Identification of Gaps and Remedies for Center Pivot Sprinkler Irrigation System in North-West Ethiopia

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Authors’ contributions
This work was carried out in collaboration between both authors. Author KMT designed the study, performed the statistical analysis, wrote the protocol, managed the literature searches and wrote the first draft of the manuscript. Author PS managed the analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT
The study was carried out to study on identification of performance gaps for improvement of center pivot sprinkler system in the Tigray region of Northwest Ethiopia. The objective of the study was to identify center pivot sprinkler irrigation system gaps and suggest remedial measures for improvement of the center pivot sprinkler irrigation system. The methods used for gap identification were observation, Interview, measurement, and using design document. Center pivot sprinkler gaps identification study revealed that Excess runoff due to leaky boots and higher application depth, absence of regular checkup for emitting devices, and improper scheduling were dominant gaps and Making functional an Automatic control system, regular checkup and maintenance of emitting accessories and proper scheduling could minimize the identified problems and finally the irrigation efficiency would be amended.

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1. INTRODUCTION

The center pivot irrigation is the best system of agricultural irrigation because of its low labor and maintenance requirements in addition to easiness of operation [1].

A typical center pivot irrigation system consists of a pump system and laterals, emitting devices (sprinklers and end-guns) and accessories such as control switches, pressure gauges, a water meter, and safety valves. In this system, the lateral is fixed at one end (the center of the field) and rotated around the field at some specified rotational speed [2]. Water is generally supplied to the lateral through a buried pipe (Mainline). Pivots are available as low, medium and high-pressure units based on sprinkler or Spray nozzle operating pressure [3]. There are many advantages of the center-pivot irrigation system such as less land-leveling, low labor cost, and high-water application efficiency. The system has some limitations such as high initial cost, unsuitability for very odd shape fields, maintenance cost, and non-uniformity due to wind speed. Many technological improvements have been made since the invention of the pivot system to minimize the limitations in its adoption as well as to save the water, energy and time. Many early center pivots (spray nozzle and gun) operated at high pressure (550-690 kPa) with lower application efficiency have been replaced with more efficient, low pressure (70-105 kPa) systems in the last six decades [4]. The other technological advancements accomplished so far include: ensuring uniform discharge with varying pressure, turning end-guns on and off based upon field positions, adjusting the speed of travel multiple times during an irrigation event, using computer control and automation over the system [5].

Center pivot irrigation systems are invented over 60 years ago to reduce labor requirements, enhance agricultural production, and optimize water use according to USDA Farm and Ranch Irrigation Survey in 2008 [6].

Center pivots provide an opportunity to apply some chemicals and many fertilizers to exactly match plant requirements. In some areas with very light soils, as much as 80% of nitrogen fertilizer is applied through the center pivot system. Substantial crop quality and pest control benefits may accrue when using this method [7].

But in Ethiopia center pivot irrigation is introduced very recently and still not widely adopted. Hiwot Agricultural Mechanization (HAM) PLC is a private company established in 1999 and envisioned to excel in agribusiness through mechanized farming methods. HAM has been engaged in the production of industrial crops like cotton and sesame using mechanized farming system. Currently, the company is implementing a modern pivot irrigation projects chosen based on its merits in meeting the growing market demand for agricultural products. It is implementing (already in business) modern irrigated farming system over 1700 hectares from a total of 2500 hectares land area in the vicinity of Kebabo using the water source from Kazza River. Other than the study area, center pivot machines are found on a few farms of the country, nine machines at wenji sugar factory farm, at Bir farm west Gojam zone and Wendogenet are installed very recently.

The study aimed to identify center pivot sprinkler irrigation gaps and suggest remedial measures for improvement of the center pivot sprinkler irrigation system.

2. RESEARCH METHODOLOGY

2.1 Description of the Study Area

Hiwot agricultural mechanization (HAM) is found in the Tigrai region of the Western zone at Tsegade woreda. HAM is located at a distance of 1350 km from Addis Ababa i.e. capital city of the country. The average elevation is about 673 m.a.s.l and it lies between 13°16’30" and 13°50’30" North latitude and 36°36’30" and 37°44’30" East Longitude. The water source for the irrigation system is from the Kaza River which is found in the Tekeze river basin.

2.2 Identification of Gaps and Remedial Measures

The identification of gaps was handled by observation, Interview, measurement, and using design document, the focus area of the problem was identified. Consequently, remedial measures suggested for each problem depending on standards and general science for center pivot sprinkler irrigation system.
3. RESULTS AND DISCUSSION

3.1 Identified Gaps for Center Pivot Sprinkler

The observed gaps on the study area were absence of end gun, malfunction of Automatic control system, absence of chemigation and fertigation system, presence of leaky boots, Formation of gullies, occurrence of runoff, absence of field drains, nozzle clogging problems and disposition, high application rate, high operating pressure, sever wind effect, minimum Coefficient of uniformity (CU) and potential application efficiency of low quarter (PELQ) were also observed as compared with distribution uniformity (DU) \[8\], miss-match of the existing crop water requirement and estimated value of CROPWAT8.0. \[9\].

3.2 Remedial Measures for Center Pivot Sprinkler Improvement

The remedial measures explained for problems identified using observation interview and measurement.

3.2.1 Introducing end gun

The absence of end gun exposes to a minimum of 35-meter fallow land at the end of center pivot, which means 0.35 ha of irrigable land for each center pivot machine becomes out of production due to absence of end gun. Therefore, introducing an end gun is important.

3.2.2 Automatic control system

The operating system of the existing center pivot sprinkler machines is handled manually which is not cost-effective. Due to these difficulties were faced for the safety of the system. The fertigation and chemigation were also not applied with water through the system. It is better to make the automatic control system functional.

The water distribution indicators of center pivot machines (CP) were ranked from poor to very good. The DU, CU, and PELQ were varied from 67% to 85%, 73% to 86%, and 66% to 80% respectively as shown in Table 1.

3.2.3 Regular maintenance of leaky boots and gully rehabilitation

Due to poor soil conservation systems on the study area, there was formation of the gully, this also aggravated runoff generated from leaky boots as shown in Fig. 2.

Therefore, regular maintenance of leaky boots and conservation works can improve the system
and field drain structures should also be constructed.

3.2.4 Options for reducing runoff

Runoff can be reduced using the following option systems [10]. Decrease application depth, increase surface storage using appropriate residue and tillage management practices, select sprinkler package that provides larger wetted radius and providing field drains.

The first two options listed are management variables, meaning they can be changed through operational practice. Decreasing the application depth will require more frequent irrigation events, which will also increase soil surface and canopy evaporation. It is commonly believed that decreased application depth and more frequent irrigations promote runoff because not enough time between irrigations elapses to dry the soil.

The application depth of the study area was high especially on last towers and the irrigation interval used was at a one-day interval, which is more frequent as compared to the estimated irrigation interval by CROPWAT model [8] and [9].

Increasing the soil surface storage through crop residue and tillage management is important in any irrigation system for storing irrigation water and catching natural precipitation.

The third option requires a change to the physical center pivot system and pumping plant. When management practices do not adequately reduce runoff, it may be necessary to make alterations to the physical center pivot system by changing the nozzle package for a more appropriate wetted radius. Wetted radius will depend on nozzle type, operating pressure, and nozzle height [11].

Table 1. Water distribution uniformity indicators for center pivot machines (Adopted from (7))

<table>
<thead>
<tr>
<th>CP</th>
<th>CU (%)</th>
<th>rank</th>
<th>DU (%)</th>
<th>rank</th>
<th>PELQ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>m4</td>
<td>80</td>
<td>good</td>
<td>71</td>
<td>good</td>
<td>67</td>
</tr>
<tr>
<td>m6</td>
<td>81</td>
<td>good</td>
<td>76</td>
<td>Very good</td>
<td>72</td>
</tr>
<tr>
<td>m7</td>
<td>86</td>
<td>Very good</td>
<td>67</td>
<td>fair</td>
<td>66</td>
</tr>
<tr>
<td>m8</td>
<td>79</td>
<td>poor</td>
<td>73</td>
<td>good</td>
<td>79</td>
</tr>
<tr>
<td>m12</td>
<td>73</td>
<td>poor</td>
<td>71</td>
<td>good</td>
<td>67</td>
</tr>
</tbody>
</table>

Fig. 2. Effect of leaky boot and formation of gully
The zero-runoff goal requires that the sprinkler package selected for the system be carefully matched to the field conditions.

3.2.5 Sprinkler package check-up

The nozzles on the sprinkler should be rechecked and relocated in an appropriate position to have an appropriate application rate since the estimated application rate was beyond the soil infiltration capacity[8]. Cleaning the clogged nozzles should be done regularly.

3.2.6 Improving water application uniformity parameters

The CU, DU, and PELQ values were not consistent with each other for each center pivot machines and. When CU becomes better DU becomes less. To improve this the operating pressure should be checked regularly and operated according to design, the actual pressure and design pressure were not matched [8].

3.2.7 Applying proper scheduling

According to Tiku and Singh [9] Improper scheduling is one source of excess runoff. Therefore, appropriate scheduling should be adopted stage-wise and irrigation intervals also should be established accordingly.

4. CONCLUSION AND RECOMMENDATION

The center pivot irrigation gab identification study revealed that Excess runoff due to leaky boots and higher application depth, absence of regular checkup for emitting devices, and improper scheduling were dominant problems. Therefore, the following measures should be adopted.

- Making functional and automatic control systems and proper scheduling could minimize the identified problems and finally, the irrigation efficiency would be amended.
- Checking the nozzle package should be accomplished to increase the uniformity of water application.
- The sprinkler nozzles should be checked for blockages, wear and tear, and application rates. The tire pressure should be checked and corrected.
- Park the center pivot machine on a smooth surface out of the wheel ruts and parallel to prevailing wind, as much as possible to avoid the effects of damaging winds and Shelterbelts (Grevillea robusta and Casuarina equisetifolia) are recommended to avoid the adverse effects of the Climatic conditions.
- Spatial and temporal evaluation procedures should be carried for effective performance assessment of the center pivot irrigation systems.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES


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