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DON'T GET STUCK IN THE MUD:

Combine harvester specifications, operation and design for wet rice field conditions in Bangladesh

CEREAL SYSTEMS INITIATIVE FOR SOUTH ASIA- MECHANIZATION EXTENSION ACTIVITY (CSISA-MEA)

DON'T GET STUCK IN THE MUD:
Combine harvester specifications, operation and design for wet rice field conditions in Bangladesh

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ABOUT CSISA-MEA

Bangladesh is one of the most mechanized countries in Asia when it comes to land preparation. By contrast, the planting and harvesting of the 11 million hectares of rice grown every year in Bangladesh is still largely carried out by hand. At present, all crops grown in Bangladesh are largely planted, weeded, and harvested manually. Increasing labor costs and shortages of labor make growing these crops increasingly expensive and vulnerable to delayed planting and harvesting. Mechanizing these operations has been recognized by the Government of Bangladesh as an important priority in efforts to maintain national food security and to avoid dependence on imports, particularly of rice. With this objective in mind, the Government has introduced subsidy programs which support businesses to invest in advanced, appropriate crop-planting, and harvesting equipment. This is resulting in the rapid adoption of crop harvesting machinery such as combine harvesters and reapers and the planting of rice using rice transplanters.

The USAID Feed the Future Bangladesh Cereal Systems Initiative for South Asia – Mechanization Extension Activity (CSISA-MEA) began in October 2019 and is implemented by CIMMYT in partnership with iDE and the Georgia Institute of Technology. The activity works in the Feed the Future zone of influence in southern Bangladesh and in the Rohingya crisis-impacted zones of the Cox's Bazar district. CSISA-MEA aims to support the mechanization of agriculture in Bangladesh by developing the capacity of the private sector to develop, manufacture, and market innovative new technology which will enable the country's farmers to appropriately mechanize agricultural production. The objective of CSISA-MEA is to enhance agricultural resilience through development of agricultural machinery light engineering companies, and develop a gender-inclusive workforce, with a special focus on the crisis-affected areas of Bangladesh.

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Why is interest in combine harvesting on the rise in Bangladesh?

Harvesting is an important and critical operation in crop production. If a crop is not harvested and threshed on time, some (and sometimes most) of it can be lost. Timely harvesting of rice is very important to reduce losses which in turn affects the total grain production; timely harvesting of paddy is currently a big challenge in Bangladesh due to labor shortages and high wage demands. Evidence indicates a progressive shrinking of agricultural labor availability, as rural workers migrate to cities or abroad to engage in more remunerative employment, particularly in the garments, transportation, construction and service sectors (Zhang et al., 2014). Due to the unavailability of mechanical harvesting systems, a significant amount of field loss of paddy occurs each year due to natural calamities and shortage of time during the harvesting period (Noby et. al., 2018). The boro rice and wheat harvest in Bangladesh is the most critical season, when labor becomes scarce and wages are high. At the same time, sudden rain and storms can hamper the harvest, with flash floods sometimes damaging entire crops. Considering the ongoing climate crisis, this is only likely to worsen, increasing the urgency for mitigating steps to be taken.

The combine harvester is the best option to address these issues. It can harvest both rice and wheat, and thresh and clean crops in a single operation. Compared to manual harvesting methods, it saves time (70%) and costs (58%), and reduces grain loss (4.5%) and risk. The benefit-to-cost ratio and break-even use of combine harvesters (based on model DR150A, China) are 1.55 and 35 ha/yr, respectively (Hassan et al., 2019). A combine harvester is a large and costly farm machine, and rather than targeting owner use, it is economically more feasible to aim to popularize it on a custom hire, service provider basis (Hossain, 2015). Combine harvester rental services have emerged as a viable business model in the haor basin in Bangladesh where crop harvesting is a risky operation. The combine harvester appears to be an effective, economical and labor-saving harvesting machine in the context of the haor region land tenure system (Islam et al., 2019). Farmers have expressed a positive interest in using the combine harvester on a custom hiring basis, as it harvests, threshes, cleans and bags in the same operation, reducing human drudgery. To popularize the combine harvester as well other farm machinery, the GOB Ministry of Agriculture has established initiatives such as the development of a National Mechanization Policy 2020 and the introduction of a subsidy program (50-70%) for the farmers of Bangladesh.

Design of combine harvesters used for rice systems

Small combine harvesters, such as those operating in Bangladesh, have either caterpillar tracks or tires to enable traction. Tables 1 and 2 list the combine harvesters currently being sold and used in Bangladesh. Table 1 presents the approximate weight, dimensions, ground contact pressure, cost and country of manufacture for each combine. Table 2 provides photographs of the same machines. One can see that most of the combines have caterpillar tracks as opposed to wheels. This lowers the ground contact pressure of the equipment, reduces the tendency to sink and increases traction in soft, slippery and muddy soils. Contact pressure is defined as the weight of the combine divided by the area of its tracks or tires in contact with the ground. This parameter is very important from the standpoint of planning the types of combines that might be most effective in Bangladesh.

One can see that even though the dimensions and weights of the machines vary, the ground pressure is relatively consistent, ranging between 17 kPa and 24 kPa, centering around 20 kPa, with the exception of the very small Ganyi machines. This shows the consistency of the design point of these machines; the goal being to keep the contact pressure below a critical value to assure proper operation in silty to clay textured soils having a high moisture content or even standing water.

There are various sizes of combine harvesters available in the country, ranging from 1.5 m to 3.5m wide (7.5 kW to 70.0 kW). Smaller machines are more maneuverable in smaller fields like those found throughout Bangladesh; larger machines are more suited to larger fields and lighter soil textures. The rated power of a combine is related, in part, to the its cutter bar width, as more power is required to cut and process the crop with a wider cutter bar.

Technical advice for operating combines in rice soils

An issue for consideration is that combines, both tracked and wheeled, can become stuck in the soft, slippery and muddy soils present in wet or puddled rice fields. Two primary reasons for this are (1) the contact pressure of the combine to the ground, and (2) the driving skill of the operator. If the contact pressure is too high, then the soil will sink or spread out, causing the combine to sink or slide. As such, combines with lower contact pressures (e.g., smaller machines with wider tracks or tires) tend to have a lower risk of becoming stuck in the mud. Tracked combines typically have greater contact areas than their wheeled counterparts, and should therefore operate better than wheeled vehicles under many of the conditions found in Bangladesh.

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The increase of ground contact area and/or reduction of combine harvester weight reduces the ground contact pressure and therefore should reduce the tendency for a combine to become stuck in the mud. Ground contact area can be increased by several methods; two examples are to increase the width of tracks for tracked combines and to reduce the tire pressure in wheeled combines. Wider tracks have larger contact areas for the same length, but also more weight; one must therefore be careful in adding wider tracks to existing equipment, in case the added weight overwhelms the effect of the increased contact area. This makes selection of the correct tracks crucial, both in the manufacturing and at the product purchasing stage. In addition, one can reduce the air pressure (that is, slightly deflate) in tires to increase their contact area and achieve increased traction. This is typically done for off-road applications, such as dirt and sandy soils, and in snow.

Figure 1 shows an increase in contact area by approximately 50% for an off-road tire when its pressure is reduced from 240 kPa to 120 kPa. While it can be beneficial to partially deflate tires on combines for harvesting in moist soils, there are disadvantages to reducing tire pressure. These include (1) the need to re-inflate tires before driving on roads, (2) potential changes in tire and tread shape, which will reduce its handling performance, (3) reduced load-carrying ability, and (4) the increased likelihood of the tire coming off the wheel rim. In addition, one should not lower the pressure of a tire to less than 70 kPa.

One can also reduce the weight of the machine to reduce the ground contact pressure. This can be done by removing parts or components of the combine (such as the snorkel, sheet metal covers, grain tanks or fuel load). Combine harvesters currently used in Bangladesh either are equipped with a 600 kg capacity grain tank or have a bag-filling capacity on the machine. The bag-filling types require an extra operator (which adds to the machine weight) and involves dropping the filled bags in the field to be collected after crop harvest. This is less convenient than tank-type combines which collect the grain for loading into bags or trailers; however, these are considerably heavier than the bagging type combines, requiring an extra operator. The bagging type of machine is therefore preferable to the tank type, if reduction of machine weight is required to reduce the risk of the combine becoming stuck in mud.

An alternative for wheeled vehicles is to use small, wheeled reapers which have low weights and large tires. As a result, they should have less chance of getting stuck in moist soils. However, these are not combine harvesters: the cut rice needs to be bundled and collected and taken to a rice thresher for threshing. This requires more labor and time than the use of a combine harvester and is often more expensive than hiring a combine harvester.

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Operator skill is the most critical measure for driving combines in moist soils. The combine harvester driver can learn to understand the fields, knowing where to drive the machine and where not to, and when to accelerate and when to brake. The driver also can learn the skills required to extract a stuck vehicle, such as by rocking the vehicle by alternatively and simultaneously applying the brakes and accelerator. Driver skill is more critical than contact pressure for combine harvesters because, as one can see in Table 1, the ground contact pressures among the sample harvesters studied are all similar.

Evidence-based approaches to combine management

Table 3 presents a template for a survey, intended for use to determine the prevalence and causes of combine harvesters becoming stuck in the mud. The survey may be adapted and modified, and if used, the results of the survey would provide guidance for future research directed at reducing the incidence of combine harvesters being stuck in the mud. This survey is useful to administer before any research funds are expended to modify combine harvesters and change their weight.

Conclusion

The combine harvester is one of the most useful and at the same time most sophisticated agricultural machinery types currently being used in Bangladesh. Recently introduced, it is comparatively new to the operators, service providers, dealers and mechanics. To get the most output from the machine, a thorough understanding of its functions, operational requirements, limitations (e.g. field and crop conditions) and its day to day and periodic maintenance is crucial. Only operators with adequate knowledge, training and experience should be allowed to drive the combines, not only to avoid accidents (during field operation, road travel and truck loading/unloading) and becoming stuck in the mud, but also to maximize machine life and financial benefits. The machine should be operated carefully and slowed down in low tractive conditions (e.g. in wet clay soil and in haor areas with deep beds of mud), while crossing bunds betweeen rice fields, or levées or riding uphill or downhill (driving in reverse may be required). When a combine is stuck in the mud, the operator should ask for assistance rather than trying to get it out by over-accelerating the machine, which may result in rollover/ over-turning and the possibility of fatal injury.

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Table 1:Weight and Ground Pressure of Current Combine Harvester used in Bangladesh

Manufacturer	Name of marketing company in Bangladesh	Model number	Cutter bar width (mm)	Approx. weight reported (kg)	Overall dimensions (mm) (LxWxH)	Power (kW)	Approx. contact pressure (kPa)	Actual price (BDT)	Subsidized price (BDT)	Country of manufacture	Type of feed	Grain put in tank or bag
Yanmar	ACI Motors Ltd.	AG600	1400	2870, 2995	4290×1940 × 2410	44	19	2,950,000	1,550,000	China	Half feed	Tank load
ACI	ACI Motors Ltd.	HF2 or 4LBZ-120	1200	1260, 1480, 1580	3860 × 1800 × 1820	26	18	1,200,000	600,000	China	Half feed	Bag load
Yanmar	ACI Motors Ltd.	4LBZJ-140D or AG600	1400	2870	4215 × 1985 × 2340	44	24	2,800,000	1,400,000	China	Half feed	Bag load
Lulin	ACI Motors Ltd.	4LZ-4.0B1	2000, 2100, 2300	3050	5100* × 500 × 2650	70	24	1,900,000	1,000,000	China	Full feed	Tank load
Kubota	Abedin Equipment Ltd.	Pro588iG	1436	2300, 2407, 2691	4240 × 1900 × 2200	46	21	3,050,000	1,650,000	Japan	Half feed	Tank load
Kubota	Abedin Equipment	Pro488	1450	2300	4170 × 2535 × 2200	35.3	21	2,790,000	1,415,000	Japan	Half feed	Tank load
Kubota	Abedin Equipment	DC-70G	2075	3000, 3030	4800 × 2620 × 2990	52	17.5	3,350,000	2,150,000	Japan	Full feed	Tank load
Kubota	Abedin Equipment	DC-70H	1980	3000, 3030	4800 × 2620 × 2990	52	17.3	3,000,000	No subsidy for this model	Japan	Full feed	Tank load
FM World	Metal	4LZ-150A	1500	2600	4110 × 1990 × 2235	53	22	2,050,000	1,025,000	China	Half feed	Tank load
FM World	Metal	4LZ-4.0E	2000, 2200	2800, 2900	4960 × 3514 × 2750	66	20	2,100,000	1,050,000	China	Full feed	Tank load
Ganyi		GY4L-0.9 (Caterpillar)	1000	450	2720 × 1300 × 1210	7.5	1.1			China		
Ganyi		GY4L-0.9A (Tyre)	1000	355	2720 × 1300 × 1210	7.5	unknown			China		
Dae Dong	Alim Industries Ltd.	DSF75GT	2075	3330	5000 × 2310 × 2800	54.5	19	3,300,000	2,100,000	South Korea	Full feed	Tank load
Alim	Alim Industries Ltd.	4LBZ-145	1450	2510	4230 × 2000 × 2200	40	24	2,225,000	1,200,000	China	Half feed	Tank load
NF BUILDERS	Chittagong Builders and Machineries Ltd.	4LBZ-120 YA	1200	1480		26	18	1,200,000	600,000	China	Half feed	Bag load
SIFANG	Chittagong Builders and Machineries Ltd.	4LZ-1.0	1350	1050	3950 × 2100 ×1935	23.5	21	1,000,000	500,000	China	Full feed	Bag load

Table 2: Photographs of combines

Manufacturer	Model number	Photograph
Yanmar	AG600	 Photo © Collected from www.shodagor.com
ACI	HF2 or 4LBZ-120	 Photo © ACI Motors Limited
Yanmar	4LBZJ-140D or AG600	 Photo © Collected from www.shodagor.com
Lulin	4LZ-4.0B1	 Photo © Collected from www.alibaba.com
Kubota	Pro588iG	 Photo © Collected from www.agriculture-xprt.com
Kubota	Pro488	 Photo © Collected from www.agriculture-xprt.com
Kubota	DC-70G	 Photo © Collected from www. foreignmachinery.en
Kubota	DC-70H	 Photo © Collected from www.alibaba.com

Manufacturer	Model number	Photograph
FM World	4LZ-150A	
FM World	4LZ-4.0E	
Ganyi	GY4L-0.9 (caterpillar)	
Ganyi	GY4L-0.9A (tire)	

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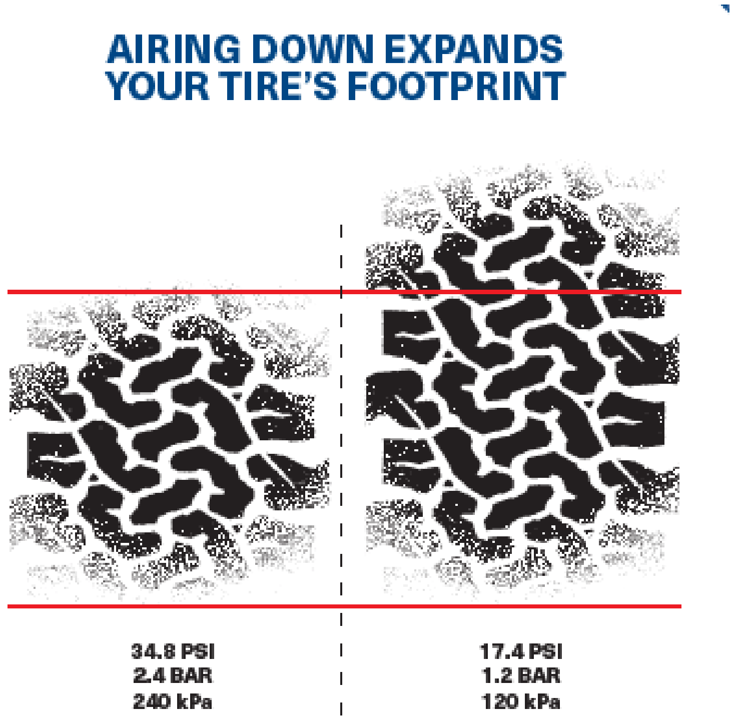
Table 3: A simple survey that may be administered to understand what types of combine harvesters are most at-risk of becoming stuck in the mud, and under what conditions they became stuck

The proposed survey is designed to gather data on the prevalence of combine harvesters becoming stuck in the mud.

Date	
Location	
Make and model of harvester	
Wheeled or tracked	
Field conditions (e.g. dry, wet, puddled, standing water)	
Weather conditions (e.g. dry, rainy)	
Who was driving	
Experience of driver (# of months)	
How full was the grain tank (e.g. empty, ¼-, ½-, ¾-, full)	

Figure 1: Photograph taken from BF Goodrich Off Road Tire Brochure showing increased contact area when tire pressure is reduced by 50%.



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This informational brief explores the hazards associated with operating combine harvesters and other tracked vehicles in wet and muddy conditions such as those in Bangladesh. Without proper operation, it is quite easy for these vehicles to become "stuck in the mud," requiring extraction by heavy lorries using winches and chains. This paper finds that proper driver training far outweighs other methods, such as lightening the vehicle and increasing the contact area between the vehicle and the ground, in the mitigation of driving in the mud.

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