Biomass bale aggregation using automatic bale pickers

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Fig. 1. An example of an automatic bale picker (ABP)

Agricultural biomass demand is increasing due to its flexibility, as biomass can be used for energy as well as livestock feed production. The costs, however, associated with biomass harvesting logistics are a major impediment to utilization. Traditionally, tractors and trailers are the common and simplest equipment used for infield bale aggregation; however, the modern automatic bale picker (ABP) combines bale picking, accumulation, and transportation to a pre-defined outlet (Fig. 1). The efficiency of ABPs, relative to traditional biomass aggregation methods has not been evaluated scientifically. Therefore, a study focused on determining the effective operation of the modern bale collection equipment ABP using mathematical simulation (R software) mimicking the bale collection process with actual turning paths was conducted. Several logistics scenarios using a tractor handling 1 and 2 bales/trip, and ABP with the capacity of 8-23 bales/trip was studied. Analytic geometry and geometric principles were used to construct the various turning cases using the turning radius of equipment.

The whole equipment path of bale aggregation to the specified outlet is shown in Fig. 2. The black dots in the layout indicate the bale locations within the field, the circles represent the equipment turning path to collect the next nearest bale. The trip number, and the odd and even bale trip paths were color-coded in red and cyan, respectively, for better visualization. The bales are collected and deposited at the field middle outlet.

Field area (8 to 259 ha) analysis showed that ABP decreased the aggregation distance by 67% and 83%, when compared to the tractor collection methods (Fig. 3). Among the outlet locations (origin, field middle, mid-width, mid-length; Fig. 4. insert), field middle produced the least aggregation distance for both tractor and ABP. Statistical results suggested that

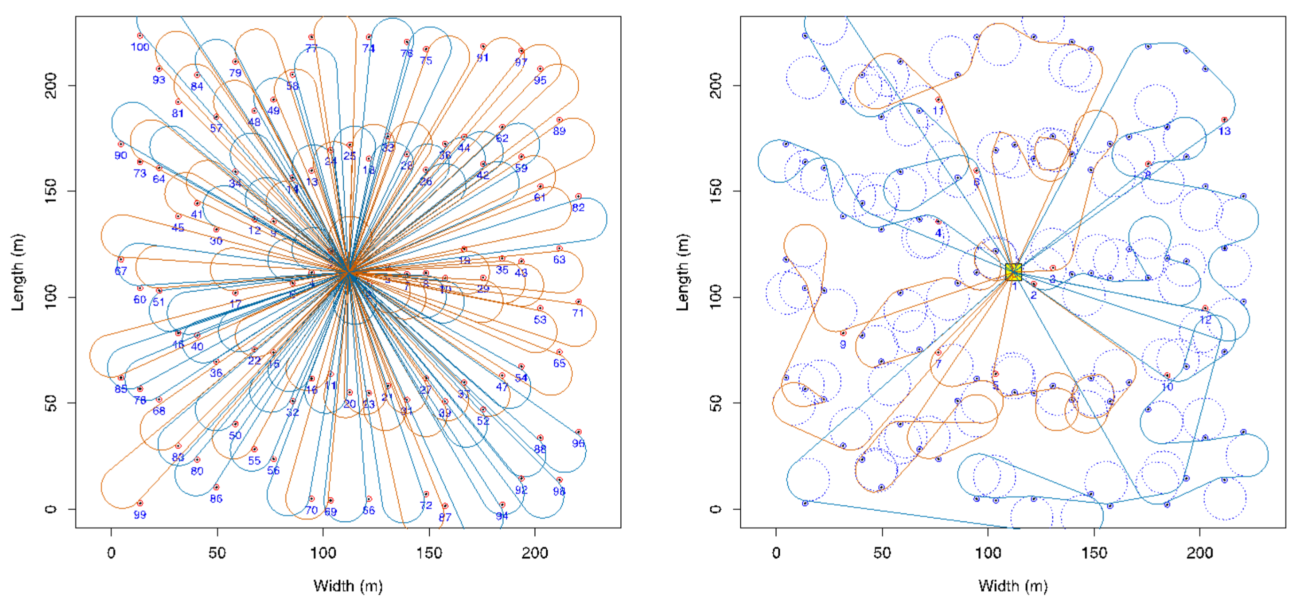

Fig. 2. Bale aggregation equipment simulation results: Left: Tractor, bales/trip = 1; Right: ABP, bales/trip = 8; simulation data: area = 5 ha; turning radius = 10 m; biomass yield/ha = 10 Mg; bale mass = 500 kg; harvester swath = 9 m; aspect ratio = 1.0; and random variation in biomass yield = 15 %.

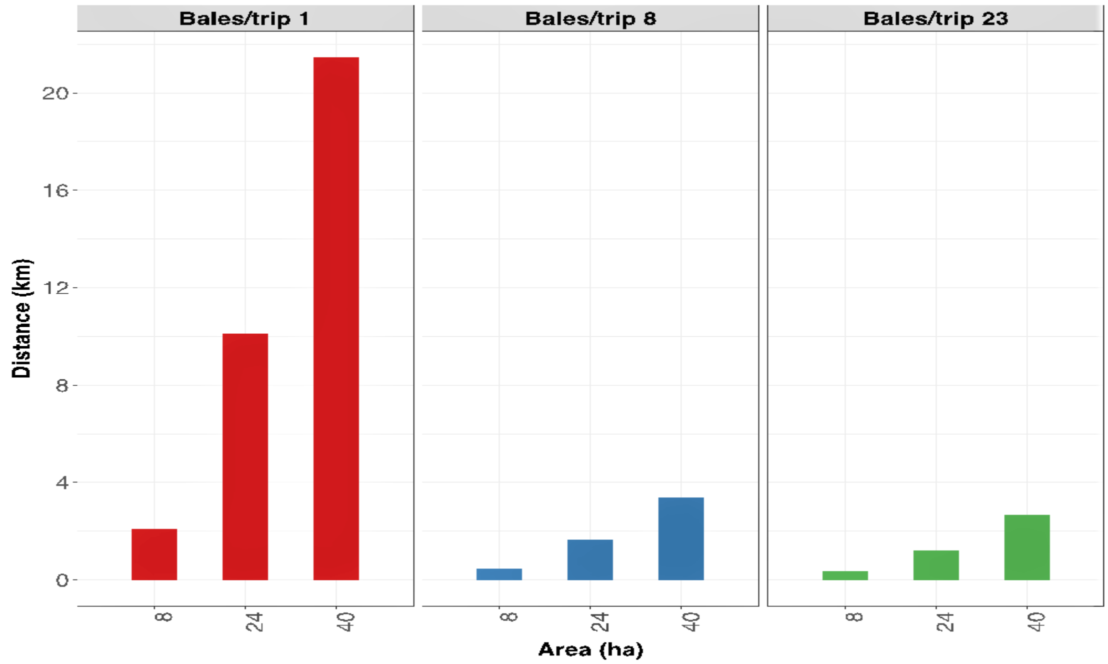

Fig. 3. Effect of field area on the aggregation logistics distance

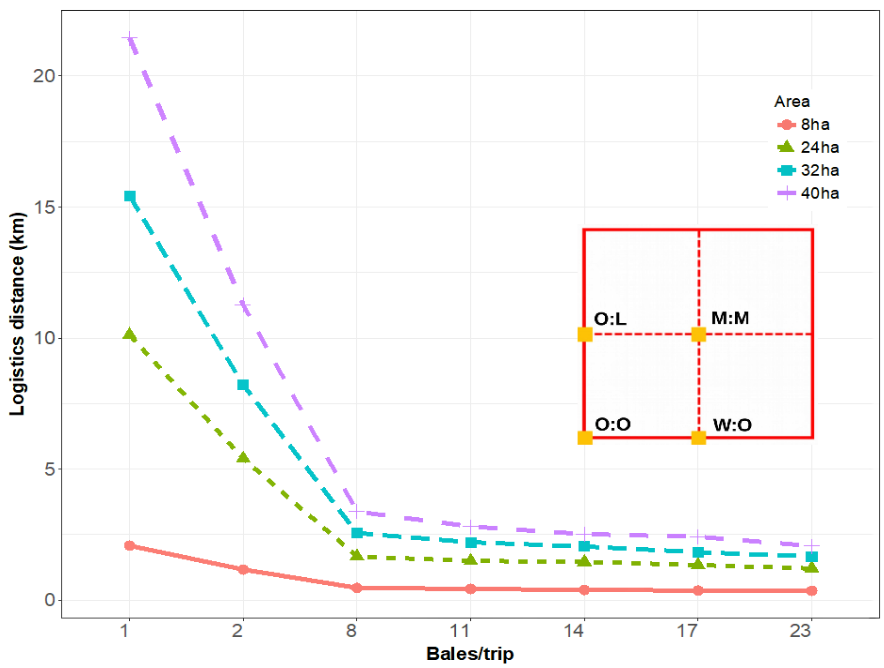

Fig. 4. Effect of number of bales/trip distance; insert – outlet locations: O:O -origin, W:O – along mid-width; O:L – along mid-length; M:M – field middle

ABP with capacity of 8 bales/trip was most efficient for infield logistics, reducing aggregation time and mitigating soil compaction (Fig. 4). These simulated results will serve to guide future economic analysis for identifying the most cost-effective approach to harvest biomass using ABPs.

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