

Appropriate and Efficient Technology System Approach in Product Design to Reduce Musculoskeletal Disorders

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ABSTRACT IN ENGLISH

The process of planting corn still uses the traditional method of using wood that is sharpened at the end while holding a bag containing corn seeds, the process of planting corn is carried out by bending the body continuously, this process is carried out minimum two workers. This process causes performance to be not optimal, besides that the work process will accelerate fatigue and cause many complaints, pain, and injuries. This study aims to measure anthropometric data of standing shoulder height, standing elbow height, forearm length, hand width, and hand grip diameter. The results of these measurements are then used to design products for these farmers. This measurement also includes a Nordic Body Map (NBM) questionnaire to determine of pain in the corn planting process. The subjects in this study were 30 people, after calculation and data processing, the right size for the product design is obtained which consists of a tool height of 140 cm, a handle height of 105 cm, a diameter of grip 5 cm, grip length of 9 cm, an operator distance with a tool of 45 cm, then the tool assembly process and testing process will be carried out.

Keywords:

Design; Musculoskeletal
Disorders; Product; System;
Technology.

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1. INTRODUCTION

Indonesia is known as an agricultural country with most of the population working in agriculture. Indonesia is an agricultural country that has vast agricultural land, diverse and abundant natural resources. In an agrarian country, agriculture has a very important role both in the sector of fulfilling basic needs, besides that agriculture plays a major role in boosting the social sector, the economic sector and trade [1]. One of the most widely developed types of plant commodities in Indonesia is corn [2]. Corn is one type of food grain crop. Corn plants come from the tropics, so corn can grow in a variety of soil conditions. For optimal growth, corn has several requirements, one of which is the tools used in the planting process, such as human, animal and other tools [3]

In carrying out the planting process, it is necessary to pay attention to the selection of corn seeds, making beds, and the tools used [4]. Usually farmers plant 1-2 corn seeds with a spacing of 40-70 cm with a seed depth of 3-6 cm. The process of planting corn still uses a very simple method, namely sharpening the ends of the wood and holding the corn seed packets by bending continuously where farmers work with a minimum of two people.



Figure 1 – (a) (b) corn planting process

One of the impacts of the risks faced by farmers in planting corn seeds in a simple way is that it requires a lot of energy and complaints of pain in the limbs and has a negative effect on health. This is certainly not effective and efficient [5]. So that it will bring performance to be not optimal, and on the other hand these working conditions will accelerate fatigue and cause many complaints, pain and injuries to corn farmers in the short and long term [6].



Figure 2 – formed angel corn planting process

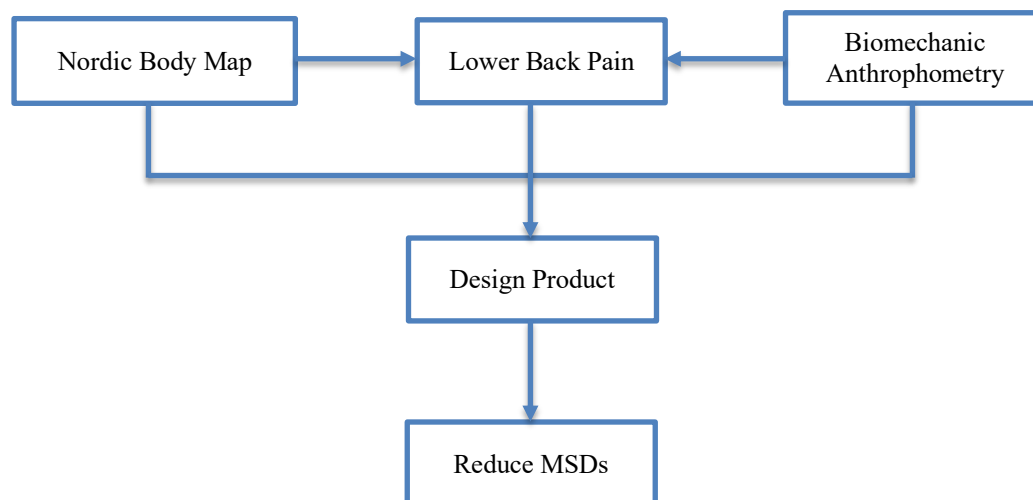
Table 1. formed angel

| No | Part of indicator | Value |
|----|-------------------|-------|
| 1. | Neck | 45° |
| 2. | Backbone | 90° |
| 3. | Shoulder | 74° |
| 4. | Wrist | 25° |

The results of a study in Sweden stated that 4.5 million workers lose a working day of 10 days per year due to illness, 60% of the pain suffered is due to low back pain and 75% of those low back pain sufferers are between 30-59 years old which is the productive age. Lower back pain is one of the complaints that can reduce human productivity and has been experienced by 50% - 80% of the population of industrialized countries, where the percentage increases according to age growth and eliminates very large working hours [2]. About 11% - 12% of patients become disabled as a result of this case and the tendency to relapse is quite high, which is around 26% - 37%, 6 thus causing the sufferer to return to work or be less productive [1,2].

[5] From data collected from the research of the Center for Research and Development of Health Ecology, Ministry of Health. This study involved 800 people from 8 informal sectors in the country. The results showed that musculoskeletal disorders were experienced by around 31.6% of farmers in Riau, 21% of wayang kulit artisans in Yogyakarta, 18% of onix craftsmen in West Java, 16.4% of gold miners in West Kalimantan, 14.9% of shoemakers in Bogor, and 8% of brass craftsmen in Central Java. Brick craftsmen in Lampung and fishermen in DKI Jakarta are the groups of workers who suffer the most from musculoskeletal disorders, around 76.7%, and 41.6%.

Research on the design of corn planting aids has been a lot of including Design Of Safety Signs Using Ergonomic Function Deployment Method At PT.XYZ : The results showed that 15 respondents using the NBM method stated that 75% of the results were "very sick" at the initial condition of the device, with the new device producing 21% "sickness". Abnormal work posture can cause the operator to experience Musculoskeletal Disorder (MSDs), which means that the design of the tool is quite good compared to the manual corn planting tool which has a review category. That way the design is the result of a review of the previous tools, from the design designed by the farmer will get many benefits in terms of both the material and the desired final result [6]. In the other research with title Design and Testing Tools Planting Corn Seeds the results : In this test for distance using a distance line seeds commonly used is 50 cm. Speed data retrieval tool work done 3 times a repetition at a distance of 17 meters. Assuming a 17-meter when the distance between seeds in each row 50 cm by 36 planting holes. From the calculation of working capacity drill this planter is 0.02 ha / hour. Planting depth results on repeatability to 1 seed planting depth average on hole fall planting is 4.08 cm. on repetition to 2 seed planting depth average on hole fall planting is 3.94 cm. while at repetition to 3 seed planting depth average on hole fall planting is 4.05 cm. [7] an then Designing a Multi-Functional Corn Seed Planting Tool for the Singorojo Kendal Community : concluded that this tool has a length of 350 mm, a width of 165 mm, a height of 925 mm, and a weight of 3.2 kg. The materials used for the manufacture of this tool include a 32 mm diameter steel pipe, a 40 mm box steel pipe, a 45 mm diameter nylon roller for seed dehumidifiers, and a stainless steel plate at the end of the tugal [8].

**Figure 3 – Research framework**

From the existing problems, it is necessary to design an appropriate technology in the form of tools that can assist farmers in planting corn seeds, so that they can improve farmers' posture and get a comfortable and optimal work system when planting corn seeds. After going through the above steps, the implementation of the design results will be carried out on the research subject, so that the results of the design are appropriate and close to the actual situation and can be used [9].

2. METHOD

This research uses biomechanics methods with an anthropometric approach, while the design process uses machine drawing software Autodesk Inventor. This method was chosen because it fits the hypothetical data that will be obtained in this study, anthropometry data [9]. The data has relevance in designing new ergonomic products. The product is designed with ergonomics that it can help reduce MSDs caused by the farmers' posture in planting corn [7,9]. In addition, supporting software is also used to carry out designs so that they can display the shape of the product design in 2D and 3D [8].

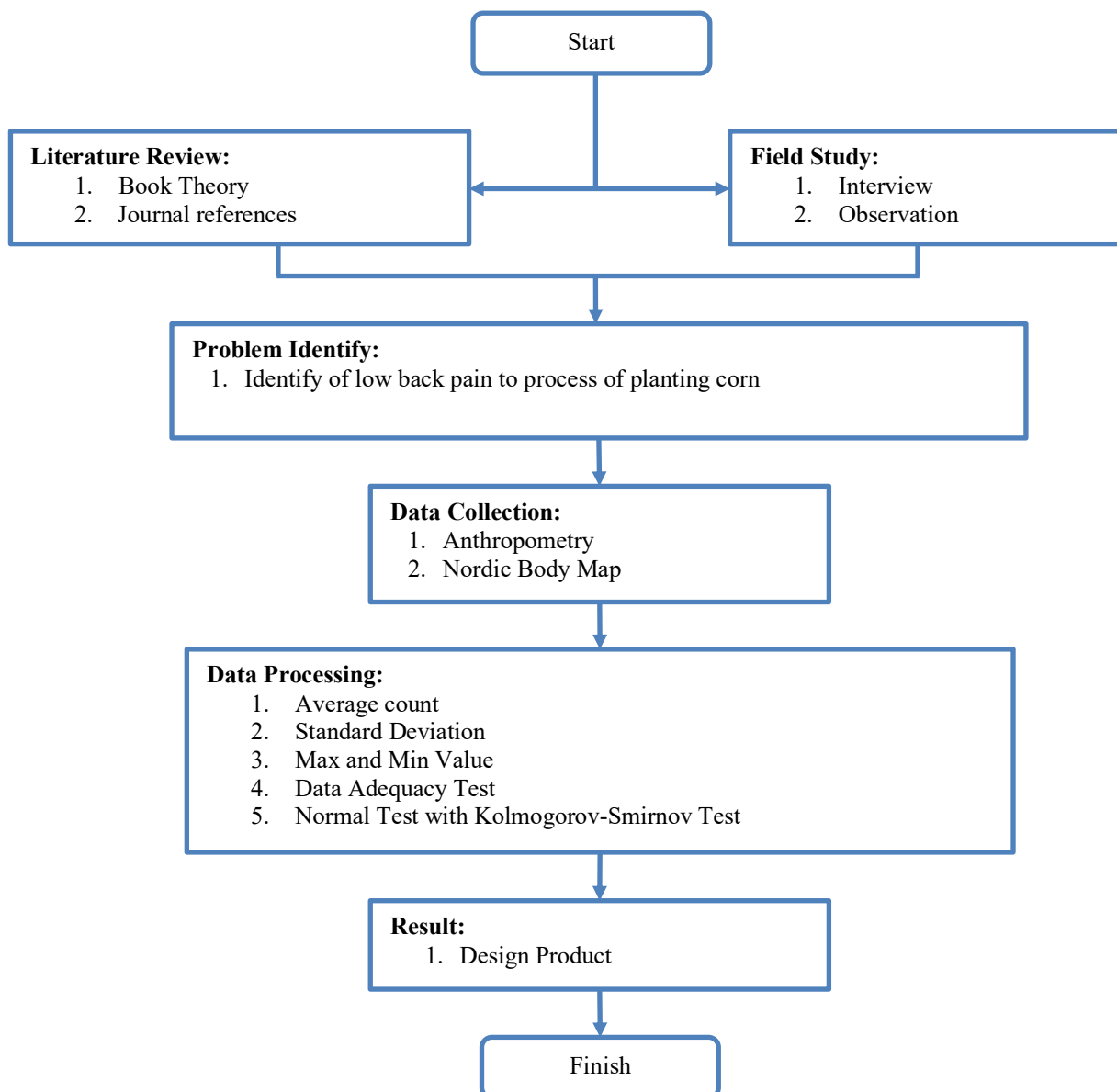


Figure 4 – Flowchart Research framework

Place and time of research

This research was conducted on Jl. Damar Wulan, Sampali, Percut Sei Tuan, Deli Serdang Regency, with 30 corn farmers in the area as subjects in the study. While the time of the research was data collection, starting from June 2022 to July 2022.

Data source

Is data obtained from interviews and direct observations in the field of farmer activities in planting corn seeds [10].

Research instruments

Research instruments are tools or facilities used by research in collecting data to make work easier and to get better results, in the sense that it is more accurate, complete and systematic so that it is easier to process. Completeness of the tool is very supportive of the quality of the data and the results obtained can be processed data. The research instruments used in this study were: Meter: Used to measure the body parts of farmers when working, NBM questionnaire sheets: Used to find out the muscle parts of farmers who experience complaints before and after doing work [11].

Data type

Nordic Body Map data by providing a questionnaire sheet to corn farmers, anthropometric data used to determine the design size of the corn seed planting tool. corn seed planter [12].

Data collection

1. Recapitulation of Employee Complaints and Desires

Before giving the Nordic Body Map questionnaire, the initial stage was carried out, namely conducting interviews with several questions to farmers to identify complaints of discomfort and difficulties in corn seed planting activities. Then give the Nordic Body Map questionnaire to find out the percentage of complaints and the greatest desire when using the tools experienced by workers when planting corn seeds [13].

2. Determination of Anthropometrics

In Design Based on the preparation of the design concept, the researcher can determine the anthropometric dimensions that will be used as a reference for determining the design size of the seed planting tool. The measurement of these anthropometric dimensions is intended so that the resulting design can be used properly and adjusted or at least approaches the characteristics and needs of its users. The anthropometric dimensions include standing shoulder height (tbb), standing elbow height (tsb), forearm length (plb), hand width (lt), hand grip diameter (dgt) for each farmer in the field of planting corn seeds, to design a facility working on the planting of corn seeds [14].

3. RESULT AND DISCUSSION

Data collection was carried out through direct data observation of corn farmer workers by directly observing the work activities of the corn seed planter and obtaining information from interviews with workers regarding complaints about body parts due to carrying out activities and also collected personal data of workers as for research subjects as many as 30 workers.

The only anthropometric dimensions of workers planting corn seeds are TBB (Standing Shoulder Height), TSB (Standing Elbow Height), PLB (Forearm Length), LT (Hand Width), DGT (Hand Grip Diameter). The TBB, TSB, LT and DGT dimensions are used because these anthropometric dimensions can determine the size of the design tool in the form of a corn seed planter that is adjusted to the anthropometric dimensions [15].

Anthropometric data obtained from measurements at the time the research was carried out were then processed by calculating with the following formula [16]:

Average count : $\bar{X} = \frac{\sum xi}{n}$ (1)

Standard Deviation : $S = \sqrt{\frac{\sum (xi - \bar{X})^2}{n-1}}$ (2)

Maximum and Minimum Value : $X_1, X_2, X_3 \dots X_n$ (3)

Data Homogeneity Test : $BKA = \bar{X} + 2\sigma$ (4)
 $BKB = \bar{X} - 2\sigma$

Data Adequacy Test :
$$N' = \left[\frac{z/s \sqrt{N \times \sum X_i^2 - (\sum x_i)^2}}{\sum x_i} \right] \dots\dots\dots (5)$$

Normal Test with Kolmogorov-Smirnov Test :
$$Z = \frac{X_i - \bar{X}}{\sigma} \dots\dots\dots(6)$$

2.1 Calculation of Design Specifications

Percentage calculations are performed to obtain the required size limit. The percentiles used in the design of this corn seed planter are the 5th, 50th and 75th percentiles. The determination of these percentiles was determined with the consideration that these percentiles can accommodate the 5th, 50th or 75th percentile data [17].

Table 2. One-Sample Kolmogorov-Smirnov Test

| | | TBB | TSB | PLB | LT | DGT |
|----------------------------------|----------------|---------------------|---------------------|-------------------|-------------------|-------------------|
| N | | 30 | 29 | 30 | 30 | 30 |
| Normal Parameters ^{a,b} | Mean | 139.37 | 105.55 | 44.67 | 9.57 | 5.03 |
| | Std. Deviation | 4.056 | 3.888 | 2.324 | 2.161 | 1.474 |
| | | | | | | |
| Most Extreme Differences | Absolute | .129 | .115 | .157 | .137 | .158 |
| | Positive | .075 | .108 | .124 | .137 | .158 |
| | Negative | -.129 | -.115 | -.157 | -.103 | -.144 |
| Test Statistic | | .129 | .115 | .157 | .137 | .158 |
| Asymp. Sig. (2-tailed) | | .200 ^{e,d} | .200 ^{e,d} | .057 ^c | .159 ^c | .053 ^c |

Table 3. Recapitulation of percentile calculation results

| | | TBB | TSB | PLB | LT | DGT |
|-------------|-------|--------|--------|-------|-------|------|
| N | Valid | 30 | 29 | 30 | 30 | 30 |
| Percentiles | 5 | 132.00 | 98.50 | 40.00 | 6.00 | 3.00 |
| | 50 | 140.00 | 105.00 | 45.00 | 9.00 | 5.00 |
| | 95 | 145.75 | 112.50 | 47.90 | 13.00 | 7.00 |

Based on table 3, the determination and processing of data for the upper and lower limits is obtained. This test aims to ensure that the data obtained during the research and processing has the right level of accuracy. In addition, the data can be shortened so that the data obtained also has consistency to be used as a measure when designing products.

3.1.1 Calculation of the Height of the Corn Seed Planting Tool

The anthropometric data needed to determine the height of the corn seed planting tool from the floor surface is the standing shoulder height (TBB) with the 50th percentile, this is so that workers are more flexible in operating the corn planting tool [18]. The use of the 50th percentile is intended so that workers with larger and smaller shoulder heights can use it easily and comfortably. The results of the calculation above, obtained the height of the 50th percentile corn seed planting tool as a result of the design of 140 cm.

3.1.2 Calculation of Handle Height for Planting Corn Seeds

The anthropometric data needed to determine the height of the handle of the seed planting tool from the floor surface is the standing elbow height (TSB) with the 50th percentile [19]. The use of the 50th percentile is intended so that workers who have a shorter standing elbow height can use a corn seed planting tool comfortably and workers who have a taller standing elbow height can also use a corn planting tool easily. The results of the calculation above, obtained the height of the 50th percentile corn seed planting tool as a result of the design of 105 cm.

3.1.3 Calculation of Handle Height for Planting Corn Seeds

The anthropometric data needed to determine the height of the handle of the seed planting tool from the floor surface is the standing elbow height (TSB) with the 50th percentile [20]. The use of the 50th percentile is intended so that workers

who have a shorter standing elbow height can use a corn seed planting tool comfortably and workers who have a taller standing elbow height can also use a corn planting tool easily. The results of the calculation above, obtained the height of the 50th percentile corn seed planting tool as a result of the design of 105 cm.

3.1.4 Calculation of the grip length of the handle of the corn seed planting tool

The anthropometric data needed to determine the length of the grip handle for the corn seed planting tool is the width of the hand (LT) with the 50th percentile. The use of the 50th percentile is intended so that workers with wider hands can grip the corn seed planting tool comfortably [21]. The results of the calculation above, obtained the design handle height of the 50th percentile corn seed planting tool by 9 cm.

3.1.5 Determining the Size of the Distance between the Operator and the Trolley Handle

The anthropometric data used to calculate the allowable distance between the operator and the trolley handle when the operator is operating is the 50th percentile forearm length (PLB), which aims to allow workers the flexibility to operate the corn seed planting tool [22]. The use of the 50th percentile is intended so that workers who have shorter arm spans can easily reach and operate the trolley and aim to provide more room for hand movement when operating the corn seed planting tool. intended for workers with greater and smaller shoulder heights to use easily and comfortably. The results of the calculation above, obtained the height of the 50th percentile corn seed planting tool designed by 45 cm.

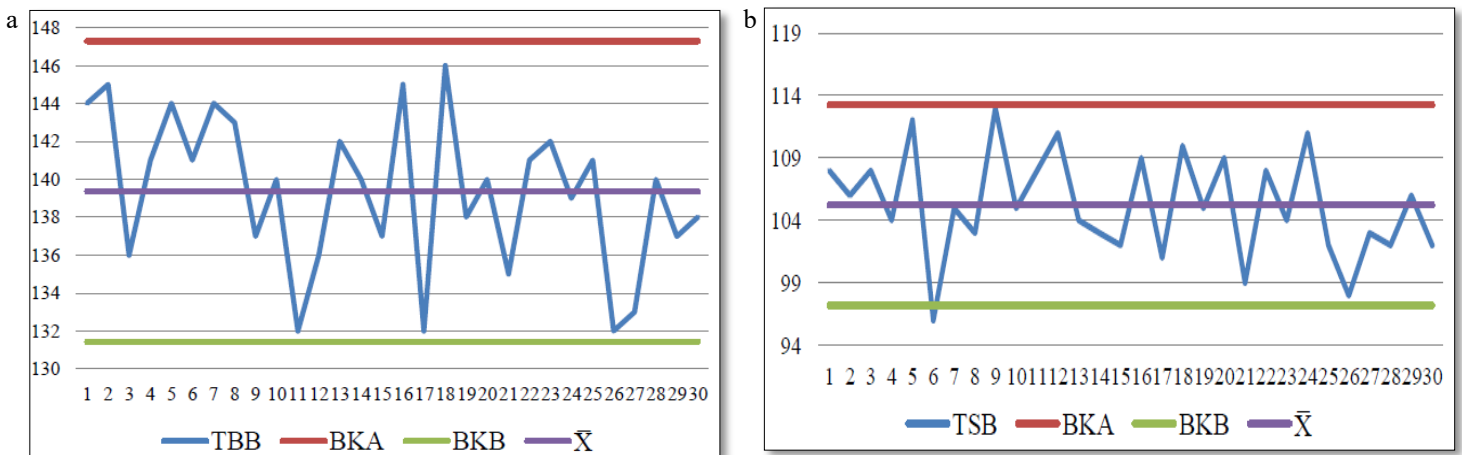


Figure 3 – (a)TBB maximum and minimum value (b) TSB maximum and minimum value

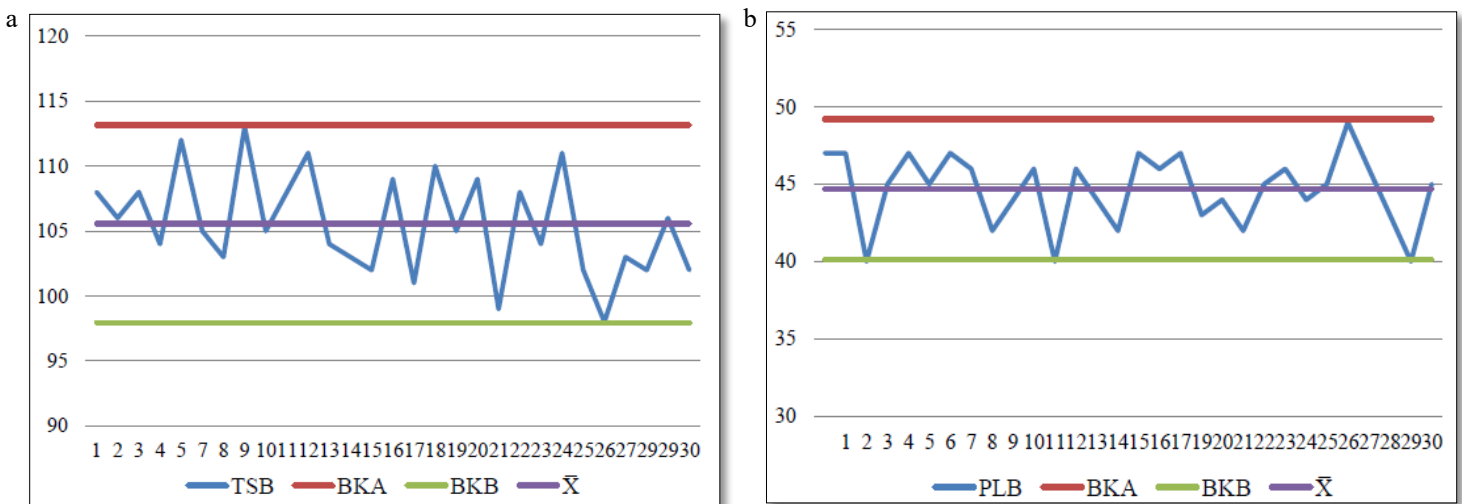


Figure 4 – (a)TSB maximum and minimum value (b) PLB maximum and minimum value

Figure 2(a) shows that the data from the TBB measurement results as a whole are included in the upper and lower limits with a maximum value of 147 cm and a lower limit of 131 cm, while the processed data can be 146 cm for the highest value and 132 cm for the highest value. Lowest. In figure 2(b) the TSB measurement contains one data from the

measurement results that are not included in the upper and lower limits, namely the TSB value of 97 cm, while the upper limit is 113 cm and the lower limit is 98cm, the highest value of the measurement results is 112cm and the lowest value by 98cm. then the data with a TSB value of 97cm must be sorted and replaced with new data so that the processing results on the TBB measurement can be used in designing the product.

Figure 3 shows the upper and lower limits on the TSB and PLB measurement results, in Figure 3(a) from the data processing results there is an upper limit with a value of 116 cm and a lower limit of 98 cm, besides that the data processed is in the range of 97cm to 115cm, so it can be concluded that the processing data from the TSB measurement results can be used in product design. Figure 3(b), which is the result of processing the upper limit and lower limit of PLB, there is an upper limit value of 49 cm and a lower limit of 40 cm. This data can also be used in the design of this product.

Proposed improvements to facilitate activities in planting corn seeds are that this tool has a container for corn output and is equipped with a corn seed storage area so that the user does not work twice as was done before designing work facilities and only occasionally fills corn seeds into the storage area [22]. Before operating, fill the seed into the seed storage box sufficiently, try not to be too full, make sure the seed reservoir is tight. The way to operate the planting is by holding the planting tool on the planter's stem with one hand, both the right hand and the left hand. Make enough arm swings to kick the tool into the ground to create a planting hole. Release the beat of the tool bar to get the corn kernels out [23].

Table 4. Recapitulation of dimensional calculation results of corn seed planting tools

| No | Part | Size (cm) |
|----|--|-----------|
| 1 | Height of Corn Planting Tool | 140 |
| 2 | Corn Planting Tool Handle Height | 105 |
| 3 | Diameter of Corn Planter Grip | 5 |
| 4 | Corn Planter Grip Length | 9 |
| 5 | Distance Between Operator and Planting Equipment | 45 |

Planting tool height adjusted to standing shoulder height (TBB), standing elbow height (TSB), forearm length (PLB), hand width (LT) and hand grip diameter (DGT) will make the operator more comfortable and save energy when working because the operator does not work twice, so it will provide comfort for the operator when working for a long time [24]. In this study, standing shoulder height, standing elbow height, forearm length, hand width, and hand grip diameter were used as a reference for designing work facilities because the operator's work is planting work for quite a long time, so the work carried out by the operator when it is enough to work with 5 body dimensions and in carrying out the process of planting corn seeds there is no need to use simple tools manually as has been done by operators while working, so that it is expected to be able to reduce operator complaints and be more comfortable when working [25].

3.2 Design Product

The design of this product is displayed in 3 dimensions (figure 6(a)) and 2 dimensions (figure 7(a)(b)), this product is designed according to the needs at the time of the study with an emphasis on the health and safety of workers who are subjects in this research, namely corn farming.

This design considers several main aspects consisting of [25]:

1. Performance Factor
It is an aspect that considers practicality, economy, safety, in accordance with the psychological and physiological conditions of humans (ergonomics) (figure 6). There are also those that consider: a. Convenience b. practicality c. Safety/security d. Ease of use e. Ease of maintenance f. Ease of repair.
2. Function Factors (figures 6 and 7)
A physical and technical design must work in accordance with the function demanded. Therefore it is necessary to consider: a. Eligibility b. reliability c. Material specification d. Structure of use or power system.
3. Factors of Production (figure 6a and figure 7 a,b)
The design must allow it to be produced according to the specified method and process. For this reason, it is necessary to consider: a. Machinery b. Raw materials c. Production process system d. Labor skill level e. Production cost.

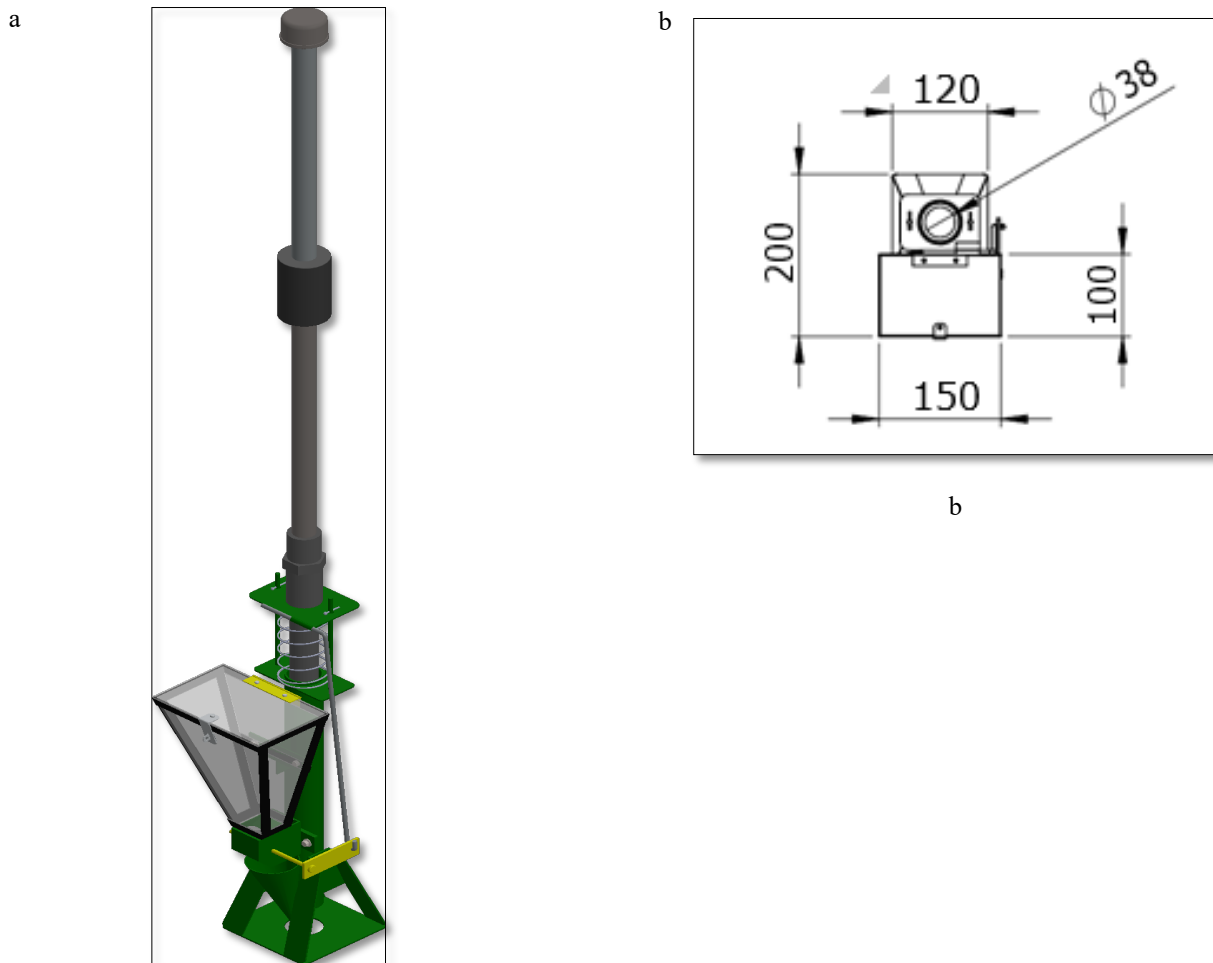


Figure 5 - (a) Corn seed planter tool (3D): (b) Corn seed planter tool 2D (top view)

5. Form Quality Factor (figures 6 and 7)

A design must be made in such a way as to be attractive so as to cause aesthetic pleasure. This is important in enhancing the taste of a person/community/consumer. For this it is necessary to pay attention : Completion of details and finishing A design is a plan that will be implemented in a finished work. If a product is done haphazardly it will look unprofessional. Therefore, every detail of the product produced must be examined carefully, because the quality of a product is very dependent on how the completion of the details and finishing are worked out perfectly. d. Form processing according to the structure and character of the material The shape that is created is also very much determined by the material used. Each material has its own characteristics that are characteristic and differentiator from other materials. Each material also brings a certain impression and image. e. Combination with other materials Combination implies combining two different elements or materials. In making product designs it is possible to have a combination of materials that will produce a product that is innovative and contains elements of novelty and uniqueness.

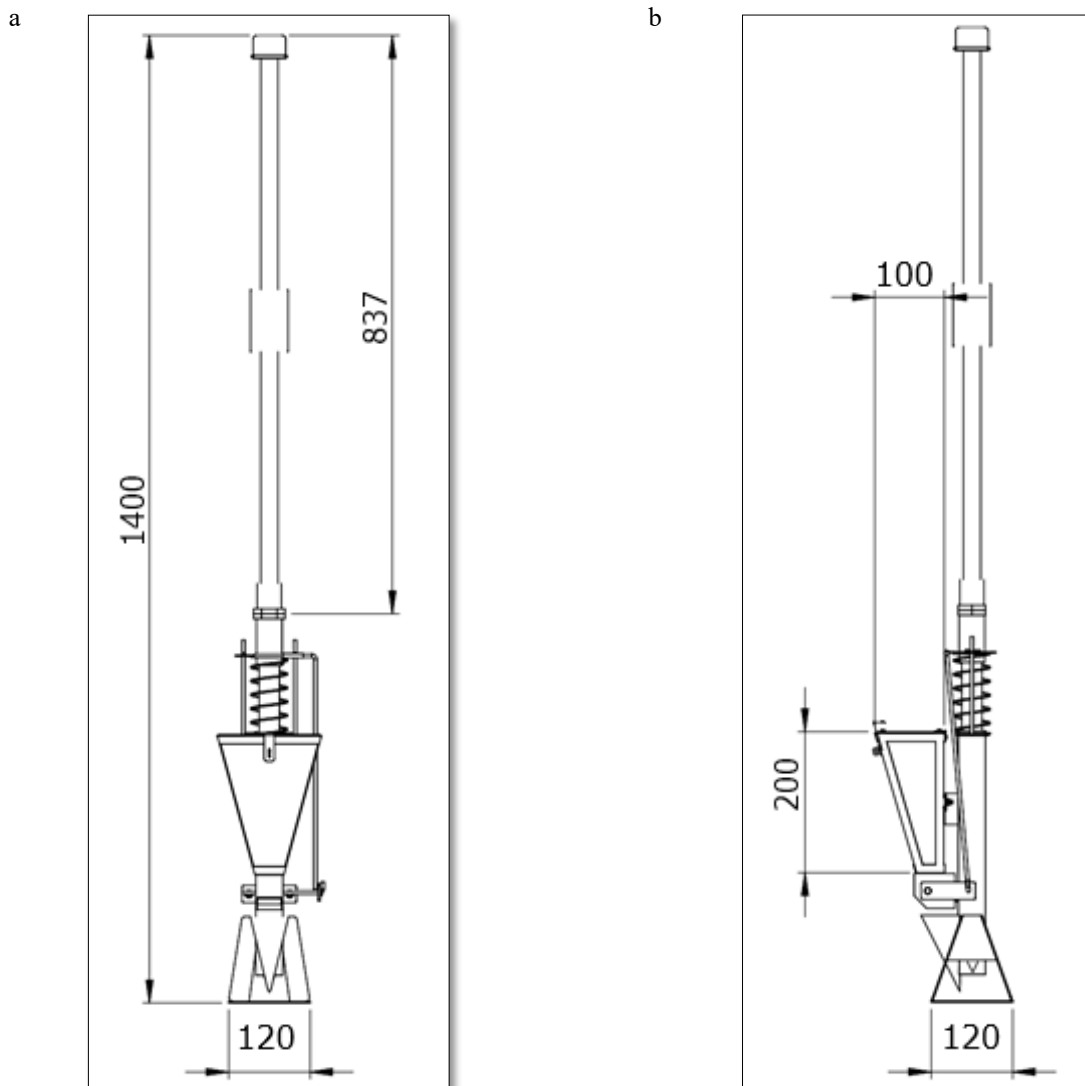


Figure 6 – (a) corn seed planter tool 2d (left-side view); (b) right-side view

4. CONCLUSION

By calculating the values of standing shoulder height, standing elbow height, forearm length, hand width, and the diameter of the operator's grip, the height of the corn seed planting tool is 140 cm, the handle height of the corn seed planting tool is 105 cm, the grip diameter of the corn seed planting tool handle 5 cm, the grip length of the corn seed planting tool is 9 cm, the distance between the operator and the corn seed planting tool is 45 cm. So that it is expected to be able to provide a sense of comfort, safety, health and efficiency for operators who work in planting corn seeds. From the recapitulation that the work of cultivating corn seeds causes complaints that are quite high in the neck, shoulders, waist, wrists and right hand. The design of this tool can help reduce musculoskeletal disorders (MSDs), for the following research the production process of the tool can be carried out and determine the estimated production costs and affordable selling prices so that it can be mass produced.

Disclaimer

The authors whose names are written certify that they have no conflict of interest.

Acknowledgement

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Nomenklatur

| | |
|------------|---|
| TBB | = Standing shoulder height |
| TSB | = Standing elbow height |
| PLB | = Forearm length |
| LT | = Hand width |
| DGT | = Hand grip diameter |
| \bar{X} | = The average value of observations |
| $\sum x_i$ | = Number of i-th observations |
| N | = Number of observations |
| S | = Standard deviation |
| X_i | = value of Xi-th |
| \bar{X} | = Average data value |
| N | = Number of data |
| N' | = Number of theoretical observations required |

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