Indian Farming 75 (01): 64-67; January 2025

Emerging technologies in farm mechanization

for rainfed agriculture

I. Srinivas*, Ashish S. Dhimate, Ravikant Adake, B. Sanjeeeva Reddy and V. R. Mallikarjuna

ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, Telangana 500 059

Labour availability for agricultural operations is reducing day-by-day. As a result, there are increasing trends in labour charges, which affect the cost of production in a significant way. In rainfed agriculture, timeliness and precision of each agricultural operation is important for successful crop production. Further, rainfed agriculture is more vulnerable to climate change impacts. This warrants mitigation measures. In this context, farm mechanization with appropriate farm machinery is very pertinent. Recently, farm mechanization in rainfed agriculture is increasing to reduce the cost of cultivation and also to enhance the productivity. Precision agriculture with additional features is gaining popularity as its relevance becomes more obvious. Various emerging technologies have been developed to enhance the sustainability, production, and profitability in a precise way. This article focusses on some of the promising technologies for the sustainability of rainfed agriculture production systems.

Keywords: CRIDA, Drone, Farm mechanization, Rainfed agriculture, Tractor

CURRENTLY, Indian rainfed agriculture accounts for 52% of total net sown area, contributing 40% of food grain production and supporting livelihood for 40% of the population in the country. As it provides diversified cropping systems with a major contribution in oilseeds, majority of pulses, and millets, it is important to the country's GDP and food security. To enhance crop production, advanced agricultural machinery for field preparation, sowing/planting, plant protection, harvesting, and threshing operations plays a significant role in conserving the resources. Most of the farmers have low knowledge and under-utilization of the farm machines in rainfed areas. The availability of labour during the peak season is becoming a herculean task. Often farmers are leaving the earthing and weeding operations because of labour scarcity and very short time window. Above all, the small holdings are limiting the use of medium- to large-scale machinery, which normally provides more precision with enhanced efficiency in addition to multitasking compatibility. Hence, farmers have to choose the appropriate machinery for each operation. Undulated topography with two-way sloppiness is most common in rainfed cropping systems. *In-situ* moisture conservation would be the most appropriate for these types of lands. Tillage is a big concern in this eco-system as excessive tillage causes more soil erosion since the majority of the soils are of alfisol type with shallow depth. Availability of proper moisture for each operation decides the outcome in terms of crop sustainability and yields during the crop season. If the sowing is not done in rows, the weeding efficiency of the implement will be affected. Similarly, pesticide application to cover the entire canopy will be affected if proper crop geometry is not followed.

Bullock-drawn implements and tractor-drawn implements like land levellers, disc ploughs, cultivators, seed drills, and weeders were most popular in the early 1980s. However, slowly, the bullock-drawn equipments are phasing out because of reduction in the draft animal population, followed by a lack of skilled labour availability. Of late, the tractorization through different supportive welfare schemes implemented by the governments helped the farmers to choose medium- to large-scale machinery to utilise them in their own fields and also to rent them on custom hiring service mode. A new era has started in the farm mechanization field with the use of automatic and autonomous machinery in addition to the use of laser levellers, machinery for conservation agriculture, robotic weeders, precision planters, etc. Brief details of some of the advanced and emerging technologies are discussed below.

Land preparation

Laser guided land leveller: Land levelling is important for soil and crop management practices. Laser guided land leveller has become popular for precise and

efficient levelling which helps improve water-use efficiency. It is also noted that it is more compatible with the lands where slope is somewhat less and soils very deep. However, consolidation of holdings in small groups will allow the laser leveller to be used more effectively, thereby increasing water holding capacity at on-farm level. It will be suitable for rainfed agriculture wherever favourable topography exists. It is normally used to achieve fine levelling with desired grade on the field. This levelling technique will be helpful for proper drainage during heavy rainfall and ensure uniform water-use efficiency during dry spells.

Laser guided land leveller comprises of laser transmitter, and receiver fitted on a mast. The transmitting unit emits an infrared beam of light that can travel up to 700 to 1000 m in a straight line. Receiver at the other end senses the infrared beam of light and converts it to an electrical signal. These electrical signals are used to activate hydraulic valve which raises and lowers the blade of a grader as per the set level grade. This enables to level the field within certain degree of desired slope using a guided laser beam to entire field. The use of a laser-guided leveller with automatic cutting and filling operations is an advanced technology for levelling the field. However, laser guided land leveller is not recommended to the lands with two way undulated topography.

Laser guided land leveller

Sowing operation

Sowing operation is most crucial operation in rainfed agriculture. It mostly depends on moisture availability in the soil at the time of sowing. The rainfall in dryland areas is very erratic with frequent dry spells during crop growing season. Proper soil moisture is required for seed germination and crop establishment. So, timeliness is very important in sowing of rainfed crops. Various farm machineries are developed to get assured moisture during the growing period of crops, like raised bed planters, zero till drills and broad bed furrow planters.

CRIDA zero-till drill cum herbicide applicator: CRIDA developed zero-till drill cum herbicide applicator to solve the sowing problems in conservation agriculture based rainfed cropping systems where the standing residues are involved in addition to the no-till condition. This machine accomplishes four task-such as sowing, fertilizer application, seed covering and pre-germination herbicide application. It mainly consists of 6 row seed and fertilizer boxes in which the inclined metering plates are used to drop the seed and the cell type metering plates which are customized to deliver the variable fertilizer are used. The seed box is fabricated and fitted on the rigid frame in such a way that angle of repose of many rainfed crop seeds is within the range of box inclination side. The zero till shanks inverted T shapes with 18 to 12 degree of downward penetration are mounted at the bottom of the frame to open the slit furrow for seed dropping followed by fertilizer placement with two individual pipes connected to seed and fertilizer boxes, respectively. A chain based furrow coverage arrangement was also fixed behind the shank for proper coverage after seed placement. The herbicide applicator consists of a PTO operated pump (0.5 HP) which delivers the herbicide covering the total width of coverage with 6 nozzles. The row spacing is adjustable.

CRIDA zero-till drill cum herbicide applicator

Precision planter: Commercially available precision planter consists of a frame, seed box, furrow openers, pneumatic seed metering mechanism, seed covering unit, and press wheel. Precision planter is an advanced seed planter with pneumatic seed metering mechanism, which are controlled by vacuum. It has advantage of timely sowing with accurate seed spacing, reduction in wastage and breakage of seed, in addition to reduction in multiple seed drop. The power required for operating planter is 50 - 75 HP. It can be operated in 2-4 rows with adjustable row spacing of 45 - 90 cm, hopper seed capacity ~ 36 litre. Moreover, high capacity planters are available in 6 and 8 rows also. Since the width of the planter is more, it needs more head land space for turnings at the end. The consolidation of land holdings in dryland agriculture would help in meeting timeliness with high precision with precision planter.

Autonomous machinery

Autonomous tractors: The drudgery prone agriculture operations like ploughing, manual weeding, spraying, etc. are discouraging the youth to get involved into farming. In addition to that, use of remote-controlled machinery, modern tractors, precision planters, rotary weeders give additional benefit for ease of operation. This requires skilled manpower to operate the machinery and follow the exact path of the plant rows. Keeping this

Precision planter

in view, some of the tractor manufacturing firms have started working on the autonomous tractors to solve the human error-based problems. Autonomous or self-driving tractors are designed to follow the preterminal path without human intervention by using artificial intelligence, GPS, 360-degree cameras, and object detection sensors. These tractors will perform various tasks such as tillage, bed preparation, sowing, spraying, weeding and harvesting with different attachments. These are mainly used in precision farming, real time data analysis, remote operations with enhanced safety and minimum drudgery. With wider adoption of autonomous tractors, the dependability on drivers will be reduced and there is scope for the farmers to adopt the timeliness of each operations besides saving in input resources.

Autonomous tractor (Figure for illustrative purposes, CANVA)

Agriculture field robot: Agriculture field robot is an innovative agricultural autonomous platform machine to automate the operations in field. Utilizing advanced technologies, these machines offer a precise and efficient way to control weeds, precise spraying, crop monitoring, etc. Most of the autonomous platforms are often equipped with GPS and sensors that enable them to navigate fields independently, identifying and targeting weeds. Sensors detect the crop and weeds, which enables the precise removal of unwanted plants (weeds). Various farming robots are developed according to cropping system. The platform frame is also engineered to bear the needful weights and is easy to drive. Some of the institutes have developed these type of autonomous platforms in India which are under field trial stage.The outcome of these projects will attract the younger generation in to the agriculture. However, the land preparation has to be at precise level to make use of these type of machinery.

Solar powered weeding robot (*Source*: Ecorobotix)

Solar and battery powered E-machinery

Most of the agricultural machinery like tractors and power tillers are mostly dependent on non-renewable energy source such as diesel, petrol etc. Shifting from non-renewable energy to renewable energy is necessary to achieve clean environment and sustainable energy.

CRIDA developed E-powered planter, ridger, weeder and sprayer: In recent years, replacement of fossil fuel with electrification is taking momentum all over India which created a positive impact on development of energy efficient electric equipment for agricultural operations. Though, energy requirement for agriculture operations like tillage, seed bed preparation is higher, some of the lighter operations like seeding, weeding, spraying, harvesting, etc. can be done by using electric equipment. Moreover, for heavy work, most of universities and industries have taken initiative to develop electric tractor. In India, small and marginal farmers are most vulnerable category for climate change, production and market risks. Hence development of electric energy based smaller equipment can help them to make agriculture sustainable both ways i.e. economically and environmentally. Among renewable energy sources, solar power could be an alternative option as enough solar radiation is available in many parts of the country during crop season. Manufacturing of solar powered technologies and application of these at farm level are being intensified with the support of central and State Government Departments through various schemes.

CRIDA has developed solar and battery powered prime mover which consists of Brushless direct current (BLDC) motor, motor charge controller, solar photovoltaic system (SPV), maximum power point tracking (MPPT) device and accelerator. Power transmission for motor speed reduction is in the ratio of 1:24 with suitable gear box and belt-pulley mechanism. Power generated from solar power system is provided to the prime mover through MPPT or supplied to battery for charging. Charged battery will be used for operating the developed platform. Accelerator controls the speed

of motor in the range of 35-120 rpm which transmits the travel speed in the range of 2-5 km/hr. Prime mover has tool bar to attach appropriate small farm tools like rotary tiller, blade harrow, 3-tyne cultivator etc.

CRIDA E-Prime mover

CRIDA E-brush cutter: Now-a-days, engine operated brush cutters have become popular among the farmers for various operation like grass cutting, paddy harvesting etc. Normally, the brush cutter is mostly run with fossil fuel like petrol. However, depletion of fossil fuel and increase in their price, and pollution are the main challenges to use fossil fuel. It is also reviewed that estimation of charging cost of battery for using time is generally lower than the internal combustion engine. Hence, direct current (DC) motor powered brush cutter is developed by ICAR-CRIDA for small farm holders to reduce the cost of cultivation.

CRIDA E-brush cutter consists of battery unit, DC motor, motor speed controller, coupler, hallow pipe, spline shaft, gear head, cutting blade, crop gathering unit, booster etc. Total weight of the prototype is 11.5 kg including battery. Operation of the developed prototype is similar to engine operated brush cutter. The battery unit has to be carried on backpack and its whole weight will be distributed on both the shoulders equally.

Application of drone in agriculture: DRONE (Dynamic remotely operated navigation equipment) is an unmanned aerial vehicle (UAV). Presently, drones are available in different sizes and types. A drone is a tool that can be used for various tasks with specific purpose and is equipped with various types of cameras and sensors. A drone controlled using a computer programme is called an autonomous drone and it works with GPS system. Drones with rotating fans are currently being used for agricultural research in India. Weather drones are drones designed specifically for collecting meteorological data. Operators can download collected data automatically from the drone's flight path to a computer once it lands.

CRIDA E-brush cutter

Agriculture spraying drone

Agricultural field monitoring drone determines the pest or disease incidence, how and where it has impacted the crop. Based on generated data, advisory will be given and appropriate decisions will be taken for the crop safety. When a disease or pest outbreak is observed in the village, the other villages will be notified, and the necessary actions will be taken. Further, production for every year can also be estimated from the data from crop planting to harvest. Drones can be used to sow seeds of plant saplings in areas that are inaccessible to humans or machines. The drone must be equipped with a variety of cameras and sensors in order to use this technology to obtain different types of information. Infrared cameras, thermal sensors, laser range finders (for measuring distance), hyperspectral and multispectral cameras, image processing etc. can be implemented to collect required dataset. As the dryland crops are vulnerable to stresses, drones can provide information on both biotic and abiotic stresses. Drones can also be utilized for foliar nutrition. However, all these spray application dosages should be monitored precisely for better environmental safety.

SUMMARY

Advanced agricultural technologies in farm mechanization contribute for enhancing farming efficiency, productivity, and sustainability with minimum environmental impact. The technologies like spraying with drones is gaining popularity among the farmers due to its timeliness and minimum drudgery as compared to manual spraying. Initial cost of some of developed technologies is quite high in addition to the use of sensor based machinery for precise control over the conventional systems. However, these technologies can be provided through specialized custom hiring centres for advanced farm mechanization for the benefit of the farmers.

*Corresponding author email: i.srinivas@icar.gov.in