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Review Article

Farm Mechanization and Use of Non-Conventional Energy in Rainfed Agriculture

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Abstract: Rainfed agriculture as on today plays an important role in the economy of the most of the countries in the world. Around 70 percent of the cultivated land in India is still under rainfed agriculture. Conservation of costly inputs and resources like soil, water, land and power is therefore necessary for sustaining yield in rainfed system of crop cultivation. Mechanization contributes more in conservation agriculture because of timeliness in farm operations. Machinery powered by non-conventional energy sources are now-a–days also gaining importance looking into the excessive use of fossil fuels and their rising cost as well as harmful emissions. Non-conventional energy sources need to supplement the fossil fuels due to their reliability and sustainability. The present study therefore discusses the importance of farm mechanization and use of non-conventional energy sources in rainfed agriculture in order to enhance crop yield and to conserve resources.

Keywords: Rainfed agriculture, like soil, water, harmful emissions, conservation agriculture.

INTRODUCTION

Use of appropriate machinery to conserve resources like soil, water, land, power and agricultural inputs mainly in rainfed farming system is very much crucial for enhancing and sustaining crop yield. About 70 percent of the cultivated land in Odisha is coming under rainfed system and the rainfed agriculture plays an important role both in the economy of the state and India. Rainfed crops account for 48 percent area under food crops and 68 percent of the area under non-food crops. In the earlier period, the rainfed farming system was mainly dependent upon the locally available inputs (seeds, manures, animal power) and following the practice of growing a number of crops, which were able to withstand drought-like situation. However, in recent times, the cropping systems have changed and currently the farmers in these rainfed areas have limited options. Many of the farmers in these regions started cultivating high value crops which require intensive use of costly inputs (chemical fertilizers/ pesticides, hybrid seeds, lifesaving irrigation, farm power etc.) and find it difficult to manage the resources on their own. This is the major reason of growing disinterest among the cultivators to continue with the farming occupation particularly in rainfed areas. The uncertainty in production due to fluctuations in total rainfall and changes in its distribution, decrease in relative productivity in rainfed lands etc. affect the livelihoods of many poor and marginalized farmers. Considering the importance and issues of rainfed farming, suitable agricultural machinery need to be propagated along with improved agronomic practices for sustaining productivity and natural resource conservation with economic benefits to the farmers. Hence introduction of appropriate machinery system for integrated management of soil, water, land and farm inputs in rainfed areas is now a days receiving greater attention to protect the land from various types of degradation, diversifying the farming system and increasing the soil carbon build up and moisture for better yield and returns from the cultivated crops as farm mechanization provides the proper avenues to facilitate agricultural production through efficient utilization of inputs. For the conservation of the costly inputs, there are the requirements and studies on the development/adaptation of machinery for sowing/planting under crop residue condition, effects of crop residue incorporation into soil on soil carbon sequestration, effect on crop yield and

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economics of no-tillage/reduced tillage machinery, enrichment through deep placement of manure and fertilizers etc. In this paper, the importance of using some of the equipments such as laser guided land leveler, seed cum fertilizer drill for dry and direct seeding, zero till drill and solar water pump has been described and their suitability mainly for the rainfed farming system has been highlighted with a view to combat against the present day's concerns of water and power scarcity.

1. Laser Guided Land Leveler

In leveled land, water reaches in equal amount to each plant. Similarly, same dose of fertilizer also reaches to each plant. Therefore, water use efficiency of plants increases ultimate growth and development. Uneven soil surface has a major impact on the germination, stand, and yield of crops due to inhomogeneous water distribution and soil moisture. Therefore, land leveling is a important step for good agronomic, soil, and crop management practices. Traditionally farmers level their fields using animal drawn or tractor-drawn levelers. These levelers are implements consisting of a blade acting as a small bucket for shifting the soil from higher to the low-lying positions. It is seen that even the best leveled fields using traditional land leveling practices are not precisely leveled and this leads to uneven distribution of irrigation water. The advanced method to level or grade the field is to use laser-guided leveling equipment. Laser land leveling is leveling the field within certain degree of desired slope using a guided laser beam throughout the field.

Laser guided land leveler is used for achieving very fine leveling with desired grade on the agricultural field. Laser leveling uses a laser transmitter unit that constantly emits 360º rotating beam parallel to the required field plane. This beam is received by a laser receiver (receiving unit) fitted on a mast on the scraper unit. The signal received is converted into cut and fill level adjustments and the corresponding changes in scrapper level are carried out automatically by a two-way hydraulic control valve. Laser leveling maintains the grade by automatically performing the cutting and filling operations. Both level grade and slope grade (one way or two way) can be achieved with the help of this precision equipment. The field is cultivated and planked before using the laser guided land leveler. A grid survey is performed using grade rod to identify highs and lows in the field and mean grade is found. A grid spacing of 10m x 10m is maintained for accurate land survey; however, this spacing can be varied depending upon the size of the field. For practical purposes and with experience, grid survey can be done by pacing off the distances rather than (measuring). A map is then drawn to indicate which areas are high; require soil to be cut and the lows which require soil to be added. Laser land leveling systems provide benefit to the farmers by precisely leveling the farm lands which leads to the benefits such as optimization of water use efficiency, better crop establishment, less time and water required in irrigation, less effort in crop management, less weed problems, uniformity in crop maturity, time efficiency in completion of task, easy land preparation for subsequent crops, less water requirement for land preparation, reduced consumption of seeds, fertilizers, chemicals and fuel, assist top soil management, saves fuel / electricity used in irrigation, more uniform moisture environment for crops, good germination and growth of crop and improved field traffic ability for the subsequent field operations.

COMPONENTS OF LASER LEVELING SYSTEM

A laser-controlled land leveling system consists of the following five major components:

(i) Drag Scrapper/bucket:

The drag bucket can be either 3-point linkage mounted on or pulled by a tractor. This system is preferred as it is easier to connect the tractor's hydraulic system to an external hydraulic by the 3-point-linkage system.

(ii) Laser Transmitter:

The laser transmitter mounts on a tripod, which allows the laser beam to sweep above the field.

(iii) Laser Receiver:

The laser receiver is a multi-directional receiver that detects the position of the laser reference plane and transmits this signal to the control box.

(iv) Control Box:

The control box accepts and processes signals from the machine mounted receiver. It displays these signals to indicate the drag buckets position relative to the finished grade.

(v) Hydraulic System:

The hydraulic system of the tractor is used to supply oil to raise and lower the leveling bucket.

Working mechanism of Laser Leveler

The system includes a laser-transmitting unit that emits an infrared beam of light that can travel up to 700m in a perfectly straight line. The second part of the laser system is a receiver that senses the infrared beam of light and converts it to an electrical signal. The electrical signal is directed by a control box to activate an electric hydraulic valve. Several times a second, this hydraulic valve raises and lowers the blade of a grader to keep it following the infrared beam. Laser leveling of a field is accomplished with a dual slope laser that automatically controls the blade of the land leveler to precisely grade the surface to eliminate all undulations tending to hold water. Laser transmitters create a reference plane over the work area by rotating the laser beam 360 degrees. The receiving system detects the beam and automatically guides the machine to maintain proper grade. The laser can be level or sloped in two directions. This is all accomplished automatically without the operator touching the hydraulic controls.

Benefits of Laser Land Leveling Over Conventional Land Leveling

- Reduction in time and water for irrigation
- Uniform distribution of water
- Less water consumption in land preparation
- Precise level and smoother soil surface
- Uniform moisture environment for crops
- Lesser weeds in the field
- Good germination and growth of crop
- Uniformity in crop maturity
- Reduced seed rate, fertilizers, chemicals and fuel requirements

Benefits of Precise Land Leveling

- Saves irrigation water of about 35 %
- Reduced weed in the field
- Increase in field areas about 3.5 %
- Reduce farm operating time by 10 %
- Assist top soil management
- Saves labor costs
- Saves fuel/electricity used in irrigation
- Increase productivity up to 50 %

2. Zero till Drill

For enhancing the productivity and sustainability of the rice-wheat and rice-pulses system without seriously affecting the natural resource base and the environment, several resource conservation technologies have been developed and are being promoted now a days. There is plenty of reliable evidence to indicate that zero-tillage, and development of a permanent raised bed planting or furrow irrigated bed planting system are becoming increasingly popular with the farmers in our state. The reasons for this are obvious. Zero tillage reduces tillage to only one pass. It allows more timely sowing, which raises yields and lowers costs by saving soil, fuel, tractor costs, water, fertilizer and herbicides. Similarly, bed planting has many advantages in regard to water savings, mechanical weeding possibilities and fertilizer placement, less lodging and better crop stand. When this is combined with zero-tillage, the permanent beds may become more favourable for farmers since bed-making costs are reduced. Zero-till seed-cum-fertilizer drill has become a very useful and important agricultural machine for the farmers. It helps them to seed a crop directly into the cultivated field just after the harvest of the previous crop with the least disturbance of the soil. It eliminates or reduces time and energy intensive conventional tillage operations reducing the cultivation costs apart from improving crop yields and farmers' profits. Zero-till drilling of pulses is also an attractive alternative to the conventional method of direct sowing (broadcasting) after *kharif* rice. Direct zero-till drilling offers the advantage of timely planting at lower fuel and labour costs. Moreover, zero-till drilling carries special significance and will prove more cost effective in situations where late harvesting of rice results in delay in sowing of pulses, particularly in case of green gram and wheat. For sowing green gram and wheat, the conventional field preparation includes 3 to 4 ploughing by desi plough depending on type of soil and one to two leveling by bullock drawn leveler. This process can be totally eliminated saving a lot of expenditure and time.

Table.1. Performance Results of Tractor Drawn 9-Row Zero Tilling Of Green Gram

Sl. No	Parameters	Zero-Till Drill	Farmer's Practice
1	Labour requirement, man-h/ha	6.25	20
2	Type of soil	Sandy loam, clay loam	Sandy loam
3	Effective working width, mm	1512	-
4	Working depth, mm	60 – 80	-
5	Cone index (before testing)	5.6	-
6	Soil moisture, % db (before testing)	14.3	14
7	Type of seeds	Green gram	Green gram
8	Seed rate, kg/ha	25	30
9	Type of fertilizer	Granular	Granular
10	Fertilizer rate, kg/h	25	20
11	Field capacity, ha/h	0.34	0.05
12	Field efficiency, %	61 (60 – 62)	-
13	Fuel consumption, l/ha	11.0	-
14	Cost of operation, Rs/h	430/-	-
15	Cost of operation, Rs/ha	1265/-	3000/-
16	Breakdown of equipment	Nil	-

3. Seed cum Fertilizer Drill for Direct Dry Seeding

Direct dry seeded rice is a resource conserving technology that saves up to 20% on water and reduces labor from 30 people/ha to 2 people/ha. Correct planting technique is essential for the success of Direct Seeded Rice (DSR). The type of seed-cum-fertilizer drill, seeding rate and depth, planting time, and priming of seeds are all important to establish a good crop stand that will result in high yields and save money on water and labor. Rice is the major *Kharif* crop of India covering 42.8 million ha amounting to 85.7 million tonnes of production. Odisha contributes more than 4 million ha area under rice cultivation. The demand of cereals to meet the food requirements of the burgeoning population is increasing while on the other hand most vital inputs of agriculture *viz.* water and labour are depleting in the area. The conventional system of rice production in this region is basically water, labour and energy intensive, adversely affecting the environment. The area under transplanted paddy is 1659 thousand hectares as compared to 2241 thousand hectares under broadcasted paddy (2014-15). Labour requirement for manual transplanting of paddy requires 300 – 350 man-hours per hectare, which is roughly 25 % of total labour requirement of rice production. Therefore, to sustain the long term production of rice, more efficient alternative methods of rice productions are needed. For this, Dry direct Seeded Rice (DSR) is the technology which is water, labour and energy efficient along with eco-friendly characteristics and can be a potential alternative to conventional puddle transplanted rice. One example is a multi-crop 9-row seed cum fertilizer drill with vertical roller metering mechanism and individual pick up chamber for both seed and fertilizers. Various sizes of seeds like rice, green gram, sunflower, maize, cotton etc can be sown by using suitable metering roller provided with the implement. Seed to seed spacing can be adjusted by changing gear ratio of ground wheel to metering unit. Only one person is required in addition to the tractor driver to fill the seed and fertilizer hopper whenever necessary. It is an improved method in comparison to the existing method of broadcasting or manual seeding behind bullock drawn plough. Seeds can be sown in distinct lines which facilitate subsequent operation of weeding and interculture. To control weeds pre-emergence weedicides should be applied after 48 hours of first rain. For further control of weeds post emergence weedicides can be sprayed after 21 days of germination. Machine sowing with multicrop seed drill followed by chemical control of weeds have given better results in comparison to transplanted rice and it gave 15 % more yield than transplanted rice.

Tabe.2 Performance evaluation of tractor drawn seed cum fertilizer drill for direct seeding of paddy

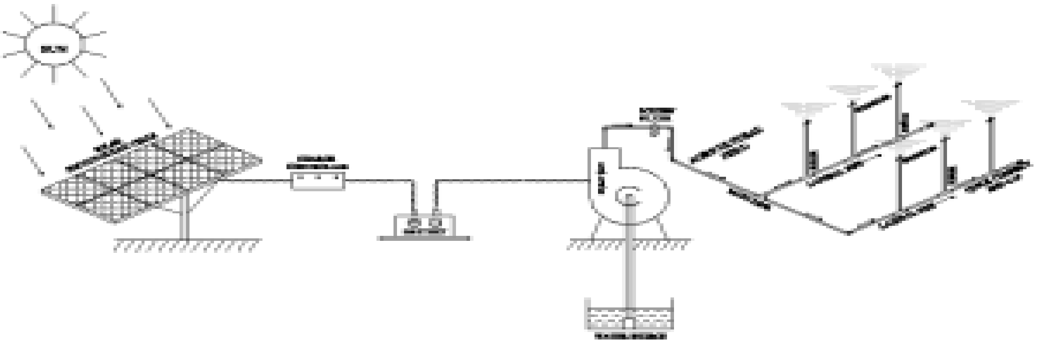
Sl No.	Parameters	Tractor drawn multicore seed cum fertilizer drill	Self-propelled transplanted	Manual transplanting
1	Effective working width, mm	2025	1904	-
2	Depth of seed placement, mm	41 -55	50-80	-
3	Row spacing, mm	225	238	-
4	Seed rate, kg/ha	50	40	75
5	Speed of operation, km/h	2.5	1.85	-
6	Field capacity, ha/h	0.4	0.16	-
7	Field efficiency, %	69.3	73	-
8	Labour requirement, man-h/ha	5	15	480
9	Soil moisture, % db (before testing)	12.4	-	-
10	Fuel consumption, l/h	3.8	0.6	-
11	Cost of operation, Rs/h	696/-	602/-	-
12	Cost of operation, Rs/ha	1740/-	5120/- (Including cost of nursery raising)	9000/-

4. Solar Water Pump

Solar photo voltaic water pumping may be adopted on an increasing scale where other energy sources are not available. Electrical and diesel powered water pumping systems are now-a-days widely used for irrigation applications. The continuous exhaustion of conventional energy sources and their environmental impacts have created an interest in choosing solar photo-voltaic water pumping system in a sustainable manner. Farmers are still using hand pumps for irrigating small patch of land. Electric and diesel operated pump sets are mostly used for lifting water from dug well, bore well and other irrigation systems. Lifting of water by hand pump is a most tedious and labour consuming operation. Similarly, non-availability and erratic supply of grid connected electricity in the remote areas and rising cost of diesel day by day necessitate the search of a reliable source of energy for assured irrigation. Installation of electric pump sets is not at all possible at most of the locations as the agricultural fields are far away from the electric grid station. In addition, the electric tariff is increasing in every year and thus increasing the cost of water pumping operation. Further, the repair and maintenance cost of electric motor operated pump sets is generally more than that of solar photo voltaic water pumping system. When not much research work was conducted on solar photo voltaic water pumping system, then, diesel pumping system was very popular among the farming community due to its low cost and portability. During this time, the diesel cost was also cheaper. But it caused environmental pollution and global warming by releasing a considerable amount of CO_2 into the atmosphere. The repair and maintenance cost of diesel pump set is also more than that of solar photo voltaic water pumping system. Hence, solar photo voltaic water pumping system is today a superior option left for the farming community as its pumping cost is cheaper as compared to electric and diesel pump sets. Moreover, the risk of environmental pollution is less and its repair and maintenance cost is very low. It can be installed at any location as per the desire of the farmers as solar energy is available profusely and free of cost in the nature. Micro-irrigation is now getting wide popularity due to its numerous advantages over other surface irrigation methods with respect to improved water use efficiency and crop yield. Hence solar powered micro-irrigation system may be a viable option looking into a reliable source of energy and water saving practice in the agriculture.

Odisha is blessed with highly fertile soil due to flowing of many rivers through it namely the Mahanadi, the Baitarani, the Bramhani, the Subarnarekha, the Budhabalanga, the Bansadhara etc (Economic Survey of Odisha, 2013). As Odisha receives an average annual rainfall of 1500 mm, there is no dearth of water resources. Farmers of the state grow different vegetable crops round the year using hand pump, electric and diesel pumps for lifting of irrigation water. Lifting of water by hand pump is a most tedious and labour consuming operation. Similarly, non-availability and erratic supply of grid connected electric supply in the remote areas and rising cost of diesel day by day necessitate the search of a sustainable source of power for assured irrigation particularly for vegetable cultivation which is now- a-days more remunerative and profitable. Cost of lifting water in the above pumping systems is many folds compared to lifting water by solar photo voltaic water pumping system (Leah C. Kelley *et al.*, 2010). Development of an affordable, durable and with a very little repair and maintenance would be preferred by the small and marginal farmers of Odisha and India in particular. Installation of electric pump sets is not at all possible at most of the locations as the agricultural fields are far away from the electric grid station. In addition, the electric tariff is increasing in every year and thus increasing the cost of water pumping operation. Further, the repair and maintenance cost of electric motor operated pump sets is generally more than that of solar photo voltaic water pumping system (Sako *et al.*, 2011). When not much research work was conducted on solar photo voltaic water pumping system, then, diesel pumping system was very popular among the farming community due to its low cost and portability. During this time, the diesel cost was also cheaper. But it caused a lot of environmental pollution and global warming by the emission of substantial quantity of CO_2 into the atmosphere. The repair and maintenance cost of diesel pump set is also more than that of solar photo voltaic water pumping system.

Hence, solar photo voltaic water pumping system is today a viable option left for the farming community as its pumping cost is cheaper compared to electric and diesel pump sets. Moreover, the risk of environmental pollution is less and its repair and maintenance cost is very low. It can be installed at any location as per the desire of the farmers as solar energy is available profusely and free of cost. Portable model of solar photo voltaic water pumping system would be an added advantage for the farmers looking into the space requirement for permanent installation and fear of theft. Similarly, the need for the optimum utilization of water and energy resources has become a vital issue during the last decade and will become more essential in the future. Hence, the use of solar powered micro-irrigation system is also the need of the hour looking into the present day's concerns of energy crisis and water scarcity particularly in agricultural sector.



SOLAR PHOTOVOLTAIC INTEGRATED SPRINKLER SYSTEM

CONCLUSION

Agricultural machinery or tools which support conservation agriculture suitable for rainfed farming system generally refer to cultivation system with minimum or zero tillage and in-situ management of crop residues. Minimum tillage is adopted in many cases with the aim of reducing tillage to the minimum necessary that would facilitate favourable seedbed condition for satisfactory establishment of crop. Zero tillage is however an extreme form of minimum tillage. Different designs of direct drilling machines, viz. zero till drill, no till plant drill, strip till drill have been developed for energy efficient and cost-effective seeding of crops. Laser guided land leveler is used to retain in-situ soil moisture longer thereby reducing water requirements. The happy seeder is also used for direct drilling of seeds into heavy stubbles, enabling the stubble to be retained on the surface as mulch. Improved design namely combo happy seeder is used to sow pulses/wheat into rice residues. Similarly, sustainable energy source along with adoption of possible water management practices may be achieved with the help of solar photovoltaic water pumping based micro-irrigation system in order to solve the problem of inadequate availability of two critical inputs such as energy and water for assured irrigation in agricultural sector. Micro-irrigation method may also be an added advantage if integrated with the solar PV device to achieve judicious utilization of water. Hence, use of solar PV system may be a sustainable proposition of energy source for water pumping to achieve assured irrigation in the state. The findings of the present study would definitely give an insight to the farming community of the state to go for adopting the technology to strengthen their agricultural production system with secured availability of energy and water.

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