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INFORMATIONAL AND CONCEPTUAL DESIGN OF A PEANUT TRACTOR DRIVEN HARVESTER FOR MEXICAN AGRICULTURE

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Abstract: In Mexico, the peanut crop production has declined due to low productivity and profitability of the crop. Since 1983 when the record was 170.433 ton production was obtained with a yield of 2,04 t·ha^{-1}. Since today is production is 94.848,58 tons, with a yield of 1,77 t·ha^{-1}. The country has a shortage of about 100.000 tons per year to meet domestic demand, so you can identify regions with greatest potential to find business opportunities and leverage the domestic market demand. To increase crop productivity peanut is due to promote mechanical harvesting in Mexico, producers require machines with easy and economical operation that can harvest under a wide range of conditions. No mechanical systems or machines are designed in the country to harvest peanuts so there are restrictions on the adoption of imported peanut combine models: a. - high initial cost of acquisition b. - differences with local farming systems c. - difficulty of proper maintenance and spare parts.

For the foregoing reasons this work aims to contribute to the informational and conceptual design of a peanuts harvester for medium size farmers in Mexico.

Key words*:* agricultural mechanization, harvester combine design, Mexico, peanuts, tractor driven combine

INTRODUCTION

In Mexico the peanut crop production has declined due to low productivity and profitability of the crop. Since 1983 when the record was 170.433 ton production was obtained with a yield of 2,04 t·ha^{-1}. Since today, production is 94.848,58 t·ha^{-1}, with a yield of 1,77 t·ha^{-1} [21].

To reap the producers in San Luis Potosi tear kills manually and reach harvest between 1.3 t·ha^{-1}. Under rained conditions this practice is the most expensive so using a thresher would lower production costs and be more profitable crop, since this production

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costs 4.965 Mexican pesos would be obtained without machinery increased to 7.860 Mexican pesos [5].

The peanut acreage decreased by high production costs 11.000 to 14.000 Mexican pesos and low productivity 1.5 $t{\cdot}ha^{-1}$. The domestic market is not supplied by domestic production. No assessment of varieties demanded by the market for the snack industry and oils demonstrating the technological components; use of new varieties, organic fertilizers and mechanization peanut crop. Seeder, combine, shelling machine and toaster needed to increase production cutting times, increasing the increments been desired by machinery, improving production systems at low cost and profitability. Having unwillingness to technological change, high attachment to traditional methods, low availability to innovation, few lines of research, lack of support for the development of new research, lack of adaptation of existing technologies [13].

In Puebla peanut harvest has reduced its costs by up to 32% production costs range from 11 to 15.000 Mexican pesos and selling kg for 6-7 Mexican pesos, with a yield of 1 to 1.5 $t{\cdot}ha^{-1}$. Producers have an average of 3 hectares, and 20 hectares in Chihuahua. 20 average wages in a week is required only for manual starting in one ha. Another 20 for threshing. Combine with rises in two-hour ha. In 5.700 Mexican pesos manual harvesting is spent, and mechanized costs 3.100 to 2.400 Mexican pesos [10]. Mechanized harvesting process is necessary in order to hand over to pick the length of time of operations, reduce the number of employees, increase productivity and reduce costs by up to several times [33].

The analysis of the situation of the park peanut harvester Mexico is not possible because the country lacks the culture of having a census and an organization that is dedicated to information of agricultural machinery of any kind (tractors, combines, implements etc.) [20]. So questions about the park peanut harvester and strippers as they are; it is efficient, modern, replenishment of this, the ratio strippers for harvesters stay in the air until action was taken. A peanut harvesting system depends on physiological, social, economic and technological factors. No mechanical systems or machines are designed in the country to harvest peanuts so there are restrictions for adopting imported peanut combine models: a. high initial cost of acquisition, b. differences with local farming systems, c. difficulty of proper maintenance and spare parts.

To increase the productivity of peanut crop should promote mechanical harvest in México, farmers require machines with easy and economical operation under a wide range of conditions and design a harvester suitable for medium sized properties [21] [22]. For the foregoing reasons this work aims to contribute to informational and conceptual design of a peanuts harvester suitable conditions for medium size farmers in Mexico. The time spent on manual harvesting and threshing between 300 and 400 $hours{\cdot}ha^{-1}$ [15]. In China the peanut harvest is low efficiency and higher labor intensity, with a high cost of production [11]. In Taiwan an average of 1128 labors hours per ha was needed to produce peanuts, one fifth of which was for harvesting usually done by hand [35] in India Present practice of hand harvesting and threshing groundnut consumes huge amount of labor to the magnitude of 84 $man\text{-}h{\cdot}ha^{-1}$ [24].

Several authors related the operation of peanut harvester machines; peanut pickers – threshers [15], [14], [25], Peanut Combines [23], green peanut Combines [31].

Factors influencing the selection, performance and design of peanut harvester:

The Machine. 1. center of gravity, 2. capacity, 3. working speed, 4. characteristics of lifting mechanisms, 5. threshing and cleaning assets and internal organs cut driving, 6. wheeled power source. *The Field.* 1. variety, 2. crop status, 3. crop plantation system and row spacing of plants, 4. along the furrows and access status, 5. property size, 6. terrain declivity.

Basic function peanuts combines include, [8] and [7]: 1. lift the vines into combine, 2. thresh the pods from the vines, 3. separate pods and vines, 4. remove the stems from the pods, 5. deliver clean, undamaged pods into the hopper.

Various attempts to design a economic peanut harvester are carried out, which are related below.

A small self-propelled one way operation groundnut combine harvester was developed in the National Chung Hsing University. The criteria of the design were that the groundnut vines with the pods could be pulled up from the ground and put in rows. Fields loss during mechanical operation could be low due to high moisture content of stumps. The combine was small in size and driven a 15 HP diesel engine. In this machine an automatic hydraulic height control to maintain the stems at pickup high. When working on an uneven ground, a stem combine device and a string type pod ripper controlled the height [35].

A peanut harvesting equipment suitable for operation by a 35 Hp tractor was designed, developed and tested at the department of biological and agricultural engineering UPM, Malaysia. The equipment consists of adjustable V-shaped digging blade where the angle of penetration can be easily adjusted with the help of bolts and nuts. Double discs lifter for gripping the loosened plant above the soil surface follows the digging blade. The loosened plant enters into a threshing mechanism, which consists of two cylinders with different numbers of fingers to achieve the stripping operation without dragging and clogging the pods then transfers them to the tank at the end of the equipment via conveyor. The weight is the 315 kg and the cost US$ 1.455. Hence the new peanut harvesting equipment was designed to provide proper and efficient digging blade (V-shaped), with the following features: suitable clearance between cylinders and their concave (35 mm), suitable spacing between concave bars (25 mm) and conveyor wire mesh (20 mm). The total power of single row equipment was about 15kW (20 HP) [1]

Design, develop and evaluated a tractor operated groundnut combine harvester in a department of agricultural machinery department of the Tamin Nadu Agricultural University. As the combine harvester has to perform the dual operations viz., harvesting and threshing, the groundnut harvesting mechanism, conveyor and threshing mechanism have to be mounted integrally to carry out harvesting and threshing simultaneously. The groundnut combine with the following components should perform the desired functions. The harvester for penetrating into the soil to the required depth and digging out the groundnut crop with pods. Pickers conveyor pick up units of sufficient width to allow for picking and conveying the dugout crops with pods from the soil surface. Collection chamber for collecting the crops with pods conveyed by the picker conveyor. Belt conveyor to convey the collected crop from end the harvester to other end. Elevator for elevating and feeding the conveyed crop with pods from the belt conveyor into the feeding chute of threshing unit. Feeding chute to regulate the flow of crops conveyed by the elevator into threshing cylinder. Thresher cylinder for separating the pods from the vines of groundnuts crops. Blower for blowing out the chaff and dust particles after the threshing operation. Sieve for separation of foreign particles, vines, etc. from the pods. The operation groundnut combine harvester resulted in 39% and 96% saving in cost and time respectively, when compared to conventional method of manual digging and stripping [24]

Designed and developed a functional model in Romania of a machine that achieves direct harvesting of peanuts by: dislocation of the plants, pulling of the plants from the soil, detachment of the pods out of plants, separation and impurities [3].

A 4HJL-2 harvester for peanut picking -up and fruit-picking was developed. This machine is mainly composed of a chain nylon elastic tooth pick-up device, transmission device, take off equipment, elevator set fruit device parts, such as using knapsack structure design, supporting power for Yangzhou 30 tractor, unit speed 52 $m \cdot min^{-1}$, collecting 57 $m \cdot min^{-1}$. Conveying speed conveyer 23 grads inclination. It can finished once peanut collecting, transportation, picking fruit, such a cleaning, set fruit, reduced human use. Field experiments show that the machine work performance is good, the collection rate 99.1 % the los rate was 3.2 %; productivity was 886 $kg \cdot h^{-1}$ [11]

At present only the peanut harvester 4HLB2 which co-developed in China by Qingdao Agricultural University, Qingdao Technological University, Harbin Institute of Technology and the Qingdao Hongsheng Auto Fittings Co. Ltd. company [6]. Currently has economic impact and technically as it is marketed worldwide, demonstrating that when the state promotes cooperation between academic institutions and companies for agricultural mechanization.

[31] Defined the functional analysis of agricultural machines, this has several components that work together as a system, and may be divided into two sub systems ;process system or support systems. The process system are those components of the machine that actually perform the functions that the machine is designed to perform and may be divided in three types; reversible, non-reversible and non-directional. The support system are the parts that support or aid the process system in performing their function and may be categorized as framing, power or control system. [27] Suggest the usage of the technique of the function structure for starting the development of agricultural machinery concepts.

To design in modern agricultural machinery was already systematized methods to improve and reduce time, money and effort, [17], [27], [34], [2].

[17] indicates actions to be executed for machine design ;lifting the physical characteristics of operation, perform the theoretical study of operation, and the sequence of events, the study of existing mechanisms and their associations, technical feasibility select systems and economic, to define the concept of machine design and build experimental prototype.

For the process of development of agricultural machinery are; design planning, informational design, conceptual design, preliminary design, detailed design, preparation for production, launch and validation, [27]. Informational design consisting of the detailed analysis of the design problem, looking for all the information necessary for full understanding of this design. The result obtained at the end of this phase, are the design specifications, which are a list of objectives that the product to be designed to meet, [26] from there are defined functions and required product properties and possible restrictions [26]. Conceptual design is defined as the stage looking to understand how the selection of product design based on your specifications resulting from informational project is determined.

MATERIAL AND METHODS

For informational design the information was compiled from databases websites of domestic and foreign government agencies, patents, academic papers, journals, conferences, manufacturers, importers and distributors, scientific journals, professional thesis, newspaper articles, books, etc.

For conceptual design was followed in this project the morphological matrix methodology described by [2] and [34]. According [2] when a project is initiated and developed, it is split into a sequence of events, in a chronological order to form a model each of these events can be divided into phases. Morphological matrix method is defined as the division of the problem in two or more dimensions, based on the required functions of the system to be designed, then the maximum number of alternatives to accomplish each of the functions are listed, which are organized in a matrix in which the various combinations can be analyzed [2].

To calculate the track width was used the equation given by [19]:

$$B = m\cdot(n + 1) - 2\cdot C_{ext} - b \quad (1)$$

where:

B [mm] - track width,
m [mm] - row spacing,
n [-] - number of row under the tractor,
C_{ext} [mm] - area outside the plant protection,
b [mm] - width of the tire.

RESULTS AND DISCUSSION

[16] relates that the varieties grown in Mexico are regionalized, for example, varieties erect growth habit Virginia type of large seeds are the most commonly grown in Guerrero and Morelos. The creeping growth habit and Spanish Runner type of small seeds are grown in Morelos and Puebla. The creeping Virginia type varieties of large seeds that require more labor to harvest handling and cultured in minimum area and southern Morelos, finally the fastigata subspecies creeping growth habit type Valencia having 3 smaller seeds per fruit and purple cuticle backyard grown in Puebla. In the table 1 show area, production and yield, distance between rows and between plants in states with more production in Mexico.

Table 1. Area, production and yield, distance between rows and between plants in states with more production in Mexico according to several sources

State	*Surface sown [ha]*	*Production [t]*	*Yield [$t\cdot ha^{-1}$]*	*Distance between rows*		*Distance between plants [cm]*	
				Creeping varieties [cm]	*Erect varieties [cm]*		
Sinaloa	*16.430,10*	*25.395,80*	*1,56*		*75*	*9 seeds·m^{-1}*	*[4]*
Morelos	*941,30*	*1.719,16*	*1,83*	*Short-guide 50 Long-guide 90*	*75*	*40*	*[9]*
Guerrero	*2.434,60*	*3.151,54*	*1,58*		*48-60*	*25-40*	*[16]*
S. Luis Potosi	*3.436,00*	*3.875,50*	*1,13*		*90*	*25*	*[5]*
Veracruz	*583,5*	*662,23*	*1,16*	*75-80*	*60*	*20-30*	*[12]*
Puebla	*6.317,90*	*6.980,70*	*1,10*	*75*		*40*	*[16]*

Informational design about peanut cultivation in Mexico. [28] Found in study of the varieties grown in Mexico the length of pods are between 2,95 and 5,17 and a average of 3,57 cm. In the Tab. 1 show area, production and yield, distance between rows and between plants in states with more production in Mexico according to several sources, and in the Tab. 2 show main characteristics of some varieties grown in Mexico and in Fig. 1 the peanut harvester design requirements. The design parameters of any root or tuber crop harvester effects the performance of the machine [30]. In the Tab. 3 is shown the peanut harvester design requirements.

Table 2. Main characteristics of some varieties grown in Mexico [16]

Variety	*Habit growth*	*Height plant [cm]*	*Days flowering*	*Yield straw [$t \cdot ha^{-1}$]*	*Fruit yield [$t \cdot ha^{-1}$]*
RF-214	*creeping*	*35*	*35*	*4.3*	*1.8*
Huitzuco93	*creeping*	*65*	*33*	*5.8*	*1.6*
A-18	*erect*	*54*	*33*	*4.0*	*1.7*
Ranferi Diaz	*erect*	*57*	*35*	*4.0*	*1.7*
Rio balsas	*erect*	*58*	*33*	*5.5*	*1.7*

Table 3. The peanut harvester design requirements

Require-ments	*Plants pick-up width*	*Area proposed*	*Appropriate travel speed*	*Good stability*	*Low cost*	*Low weight*	*Ease of transit*	*Low power*	*Maintenance interval*	*Width track*
Quantify	*1 m*	*20 ha or more*	*Max 40 $km \cdot h^{-1}$*	*Lower gravity center*	*10.000 -14.000 $ US*	*Less 3.500 kg*	*Multiple of 75 cm*	*45 HP*	*More 300 hours*	*2800 mm*

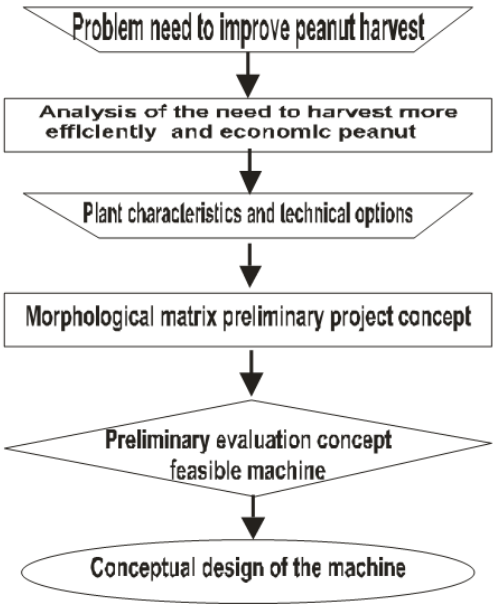

Figure 1. The peanut harvester flowchart of the project phases

A.-To provide Traction and power	A1.-Animal drawn	A2.-Two wheels tractor	A3.-Pull type Harvester	A4.-Traction Driven	A5.-Self-propelled
B.-To provide picking	B1.-Pick up header with rigid fingers	B2.- Pick up header with Iron type spring	B3.- Pick up header with Leaf spring fingers	B4.- Pick up header with flexible fingers with	B5.-Collecting chamber
C.-To Provide threshing	C1.-five cylinders	C2.-four cylinders	C3.-One rotor Axial threshing	C4.-Two rotors Axial threshing	C5.-Spiral arc panel threshing
D.-To provide cleaning	D1.-Radial flow	D2.-Cross flow fan	D3.-axial flow blower cross axial position	D4.-axial flow blower longitudinal axial	
E.-To provide conveying	E1.-Screw conveyor	E2.-Pneumatic conveyor	E3.-Bucket conveyor	E4.-Belt conveyor	
F.-To provide storage	F1.-Hooper In the combine	F2.-Hooper Trailer	F3.-Bagging System		

Figure 2. Matrix peanut functions and alternatives for peanut tractor driven harvester conception

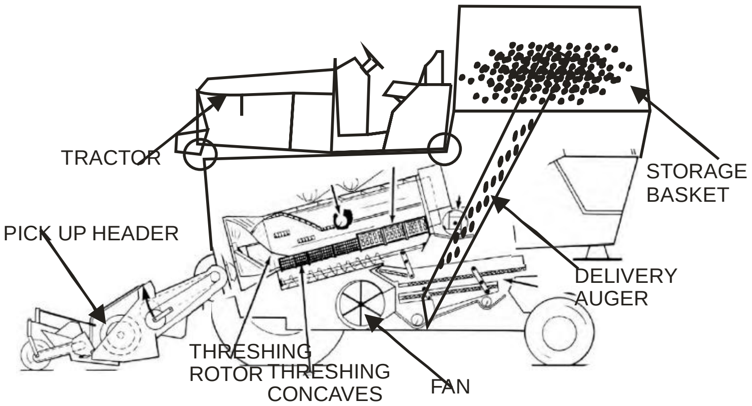

Figure 3. Tractor driven peanut combine QKX13

Conceptual design. The conceptual design phase of a harvesting equipment involves abstracting to find the essential problems of mechanization, establishing function structures for machine, searching for solution principles, combining solution principles into conception and selecting a suitable conception [34].

In the Fig. 2 show he peanut harvester flowchart of the project phases.

For the matrix in Fig. 2 can specify the desired machine concept; (A4-B1-C4-D1-E1-F1), the combine will be driven by the tractor has a pick up head, axial two rotors threshing system, radial flow fan cleaning system, convey system by screw, and storage of the product harvested by hopper installed in the combine and will have a track width of 2.80 m calculated according to equation (1) [32] the harvester with a threshing axial system are better able to harvest and reduce mechanical damage, compared to the harvester with threshing radial system.

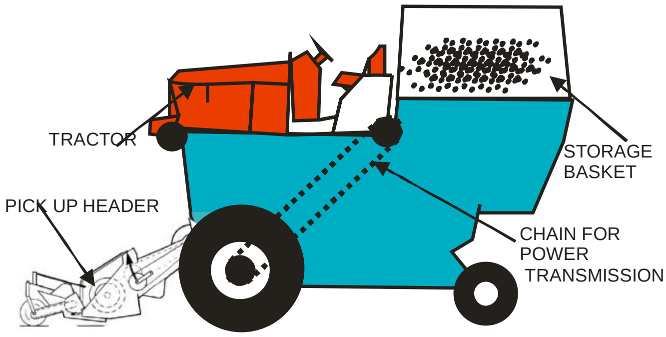

Figure 4. Tractor driven peanut combine QKX13 power transmission system schematic

According [18] the pull type combine for use the engine and the tractor traction to move and drive mechanisms have lower cost to self-propelled combines, but has low operational performance, difficulty maneuvering and problems with the coupling system, by the other hand, the self-propelled combine presents minimal problems maneuver, the direction easily control, and high initial cost of acquisition and maintenance. So the peanut tractor driven harvester has the advantages of the pull type and self propelled combines without the disadvantages of both.

CONCLUSIONS

The morphological matrix method proved be effective for the conceptual design of a peanut harvester for medium sized properties in Mexico. It should continue with the next phases of design (preliminary design, detail design, prototype construction, test and evaluation and final documentation of complete machine). So you can test the ability of this machine in the production of peanut efficiently and economically.

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INFORMACIONA I KONCEPTUALNA KONSTRUKCIJA TRAKTORSKOG KOMBAJNA ZA KIKIRIKI ZA MEKSIČKU POLJOPRIVREDU

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Sažetak: Proizvodnja kikirikija u Meksiku je opala zbog male produktivnosti i profitabilnosti useva. Od 1983, kada je proizvedeno 170.433 tona, sa prinosom od 2.04 $t{\cdot}ha^{-1}$, danas se proizvodi 94.848,58 tona sa prinosom od 1.77 $t{\cdot}ha^{-1}$. Zemlji nedostaje oko 100.000 tona godišnje za domaće potrebe, pa treba identifikovate regione sa najvećim potencijalom za zadovoljenje potreba domaćeg tržišta. Za povećanje produktivnosti predstavljena je mašinska žetva kikirikija u Meksiku, pa proizvođači traže mašine za jednostavnu i ekonomičnu upotrebu u različitim uslovima žetve. Domaće mašine nisu konstruisane pa postoje ograničenja u prilagođavanju uvoznih kombajna: a. visoki početni troškovi, b. neusklađenost sa lokalnim uzgojnim sistemima, c. teškoće sa pravilnim održavanjem i rezervnim delovima.

Iz navedenih razloga, cilj ovog rada je da doprinese informacionoj i konceptualnoj konstrukciji kombajna za kikiriki za srednje farme u Meksiku.

Ključne reči: poljoprivredna mehanizacija, konstrukcija kombajna, Meksiko, kikiriki, kombajn sa traktorskim pogonom

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