labor substitution, but also the reduction of uncertainty and delay. Research on rice production efficiency in China has shown that mechanization affects production efficiency differently across cultivation stages, and that its benefits are stronger when service access and operation timing are reliable (Shi et al., 2021).

Field management in a full-process system also becomes easier once transplanting is standardized. Uniform transplanting density and timing allow more consistent irrigation, fertilizer scheduling, and pest monitoring. In this sense, mechanized transplanting works as an organizational bridge between pre-production and in-season management. The Mashan materials further indicate that the center organizes technical training and expert guidance, especially during periods of high pest pressure. This suggests that field management is treated not as a purely mechanical issue, but as a combined agronomic and service task.

3.3 Green pest control and mechanized plant protection

Green pest control is sometimes misunderstood as the opposite of mechanized plant protection. In practice, the two can support each other when operations are timely, targeted, and professionally managed. Rice fields are highly sensitive to missed control windows, especially under humid and high-risk conditions. Small farmers working alone may delay control because of labor shortage, equipment limitations, or uncertainty about when and how to act. Agricultural socialized services can reduce these bottlenecks by making both technical advice and field operations more accessible (Shi et al., 2023).

The Mashan materials report that the center regularly organizes technical exchanges and invites district-level machinery and agronomy experts to provide field guidance during periods of frequent pest occurrence. More than 20 training sessions had been organized, and pest diagnosis and control had covered more than 5,000 mu. These details suggest a service model in which green plant protection is not limited to pesticide application, but includes diagnosis, timing, technical instruction, and operation support.

Recent research on UAV-based herbicide application in direct-seeded rice found that UAV systems could achieve weed control effects comparable to conventional knapsack systems under suitable conditions, while reducing labor burden and operator exposure (Paul et al., 2024). This finding should not be applied mechanically to every rice production context, but it supports a broader principle: plant protection can become greener when application is more precise and professionally managed.

For a service center like Mashan, the green value of mechanized plant protection lies mainly in timeliness, standardization, and risk reduction. Timely intervention helps avoid later over-application caused by delayed action. Standardized service can reduce variation caused by different farmers using different equipment and habits. Professionalized service also lowers the barrier to adopting improved control methods. In this sense, “green” means better organized and more accurate input use, not simply less machine use.

3.4 Application of mechanized rice harvesting

Harvest is the stage where yield, labor, weather, and grain quality meet most directly. Rice can tolerate some management imperfections during the growing season, but harvest delays under rain, typhoon conditions, or limited machine access can quickly lead to lodging, high-moisture grain, shattering, quality decline, and grain loss. This is why harvest is a central test of whether full-process mechanization works in practice.

The literature is clear on this point. A review of rice harvest losses shows that losses occur not only during reaping, but throughout the harvest process, including threshing, winnowing, transportation, and storage transfer. Poor harvest management, inappropriate techniques, and weak infrastructure all contribute to those losses (Qu et al., 2021).

For Mashan, mechanized harvesting is one of the center’s most visible strengths. The internal materials report that during the overlap of the “double rush” farming season and typhoon weather, the center deployed more than 20 harvester operations for emergency early-rice harvesting, completed urgent harvesting on more than 12,000 mu, and dried more than 14,000 tons of grain afterward (Figure 2). These figures do not represent a controlled experiment, but they clearly demonstrate operational capacity during a period when timeliness matters most.