survey would become the basis for comparison for the performance and economic viability of the equipment. The main components were patterned from existing designs with some modifications. It was tested for its functionality and for its performance then it was compared with the conventional method of farming to show the advantages of implementing no-till farming system. Recommendations were made for future studies regarding the no-till farming equipment.

2.3 Definition of terms

Alley cropping A method of planting in which rows of a crop are sown between rows or hedges of nitrogen-fixing plants, the roots of which enrich the soil.

Puddling An old method, messy but effective, of protecting fine feeder roots when transplanting. Its object is to coat all the roots with a thin film of wet soil, by dipping them into a soupy mixture of loam and water (mud), just before planting.

Slash and Burn Farmers slash the vegetation on a plot of land, burn the dry residues, and then seed into the uncovered soil

Soil Degradation Loss in the quality or productivity of soil as a result of human activities. Degradation is attributed to changes in soil nutrient status, loss of soil organic matter, deterioration of soil structure, and toxicity due to accumulations of naturally occurring or anthropogenic materials.

Tilth Physical condition of soil, especially in relation to its suitability for planting or growing a crop.

Water Infiltration The vertical movement of water in a soil. It is the ease or difficulty with which water can pass into and through a soil profile is important so as to avoid detrimental effects such as compaction, surface smearing and other properties that generally lead to structure decline.

Chapter 3

METHODOLOGY

This chapter discusses the method of research used, the selection of locale, the selection of respondents, the instrumentation of the study, and the procedure on how the study was executed.

The study was composed of five major activities; the baseline survey; the design and fabrication of the equipment; the functional testing of the equipment; the on-farm trials; and the final survey

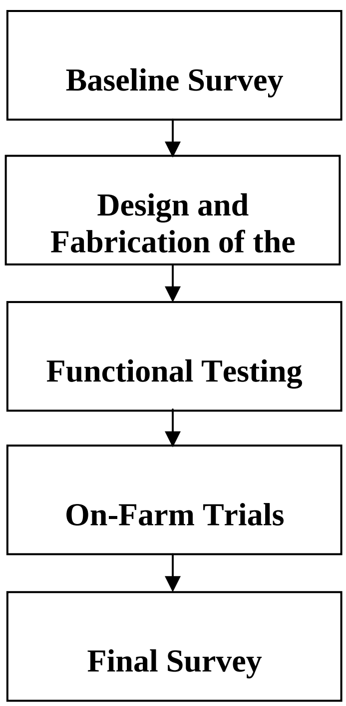


Figure 3.1
Flow of Activities of the Study

3.1 Research Method

Descriptive method was used. Comparison between conventional and no-tillage was done using data gathered from interviews and physical measurements during functional testing. The economic viability was determined by comparing the initial cost and operating cost of both conventional and no-till farming system. The adaptability of the equipment to sloping land was evaluated based on the observations between using the equipment in sloping and non-sloping lands. Trials were done during the wet season and dry season to determine the adaptability of the equipment in moist and dry soil.

3.2 Research Locals

The researchers have formulated criteria in choosing the local of the study:

1. the local must be agricultural
2. it must be elevated
3. the soils must be fit for vegetable farming
4. it must be tropical
5. it must have small scale farmers
6. it must be accessible to the researchers

The researchers had considered the province of Laguna, Rizal, Cavite, and Quezon. Among these provinces, Quezon province was the most accessible for the researchers, thus it was chosen as the research locale.

3.3 Samples and Sampling technique Used

Two respondents were chosen. They were referred by the members of the multi-purpose cooperative of Barangay, Palola. Both of them are officers of the Passion Fruit Club of Barangay Palola, Lucban, Quezon.

Respondents were selected based on the following criteria:

1. Respondents should be small-scale vegetable farmers
2. They must have low income
3. They must have their own family

3.4 Instrumentation

For comparison, baseline and final data were gathered using interviews. The data from the baseline interview was used to compare the economy and time spent in no-till farming using the equipment prototype with conventional farming. In the functional test, an industrial spring scale was used to determine the force needed to pull the equipment. To measure depth, width, slope and area, a measuring tape was used. A stop watch was used to measure time parameters. The rest of the data were based on visual observations during the tests and trials.

3.5 Procedure

As stated, the study was composed of five activities; (1) baseline survey, (2) design and fabrication of equipment, (3) functional testing, (4) on-farm trials, and (5) final survey.

3.5.1 Baseline Survey

The baseline survey involved interviews with the respondents to gather initial data that were used as basis of comparison for the study. The procedure below was followed:

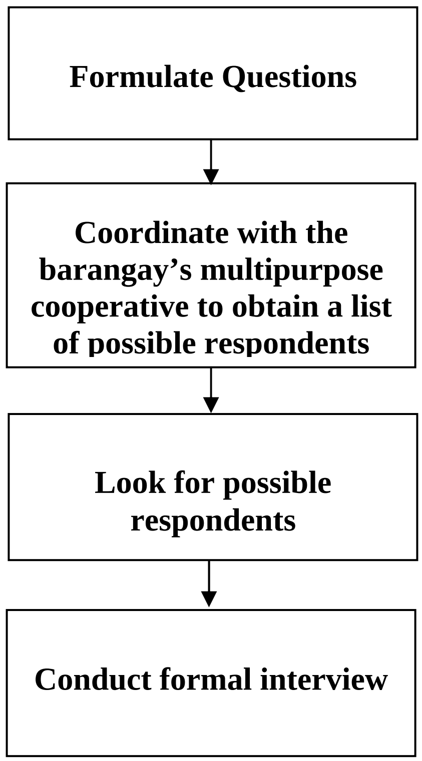


Figure 3.2
Procedure of the Baseline Interview

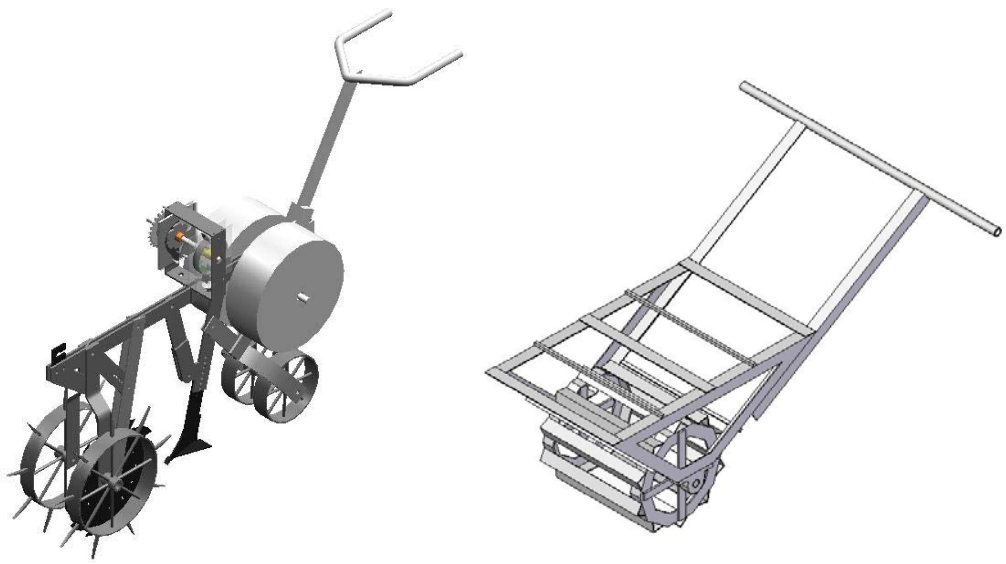
After the questions were formulated, the multipurpose cooperative of the barangay was visited. The cooperative members present at that time referred the researchers to some farmers. The houses of these farmers were visited and the farmers were interviewed in their houses.

** See Appendix A for the survey form*

3.5.2 Design and Fabrication of the Equipment

The equipment was composed of a coulter, an opener, a seeder, a fertilizer dispenser, and a soil compactor. The design of the equipment was patterned on animal drawn no-till equipment from Brazil. Four factors were considered in the design:

1. Performance
2. Ease of manufacture
3. Low initial cost
4. Use of readily available materials and purchased components



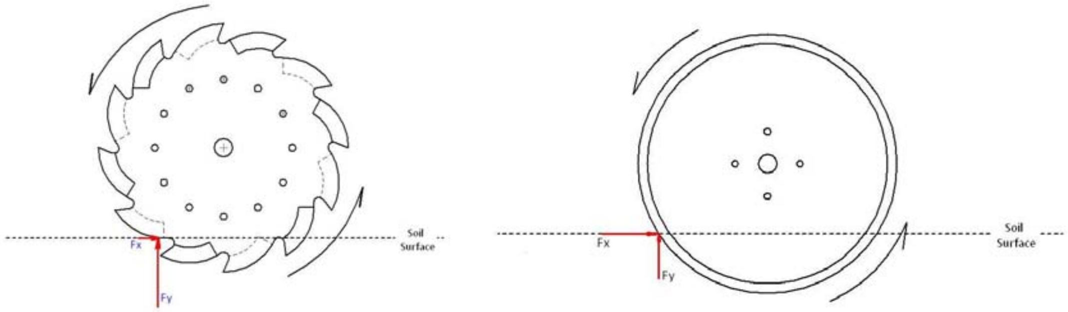
(a) (b)

Figure 3.3. No-Till Equipment: (a) Drill and Planter; (b) Residue Roller

3.5.2.1 Design and Fabrication of the Coulter

The 14-inch coulter, shown in Figure 3.4(a), had 12 teeth and was designed to cut through residue. Theoretically, the teeth should lessen the horizontal pulling force and should increase acceleration at the cutting point. The unsharpened portion at the back of the teeth should contribute to the production of moment required to cut the residue.

It was made from 3/16 in MS plate cut to size and shaped using an acetylene torch. The blades were ground to desired sharpness using a hand grinder while the coulter was mounted on a jig.



(a) (b)

Figure 3.4. Coulters: (a) Toothed Coulter; (b) Plain Coulter

3.5.2.2 Design and Fabrication of the Press Wheels

The 12-inch press wheels have 8 spikes to assure rotation of the wheels. The press wheels were designed to: (1) press the residue to facilitate cutting and minimize "hair-pinning"; and (2) provide the power for the seeder and fertilizer dispenser.

The press wheel consisted of the wheel, the hub, spokes, and the spikes. The wheels were made from 1.5 in x 3/16 in flat bar that was rolled into a wheel. The hub was turned in the CNC lathe machine from a 1.5 in diameter CRS. The spokes were from a 3/8 in diameter CRS bar that were cut to size then welded to the wheel and hub. The spikes, likewise, were cut to a length of 2.5 in from a 3/8 in CRS bar and welded to the wheel as shown in Figure 3.5.

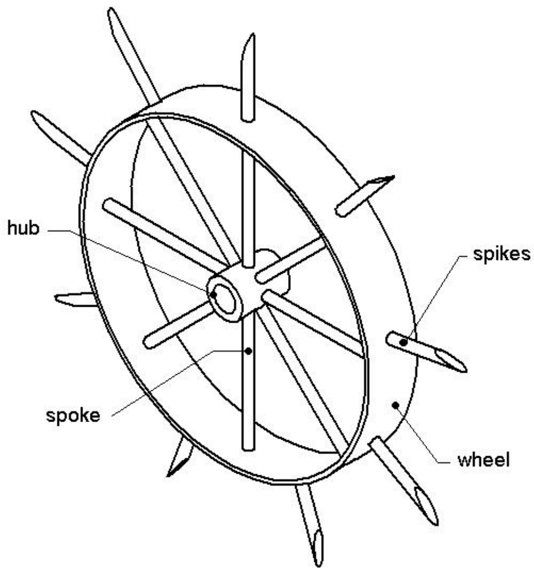


Figure 3.5. Press Wheel

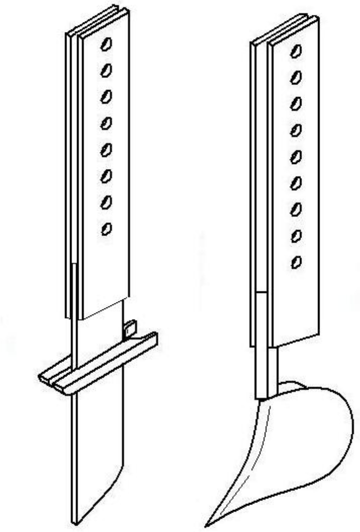
3.5.2.3 Design and Fabrication of the Opener

Two types of openers were used in the study: (1) the mould board type, and (2) the shank type. The mould board type was designed based on the conventional mould board. The design provided space under the opener for seed placement. It was also designed and tested to produce a maximum opening width of 9.0 cm and a maximum depth of 8.5 cm.

The mould board type was made from 3/16 in MS plate formed and welded to its shape. It was then cut to size and shaped using an acetylene torch, then ground while it was mounted on a vise. The mould board was welded to the adjustment link as shown in Figure 3.6(b).

The shank type opener was designed to provide a narrow opening which is ideal for smaller seeds. It was designed to have a block to facilitate seed placement from the hose.

The shank type opener was made from 3/16 in MS plate cut to size and shaped as shown in Figure 3.6(a). It was ground while mounted on the vise. After which, the shank was welded to the adjustment link.



(a) (b)

Figure 3.6. Openers: (a) shank type opener; (b) mould-board type

3.5.2.4 Design and Fabrication of the Handle

The handle was mounted at the rear end of the drill. Its main function was to provide stability and maneuvering control of the equipment. The handle was fabricated at a height that was comfortable to the farmer.

The handle was made from 1 in steel tube cut to size, formed and welded together to form a 'Y'. The link was made from 2in x 3/16 in MS plate cut to size and welded on the handle as shown in Figure 3.7.

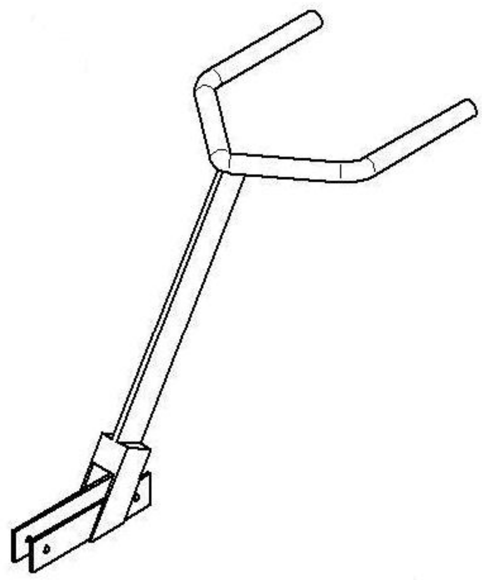


Figure 3.7. Handle

3.5.2.5 Design and Fabrication of Seeder

The design of the seeder was based on a gear where flutes or pockets were shaped in circle. It was designed to collect and deliver seed/s as the equipment moves. The seed mechanism was designed to carry two seeds at most. The number of flutes varied depending in the spacing needed between individual seeds or batches of seeds. Three types of vegetable seeds were considered in the study, (1) the mongo seeds, (2) cabbage seeds, and (3) bell pepper seeds. For each type, a seed metering disk was designed and fabricated since the size of the flutes varies to the size and shape of the seeds. The seeds were chosen to determine if the designed seeder would work on an oval shape seed, a spherical seed, and a flat seed.

The seeder consisted of the seed metering disk, spacers, side plates, bushing, the shaft, frame, and delivery hose. The metering disk, spacers, and side plates were made of acrylic material. The thickness of the acrylic used in the metering disks and the spacers depended on the size of the seeds (i.e. in mongo seeds a 3/8 in thick acrylic was used; in cabbage seeds 1/8 in thick acrylic was used; and in bell pepper seeds 3/16 in thick acrylic was used). The metering disks, spacers, and side plates were machined to its form using CNC milling machine. The bushing was turned from a 1 in diameter brass bar using the CNC lathe machine. The shaft was turned from a 5/8 in diameter CRS using the CNC lathe machine as well. The frame was made from 2 in x 3/16 in flat bar cut size and welded together as shown in Figure 3.8.

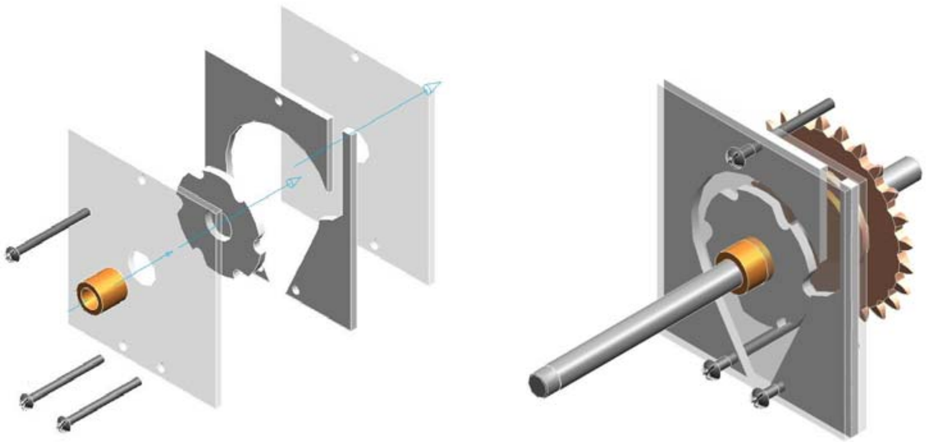


Figure 3.8. Seeder Mechanism

3.5.2.6 Design and Fabrication of Fertilizer Dispenser

The fertilizer dispenser has 12 compartments arranged in circle and was designed to deliver fertilizer on top of the soil after it was compressed. An inorganic powder fertilizer was used in the study. The design of the dispenser can be compared to a water mill. It was mounted to a common shaft with the seeder mechanism.

The fertilizer dispenser consisted of the fertilizer wheel, plates, divisions, boundary walls, and bushing. The fertilizer wheel, plates, and flutes were made from 3/16 in acrylics and were machined to their forms through the CNC milling machine. The flutes were cut to size and were fitted to the machined niche. The boundary walls were made of G.I. sheet cut to sizes and then fitted into the niche. The bushing was turned from a 1in diameter brass bar. It was then mounted on the same shaft and frame with the seeder as shown in Figure 3.9.

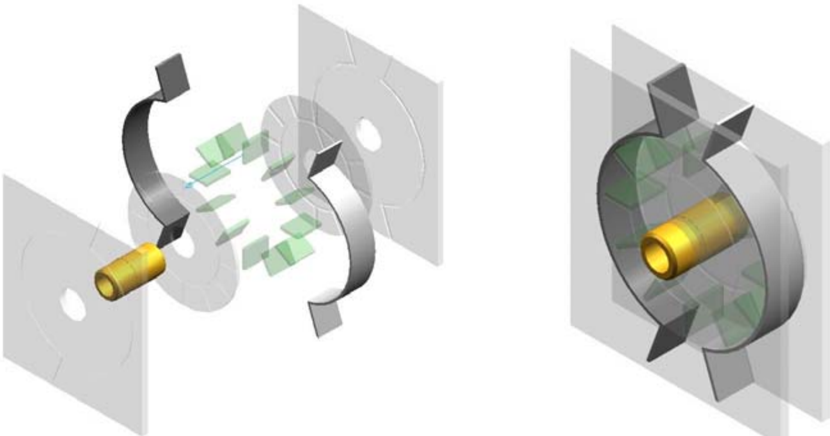


Figure 3.9. Fertilizer Dispenser

3.5.2.7 Design and Fabrication of Soil Compactor

The soil compactor has a pair of wheels with 10 in diameter and was designed to: (1) control the planting depth of the drill; (2) firm the soil over the slot to assure seed to soil contact and to protect the seeds against insects or pests. The distance between wheels can be adjusted to prevent too much compression of the soil. Its rotation was relative to the movement of the equipment.

The soil compactor consisted of the hubs, a pair of wheel, spokes, bushings and the shaft. The hubs were turned from a 1.5 in diameter CRS using the CNC lathe machine. The pair of wheel was made from 2 in x 3/16 in MS plate rolled to form a wheel. The spokes was made from 3/8 in diameter CRS were cut to size then welded to the wheel and hub as shown in Figure 3.10. The bushings were turned from a 1 in diameter brass bar and were fitted to the hub. The shaft was turned from a 5/8 in diameter CRS using the CNC lathe machine.

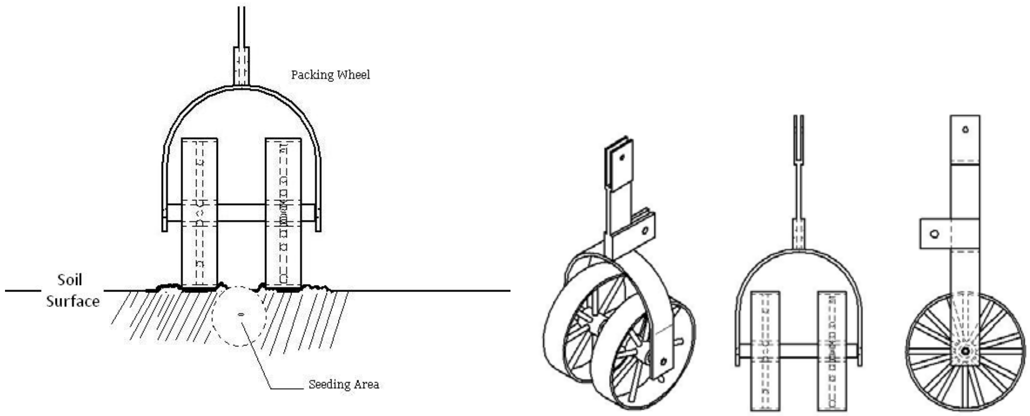


Figure 3.10. Soil Compactor

3.5.2.8 Design and Fabrication of Residue Roller

The 12.5 in diameter residue roller has 10 blades and was designed to crimp crop residue to facilitate killing. The blades were arranged in circle to add impact as it crimps the residues. The design of a frame can be compared to push cart. It was designed to carry weights to ease crimping of the residues.

The residue roller consisted of the wheels, blades, frame, and the handle. The wheels were made from 1.5 in x 1/8 in angle bar formed to a wheel. The blades were also made from the same angle bars cut to size and welded to the wheels as shown. The frame was made from a combination of angle bars, flat bars and square bars for additional strength. They were cut to size and welded together as shown. The handle was made from 1in diameter steel tube welded to its links made from angle bars. The handle was connected to the frame as shown in Figure 3.11.

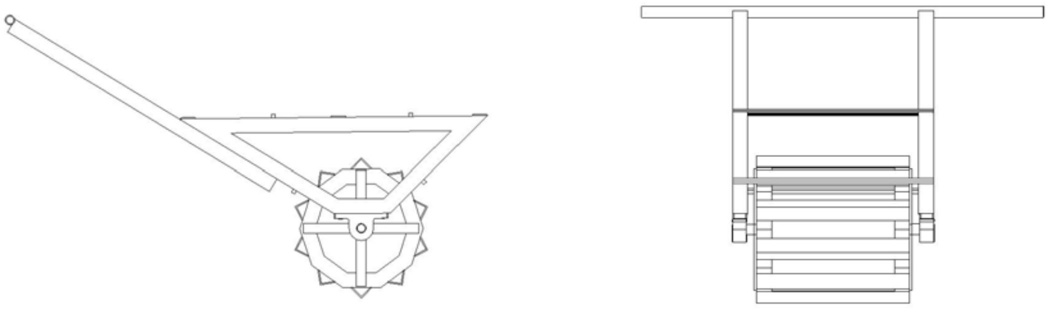


Figure 3.11. Residue Roller

3.5.2.9 Design and Fabrication of Dibbler

The dibbler was designed for single spot seeding. Using the principle of the lever, one jaw could open the soil with very little effort. Delivery of seeds was controlled horizontal metering plate. The seeds passed through a plastic hose, through the pipe, and into the hole

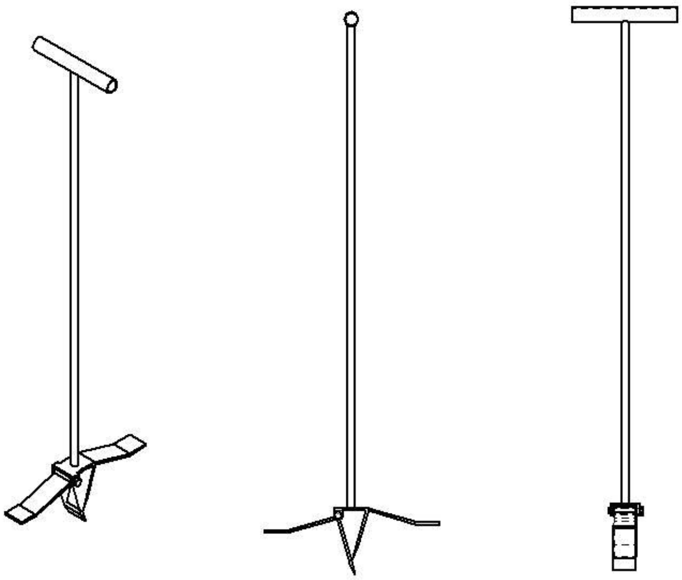


Figure 3.12. Dibbler

The dibbler consisted of the seeding mechanism, openers and the handle. The seeding mechanism was made from 5/16 in acrylic cut to size and assembled as shown in Figure 3.13. The openers were made from 2 in x 3/16 in flat bars cut to size, formed, and welded together as shown in Figure 3.12. The handle was made from 5/8 in diameter steel tube welded to the welded to the wings as shown in Figure 3.12.

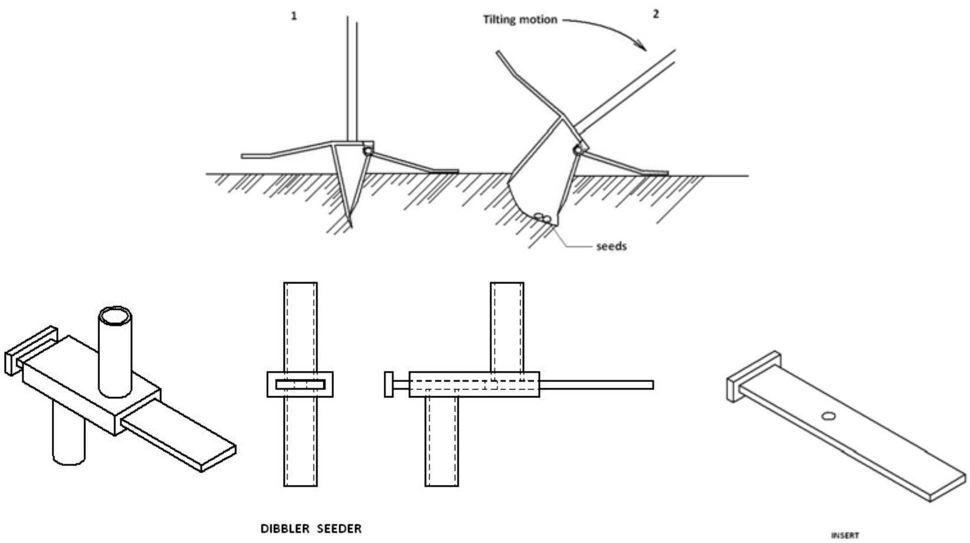


Figure 3.13. Dibbler action and seeding plates

3.5.3 Functional Testing

The functional testing was consisted of tests on the coulter, opener, seeder mechanism, fertilizer dispenser, soil compactor, residue roller, and dibbler. The tests were done to determine the functionality of the equipment. Criteria were set to guide the researchers in the activity.

3.5.3.1 Testing the coulter

Testing Procedure

The test of coulter consisted of test on the depth of cut of the coulter, test of cutting efficiency of the coulter, and the force needed to pull the coulter.

The test of the coulter began with the mounting of coulter on the drill. Then, the drill was positioned in the test plot. Weights were added before it was pulled. The force to pull the drill was then read from the industrial weighing scale positioned in front of the drill. Then, uncut stolons and occurrence of “hair pinning” was observed to determine the cutting efficiency of the coulter. The depth and width of opening was measured using a tape measure.

3.5.3.2 Testing the opener

Testing Procedure

The test of the opener consisted of the measurement of depth of penetration and the width of opening.

The test of the opener began with the mounting of the opener in the drill. Then, the drill was positioned at the test plot. Weights were added before it was pulled. Then the forced was read from the weighing scale. The depth and width of penetration was measured using a tape measure.

3.5.3.3 Testing the seeder mechanism

Testing Procedure

The test of the seeder mechanism consisted of test on planting depth and seed spacing efficiency

The test began with mounting the seeder on the drill. The drill was then positioned at the test plot. Then the drill was pulled. The seeds dropped were located.

The distance between seeds and the depth of the seeds from the nominal surface were measured using a tape measure.

3.5.3.4 Testing the fertilizer dispenser

Testing Procedure

The functional testing of the fertilizer dispenser consisted of the measurement of the mass dropped by the dispenser per meter.

The fertilizer was mounted in the drill. Then, the equipment was pulled until the fertilizer in the bin was consumed. Then, the length of run was measured.

3.5.3.5 Testing the soil compactor

Testing Procedure

The functional testing of the soil compactor consisted of observation if the compactor has enabled a good contact between the soil and the seeds.

In the test of the soil compactor, the coulter and opener was also mounted. The drill was then positioned in the test plot. Weights were added before it was pulled. The force was read from the weighing scale. The contact between the soil and the seeds were observed to determine functionality of the compactor.

3.5.3.6 Testing the Residue Roller

Testing Procedure

The functional testing of the residue roller consisted tests on the efficiency of crimping crop residues and the downward force needed to crimp the residue

The test began with the assembly of the residue roller. Then, it was positioned at the test plots. Before it was pushed, weights were added to determine the downward force needed to crimp the residue. The crimping efficiency of the roller was also observed.

3.5.3.7 Testing the Dibbler

Testing Procedure

The functional test of the dibbler consisted of tests on soil and residue penetration, seeding efficiency, seeds dropped per seeding action, ease of operation, and the rate of seeding.

The test began with the assembly of the dibbler. Plots were selected for the test. Then seeding efficiency and ease of operation was observed. Effective penetration of the opener of the dibbler to the soil and the residue was also observed.

3.5.4 On-Farm Trials

The respondents in the baseline survey were invited to the on-farm trial, however the farmers were harvesting during the time of the on-farm trial, and only one respondent was able to view the function of the no-till equipment.

The on-farm trial began with the preparation of test plots. Then the no-till farming equipment was introduced to the farmer. The drill was then run on the first row. The drill was then maneuvered for the next run. Then the drill was run on the next row. Simultaneous to the run, the operation of the drill was explained to the farmer.

3.5.5 Final Survey

The final survey involved interviews with the respondent present on the trial. The interview was initiated to gather final data needed for the comparison of no-till farming with conventional farming. Comments and suggestions from the respondent were also taken into account in the interview.

Chapter 4

RESULTS AND ANALYSIS

This chapter discusses the results gathered in the baseline and final interviews, the functional testing, and the on-farm trial.

4.1 Attributes of Lucban

Table 4.1
Attributes of Lucban

Land Area	15,415 ha
Elevation (average)	1,500 ft above sea level
Population	44,560
- Male	50.68%
- Female	49.32%
Vegetable Farming in Lucban	Almost 30% of farming activity
Agricultural Products	1. Green Pachoy (Singkang) 2. Kinchay 3. Bitter Melon 4. Radish (Labanos)
List of Cooperatives	1. Hog Raisers 2. San Luis Development 3. Palola Multi-purpose Cooperative

Table 4.1 shows that Lucban is a candidate of having problems with soil erosion due to its relatively high elevation. According Mang Angelo and Mang Ariel, both officers of the cooperative, most of the plots in Barangay Palola are sloping and most farmers practice land tilling. Thus, soil erosion, indeed, can be a really big problem later on in the place. Meanwhile, support for the development and dissemination of agricultural technology, such as no-till farming system, can be channeled through the cooperative through seminars and trainings.

4.2 Local Fabricators in Lucban

The town of Lucban was mapped for local fabricators. Two fabricators were found and are shown in Table 4.2.

Table 4.2
Local Fabricators

Fabricator	Tools/Equipment
Jonnny Bon (Blacksmith)	1. Welding 2. Grinder 3. Anvil 4. Mallet 5. Punch (Punsod)
Fred Salvacion	1. Drill press 2. Oxy-acetylene 3. Welding 4. Grinder

The table shows that the two fabricators have no ability to turn or mill parts. According to the two fabricators, there are machine shops in the next town, which is approximately 30 to 60 minutes away.

4.3 Comparison of Farming Process

Table 4.3
Comparison between the processes of No-Till Farming and Conventional Farming

Farming Process	Conventional Farming	No-Till Farming
Land Preparation	1. Slashing 2. Raking 3. Burning 4. Plowing 5. Application of fertilizer 6. Harrowing 7. Ridging	1. Mechanical killing (residue roller) 2. Herbicide spraying
Planting	1. Sowing of nursery 2. Transplanting	1. Use of no-till equipment

Table 4.3 shows the difference of farming process between no-till farming and conventional farming. The table shows that no-till farming eliminates several farming activities like the slashing, raking, burning, plowing, manual application of fertilizer, harrowing, ridging, plotting, and manual sowing.

Table 4.4
Comparison of time consumed per hectare between
No-Till farming and Conventional farming

Conventional Farming	Time consumed per hectare	Manpower needed	No-Till Farming	Time consumed per hectare	Manpower needed
Slashing *(using grass cutter)*	3 days	1 persons	Mechanical killing (residue roller)	2 days	2 persons
Raking	2-3 days	2 persons			
Burning					
Plowing	4 days	1 persons; 1 carabao	Herbicide spraying	*simultaneous with mechanical killing*	1 person
Manual Application of Fertilizer	1-2 days	1 persons	Use of no-till equipment	1 day	3 persons; 1 carabao
Harrowing (Suyod)	3 days	1 persons; 1 carabao			
Ridging	3 days	5 persons			
Sowing of nursery	Half day	1 persons			
Manual transplanting	3 days	5 persons			

** See Appendix B for breakdown of man-power and animal-power requirement*

Table 4.4 shows that conventional farming would take at least a month, including decomposition of fertilizers, to finish. The table shows that no-till farming reduces man-hour and animal-hour of planting operation. According to Mang Angelo and Mang Ariel, each person is paid 200Php per day of work and a carabao cost 500Php a day. This shows that the operational cost of farming operation would be reduced in no-till farming.

Table 4.5
Labor Cost per hectare in
No-till farming and Conventional farming

Conventional Farming	Cost	No-Till Farming	Cost
Slashing	600	Use of residue roller	800
Raking	800	Herbicide spraying	400
Burning			
Plowing	800		
Manual Application of Fertilizer	200	Use of no-till drill and planter	600
Harrowing (Suyod)	600	Rent of Carabo *(for no-till drill and planter)*	500
Ridging	3000		
Sowing of nursery	100		
Manual Transplanting	3000		
Rent of carabao *(for plowing and harrowing)*	3500		
Total Labor Cost	**12600**		**2300**

The operation and labor cost shown in Table 4.5 is based on minimum man-power requirement at minimum working days.

Table 4.6
Cost of tools used in No-Till Drill and Planter and
Conventional Farming

Conventional Farming Equipment	Cost	No-Till Drill and Planter	Cost
Grass Cutter	14,000	Residue Roller	3,234.11
Bolo	300	Nab-sack sprayer	2,200.00
Piko	280	Drill and Planter	11,953.83
Rake	220		
Plow	3,500		
Harrower	1,800		
Shovel	220		
Crow Bar	250		
TOTAL	**20,570**		**17,387.94**

** See Appendix C for breakdown of initial cost*

The initial investment on equipment for conventional system and no-till system would be 20,570Php and 17,387.94Php, respectively. Table 4.5 shows that no-till farming equipment would cost less than the equipment used in conventional farming.

Farmers used grass cutters in land preparation. Based from the baseline interview, farmers consumed 6.34 liters of fuel (*premium*) per hectare. The fuel costs 46.87Php per liter at present. The cost of fuel per hectare would then be 297.3588Php. Small scale farmers have an average planting area of 6 hectares per rotation and 3 rotations per years. A Round-up herbicide cost 550Php per liter; 2 liters of herbicide is consumed per hectare. Thus, the cost of herbicide would amount to 1100Php per hectare.

Table 4.7
Comparing Alternatives
Scenario 1: New farmers choosing the best alternative

CONVENTIONAL SYSTEM		
KNOWN:		
First Cost =	20570	Php
Operational Cost =	297.3588	Php/hec
Labor Cost =	12600	Php/hec
Taxes & Insurance =	Exempted	
Planting Area =	1	ha/rotation
Crop Rotation per year =	3	rotations/yr
Life =	10	years
Minimum required rate of return =	0.15	15%
Depreciation =	1013.11493	Php/year
Operation Cost =	892.0764	Php/year
Labor Cost =	37800	Php/year
Interest on capital =	3085.5	Php/year
First Annual Cost =	**63360.6913**	**Php**
Succeeding Annual Cost =	**42790.6913**	**Php**

NO-TILL SYSTEM (Drill and Planter)		
KNOWN:		
First Cost =	17387.94	Php
Operational Cost =	1100	Php/hec
Labor Cost =	2300	Php/hec
Taxes & Insurance =	Exempted	
Planting Area =	1	ha/rotation
Crop Rotation per year =	3	rotations/yr
Life =	10	years
Minimum required rate of return =	0.15	15%
Depreciation =	856.391908	Php/year
Operation Cost =	3300	Php/year
Labor Cost =	6900	Php/year
Interest on capital =	2608.191	Php/year
First Annual Cost =	**31052.5229**	**Php**
Succeeding Annual Cost =	**13664.5829**	**Php**

** See Appendix D for computation of annual cost*

Table 4.7 shows that no-till farming system would cost less than conventional farming if a person was to start a farming profession. The first annual cost of the no-till system would be lesser by 32,308 Php than the conventional system. Also, in the succeeding years, no-till system would be lesser by 29,126 Php.

Table 4.8
Comparing Alternatives
Scenario 2: Conventional farmers shifting to No-till system

CONVENTIONAL SYSTEM		
KNOWN:		
First Cost =	0	Php
Operational Cost =	297.3588	Php/hec
Labor Cost =	12600	Php/hec
Taxes & Insurance =	Exempted	
Planting Are =	1	ha/rotation
Crop Rotation per year =	3	rotations
Life =	10	years
Minimum required rate of return =	0.15	15%
Depreciation =	1013.11493	Php/year
Operation Cost =	892.0764	Php/year
Labor Cost =	37800	Php/year
Interest on capital =	0	Php/year
First Annual Cost =	**39705.1913**	**Php**
Succeeding Annual Cost=	**39705.1913**	**Php**

NO-TILL SYSTEM (Drill and Planter)		
KNOWN:		
First Cost =	17387.94	Php
Operational Cost =	1100	Php/hec
Labor Cost =	2300	Php/hec
Taxes & Insurance =	Exempted	
Planting Are =	1	ha/rotation
Crop Rotation per year =	3	rotations
Life =	10	years
Minimum required rate of return =	0.15	15%
Depreciation =	856.391908	Php/year
Operation Cost =	3300	Php/year
Labor Cost =	6900	Php/year
Interest on capital =	2608.191	Php/year
Salvage Value of Conventional Farming =	10438.9	Php
First Annual Cost =	**20613.6229**	**Php**
Succeeding Annual Cost=	**13664.5829**	**Php**

** See Appendix E for computations of annual cost*

Table 4.8 shows that it would also be more economical for a farmer, practicing conventional farming, to shift to no-till farming system. The table shows that the farmer would save 19,092 Php of his first annual cost upon adoption of no-till farming system. Also, succeeding annual cost after the first year would be 26, 040 Php lesser.

Table 4.9
Time consumed using Three Dibblers

No-Till Farming	Time consumed per hectare	Manpower needed	Labor Cost
Mechanical killing (residue roller)	2 days	2 persons	800
Herbicide spraying	*simultaneous with mechanical killing*	1 person	400
Use of 3 Dibblers	5.5 days	3 person	3300

Table 4.9 shows the time consumed, man-power requirement, and the labor cost of using three dibblers simultaneously.

Table 4.10
Cost of tools used in No-Till
(using 3 Dibbler)

No-Till Equipment	Cost
Residue Roller	3,234.11
Nab-sack sprayer	2,200.00
3 Dibblers	2,532.46
Total	**7,966.57**

** See Appendix C for breakdown of initial cost*

Table 4.10 shows breakdown of cost of using dibblers.

Table 4.11
Comparing Alternatives
Comparison of using Dibbler, and Drill and Planter

NO-TILL SYSTEM (Using 3 Dibbler)		
KNOWN:		
First Cost =	7966.57	Php
Operational Cost =	1100	Php/hec
Labor Cost =	4500	Php/hec
Taxes & Insurance =	Exempted	
Planting Area =	1	ha/rotation
Crop Rotation per year =	3	rotations
Life =	10	years
Minimum required rate of return =	0.15	15%
Depreciation =	392.370004	Php/year
Operation Cost =	3300	Php/year
Labor Cost =	13500	Php/year
Interest on capital =	1194.9855	Php/year
First Annual Cost =	**26353.9255**	**Php**
Succeeding Annual Cost =	**18387.3555**	**Php**

NO-TILL SYSTEM (Drill and Planter)		
KNOWN:		
First Cost =	17387.94	Php
Operational Cost =	1100	Php/hec
Labor Cost =	2300	Php/hec
Taxes & Insurance =	Exempted	
Planting Area =	1	ha/rotation
Crop Rotation per year =	3	rotations
Life =	10	years
Minimum required rate of return =	0.15	15%
Depreciation =	856.391908	Php/year
Operation Cost =	3300	Php/year
Labor Cost =	6900	Php/year
Interest on capital =	2608.191	Php/year
First Annual Cost =	**31052.5229**	**Php**
Succeeding Annual Cost =	**13664.5829**	**Php**

** See Appendix F for computations of annual cost*

Table 4.11 shows that by using the dibbler, the first annual cost would be lesser by 4,698 Php. However, in the succeeding years, the annual cost for the dibbler would be greater by 4,722 Php. Also, the time spent in planting would be more than 2 times longer. The study also found that at 2 or more hectares, the use of the dibbler would incur greater annual costs than using the equipment.

4.4 Depth and width measurements

Table 4.12
Comparison of Shank Opener and Mould Board Opener

(a) Shank type opener on dry soil

	(opener setting at # 4)	
	Depth (mm)	Width (mm)
1st trial	45	35
2nd trial	40	30
3rd trial	42	35

(b) Mould board type opener on moist soil

	(opener setting at # 4)	
	Depth (mm)	Width (mm)
1st trial	47	50
2nd trial	48	55
3rd trial	45	50

The depth width of soil opening for both shank type and mould board type was enough for seeding. For transplanting, deeper and wider soil opening would be required.

4.5 Pulling Force measurements

Table 4.13
Required Pulling Force on Dry Soil

(a) Press wheels and Packing wheels

Pulling Force

Trials	Force reading (kg)		
	minimum	maximum	constant
1st	10	25	15
2nd	10	25	15
3rd	10	25	15

(b) Wheels and Coulter

Pulling Force

Trials	Force reading (kg)		
	minimum	maximum	constant
1st	20	45	30
2nd	20	45	30
3rd	20	45	30

(c) Wheels, Coulter and Shank opener at 4th setting

Pulling Force

Trials	Force reading (kg)		
	minimum	maximum	constant
1st	25	60	30
2nd	30	60	30
3rd	30	65	35

(d) Wheels, Coulter and Mould board opener at 4th setting

Pulling Force

Trials	Force reading (kg)		
	minimum	maximum	constant
1st	40	70	45
2nd	35	70	40
3rd	35	75	45

With two 25 kg weights placed at the rear end of the drill, the drill was pulled to determine the maximum, minimum and the constant pulling force required to move the equipment. The pulling force required to move the equipment from rest was around 70 kg. The pulling force observed while the equipment was moving at a more or less constant speed was 45 kg. From the 45 kg force, 33.33% came from the press wheels, the compactor and the frame; 33.33% came from the coulter. The required pulling force of the shank opener at constant speed was 33.33% less than that of the mini-mould board opener.

Table 4.14
Required Pulling Force on Wet Soil

Wheels, Coulter and Mould board opener at 4th setting

Pulling Force

Trials	Force reading (kg)	
	minimum	maximum
1st	60	90
2nd	60	90
3rd	50	90

Table 4.2 shows that on wet soil the equipment required higher pulling force than on dry soil. However, with only 90 kg required pulling force, it could still be pulled by the carabao, since a carabao can pull a maximum force of 350. [22]

4.6 Seeding and Fertilizer Dispensing

For the mung bean, in the first trial, the average number seeds that dropped per position were 2 seeds while the average spacing was 498 mm with a standard deviation of 92 mm. In the second trial, the average number of seeds that dropped per position was also 2 seeds while the average spacing was 499 mm but with a larger standard deviation of 177 mm. This shows that the seeding was erratic. The seeder mechanism was also tested on cabbage (round) and bell pepper (flat). The mechanism worked for both types of seeds and the average number of seeds per position for cabbage and bell pepper was 5 seeds and 4 seeds, respectively.

There were no problems in the delivery of fertilizers. The rate of delivery of fertilizer dispenser was about 45 grams per minute.

4.7 Dibbler

The dibbler penetrated the soil easily and might cut through thick residues. It delivered seeds at 10 to 11 seeds per minute. However, mud sticking to the openers causes big problems on the delivery of the seed.

4.8 Residue Roller

The residue roller was able to crimp the stems and stolons of some weeds and cover crops. It was operated by one person at 50 meters per minute. However, it was observed that some weeds were not killed, even those whose stems were already crimped.

Chapter 5

CONCLUSION AND RECOMMENDATION

This chapter discusses the generalizations that were derived from the results of the study regarding the development and testing of the farming equipment. It also discusses the problems encountered in the study and the recommendations that were proposed.

5.1 Conclusion

The results have shown that no-till farming has reduced the man-hour and animal-hour requirement by 308 man-hours and 48 animal-hours, respectively. Also, this study proves that no-till system is more economical than conventional system. Assuming that both system have the same yield (refer to Table 2.1), the annual cost of no-till system is lesser than the conventional system. It is proven that if a person is to start a farming profession it is best to apply the no-till system since its annual cost is lesser by 32,308 Php and the succeeding years of farming by 29,126 Php; Also, it would beneficial for a farmer practicing conventional system to shift to the no-till system since no-till has reduced the annual cost on its first year of adoption by 19,092 Php and 26,040 Php on the succeeding years.

Based on the surveys, the no-till equipment could be produced and modified using locally available materials by local fabricators. The no-till equipment prototype cost 11,000Php and could be modified to cost much lower. The dibbler likewise was relatively cheap and could be made by the farmers themselves using materials from the farm and household. The dibbler, which operated at 10 to 11 seeds per minute, was applicable in very steep slopes.

The annual cost of using dibbler and drill and planter was also compared. The first annual cost of using dibbler is lesser by 4,698 Php. However, its annual cost would be higher by 4,722 Php in the succeeding years. Also, the time spent on farming is 2 times more than using the drill and planting.

Based on the test, the maximum force required to pull the equipment on dry soil was 75 kg. Thus, a maximum of 3 rows could be joined together since a carabao can pull a maximum force of 250 kg. On wet soil the maximum pulling force required was 90 kg. Thus, a maximum of 2 rows could be joined. The development of multiple rows may also solve the problem in stability and since it is multiple rows, the seeding time will be much faster.

Although the equipment was made to work, there were some design flaws that were observed.

1. The equipment was difficult to balance due to the high location of center of gravity and inappropriate handle design.
2. The seeder functioned inconsistently. The standard deviation was 91 mm and 177 mm. The difference between the standard deviation of the two tests made was considerably large.

Furthermore, the residue roller was not enough to kill the stems and stolons of the weeds since most of the weeds that were crimped were still able to survive. However, the roller was able to give direction to the orientation of bending of the stems, thus, it was able to facilitate easier cutting of residues. Herbicides were also used, after rolling, to kill the weeds but due to lack of time, no data were gathered.

5.2 Recommendations

Based on the findings, the following recommendations are proposed:

- Modify design to solve stability problems and seeder problems. To solve problems on stability it is recommended to: (1) position the weights near the ground, (2) design the center of gravity of the equipment be near the ground, and (3) position the handle near the opener for ease of maneuver. To solve problems on seeder problems it is recommended to: (1) minimize size of the channel between the seed metering disk and the spacers to eliminate premature drop of seeds, and (2) position the seeder and fertilizer dispenser near the ground to avoid delay of delivery.
- Design, fabricate and test multiple-row equipment and compare its cost effectiveness and performance with the single-row equipment.
- Design, fabricate and develop a rider-type no-till equipment to eliminate the need to use weights.
- Make projections on maintenance cost.
- Evaluate the cost effectiveness and productivity of using the no-till equipment on rice, maize and other crops planted on large plain areas.
- Compare the yield between using the no-till method and using conventional in vegetable farming.
- Do force analysis on the equipment for design optimization
- Evaluate the performance of the equipment on different soil types and moisture
- Develop a mechanical cover crop killer to minimize the use of chemicals in killing weeds
- Develop a motorized no-till planter

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Appendix A

Survey Form

Name: **Ariel Dañez** Age: **34** Sex: **Male**

Status: **Married**

If married,
Number of Children: Boys: **2** Number of children studying: **2**
Girls: ____

Income from Farming: **40% of Capital** Others sources of income: **None**

Properties Educational Attainment: **B.S. Accountancy**

Land: ✔
Animal: ✔ Mechanical skills: ____
Farming Equipment: ✔

Plantation Area: **6 Hectares**

Years of farming experience: **24 years** Hours of land preparation and planting **2 weeks land preparation; 4 days planting**

Farming Techniques: Number of farmers for the job: **5**

Weeding

Hand weeding ____
Slash and Burn ✔ **(using grass cutter; no burning)**
Use of Herbicides ✔ Equipment Used: **bladed tools**
plow
Plowing ✔ **harrow**
Harrowing ✔ **nab-sack sprayer**
Furrowing ✔
Ridging ✔ Crops : **Raddish, Pechay, Sayote,**
Planting ✔ **Cucumber, Bitter melon**
Seeding ✔
Transplanting ✔

How much are you willing to invest for a planting equipment? **Php 15000.00**

Manual ✔
Using Devices ____

Application of Fertilizers

Manual ✔
Using Devices ____

Application of Herbicides

Manual ____
Using Devices ✔

Appendix B

(a) Man-hours

Conventional Farming	Time consumed per hectare (days)	Hours of work/day	Manpower needed	man-hour
Slashing *(using grass cutter)*	3	8	1	24
Raking Burning	2	8	2	32
Plowing	4	8	1	32
Manual Application of Fertilizer	1	8	1	8
Harrowing (Suyod)	3	8	1	24
Ridging	3	8	5	120
Sowing of nursery	0.50	8	1	4
Manual transplanting	3	8	5	120
		TOTAL MAN-HOURS		**364**

No-Till Farming	Time consumed per hectare	Hours of work/day	Manpower needed	man-hour
Mechanical killing (residue roller)	2	8	1	16
Herbicide spraying	2	8	1	16
Use of no-till equipment	1	8	3	24
		TOTAL MAN-HOURS		**56**

(b) Animal-hours

Conventional Farming	Time consumed per hectare (days)	Hours of work/day	Animal-power needed	animal-hours
Plowing	4	8	1	32
Harrowing	3	8	1	24
		TOTAL ANIMAL-HOURS		**56**

No-Till Farming	Time consumed per hectare (days)	Hours of work/day	Animal-power needed	animal-hours
Plowing	1	8	1	8
		TOTAL ANIMAL-HOURS		**8**

Appendix C

Breakdown of Initial Costs

(a) Drill and Planter

MATERIALS USED		Unit	Unit Cost	Cost
M/S Flat Bar	3/16" x 2" x 20'	2	570	1140
CRS	1 1/2' x 1'	0.05	1845	92.25
CRS	¾" x 1 1/2'	0.075	700	52.5
CRS	5/8" x 2 1/2'	0.125	500	62.5
CRS	3/8" x 10'	0.5	160	80
Steel Tube	1" x 4 1/2'	0.225	400	90
Chain and Sprockets		1	375	375
Acrylics	1/8" x 12" x 12"	1	80	80
	3/16" x 12" x 12	1	120	120
	1/4" x 12" x 12"	1	140	140
Brass	1" x 1'	1	650	650
Bearings		3	58	174
Bolt and Nut	1/2" x 2"	6	13	78
	3/8" x 2"	12	4.75	57
Funnel		1	8	8
Plastic hose	3/8" x 3'	0.6098	8	4.878049
	Total Cost of Materials			**3199.25**

FABRICATION PROCESS				Electric Cost	Labor Cost	Cost
Drilling				2.39	180	182.39
Welding				171.79	240	411.79
Lathe CNC				102.92	1,500.00	1,602.92
Grinding				147.07	750	897.07
Milling CNC				310.41	250	560.41
Rolling	12"	2	300	600	-	600
	10"	2	250	500	-	500
Bench work	4 persons	5 days	200/day	-	4,000.00	4,000.00
				Total Cost of Materials		**8754.58**

INITIAL COST of the DRILL 11953.83

(b) Residue Roller

Materials used		**Unit**	**Cost Per Unit**	**Cost**
M/S Flat Bar	3/16" x 2" x 10'	0.5	570	285
Angle Bar	1.5"x 1/8" x 20'	2	660	1320
Steel Tube	1" x 6'	0.3	400	120
Pillow Block		2	150	300
Bolt and Nut		6	4.75	28.5
	Total Cost Of Materials			**2053.5**

Residue Roller Fabrication		**Electric Cost**	**Labor Cost**	**Cost**
Drilling		0.19	30	30.19
Welding		93.24778	180	273.2478
Grinding		27.17507	250	277.1751
Benchwork	1 person 3 days	200/day	600	600
	Total Cost of Fabrication			**1180.613**

INITIAL COST of RESIDUE ROLLER 3234.113

(c) Dibbler

Materials Used		**Unit**	**Cost per unit**	**Cost**
M/S Flat Bar	3/16" x 2" x 20'	0.1	570	57
Steel Tube	¾" x 3'	0.15	300	45
Steel tube	1" x 1'	0.05	400	20
Acrylic	1' x 1' x ¼"	1	140	140
Bolt and Nut	3/8" x 1.5"	2	4.75	9.5
	Total Cost Of Materials			**271.5**

Dibbler Fabrication		**Electric Cost**	**Labor Cost**	**Cost**
Drilling		0.158333	30	30.15833
Welding		15.48342	60	75.48342
Grinding		4.51231	62.5	67.01231
Benchwork	1 person 2 days	200/day	400	400
	Total Cost of Fabrication			**572.6541**

INITIAL COST of DIBBLER 844.1541

Appendix D

Annual Cost Computations: Scenario 1

<u>*Conventional Farming*</u>

Depreciation:

$$Depreciation = \frac{First\ Cost}{\frac{F}{A}} = \frac{First\ Cost}{\left[\frac{(1+i)^t - 1}{i}\right]} = \frac{20,570\ Php}{\left[\frac{(1+0.15)^{10} - 1}{0.15}\right]} = 1,013.11\ Php$$

Operation Cost:

$$Operation\,Cost = Operation\,Cost\ per\ Hectare(\#of\ crop\,rotation)(\#of\ Hectares)$$

$$= 297.3588 Php\ per\ Hectare(3)(1) = 892.0764\ Php$$

Labor Cost:

$$Labor\ Cost = Labor\ Cost\ per\ Hectare(\#of\ crop\,rotation)(\#of\ Hectares)$$

$$= 12,600 Php\,(3)(1) = 37,800\ Php$$

Interest on Capital:

$$Initial\ Capital = First\ Cost(Interest\ on\ Capital)$$

$$= 20,570(0.15) = 3085.5 Php$$

First Annual Cost:

$$FirstAnnualCost = 20,570 + 1,013.1149 + 892.0764 + 37,800 + 3,085.5$$
$$= 63,360.6913 Php$$

Succeeding Annual Cost

$$Succeeding\ Annual\ Cost = 1,013.1149 + 892.0764 + 37,800 + 3,085.5$$
$$= 42,790.6913\ Php$$

No-till Drill and Planter

Depreciation:

$$Depreciation = \frac{First\,Cost}{\frac{F}{A}} = \frac{First\,Cost}{\left[\frac{(1+i)^{l}-1}{i}\right]} = \frac{17,387.94}{\left[\frac{(1+0.15)^{10}-1}{0.15}\right]} = 856.3919\,Php$$

Operation Cost:

$$Operation\,Cost = Operation\,Cost\ per\ Hectare(\#of\ crop\,rotation)(\#of\ Hectares)$$

$$= 1{,}100 Php\ per\ Hectare(3)(1) = 3{,}300\,Php$$

Labor Cost:

$$Labor\ Cost = Labor\ Cost\ per\ Hectare(\#of\ crop\,rotation)(\#of\ Hectares)$$

$$= 2{,}300 Php\,(3)(1) = 6{,}900\ Php$$

Interest on Capital:

$$Initial\ Capital = First\ Cost(Interest\ on\ Capital)$$

$$= 17{,}387.94\ Php\ (0.15) = 2{,}608.191\ Php$$

First Annual Cost:

$$FirstAnnualCost = 17{,}387.94 + 856.3919 - 7 + 3{,}300 + 6{,}900 + 2{,}608.191$$
$$= 31{,}052.5229\ Php$$

Succeeding Annual Cost

$$Succeeding\ Annual\ Cost = 856.3919 + 3{,}300 + 6{,}900 + 2{,}608.191$$
$$= 13{,}664.5829\ Php$$

Appendix E
Annual Cost Computations: Scenario 2

Conventional Farming

Operation Cost:

$$Operation\,Cost = Operation\,Cost\ per\ Hectare(\#of\ crop\,rotation)(\#of\ Hectares)$$

$$= 297.3588 Php\ per\ Hectare(3)(1) = 892.0764\,Php$$

Labor Cost:

$$Labor\,Cost = Labor\,Cost\ per\ Hectare(\#of\ crop\,rotation)(\#of\ Hectares)$$

$$= 12{,}600 Php\,(3)(1) = 37{,}800\,Php$$

First Annual Cost:

$$FirstAnnualCost = 1{,}013.11 + 892.0764 + 37{,}800$$
$$= 39{,}705.1913\ Php$$

Succeeding Annual Cost would be equal to the first annual cost since the first cost was not considered.

Salvage Value

$$C_L = C_O - (Lxd) = 20{,}570 - (10 * 1013.11) = 10{,}438.9 Php$$

No-Till Drill and Planter

The first annual cost would be the same in the first annual cost in scenario 1 with 31,052.5229 Php.

$$Actual\ First\ Annual\,Cost = First\ Annual\,Cost - Salvage\,Value$$
$$= 31{,}052.5229 - 10{,}438.9 = 20{,}613.6229\ \ Php$$

The succeeding annual cost would be the same with the succeeding annual cost in scenario 1 with 13,664.5829 Php.

Appendix F
Annual Cost Computations
Comparison of Dibbler and Drill & Planter

Dibbler

Depreciation:

$$Depreciation = \frac{First\,Cost}{\frac{F}{A}} = \frac{First\,Cost}{\left[\frac{(1+i)^{l}-1}{i}\right]} = \frac{7{,}966.57}{\left[\frac{(1+0.15)^{10}-1}{0.15}\right]} = 392.37\,Php$$

Operation Cost:

$$Operation\,Cost = Operation\,Cost\ per\ Hectare(\#of\ crop\,rotation)(\#of\ Hectares)$$

$$= 1{,}100\,Php\ per\ Hectare(3)(1) = 3{,}300\,Php$$

Labor Cost:

$$Labor\,Cost = Labor\,Cost\ per\ Hectare(\#of\ crop\,rotation)(\#of\ Hectares)$$

$$= 4{,}500\,Php\,(3)(1) = 13{,}500\,Php$$

Interest on Capital:

$$Initial\,Capital = First\,Cost(Interest\,on\,Capital)$$

$$= 7{,}966.57(0.15) = 1{,}194.9855\,Php$$

$$FirstAnnualCost = 7{,}966.57 + 392.37 + 3{,}300 + 13{,}500 + 1{,}194.9855$$
$$= 26{,}323.9255\,Php$$

$$Succeeding\ AnnualCost = 392.37 + 3{,}300 + 13{,}500 + 1{,}194.9855$$
$$= 18{,}387.3555\,Php$$

Drill and Planter

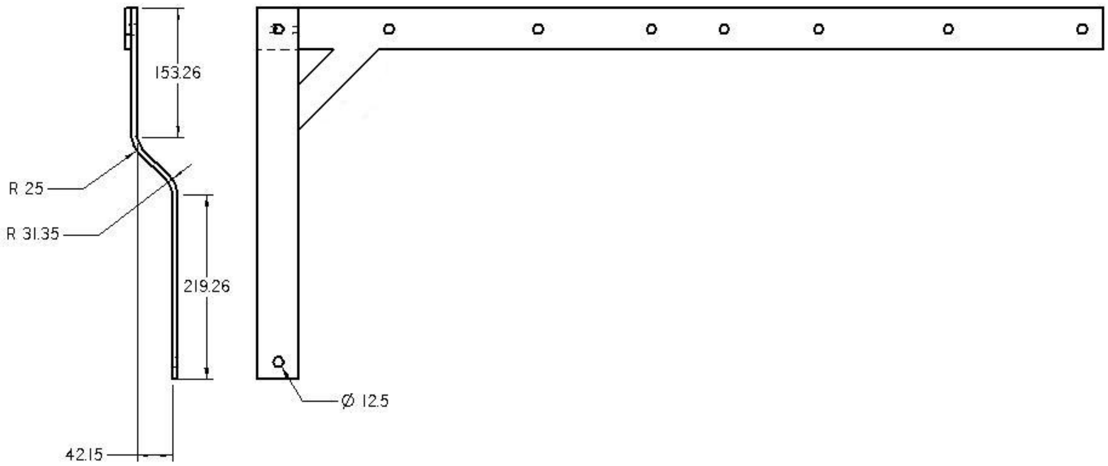
The first annual cost and succeeding annual cost of the drill and planter would have the same values with the first annual cost and succeeding annual cost in scenario 1.

Appendix G

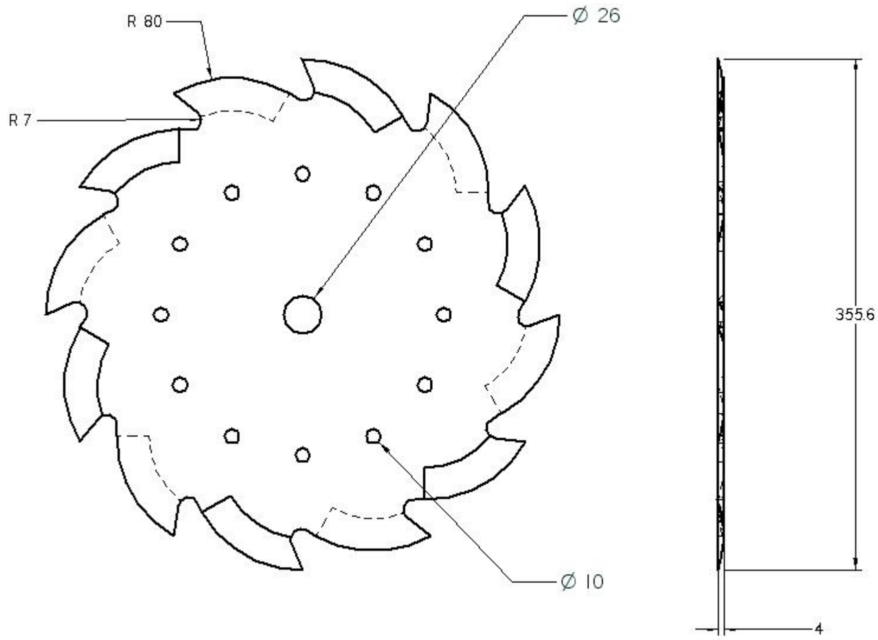
Working Drawings

I. Drill and Planter

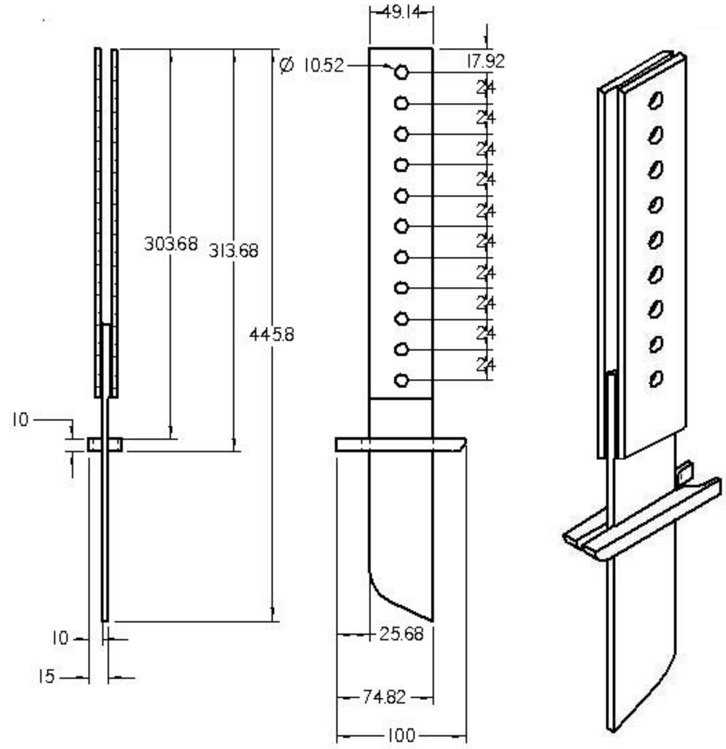
(a) Main Frame



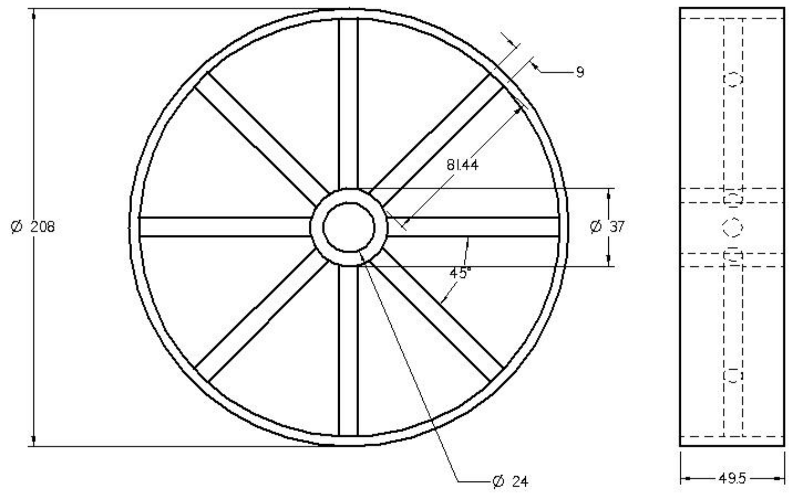
(b) Coulter



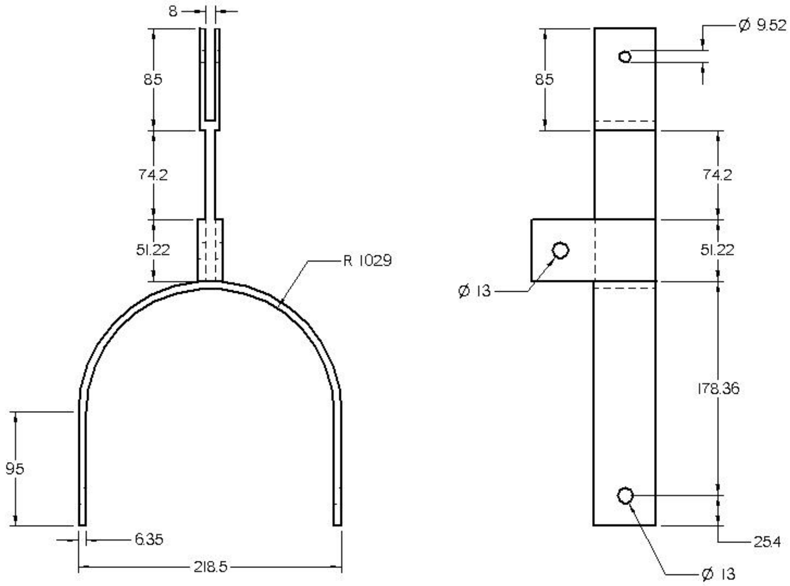
(c) Opener (shank type)



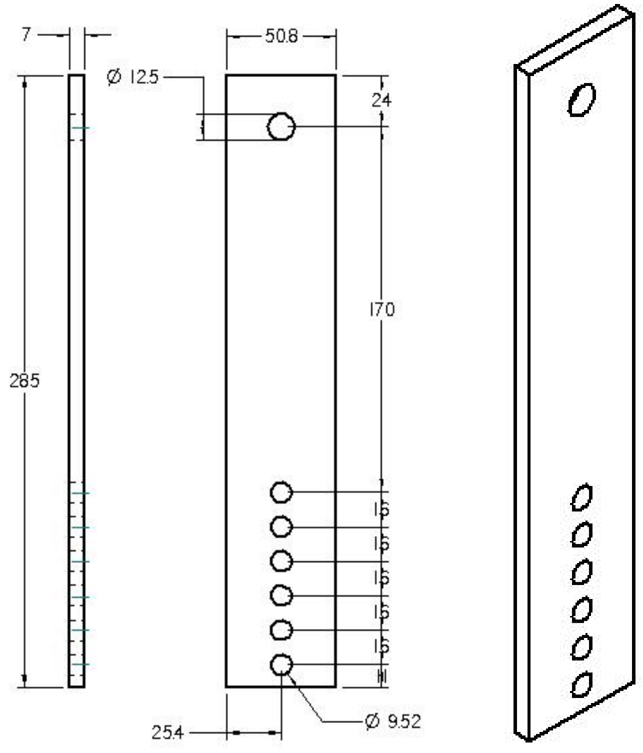
(d) Soil Compactor



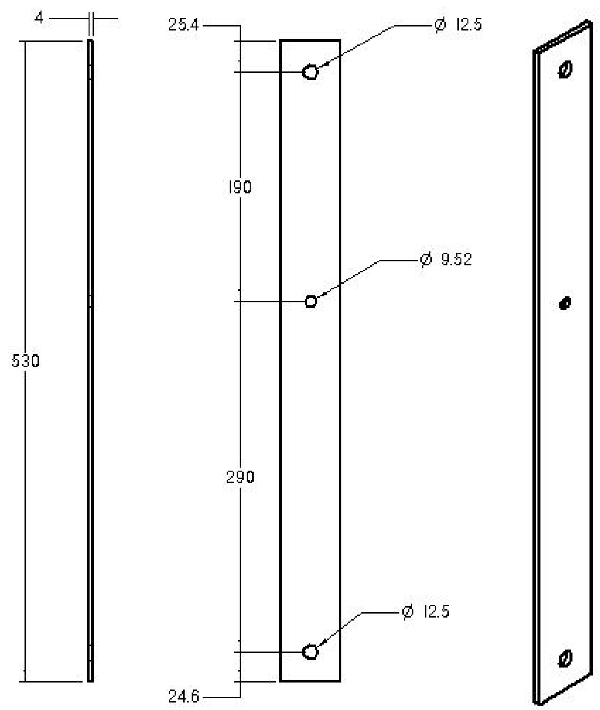
(e) Compactor Frame



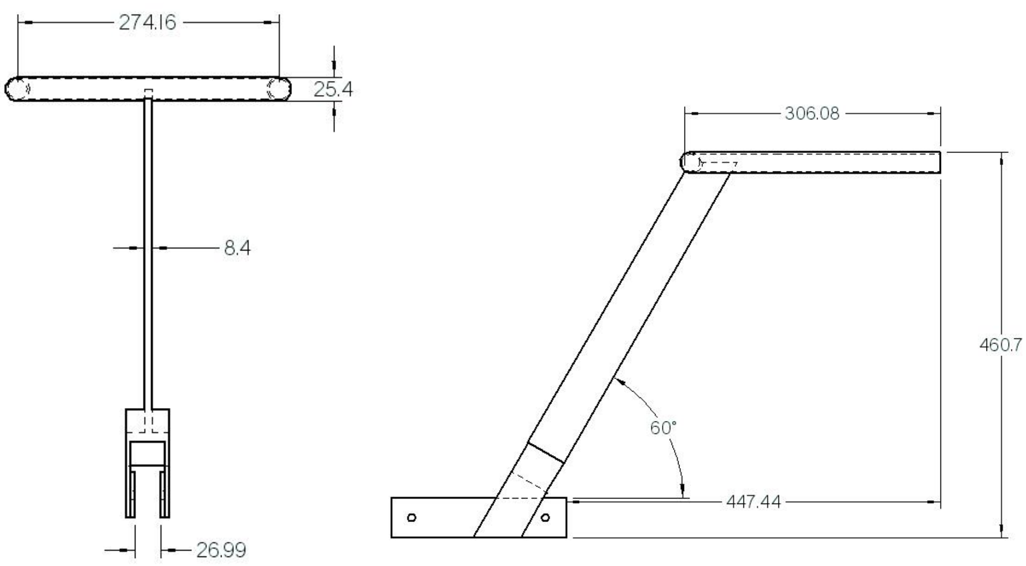
(f) Compactor Adjustment



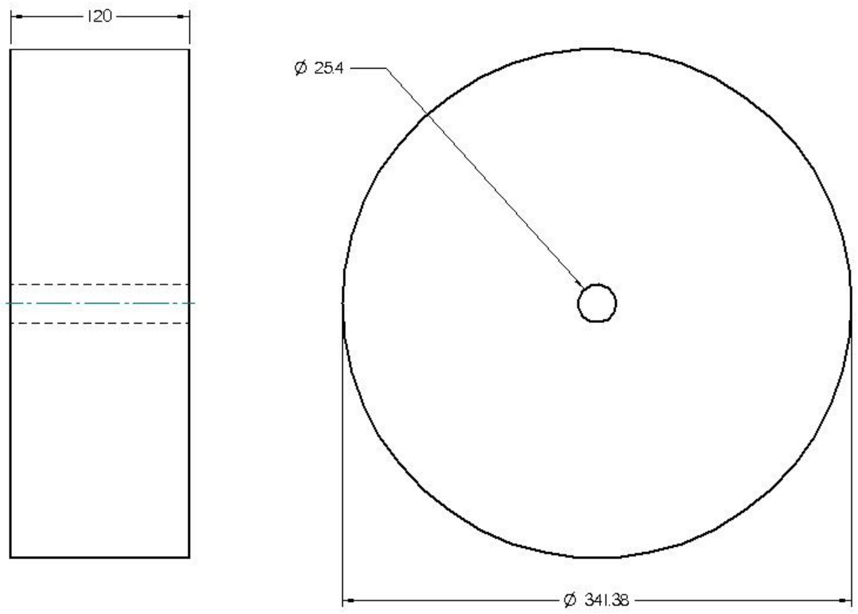
(g) Coulter Link



(h) Handle

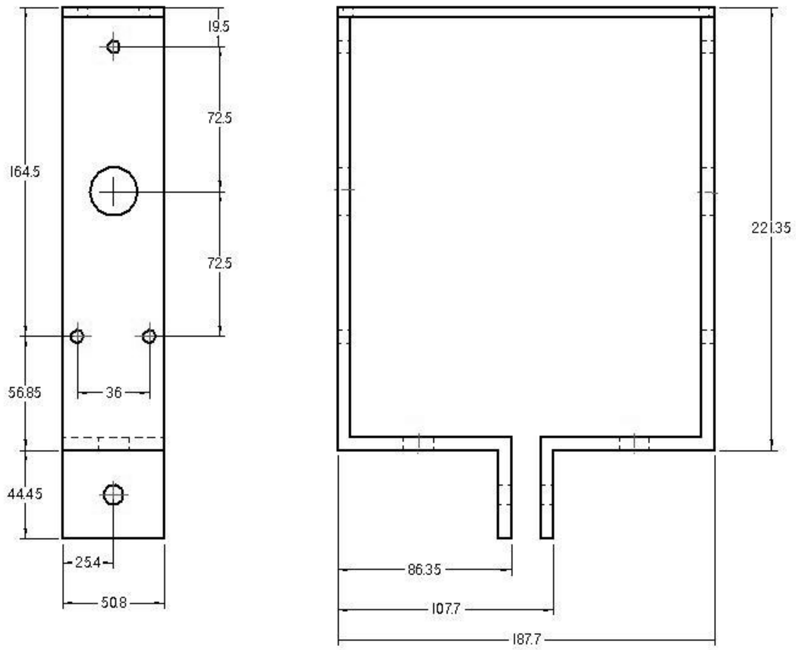


(i) Weight Added

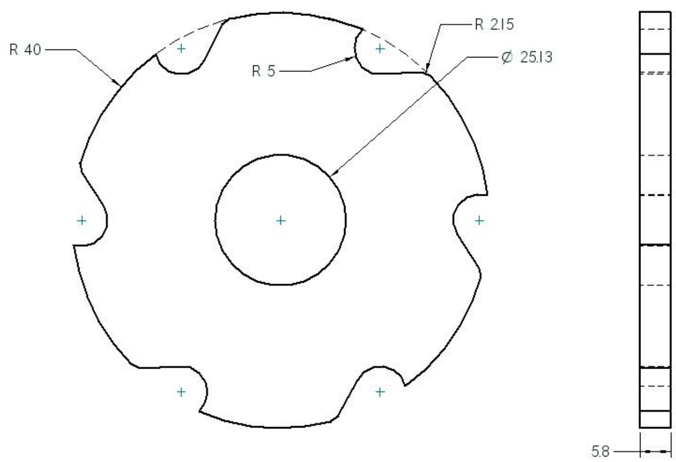


II. Seeder Mechanism

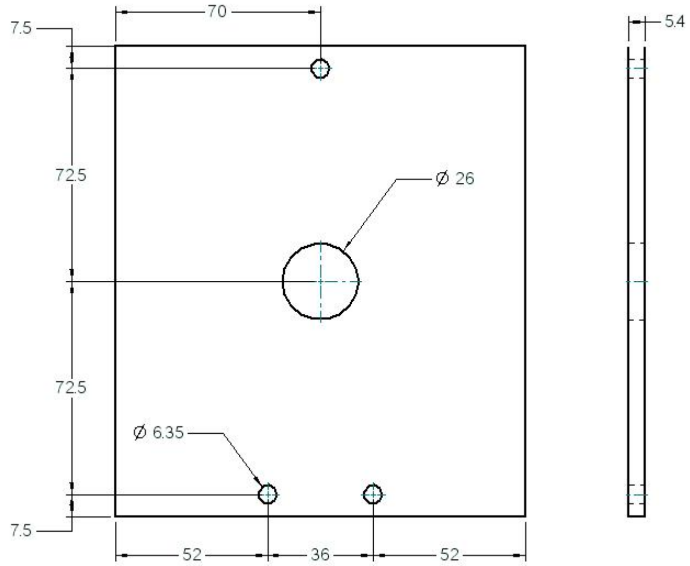
(a) Frame



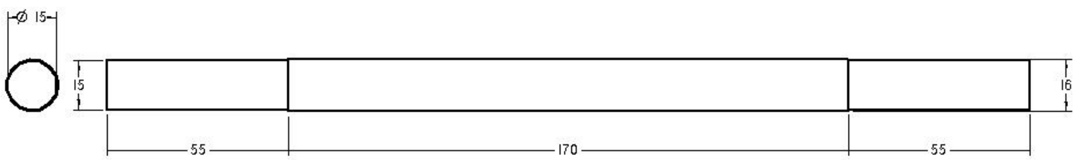
(b) Metering Disk



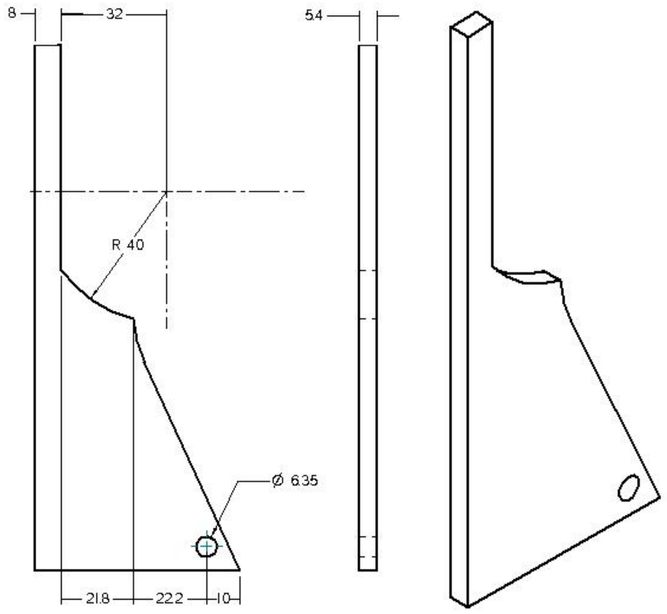
(c) Seeder Plate



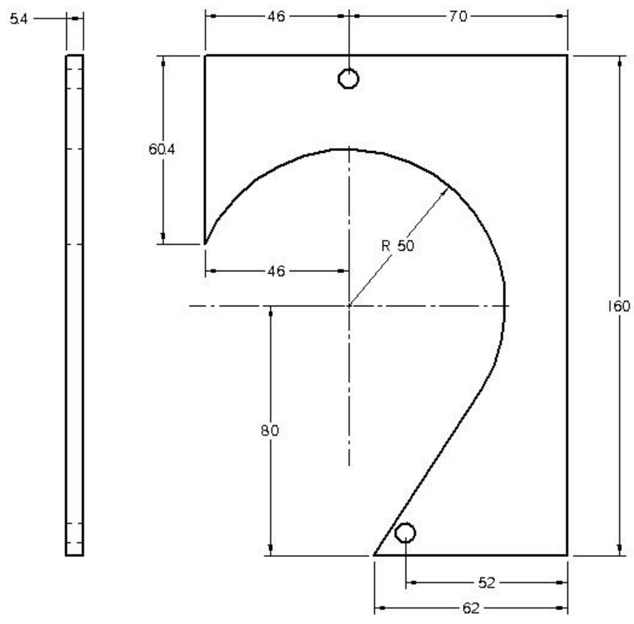
(d) Shaft



(e) Seeder spacer1

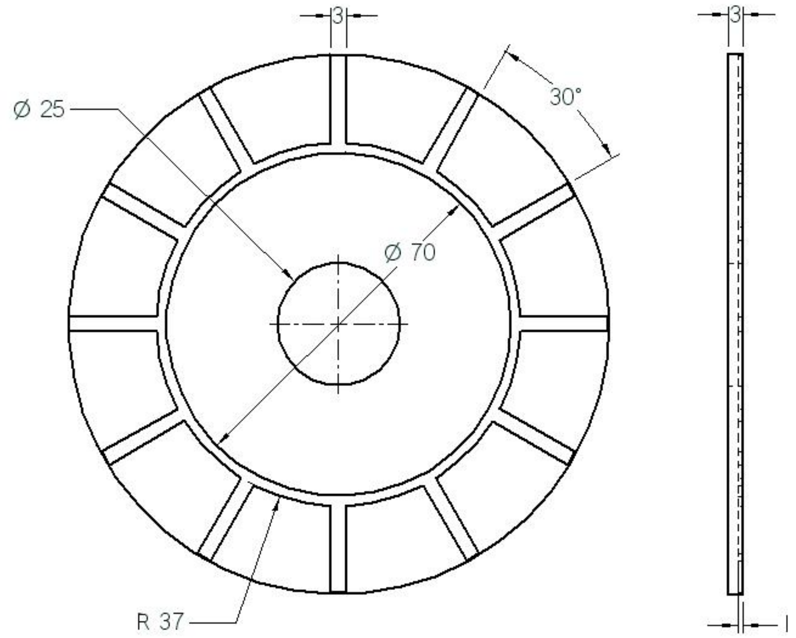


(f) Seeder Spacer2

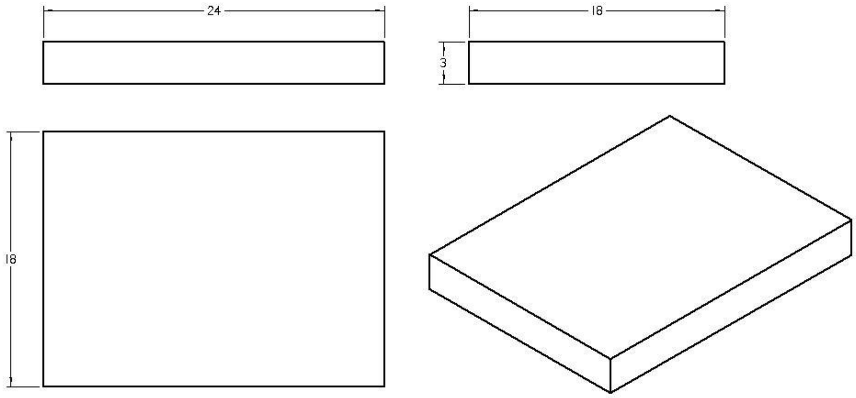


III. Fertilizer Dispenser

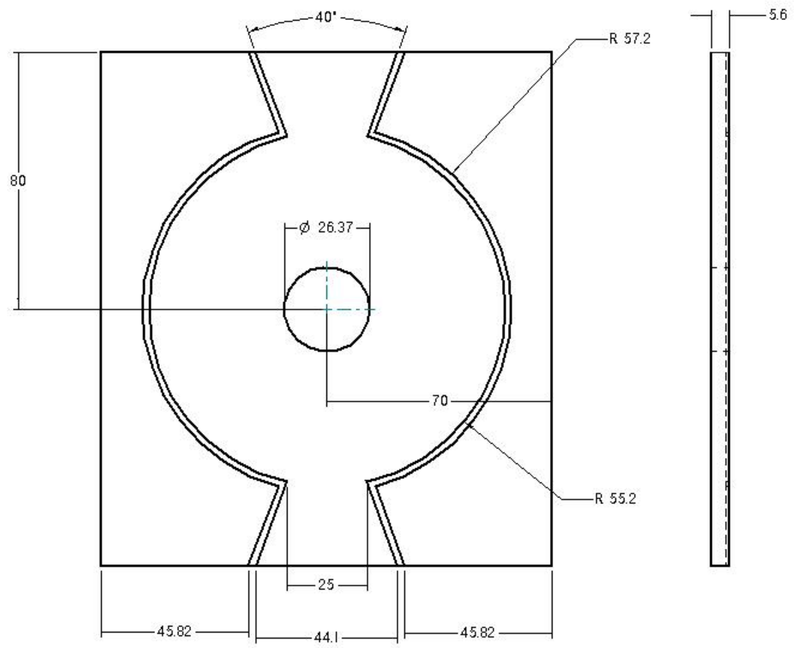
(a) Divider Support



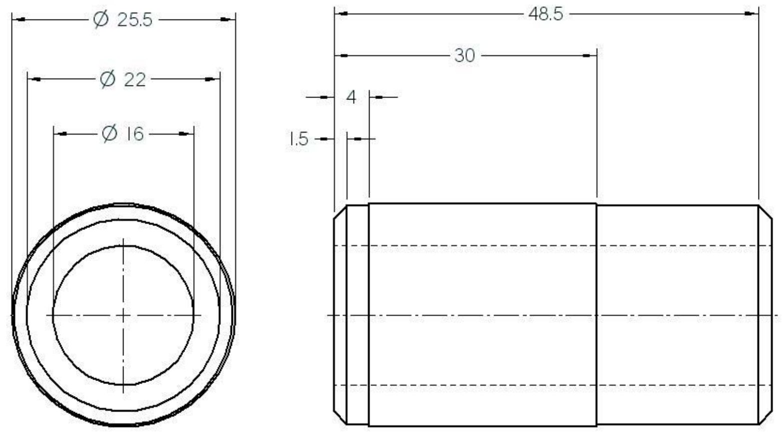
(b) Divider



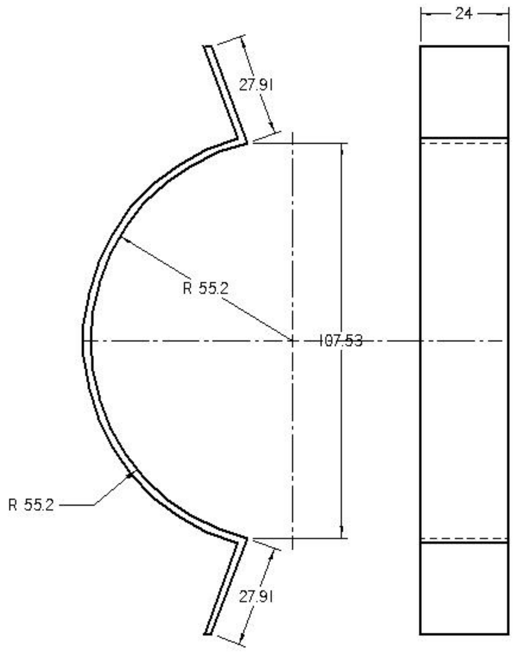
(c) Guide Plate



(d) Bushing

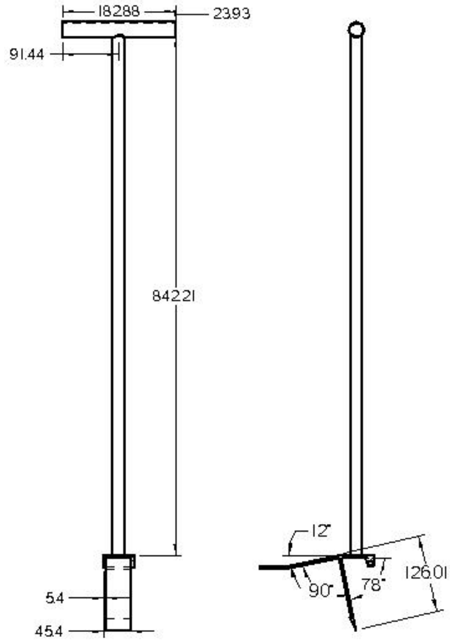


(e) Sheet Metal Cover

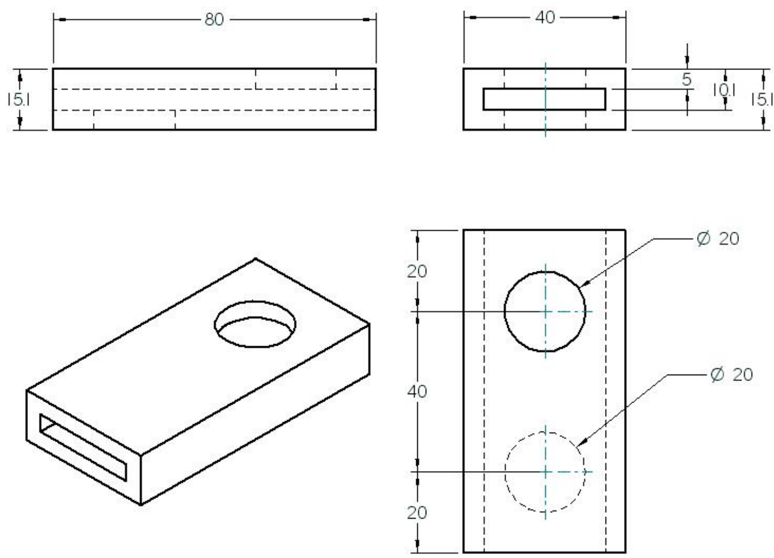


IV. Dibbler

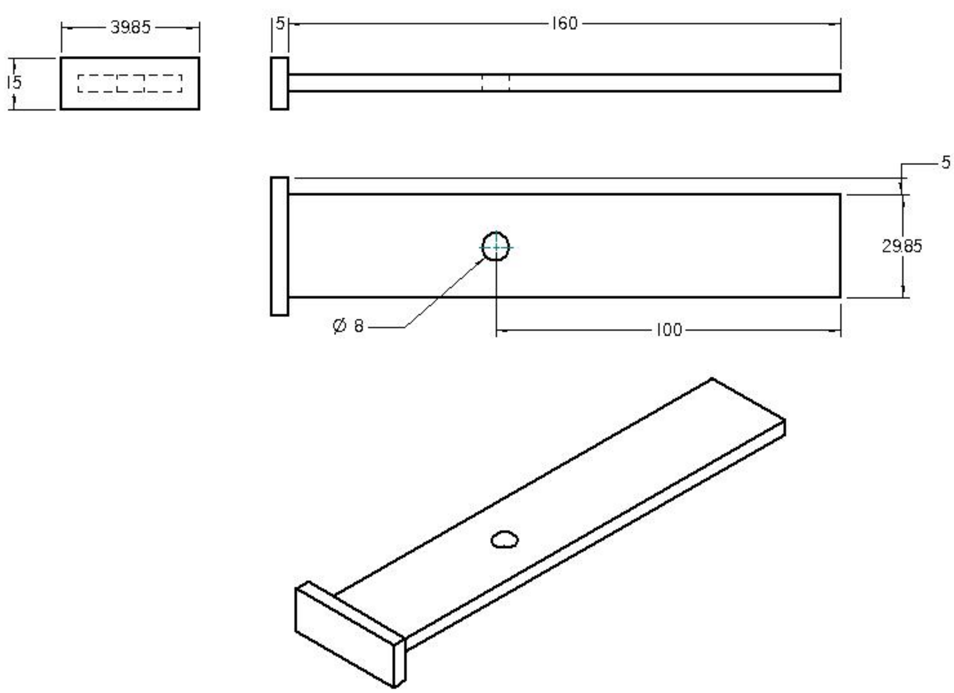
(a) Frame



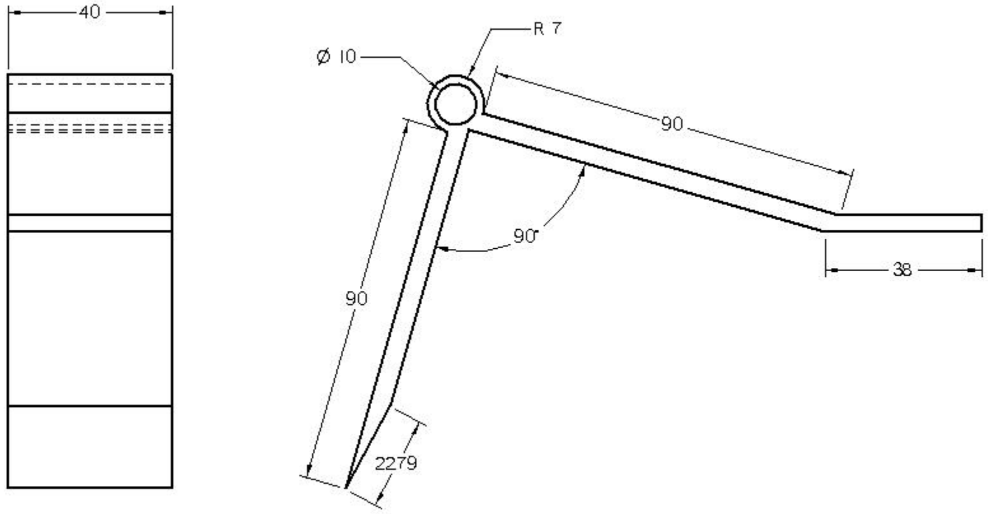
(b) Seeder Frame



(c) Seeder Insert

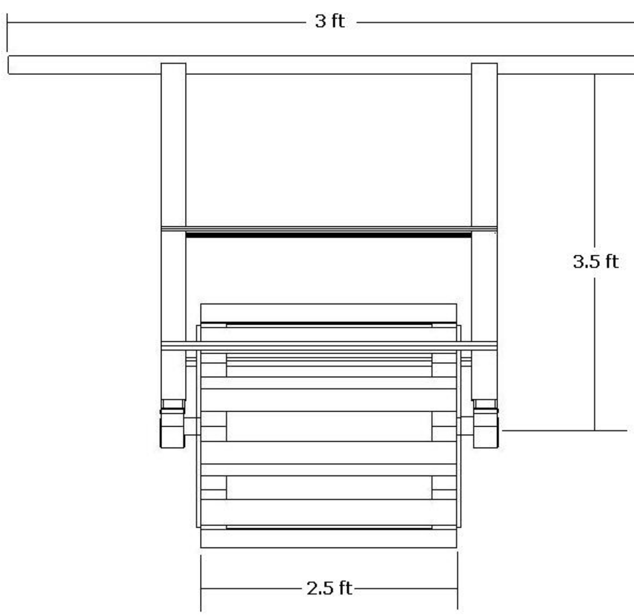


(d) Opener

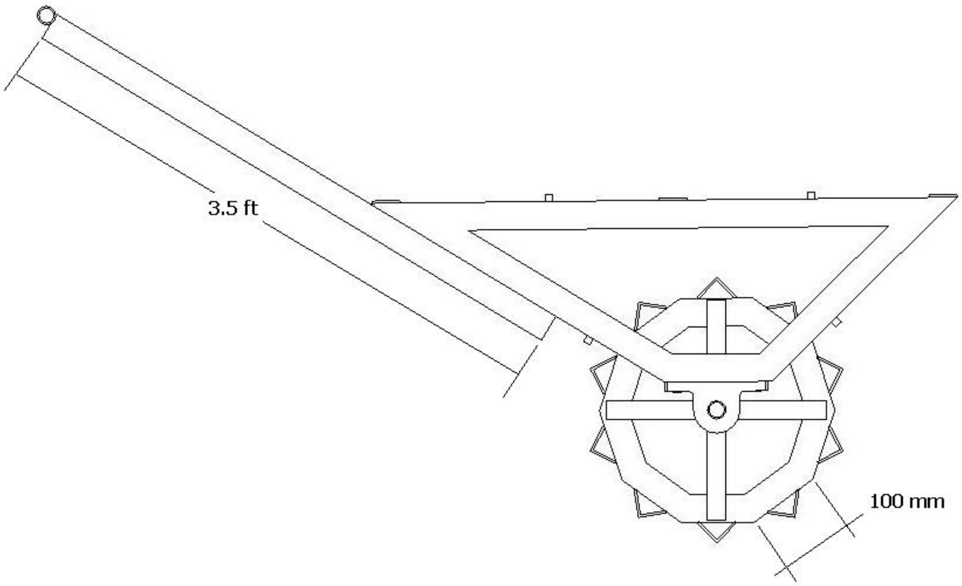


V. Residue Roller

(a) Front View



(b) Side View



Appendix H

Actual Prototype

(a) No-till Drill and Planter

(b) No-Till Equipment with added weights

(c) Seeder & Fertilizer Dispenser Assembly

(d) Seeder & Fertilizer Dispenser Mounting

(e) Residue Roller ***(w/ 50 kg weigh)***

(f) Dibbler

(g) Soil Compaction

(h) Cut Stolons

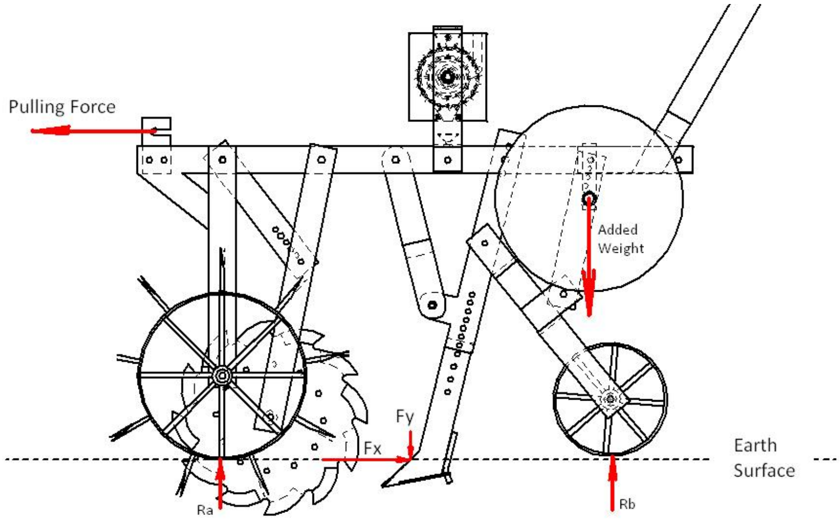
(i) Crimping Effect

(j) Dibbler Seeder

(k) Coulter Penetration

(l) Opener Test Result

(m) Roller Test Results



(n) Force Analysis