# Prototyping of a Multi-Purpose Mechanized Chopper

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## Abstract

*The multi-purpose mechanized chopper was designed and fabricated using metalworking concepts. It has a housing frame 70 cm wide, IO cm long, 80 cm high; with detachable spout and a rotating rotor which is mounted with eight (8) chopping blades, fifty (50) centimeters long. A 30 cm wide chute conveys the materials to be chopped to a chopping board with blades. It is powered by 7.5 hp diesel engine, the usual pump motor size for the "kuligligs" which is the popular service vehicle of most farmers nowadays. The machine could chop different farm wastes like stalks of corn, tobacco, banana, papaya, sugarcane, and rice whether fresh or dried. Its average speed is 100 kilograms in ten (10) minutes.*

*One unit of said prototype costs fifty three thousand nine hundred sixty six pesos (P 53,966.00), including its own 7.5 hp diesel engine, and only costs twenty nine thousand nine hundred sixty six pesos (P 29,966.000) without the motor.*

## Introduction

### Background of the Study

Agriculture and environment are related in many ways. While agriculture demands high environmental quality, agriculture is a great source of wastes. An increase in the global population demands increase in agricultural production through higher yields and higher crop intensities, or an increase in the number of times a piece of land is cropped in one year, and an increase in arable land areas. This increase in yield and number of cropping season leads to an increase in agricultural wastes in the form of leaves, stalks, bagasse and other organic plant parts.

Com is one of the most popular crops grown in Ilocos Sur and the whole Ilocos Region in which a total of 61,292.00 hectares is dedicated to corn. This total hectarage produce about 296,467 MT. Ilocos Sur's share is about 8,521 hectares, yielding 43,319

MT, about 15% of the total regional yield. It is a very useful plant to the farmers. The cobs are sold as natural food when boiled, and as raw material to an array of processed foods- from the fast growing Jlocos export product, the *chicacorn,* to the com chips, which are favorite junk foods for all seasons. The stalks also serve a variety of purposes: firewood, organic fertilizer when decomposed or animal feed stock when chopped.

On the other hand, tobacco and sugar cane are also two of the favorite crops of Ilocanoes needing a considerable time of handling after taking the main component of these crops during harvesting. Manual chopping of the stalks for a hectare planted to such crops would take several weeks of disposal. At times, burning would be the easiest recourse for the non-environmentalist farmer. But if a device is available to speed up chopping to enhance disintegration, then the use of these agricultural wastes will be maximized.

The persistent request of the Local Governments of Burgos, Sta. Maria, and Sto. Domingo, through the assessed need of corn growers therein, as aired by the Municipal/City Agricultural Officers, inspired the conceptualization of this prototyping for a multipurpose chopper. Such machine shall be useful for environmental and agricultural concerns. It could hasten the decomposition of biodegradable garbage, like twigs, branches, fruit peelings and other forms. An additional market for the machine is the Ilocos Sur Polytechnic College, an agricultural school, conducting research within its service area: Santa to Tagudin, including upland municipalities of Burgos, Salcedo and Cervantes.

## Objectives of the Study

The overall objective of this research is to design and construct a mechanized multi-purpose chopper so that some agricultural developments shall be realized; to wit:

I. The localization of an agricultural technology, in the form of an equipment to effectively and efficiently address the chopping requirements of various crops and stalks for faster handling, stocking, and/or safekeeping purposes; and
2. The preparation of raw materials needed in the making of organic fertilizer shall have been facilitated.

## Research Methodology

This study made use of the experimental type of research, conducted in two phases; namely:

Phase I. The design and fabrication of the prototype; and

Phase 2. Qualitative testing to identify the chopping capacity using selected parameters applied to corn, tobacco, sugarcane, banana and papaya stalks.

The first phase set the most functional arrangement and sizes of the component parts to form the basic structure.

The second phase tested the performance of the assembled machine, and adjustments were then made to improve the quality of the output.

The t-test is used to measure the level of significance of the improvement between the manual handling of selected agricultural wastes and with the introduced technology using the machine.

## Results and Discussion

The critical parts of the multi-purpose chopper were finalized by comparing how the machine performs between selected designs variables.

### a. Design Parameters

#### a.1. Choice of the machine capacity

It was earlier proposed that a 6.5 hp capacity of motor will be utilized for the prototyping. However, there is no available size in the market, hence the researchers opted to what is readily available, a 7.5 hp motor.

#### a.2. Lay-out of the Blades

An important parameter considered in the prototyping is the positioning of the blades for higher productivity. A comparative study was made whether: a) straight and b) inclined at an angle of 20°. Table 3 presents the results of the comparison. Obviously, the straight blades chopped slower than the inclined blades. This gave the researchers the basis in deciding to adopt the tilted positioning of blades.

Table 3. Performance Testing Between Straight and Inclined Chopping Primary Blades using Com Stalks as Specimen

| Type of Stalk | Chopped Comstalks, in kgs | | | | | | | | Length of Chopped Materials, inches |
|---|---|---|---|---|---|---|---|---|---|
| | Straight Position of Blades | | | | Blades Inclined @20 from the Plane of the Rotor | | | | |
| | Tr, | T, | T | Ave | T, | T, | r, | Ave | |
| Fresh | 50 | 52 | 51 | 51.00 | 80 | 81 | 81.5 | 80.83 | 4-6 |
| Dried | 68 | 70 | 67 | 68.33 | 90 | 92 | 91 | 91.00 | |

**a.3. Adoption of primary and secondary blades**

During the proposal stage, the researchers assumed that two sets of blades would tum the chopping activity finer and faster results. But this plan did not tum out to be practical because the secondary blades caused impediments to the primary blades in chopping the stalks fed to the chute. Instead of assisting in pulling the stalks toward the blades, the secondary blades pushed the cutting specimen opposite the direction of the primary blades. The total effect is not synergistic. The primary and secondary blades do not work supportively. Hence, the idea of inserting secondary blades was dropped.


*Fig. 1. Front View (Feeding Side)*

**b. Assembly of the Component Parts**

The structure of the multi-purpose mechanized chopper is made of bars, G. I. sheet and pipes, shafting, hard steel, using pillow blocks, flywheel, bolts and nuts. It has a detachable extended spout to accommodate greater length and volume of raw materials with a lifting rotor guard. The flywheel is guarded and connected on both ends of the shafting. The machine is also fabricated with a travel shoe for ease of travelling by "kuliglig" or towed by a cow or a carabao. The rotor has a diameter of I0 cm and length of 52 cm where the 8 pieces of detachable blades, 51 cm long and 5 cm wide, are attached. The gadget is operated by a 7.5 hp diesel engine belt driver which is conn ected to the grinder pulley to drive the rotor which is also equipped with a fly wheel.

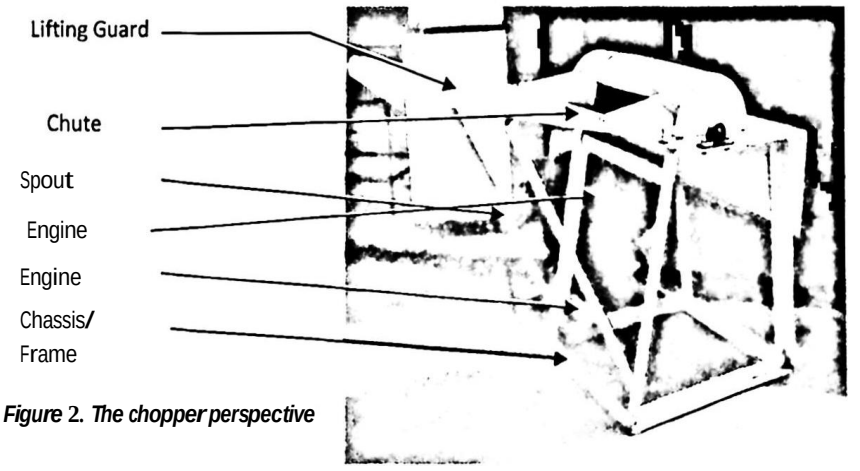


***Figure 2. The chopper perspective***

The 8-piece detachable chopping blades are in a closed type sharper mounted on the rotor at 20° from the horizontal plane, **4"** and 2" apart. Figures 1 to 3 show the front view, the perspective, and the rotor assembly, respectively.

The chute (outlet for chopped materials) is allowed to move via a flapping metal cover which readily closes to direct the flow of materials outside.

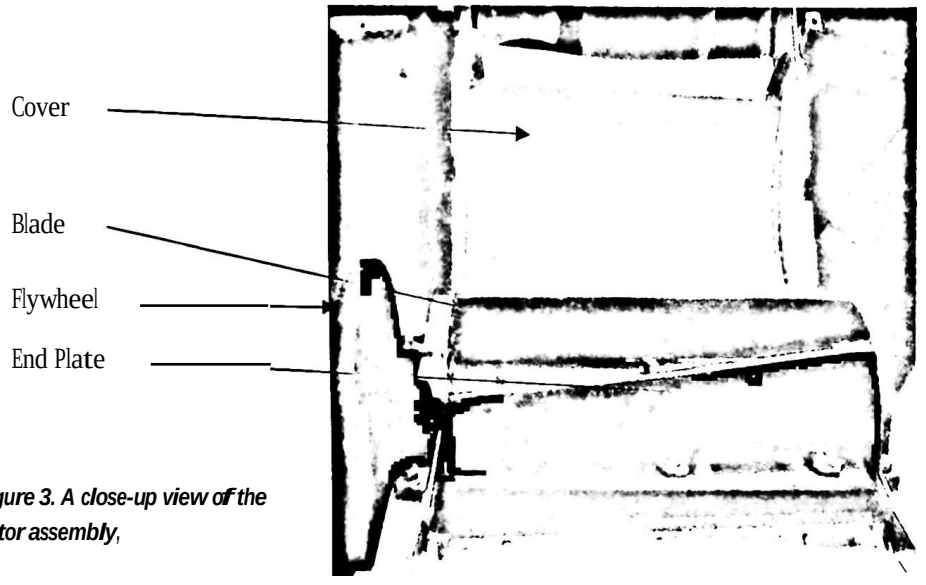


***Figure 3. A close-up view of the rotor assembly,***

**c. Comparative Features of the Prototype Against Existing Local Choppers**

The researchers are fully aware of the presence of equipment fabricators at Bangar and Bacnotan, both in the province of La Union. However, the proposed gadget invites a different set-up which really offers more ease of handling and operation. Table 4 presents the matrix of distinguishing features of the proposed gadget over other existing ones.

Table 4. The Proposed vs Existing Choppers

| Parameters | Prototype | Existing | Significance of the Assessed Difference |
|---|---|---|---|
| Size | 110 cm high, 104 cm wide | 90 cm high, 50 cm wide | Slightly made higher for the sake of balance and proportion due to the added flywheel and heavy duty rotor. |
| Weight | Abt 140 kgs | Abt 85 kgs | Thicker steel plates were used to support the flywheel and heavy duty rotor. |
| Engine | 7.5 HP diesel-fed | 8 HP – gasoline fed | Adopted the *kuliglig* engine to coincide with what most farmers already have, diesel is more economical, and more powerful. |
| Capacity | 50 kls of corn stalks in 3 min | 12 kls of corn stalks in 3 min | Higher productivity by 18 kilos with straight blades, even higher with tilted blades |
| Add'l accessories | Flywheel | - | To increase the speed of the machine |
| | Travel shoe | - | To enhance its transportability, which may be tied tight with *kuliglig* trailer. |
| | 4 pcs 51 cm long, 5 cm high Primary Blades | 4 pcs 30 cm long, 5 cm high Primary Blades | More efficient and effective cutting power than the existing choppers |
| | Detachable rotor | Fixed | For a better sharpening/ hoaning mechanism |
| Style | Detachable spout | Fixed | To facilitate traveling |

### d. Performance Testing of the Prototype

Aside from corn stalks, the prototype chopper was tested to chop tobacco, rice hay, banana, papaya and sugarcane stalks. The samples showed more chopped materials within the same period with the adopted features based from earlier tests. Tables 5 and 6 show the results with the position of the blades as parameter.

Initial trials conducted manifested difficulty in chopping coconut husks. The rotor does not work continuously, while the V-belt slipped, damaging it significantly. Other trials conducted in chopping dried rice hull caused clogging to the rotor and the blade.

Basing from the results of the comparative performances, the hissed type-straight angle position has finer results than the hissed type, inclined position.

Table 5. The Chopping Results of the Machine Using Hissed type sharpened blade, inclined position, 20".

| Type of stalks | 10 minutes chopping, kgs | | | Length of chopped materials, inches |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | |
| Tobacco (Virginia) | | | | |
| Dried | 140 | 150 | 130 | 3–5 |
| Fresh | 200 | 220 | 180 | |
| Fresh Banana | 300 | 310 | 320 | 4 |
| Fresh Papaya | 170 | 160 | 180 | 2 |
| Fresh Rice Hay | 200 | 205 | 195 | 4-6 |
| Waste Sugarcane stalks | 50 | 48 | 51 | 2-4 |

Table 6. The Chopping Result of the Machine, Hissed type- sharpened blade, straight angle position.

| Type of stalks | IO minutes chopping, in kgs | | | Length of chopped materials, inches |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | |
| Tobacco | | | | |
| Dried | 100 | 102 | 98 | 2-3 |
| Fresh | 150 | 151 | 149 | |
| Fresh Banana | 280 | 300 | 305 | 2 |
| Fresh Papaya | 150 | 155 | 160 | 3-4 |
| Fresh Rice Hay | 40 | 42 | 39 | |
| Waste Sugarcane stalks | 50 | 49 | 48 | I · 2 |

**Statistical Analysis of the Results**

The observed outputs were subjected to t-test of significant difference. The results are shown in Tables 7, 8 and 9, and are interpreted correspondingly.

Table 7. Results of t-Test of Significant Differences, by Weight Using Cornstalks

| Type of Stalks | Inclined Position | Straight Angle Position | Mean Difference | t-value | t-prob | Interpretation |
|---|---|---|---|---|---|---|
| Com stalks (Fresh) | 80.83 | 51.00 | 29.83 | 41.065 | .00Θ | Significant |
| Com stalks (Dried) | 91.00 | 68.33 | 22.67 | 21.503 | .00Θ | Significant |
| As a Whole | 85.92 | 59.67 | 26.25 | 5.795 | .00Θ | Significant |

Significant at .01 probability level

There exists significant difference between the output using the inclined and straight positioning of blades, whether fresh, dried or taken as a whole. This suggests that the machine performs better when the blades are inclined than when straight.

Table 8. Results of t-Test of Significant Differences by Weight of Selected Chopped Materials

| Type of Stalks | Inclined Position | Straight Angle Position | Mean Difference | t-value | t-prob | Interpretation |
|---|---|---|---|---|---|---|
| Tobacco (Dried) | 140.00 | 100.00 | 40.00 | 6.794 | .002 | Significant |
| Tobacco (Fresh) | 200.00 | 150.00 | 50.00 | 4.325 | .012 | Significant |
| Fresh Banana | 310.00 | 295.00 | 15.00 | 1.567 | .192 | Not Significant |
| Fresh Papaya | 170.00 | 155.00 | 15.00 | 2.324 | .081 | Not Significant |
| Fresh Rice Hay | 200.00 | 40.33 | 159.67 | 52.897 | .000 | Significant |
| Waste Sugarcane Stalks | 49.67 | 49.00 | .67 | .632 | .561 | Not Significant |
| As a Whole | 178.28 | 131.56 | 46.72 | 1.661 | .106 | Not Significant |

Significant at .05 probability level
Significant at .01 probability level

Still using the same statistical treatment with the machine's performance in chopping other agricultural wastes with the two (2) different positions as revealed in Tables 5 and 6, the results show that:

a. Between the inclined and straight position in chopping dried and fresh tobacco stalks, the result is significant;
b. Between the inclined and straight position in chopping fresh banana, fresh papaya and waste sugarcane stalks, the result is not significant;
c. Between the inclined and straight position in chopping fresh rice hay, the result was highly significant.

These results would just suggest that the inclined blades would work better for dried and fresh tobacco stalks, just like cornstalks, as well as fresh rice hay, but there is not much difference in its performance when chopping bananas, papaya or sugarcane stalks. This finding would only mean that the inclined blades would chop cornstalks, tobacco stalks and rice hay faster than how it chops fresh bananas, fresh papayas or sugarcane stalks. In other words, whether inclined or straight, the chopping output is not affected when chopping fresh bananas, fresh papayas or sugarcane stalks.

Table 9. Results of t-Test of Significant Differences in Length of Chopped Materials

| | Inclined Position | Straight Angle Position | Mean Difference | t-value | t-prob | Interpretation |
|---|---|---|---|---|---|---|
| As a Whole | 3.80 | 2.90 | .90 | 1.306 | .228 | Not Significant |

When the chopped materials are taken as a whole, Table 9 reveals that there is no significant difference in the length of the chopped materials between the two positions of blades. In other words, the length of the chopped materials is not affected by the position of the blades. Practically speaking, the chopping length would be immaterial since the ultimate objective is just to hasten decomposition.

**Financial Requirements**

The prototype has been manufactured in the amount of P53,966.00 due to the variations instilled in developing the design with the parameters considered. However, the cost could be reduced for subsequent fabrications. The estimate already includes the cost of the kuliglig motor, a popular farm facility- almost owned by every farmer. If the purchasing farmer already has it, then it could be discounted from the given price. The price of the machine without the motor would be Ph P 29,966.00, subject to current prices of steel plates, angle bars and other spare parts composing it. Initial assemblies are envisioned to be more expensive due to trials and experimentation which are inherent in this prototyping activity. Eventually, after this prototype development, the selling price will be less, and in the long run, reasonable and affordable, compared to the market prices of fellow fabricators, because the motor used by them are built-in, and undetachable, therefore, not deductible from the set price therefrom.

**Analysis of Return on Investment**

The average corn yield for Ilocos Sur, as stated earlier is 43,319 MT from 8,521 hectares, or roughly 5 MT per hectare, leaving behind more wastes than the yield. If a farmer owns only half hectare land planted to corn, a conservative yield would be 2,500 kgs, and approximately 4000 kgs of cornstalks. Using the observed productivity of the machine for dried cornstalks at 80 kgs in 3 minutes, the machine can chop 1,600 kgs in an hour.in other words, the machine could finish chopping the cornstalks in 2.5 hrs. Please refer to Table 10. In a hectare, Ph P 12,500 is saved by the machine due to corn alone. In short, what the machine can do in 2.5 hours will be done by 20 men. The rate of work improvement is 160 times faster.

A practical comparison to compute the farmer's return on investment if he buys the machine would be considering how much he will pay somebody to chop the cornstalks manually. It would take a man one hour to chop approximately IO kgs of dried talks, provided he has complete facilities: a sharp bolo, wedge where the stalks are cut, and a wide platform to contain the chopped pieces. If other wastes are included, the farmer could save about Ph P 20,000 in one cropping season. Using this derived figure, the payback period will last for 2.7 years if a farmer buys the machine with the motor, and 1.3 years if he buys only the chopper.

Table IO. Simplified Computation on the Mechanized Chopper's Return on Investment

| Particulars | Cost of Machine | Computations | Rate | Units/Remarks |
|---|---|---|---|---|
| With motor | 53966 | | | |
| Without motor | 23966 | | | |
| Estimated weight of cornstalks to be chopped | | | 4000 | kgs |
| Productivity | 80 | kgs in 3 min | 1600 | kgs/hr |
| Time for machine to chop | | | 2.5 | hrs |
| Manual productivity | | | 10 | kgs/hr |
| Time to chop 4000 kgs | | (4000/(1O8) | 50 | man-days |
| Labor rate | | | 250 | per day |
| Labor Expense | | 5O250 | 12,500 | Savings due to com alone in one cropping season. |

The payback period may be shortened if the farmer maximizes the use of the chopper.

Another point of comparison could be from the rate of work improvement done by the machine. In a case when it is to be hired to do chopping for outside clients, the rate per hour could be computed based from the amount saved divided by the improvement rate of 160, giving a ratio of 78.125. This could be the machine's rental rate per hour. With this scheme, the faster is its payback period.

## Conclusions

An analysis of the observed results during the dry-run provided the decisions adopted in the design of the prototype: a) position of the blades; as well as b) the choice in adopting primary and secondary blades.

1. Because of the higher productivity of chopping various stalks as reinforced in the results shown from Tables 5 and 6, when laid in an inclined position, the blades are positioned so.
2. The insertion of secondary blades does not invite synergy with the primary blades, thus creating lesser productivity. Therefore, only one set of blades was adopted in the design.
3. There is significant difference in the performance of the prototype with inclined blades when chopping com, tobacco and rice hay stalks, but no significant difference exist in chopping fresh bananas and papayas.
4. There is no significant difference in the length of the chopped materials with the position of the blades.

## Recommendation

In view of the above conclusions, the researchers highly recommend the adoption of the prototyped mechanized multi-purpose chopper which was designed to offer an innovation to local agricultural technology. It expedites the processing of organic fertilizer because of the ease of chopping agricultural wastes which are ingredients in the production of such. Moreover, it facilitates handling of dried agricultural feed stock like corn stalks for easier storage.

The prototype is highly recommended for com, tobacco, sugarcane, banana, papaya and rice hay stalks, but not recommended for coconut husks and other agricultural wastes with similar hardness so as not to damage the rotor and the blades. However, there are still areas to be studied to improve the machine's performance, like experimenting on the distances of the blades, the flywheel, and other combinations.

## References

American Institute of Steel Construction (AISC) Manual

Manual for Welding Standards

Interviews from Farmers and Market Garbage Collectors

Observations from the output of existing choppers in Bangar, La Union