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EFFECT OF IRRIGATION SYSTEM ON WATER USE EFFICIENCY AND USEFULNESS OF FODDER CROP PRODUCTION IN NEPAL

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Summary

In Nepal, a lack of efficient irrigation infrastructure is a serious hindrance to agricultural productivity. Although basin/border irrigation for cereal crops and furrow irrigation for fodder crops are now the most used irrigation methods, drip irrigation is a technology that can greatly improve WUE. Our findings show that drip irrigation, which applies water in a controlled and timely manner, improves fodder yields and, in particular, WUE during dry seasons, resulting in more efficient use and conservation of available land, fertilizer, and water. Drip irrigation, based on our field experience, is a relatively low-input technology that can significantly boost smallholder farmers' ability to sow fodder and other crops throughout the dry season while also increasing resistance to unpredictable water sources in a changing environment.

Keywords: Irrigation efficiency, furrow irrigation, drip irrigation, fodder crop, forage, biomass, Nepal

Introduction

In Nepal, furrow irrigation is the most common form of water delivery. Furrow irrigation, a system where water is transferred from a head ditch to crop furrows via siphons, is one of the simplest and most ancient forms of irrigation delivery (Soussa, 2010). Although this is highly variable, it can produce reasonable irrigation efficiency (IE). Furrow irrigation efficiency is influenced by field slope and length, as well as water infiltration rates. Control of the rate of irrigation application and reduction in drainage beyond the root zone is difficult. With water delivered by inundation of furrows, waterlogging is common (Hansen et al., 1980). On slopes, more water is delivered to the upper portion of the field, increasing deep water drainage beyond the root zone and denying full recharge to the root zones of plants at the lower end of the field. Excessive runoff can come from heavy or prolonged water application, whereas low rates of application result in slow water advance, resulting in poor water distribution and deep drainage losses. The efficiency of furrow irrigation is also affected by soil type and variation in infiltration rates across and down the field.

Compared to furrow systems, drip irrigation can substantially improve water use efficiency (WUE) by minimizing evaporative loss of water and maximizing capture of in-season rainfall by the soil profile (Ishaq, 2002). The main disadvantage of drip irrigation systems is the cost of installation and maintenance. Historically, irrigation scheduling in drip irrigation systems has proved to be slightly more difficult than for other irrigation delivery methods (Bhattarai et al., 2008; Micheal, 2008). Nevertheless, drip irrigation can help satisfy the demands associated with increased pressures of growers to increase WUE and maximize production (Bhattarai, 2008). Surface drip irrigation slowly releases water directly to the roots of crops, saving 60%–70% in water consumption and reducing the chance of disease infestation as waterlogged plants are susceptible to fungal and other diseases (Tubiello, Velde, 2010). This system of irrigation keeps the topsoil layer moist but not excessively wet, and can be used to provide the exact amount of water required to the plants (Jha, Dave, 2013).

Research aim: Research was conducted to evaluate the effect of irrigation method (furrow vs. drip) on the productivity of nutritious fodder species during off-monsoon dry periods in different elevation zones of central Nepal

The **objective** has been set to assess the effect of irrigation method on the productivity of common nutritional fodder species using a split-plot design.

Research objects and methods

From March 2018 to July 2019, field experiments were conducted in farmers' fields in three locations in Nepal, each representing a different agro-ecological zone of the GRB: Baireni village in Dhading district (highland), Tindobate in Syangja district (mid-hills), and Jayanagar in Kapilvastu district (lowland). In Nepal, the GRB covers 31,100 km2. (Figure 1). The field sites in Dhading, Syangja, and Kapilvastu were 583, 780, and 126 meters above sea level, respectively.

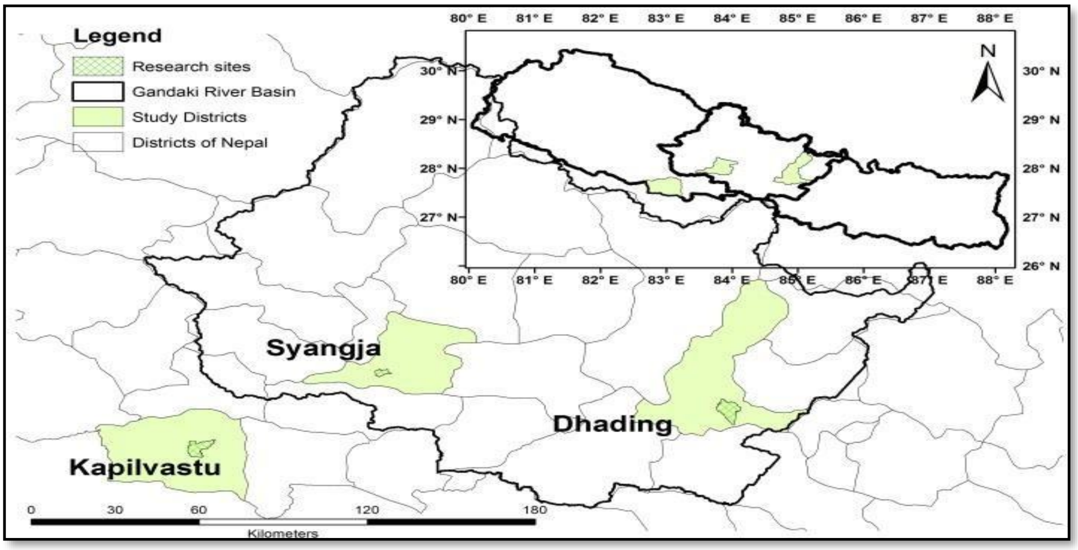

Figure 1. Gandaki River Basin, Nepal, showing locations of field sites

The soils of Nepal are very variable and are derived mainly from young parent material (Manandhar, 1989). Soils in Nepal have been categorised as alluvial, sandy, gravelly, residual, and glacial kinds based on soil texture, route of transportation, and color. Alluvial soil can be found in the Terai region's valleys, as well as the middle hill valleys near Kathmandu and Pokhara. In all of the field areas, the soil type was predominantly sandy and silty alluvial.

Using a split-plot design, we examined the influence of drip and furrow irrigation on the production of typical nutritious fodder species. Three sites (Dhading, Syangja, and Kapilvastu, representing different elevations and ecological zones in the GRB), two fodder crops (teosinte and cowpea), and two irrigation methods were taken into consideration (drip and furrow). The major outcome examined was fodder biomass (green and dry weight). Except for the irrigation system, all of the plots were subjected to standard agronomic procedures. Green fodder from 1m^2 of each plot was cut and weighed immediately on site to calculate biomass (over-ground) green (fresh) weight. After drying for 24 hours at 70°C in an oven, 500 gram samples of fresh biomass were weighed to measure dry weight. Each plot's biomass was averaged from two sample cuts.

Meteorological conditions: From March 2018 to July 2019, automatic weather stations were established at each location to detect rainfall and maximum and minimum air temperature. The summer monsoon usually begins in early June, while the months of March–May are hot and dry (particularly in the lower-elevation Kapilvastu site).

Soil measurements: Before seeding, a core sampler was used to collect five soil samples from 15–20 cm depth at each site, which were then merged to create a composite site sample. These samples were air dried for three days in the shade and thoroughly blended after any debris was removed. Texture, pH, total organic matter, total nitrogen (N), accessible phosphorous (P_2O_5), extractable potash (K_2O), field capacity (FC), permanent wilting point (PWP), and bulk density were among the physical and chemical properties of the soil that were examined (BD). Soil samples were passed through a 0.5 mm filter for organic matter analysis, and 500 g of the sample was retained in a plastic bottle for subsequent examination. (Table 1) shows the soil parameters at the experimental sites as well as the analysis methodologies.

Table 1. Soil properties collected from experimental sites.

Experimental Site	pH	OM (%)	Total N%	P_2O_5 (kgha^{-1})	K_2O (kgha^{-1})	Sand (%)	FC (%)	PWP (%)	Silt (%)	Clay (%)	Text	BD (gcm^{-3})
Kapilvastu	6.98	0.55	0.04	42	93.5	39.3	17	29.6	38.4	23.8	L	1.38
Syangja	6.8	0.81	0.05	41.6	177.8	41.8	13	25.2	37.5	20.4	L	1.42
Dhading	5.3	1.4	0.08	7.8	104.3	49.6	12.3	26	28.9	22.1	L	1.43

Cowpea and teosinte were the two nutritious fodder plants recommended for irrigation during the dry season. Cowpea (Vigna unguiculata) is a leguminous fodder crop that is normally planted as a single crop or in a blend with maize, teosinte, or a napier-bajra hybrid below 500 m altitude. Cowpea is a crop that thrives in hot climates with little rainfall. The crop is grown in semi-arid tropical and sub-tropical climates. Teosinte forage (Euchlaena mexicana) possesses many of the same features as maize, including profuse tillering, multi-cutting, high yield, and nutritional value. It's a crop that grows tall and fast. It is less nutritious and pleasant than maize, but it produces a lot of feed because to its extensive tilling capacity. Teosinte can withstand periods of severe drought as well as flooding caused by heavy monsoon rains. In most cases, it does not become lodged. Both crops are well adapted to warm weather and minimal rainfall, and both are commonly grown in semiarid parts of the tropics and sub-tropics.

Irrigation schedule: On drip treatment plots, water was applied at a rate of 80 liters per day (4 liters per minute for 20 minutes), whereas furrow treatment plots were inundated with 200 liters per day, based on local experience. On rainy days or other days with sufficient moisture, the plots were not irrigated. Irrigation scheduling solutions were established to avoid over-watering while also limiting yield loss due to water scarcity or drought stress.

Water use efficiency: WUE (kg/m3) of drip and furrow irrigation systems was calculated by the formula: WUE (kg/m^3) = Y/WR Where, Y = Yield (dry matter) of crop (kg/ha), WR = Total water consumed for crop production (m^3/ha)

Manure and nutrient management: Fertilizers were sprayed at all locations to supply nitrogen (N), phosphorous (P), and potassium (K) at 60:40:40 kg/ha for cowpea and 120:60:40 kg/ha for teosinte. For supplying these suggested levels of N, P, and K, urea, single super phosphate (SSP), and muriate of potash (MOP) were used as fertilizer sources.

Statistical analysis: The statistical analysis was carried out using MSTAT-C. ANOVA was used to analyze numerous components and field conditions, and to determine whether the difference between multiple sample averages across each factor (location, irrigation method, crop) was statistically significant at the 5% level.

Research results and discussion

Dry Matter Yield: Cumulative forage dry matter output differed considerably between sites ($p < 0.01$). Syangja produced the largest output (6841 $kgha^{-1}$), followed by Dhading (5441 $kgha^{-1}$), and Kapilvastu (3102 $kgha^{-1}$). In addition, the tallest and most numerous tillerings were seen in Syangja. This disparity is most likely due to variances in temperature and soil fertility native to each site. The crop species had an impact on relative yields: Kapilvastu had the highest yield for cowpea but the lowest yield for teosinte (Table 2). Effect of irrigation systems on dry matter output was non-significant ($p < 0.01$), with drip irrigation producing a 7% higher mean yield. This was similar to previous research (Micheal, 2008), which found that drip irrigation provided similar or higher yields than traditional irrigation systems. Cropping system had a substantial impact on dry matter production ($p < 0.01$). The maximum dry weight was generated by monocropped teosinte, followed by a blend of teosinte and cowpea. The reduced yield seen here for intercropping could be due to intercropping reducing the teosinte's tillering potential (Table 2).

Table 2. Interaction of site and crop species for biomass production

Location	Dry Matter Yield ($kgha^{-1}$)		
	Cowpea	Teosinte	Cowpea/Teosinte
Kapilvastu	2390	3802	2866
Syangja	2268	9358	9108
Dhading	1204	9407	6412

Green Biomass Yield: Kapilvastu had the largest combined green biomass weights of teosinte and cowpea fodder, while Dhading had the lowest ($p > 0.05$). Teosinte and cowpea green biomass weights were statistically equivalent ($p > 0.05$) for Syangja and Kapilvastu, and Kapilvastu and Dhading, respectively (Table 3).

Table 3. Teosinte and cowpea green biomass yield (kgm^{-2}) at various sites in Nepal

Location	Green Biomass Production (kgm^{-2})	
	Teosinte	**Cowpea**
Kapilvastu	9.236	5.008
Syangja	8.258	4.698
Dhading	7.256	4.158

Teosinte and cowpea green biomass weight were affected by irrigation type ($p < 0.05$). Drip irrigation resulted in reduced green fodder yield for both species (Table4), with overall green crop yield 13 percent greater for furrow irrigation than drip irrigation (Table 4).

Table 4. Effect of Irrigation system on green biomass yield (kgm^{-2}) of teosinte and cowpea.

Irrigation	Green Biomass Production (kgm^{-2})	
	Teosinte	Cowpea
Furrow	8.882	4.899
Drip	7.857	4.324

Irrigation Water Consumption: In furrow irrigation, water flows in narrow, parallel channels (furrows) between crops that are frequently planted on ridges between the furrows. Although furrow irrigation delivers reasonable IE, various parameters like as field slope, length of run, soil type, water infiltration rates, length and rate of application, as well as evaporative and drainage losses, all influence the overall efficiency of this technique.

Drip irrigation systems are commonly employed to improve WUE in dry or semi-arid conditions, and they are important production tools in locations where water is scarce. This irrigation method has several advantages over furrow systems, including reduced water use, ability to apply fertilizer through the drip system, more precise water distribution, and reduced soil-borne diseases and weed growth as row middles remain drier than with furrow irrigation (Loccascio, 2005). When compared to alternative irrigation methods, drip irrigation systems have higher water efficiency due to less soil percolation and surface evaporation.

In Kapilvastu, Syangja, and Dhading, respectively, the total volume of water applied to the crop under furrow irrigation was 1432, 1968, and 2209 m^3/ha. Similarly, the total volume of water applied using drip irrigation was 586, 406, and 579 m^3/ha, respectively, or 71 percent less than furrow irrigation (Figure 2). These findings show that the total volume of water utilized by the drip irrigation system was significantly lower than that of the furrow irrigation system. Because the yields were equal, these findings show that drip irrigation improves WUE (kg/m^3) by more than a factor of three when compared to furrow irrigation, as assessed in the following subsections.

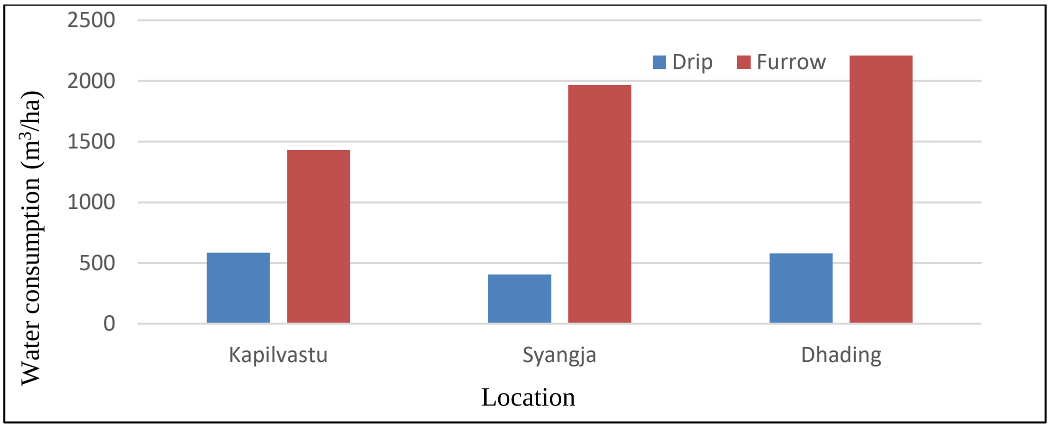

Figure 2. Water use efficiency at the field locations in Nepal

Combined Forage Dry Matter Water Use Efficiency: The irrigation system has a considerable impact on forage yields (Figure 3). Kapilvastu, Syangja, and Dhading produced total dry matter yields of 2469 kg/ha, 5396 kg/ha, and 4186 kg/ha, respectively, under drip irrigation. Similarly, with furrow irrigation, total dry matter yields in Kapilvastu, Syangja, and Dhading were 2101 kg/ha, 5013 kg/ha, and 4231 kg/ha, respectively. At two of the three sites, total dry matter forage output was higher with the drip irrigation system than with the furrow irrigation technique.

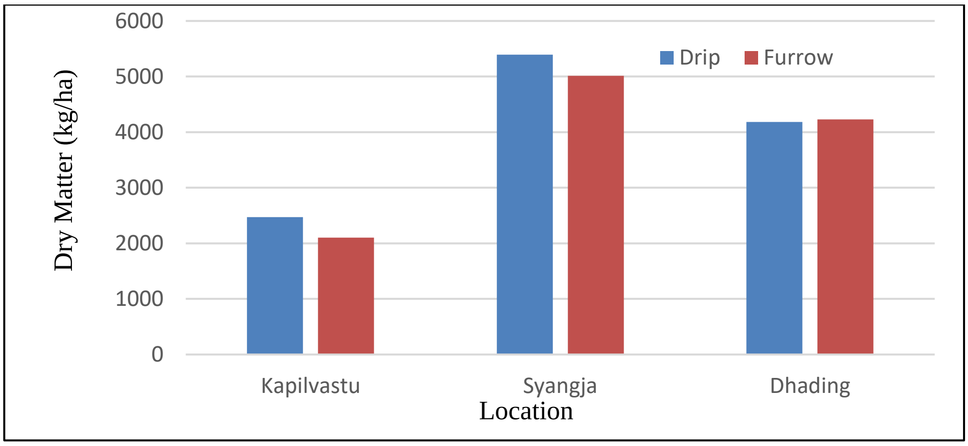

Figure 3. Dry matter production at the field locations under different irrigation types in Nepal

Irrigation Water use Efficiency and Yield: Drip irrigation cut water use by 62.0% in Kapilvastu and increased fodder production by 15.8%, while it saved 81.0% in Syangja and increased yield by 7.6%. Water was conserved by 74% in Dhading, although yield was down by 1.8 percent. When the three locations were combined, drip irrigation used 71% less water while producing 8% more dry matter. In Kapilvastu, WUE for drip irrigation was 4.36 kg/m^3 compared to 1.51 kg/m^3 for furrow irrigation; in Syangja, 13.82 kg/m^3 for drip and 2.49 kg/m^3 for furrow irrigation; and in Dhading, 7.71 kg/m^3 for drip and 1.99 kg/m^3 for furrow irrigation (Figure 4). When the three locations were added together, WUE increased by a factor of 3.98 when furrow irrigation was replaced with drip irrigation. In comparison to the other two sites, the Kapilvastu site has a lower WUE due to the hotter circumstances.

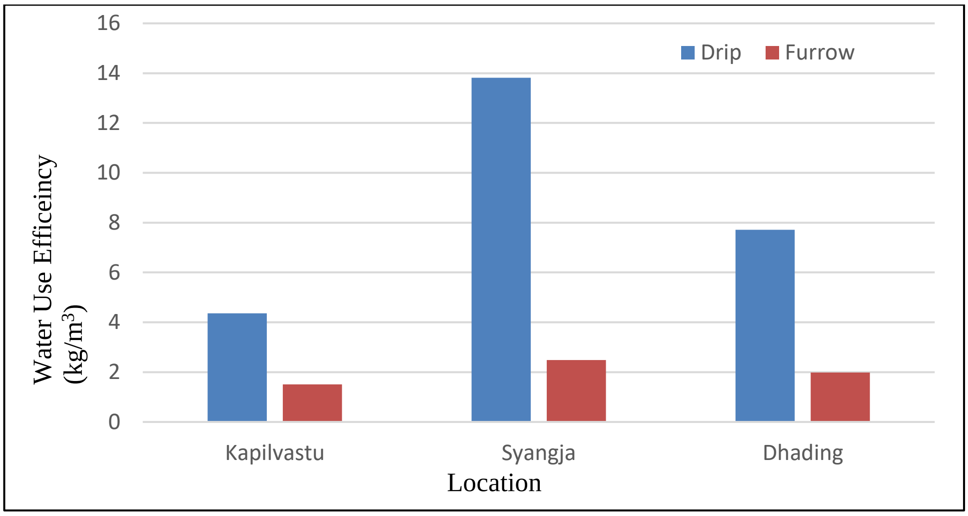

Figure 4. Water use efficiency in various locations, in Nepal

Conclusion

In conclusion, the drip irrigation system performed admirably. When compared to furrow irrigation, drip irrigation saved water, produced equivalent or higher yields, and had a far superior WUE. The drip irrigation method should allow growing fodder in more areas of Nepal and better utilization of limited water and land resources. The study's main finding is that drip irrigation produced identical dry forage biomass as standard furrow irrigation while using significantly less water. Intercropping did not yield more than single cropping, despite the fact that intercropping can have other key agronomic benefits. In Nepal's water-scarce districts, improved WUE of drip irrigation could enable for long-term extension of irrigated land and cost-effective provision of appropriate grain for livestock systems.

References

1. Soussa, H.K. 2010. Effects of drip irrigation water amount on crop yield, productivity and efficiency of water use in desert regions in Egypt. *Nile Water science & Engineering Journal*, Vol. 3, p. 96–109.
2. Hansen, V.E., Israelsen, O., Stringham, G. 1980. Irrigation Principles and Practices, 4th ed. John Wiley & Sons. New York, NY, USA, P. 417. Available at: https://www.napavalley.edu/people/ajohnson/Documents/VWT%20130%20Spring%202015/9%20-%20Water%20(222-238).pdf (Accessed 06/03/2022).
3. Ishfaq, M. 2002. Water New Technology; Global Water Institute: Lahore, Pakistan, p. 8.
4. Bhattarai, S.P., Midmore, D.J., Pendergast, L. Yield. 2008. water-use efficiencies and root distribution of soybean, chickpea and pumpkin under different subsurface drip irrigation depths and oxygation treatments in vertisols. *Irrigation Science*, Vol. 26, p. 439–450. Available at: https://link.springer.com/article/10.1007/s00271-008-0112-5 (Accessed 06/03/2022).
5. Michael, A.M. 2008. Irrigation: Theory and Practice, 2nd ed. Vikas Publishing House PVT. Ltd. Delhi, India, P. 768. Available at: https://books.google.lt/books?hl=en&lr=&id=uDvuqawJDI4C&oi=fnd&pg=PA1&ots=RHkh5Nwsf4&sig=xsfDd2Tj_qsKush_V2H8BlLBgCk&redir_esc=y#v=onepage&q&f=false (Accessed 06/03/2022).
6. Tubiello, F., van der Velde, M. 2010. Land and Water Use Options for Climate Change Adaptation and Mitigation in Agriculture. SOLAW Background Thematic Report—TR04A. GET-Carbon. New York, NY, USA.,P. 25.
7. Jha, A.K., Dave, W. 2013. Trilateral Afghanistan and Pakistan Irrigation and Soil Conservation. Afghanistan Ministry of Agriculture, Irrigation and Livestock (MAIL) and USDA-Foreign Agricultural Services. Kabul, Afghanistan, P. 54.
8. Manandhar, D.N. 1989. Climate and Crops of Nepal. Nepal Agricultural Research Council and Swiss Agency for Development and Cooperation. Kathmandu, Nepal. Available at: https://agris.fao.org/agris-search/search.do?recordID=NP9600108 (Accessed 06/03/2022).
9. Locascio, S.J. 2005. Management of irrigation for vegetables: Past, present and future. *HortTechnology*, Vol. 15, p. 482–485. Available at: https://journals.ashs.org/horttech/downloadpdf/journals/horttech/15/3/article-p482.xml (Accessed 06/03/2022).