Revision of the current wheat harvesting technique

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Abstract:
Algeria is among the biggest wheat consumers in the world. Previous study revealed that some losses of wheat productions were linked to the fact that grain was threshed then stored which makes it vulnerable to climatic aggressions and pests.
In order to make harvesting possible without threshing in the midst of mechanization era in field crops, we tried through TRIZ to propose a way to keep grain in its cob to better preserve it by introducing a modification in the second operational phase of combine harvester. The solution suggests abandoning threshing and adopting cob and straw separating.
Keywords: grain preservation; harvesting; mechanization; threshing; TRIZ.
Jel Classification Codes: O310, Q160, Q29.

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1. INTRODUCTION

Wheat is the most common commodity in human daily life and its consumption continues to increase. Indeed, a global increase of 12% is expected in 2030 compared to the year 2021. This makes Algeria being one of the largest consumers of this food with a very high level exceeding 200 kg per capita per year (OCDE/FAO, 2021).

The importance of this product makes it one of the priorities in the policies adopted for better management of the cereal sector. Ensuring an uninterrupted availability of wheat is imperative to meet the challenge of the country's food security, so much linked to precious food. That is why Algeria is betting a lot on reducing imports by controlling production and counting on its stock (Assoko, 2022).

The storage of wheat involves robust servicing to preserve the grain and this generates very high costs without guaranteeing the avoidance of the losses estimated very important by Rastoin & al. in 2018. A previous study we conducted proved a close link between wheat storage and harvesting technique through historical research. After discussion of the problem through resolution by TRIZ, it was found that the best way to store wheat is to leave the grain in its cob(Bouchafaa & Kaci, 2022). However, and with mechanization, the use of the combine harvester means that the wheat is threshed at harvest time and therefore grain is automaticly stripped of its cod. This paper tries to find a way to solve this problem and suggest a manner to achieve successful harvesting without threshing in the era of mechanization where the combine harvester is the star of the harvesting season.

First, let’s try to analyze the necessity of using the combine harvester to accomplish successfully the harvesting operation. In this way, we will carr out some investigations so that we could obtain elements that will help us to assimilate different phases of wheat processing from harvest to storage.

2. IMPORTANCE OF COMBINE HARVESTER NOWADAYS

As explained previously, wheat is one of the most consumed foods in the world. That is why it is part of field crops. Large areas are employed to cereal cultivation with an increasingly frank intensification in such a way that it became imperative to abandon traditional practices and adopt modern techniques with modern tools to control production which must cover demand constantly growing.

All these constaints contributed to the appearance of the combine harvester. It was therefore a matter of producing in large quantities but also of harvesting in a short time. So, that is the main function of the combine harvester. However, this machine thresh the grain at the same time it harvests wheat, which makes it vulnerable to climatic aggressions and pests. Faced with this situation, it becomes interesting to try to avoid threshing at harvest time, something that is impossible with the use of the combine harvester. In the sense of Altshuller, this constitutes a physical contradiction

The problem thus posed contradicts the function of the combine harvester and the vulnerability of threshed grain at harvest time. By applying the TRIZ (Theory of Innovative Problem Solving), we can model our problem in the form of a vepole.

« ***Vepole modeling is based on a simple assumption. The problems of a system can be reduced to a stricted number of elementary parts in interaction between two substances. One of the substances "the tool" acts on the other "the product". The field is a scalar of force which allows the interaction (of the tool on the product. Once the problem has been modeled, it is similar to a vepole problem*** ».(Rousselot & al, 2008) **[Our translation]**

In order to better explain our problem, we must specify the studied system and the different parts that will make up our vepole problem. This is what we try to do in the next section.

3. PROBLEM MODELING IN THE FORM OF A VEPOLE

The simplest functional model in the vepole representation is a triangle called « triad ». For our problem, the combine harvests wheat (with great speed and therefore a reduced time) but trheshes the grain and therefore subjects it to climatic aggressions and pests. With this diagnosis, we can carry out a schematization of the problem thanks to the vepole representation. Lest's first define the principal function of the Combine harvester.

« ***The combine harvester is a grain harvesting machine that performs stalk cutting, cobs threshing, grain separation and cleaning*** » (Cemagref, 2021) **[Our translation]**

So, we can model the combine harvester functions as follows :

1- The Combine harvester cuts the wheat stalk ;
2- The combine harvester threshes cobs ;
3- The combine harvester separates and clean the grain.

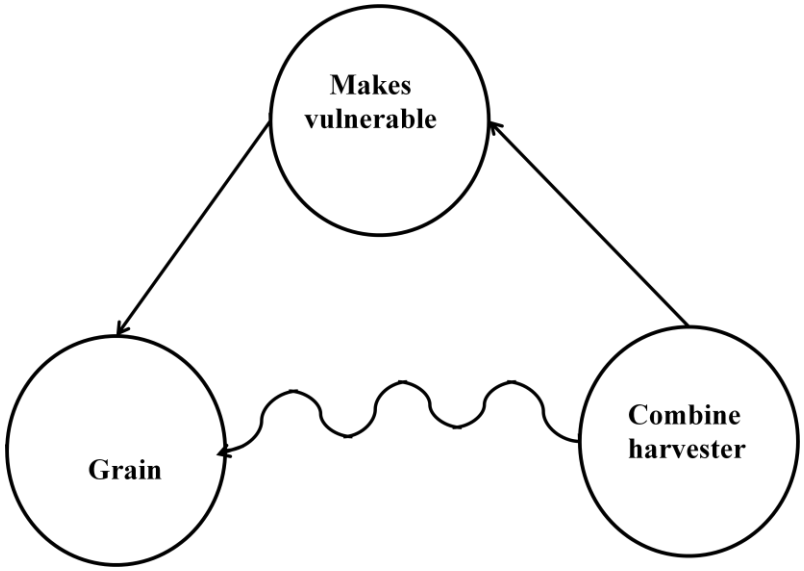
Functions 2 and 3 are the cause of the physical contradiction, subject of our study. Combination of both leads to the formulation of our vepole problem. So let's note that ***« Combine harvester helps cutting wheat stalk fast but causes grain vulnerability »***.

As announced, the formulation is not strictly a vepole where we must have a tool acting on a product to accomplish a function. Therefore, we suggest the following problem position:

« ***the combine (tool) harvests (function) the grain (product) of wheat but makes it vulnerable (contradiction)***».

This is the formulation of our problem in the forme of vepole. The corresponding schematization in the figure 1 below summarizes the proposed problem.

Fig.1. Vepole model



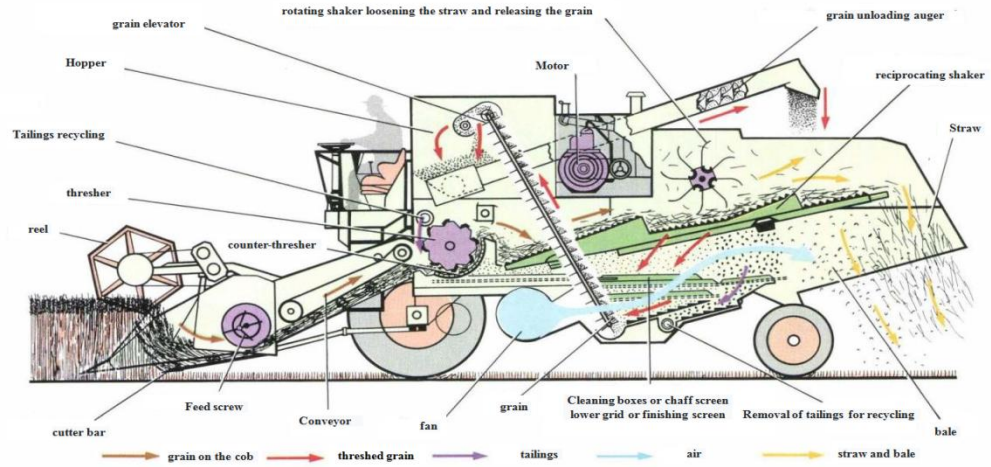
Source: made by ourselves

When the arrow connecting the tool and the object is curvilinear, the action of the first on the last is harmful. Our goal is to make this connection satisfying. this means that we must make changes to the tool to perform its function without adverse effect on the product. To do so, we need to understand how the combine harvester works, and even how this machine is made.

4.COMPOSITION AND FUNCTIONALITY OF THE COMBINE HARVESTER

The figure 2. below shows the components of the combine harvester and explains how it works as well as the different grain processing phases.

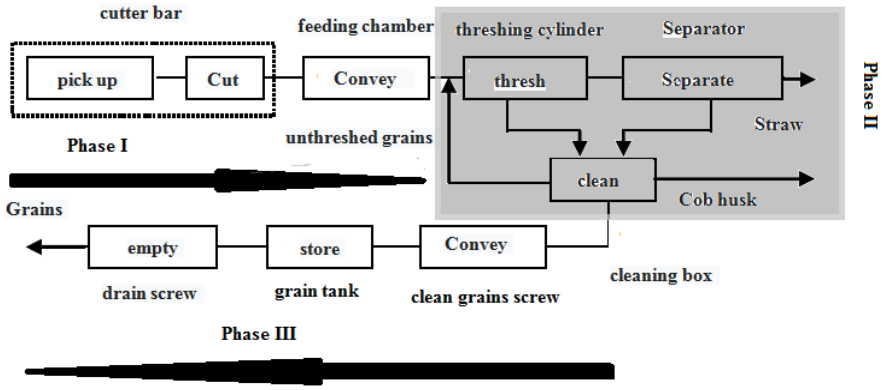
Fig.2. Detailed view and crop flow in a combine harvester



Source : Support Massey-Fergusson in El Aïssaoui, 2010 **[Our translation]**

As shown in Fig 2. above, stalk is first cut by the cutter bar and driven to the conveyor through the feed screw. Then, grains are extracted by shock and friction operations between thresher and counter-thresher. Finally, grains are cleaned by reciprocating shakerand saparated through the grain elevator to the hopper. These processes can be represented by a simplified diagram proposed by Al Aissaoui, 2010.

Fig.3. Processes of functions and operations of a combine harvester



Source : developed by ourselves from El Aïssaoui, 2010

According to the figure 3. Above, combine harvester works in three phases and we note that :

1- In phase I, grains are collected but not yet threshed which constitutes an advantage within the meaning of the TRIZ ;
2- In phase II grains are threshed, separated and cleaned. In this phase threshing is not desired because we don't the grain to be removed from its cob, but we still need to maintain the process separating the grain in its cob from the straw.
3- In phase III, the grain is transported to the threshed grain tank to be finally stored. Here we don't want the grain to threshed.

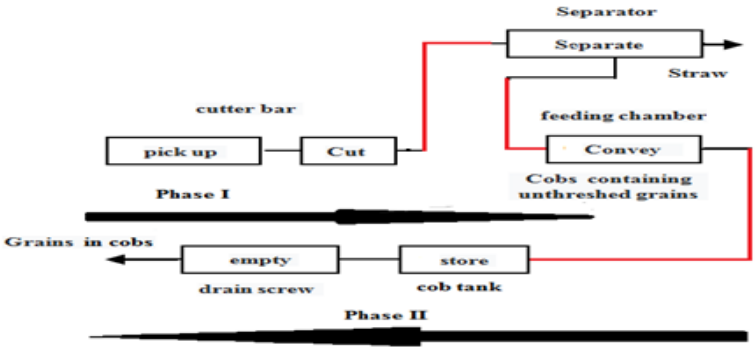
A better comprehension of how the machine works allowed us to realize that our contradiction problem is actually in phase II because the ideal would be to keep grain in its cob and just separate it from the stalk; ie avoid thresing. This is only possible if phase II is eliminated; which requires improvements at the level of phase I.

5. THE DESIGN OF THE IDEAL SOLUTION

According to TRIZ, the solution to be proposed must achieve, without compromise, an ideal final result, defined as « ***the ratio between the benefits provided by the solution and the costs and harm it generates*** » (Gendre and Lusseau, 2010) **[Our translation]** which should be as big as possible.

As explained previously, we have to imagine a solution which permits elimination of threshing in the process of combine harvester machine and keep other necessery features such as stalk cutting and grain separating. We can simplify the desired result by the following digram in the figure 4 below :

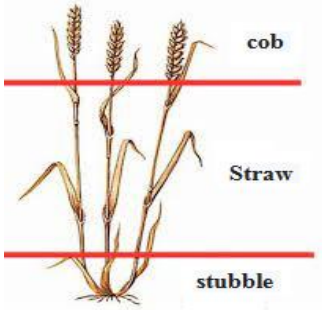
Fig.4. Processes of functions and operations proposed by preliminary solution



Source: made by ourselves

Through the solution we are proposing, we would like the collection, cutting and cobs separating from straw to be done at the level of phase I, in short no thresing. In this way, the grain will be kept in its natural shelter and preserved from any degradation. Phase II will only insure the evacuation of separated substances.
This diagram leads us to imagine a machine carrying out the harvest without threshing with perfect separation of the cob from the straw in the way that we try to schematize as shown in the figure 5 below:

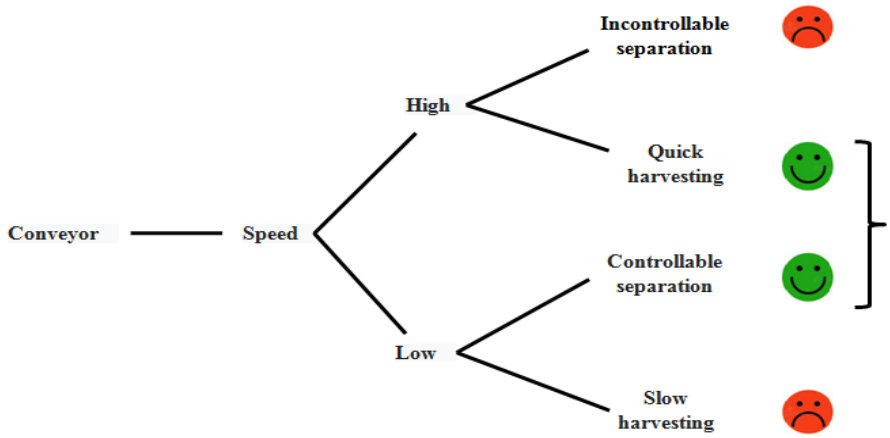
Fig.5. The different parts of the wheat plant



Source :https://www.pinteest.fr/pin/208010076517538362/ **[Our translation]**

We have to imagine a machine that has to cut the wheat plant to get the stalk at first. Then it must proceed to the separation of the straw and the cob with the grains inside and finally evacuates harvested wheat in the desired condition.
Before suggesting a design of our machine, let's remind ideal solution proposes two cut levels. Also, we realize by analyzing more closely the cutting mechanism carried out by the combine harvester that this process is done at such high speed that the separation could not be controlled.This leads us once again to another contradiction. Indeed, a high speed of the conveyor allows a reduced harvesting time but can make the process separating cobs from straws uncontrollable. We can represent this constraint by the following diagram :

Fig.6. The contradiction problem solution

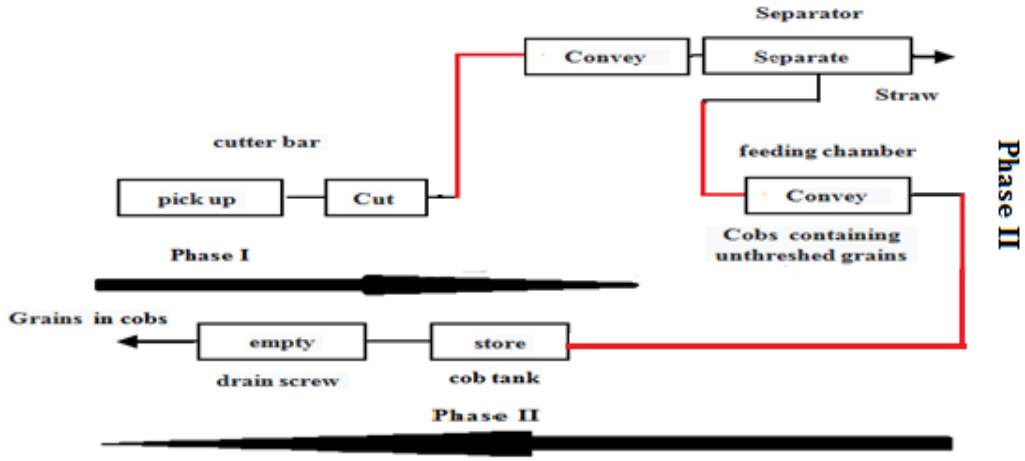


Source: made by ourselves

The figure 6 above proposes a diagram for an ideal situation combining rapid harvesting and a controllable separation process. As in TRIZ there is no compromise, we would like to design a model to ensure the desired ideality.

The prototype to be designed and inspired by the combine harvester and which mustn't carry out threshing process, will have to ensure wheat plant cutting to obtain the stalk which passes through conveyor at enough high speed for a rapid harvest. we must think of placing a bar high enough on the conveyor to let straw pass and prevent cob passage and separation will thus be ensured. In this way, we will have to split phase I into two independent phases.This leads us to make some corrections to our previously proposed solution scheme to distinguish the cutting phase from separation phase. Thus, we get the following result summarized in the figure 7 below :

Fig.7. Processes of functions and operations proposed by final solution



Source: made by ourselves

Two very important points at the end of this operation are to be considered :

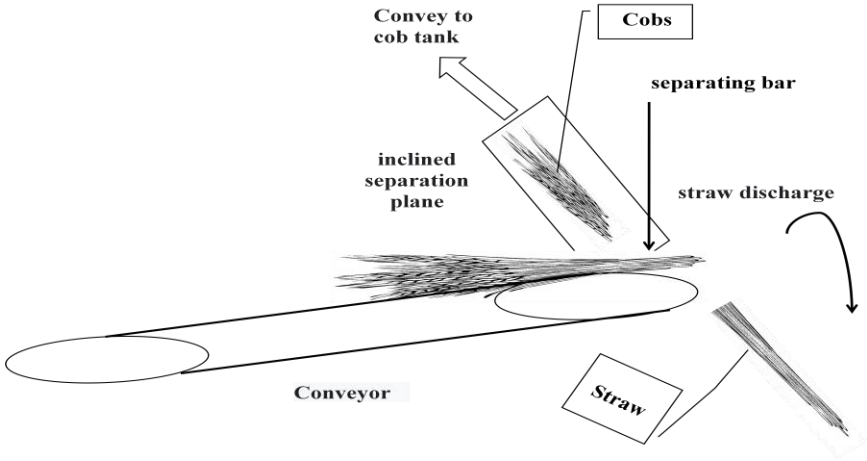
- Arrangements should be made for the immediate recovery of separated cobs. To do so, we can slightly tilt the plane where the separation takes place and put a second

conveyor to collect the cobs ;

- Regarding the bar to be placed for the separation, it is necessary to think of a material that cannot damage the cob.

Finally, we can present a diagram of the separation process, the subject of phase II. So, we propose our innovative solution in the figue 8 below :

Fig8. Process of cobs an straw separating diagram



Source: made by ourselves

6. CONCLUSION

Since nearly a century, Algeria is suffering from dependency on international wheat market. A previous study concerning this deficit revealed significant losses in production related to grain storage due to climatic aggressions and pests. The analysis led to the proposal to harvest without threshing to keep the grain on its cob. The mechanization used in agriculture more than a century ago opposes this solution. It was therefore necessary to think of removing the contradiction noted by using TRIZ techniques to suggest a way to ensure wheat grain protection in the era of field crops.

Our solution proposes modifications at the second phase of combine harvester operation by eliminating threshing process and simply replacing it with cob and straw separating process. In this way the grains will be kept in their cobs to be stored without risk.

The separation process can be ensured by a bar blocking the passage of the ears, thus separating them from the straw. We just have to make sure that cob will not be damaged.That is why and to obtain the desired result, a study of the parameters of the proposed new device is recommended. At the end, the machine thus modified can no longer be called « Combine Harvester » !

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