International Journal of GEOMATE, Jan., 2018 Vol.14, Issue 41, pp.173-180
Geotec., Const. Mat. & Env., DOI: https://doi.org/10.21660/2018.41.7267
ISSN: 2186-2982 (Print), 2186-2990 (Online), Japan

IMPACT OF LAND LEVELING ON THE WATER BALANCE FOR AGRICULTURE IN EASTERN AFGHANISTAN

*Shakerullah Hashimi[1], Najumuddin Anjum[2], Pervaiz Ahmad Naseri[3], Takamitsu Kajisa[4]

[1,4]Graduate School of Bioresources, Mie University, 514-8507 Kurimamachiya-cho 1577, Tsu, Japan; [2,3] On-Farm Water Management project, Ministry of Agriculture, Irrigation, and Livestock of Afghanistan

*Corresponding Author, Received: 10 June 2017, Revised: 3 Aug. 2017, Accepted: 26 Dec. 2017

ABSTRACT: The aim of this study was to investigate the effect of laser land leveling (LL-leveling) on infiltration. Therefore, herein, both the water balance at the land surface and the impact of LL-leveling on infiltration was investigated. The field experiments were comprised of two parts: Farm-A underwent LL-leveling, and Farm-B was used as the control farm with all other practices maintained the same. Also, this research attempts to evaluate the relation of infiltration to field size, water depth (*WD*), irrigation interval and cultivation age. The findings indicated a fairly negative correlation between field size and irrigation interval; But, a positive association depicted between *WD* and infiltration. Infiltration has become reduced by increasing field size and irrigation interval. While it decreased by increasing *WD*. However, cultivation age was not significantly correlated to *WD*. In addition, the results were summarized on farms basis, in Farm-A, infiltration was shown smaller than that of Farm-B. Moreover, the findings from Farm-A illustrate that, from a water balance perspective, water infiltration was reduced due to larger field size, smaller water input, or prolonged irrigation interval. Hence, in Farm-A, the infiltration was decreased by an average 77%, 25%, and 18 % in the field of corn, eggplant and wheat, respectively. In brief, infiltration is significantly correlated to field size, *WD* and irrigation interval. Further, LL-leveling has merits to reduce water input, increase the areal size of the field and extend irrigation interval length.

Keywords: Cultivation Age, Irrigation Interval, LL-leveling, Field Size, Water Depth

1. INTRODUCTION

The main challenges faced by the Afghan agricultural sector are the shortage of water and the high demand for irrigation water [1]. The country is not self-sufficient in its water requirements nor is it relieved from the impacts of its neighbors'. While undeniably land-locked, the country has five river basins of which four major rivers flow into neighboring countries. However, only a small proportion (around one third) of the water that originates here is utilized within the country. The economy of Afghanistan relies mostly on agriculture, particularly on irrigated agriculture.

Nonetheless, farmers still use traditional farming techniques wherein oxen provide the draught power. The farmers' knowledge of new irrigation technologies and cultural practices is insufficient. Consequently, the efficiency of the irrigation system is quite low (30%—35%) mainly due to high conveyance losses in the traditional watercourses with earth canals, high operational losses in modern schemes with lined conveyance canals, and high on-farm distribution losses (e.g., over-irrigation, poorly leveled land) in both traditional and modern irrigation schemes. The productivity levels are low even by regional standards. About 20% of both the traditional and modern irrigation systems require an upgrade of the on-farm water management in order to improve the low crop yield or to address water logging and salinization. In fact, the land production potential under low and variable rainfall can be improved by promoting technology transfer [2]-[3]. In traditional as well as modern irrigation schemes, the dominant irrigation method is basin/border irrigation for cereals, furrow irrigation for vegetables and grapes. Farmers are usually not aware about crop water requirements, and over-irrigation is a common practice.

The cropping intensity (it is the ratio of net area sown to the total cropped area) varies widely between irrigation systems depending on water availability. It reaches 200% in the upper parts, up to -thirds of the crop area remains fallow each year on a rotational basis. In the large schemes supplied by rivers, floods often damage irrigated land as a result of the frequent change in river course due to the high sediment loads and unfavorable geomorphological conditions [2]-[3]. The overall efficiency is only about 30%-35% for both modern and traditional irrigation schemes, resulting in significant water losses and low productivity [4]. Traditional management approaches to irrigation supply and conveyance often contribute to high-water losses.

Moreover, low irrigation efficiency is further accentuated by traditional irrigation methods and practices used by farmers, as well as inadequate land leveling [5]. Furthermore, poor farm designs and uneven fields are responsible for 30% of the water losses [6]. Water scarcity can be overcome by improving water use efficiency at the field level [7]. With traditional application of water to the fields, crop yields decrease by 75%-85% on average, a percentage that varies widely among farms.

About 18 million acre-feet of water are lost while irrigating uneven fields [8]. Due to the low water use efficiency and lack of inputs (chemical fertilizer, improved seed and so on), crop yields are very low. At present, the average yield of irrigated wheat is around 3.0 tons/ha and rain-fed are 1.2 tons/ha in 2014 [9].

Irrigated agriculture is the mainstay of food security and income for most of the rural population in Afghanistan. It accounts for more than half of the country's GDP and 70% of the total crop production; moreover, it provides a reliable and sustainable production base for several rural communities. The total cultivable area of Afghanistan is about 8 million hectares, which is 12% of the total area of the country. Nearly 3.9 million ha of cultivated land exists in Afghanistan, of which 1.3 million ha is rainfed and 2.6 million ha are irrigated. This irrigated area produces almost 85% of the total agricultural production [10]. LL-leveling and agricultural technology transfer programs were implemented from 2008 to 2011 for wheat crops in the Kama district (Nangarhar and Balkh provinces, Afghanistan). During this period, the maximum reported wheat yield was 6.18 tons/ha and the minimum was 4.01 tons/ha [11].

LL-leveling and layout improvements were conducted in the Bihsud district (Nangarhar province, Afghanistan). The production of wheat, corn, and eggplant increased by 40%, 21%, and 38%, conversely, water demand reduced by 21%, 27%, and 17%, in the fields of corn, wheat, and eggplant, respectively. Furthermore, water productivity grew by 53%, 39, and 37%, severally [12].

Seepage is the lateral movement of subsurface water in soil, whereas, percolation is the vertical movement of water beyond the root zone to the water table, and the two are often inseparable [13]. Percolation losses have reported to vary from 0.1 to several hundred mm/day [14]. These rates can be decreased by increasing the resistance to water movement in the soil and be reducing the hydrostatic pressure of the ponded water [15].

However, studies conducted in eastern Afghanistan in 2016 on crop yields and water efficiencies in LL-leveled areas did not confirm a difference in the vertical movement of water through soil (infiltration). Thus, herein, the water balance at the land surface and the effects of LL-leveling on infiltration has been investigated. The current research was undertaken at the irrigation demonstration site of the on-farm water management project in the Barabad village, (Bihsud district, Nangarhar Province; Fig.1). The objective of this study is to investigate the vertical movement of water into soil in relation to cultivation age, the durations of the irrigation interval, water inputs, and crop type.

2. MATERIALS AND METHODS

The field experiments were conducted in the eastern region of Afghanistan from November 2013 to September 2014, shortly after LL-leveling. The experimental farms are located in the Barabad village under the agriculture command area of the Barabad irrigation canal near Jalalabad city, Nangarhar province, Afghanistan (34.27° N, 070.24° E, elevation = 572 m). The region is classified as a semi-arid, Mediterranean-type climate with an annual maximum air temperature of 42°C, an annual minimum air temperature of −2°C, and an annual precipitation varying from 178 mm to 324 mm. The monsoon begins in January and lasts until May, with little rain during the summer season. The wind speed is roughly 30 km/h, and the maximum wind pressure occurs between July and November [16].

Prior to the final selection of the experimental farms, a total of 29 fields, 14 water channels, 39 water inlets, and approximately 752 m^2 of fields were mapped (Fig.1). Following layout improvements and LL-leveling, a total of 12 fields, 2 water channels, 12 water inlets, and approximately 1925 m^2 of fields were mapped (Fig.2). The research was conducted on two separate agricultural farms that were both located along a main irrigation canal. The field experiments included two parts. The first part involved the Farm-A layout improvement, and the second part involved LL-leveling.

LL-leveling is also called laser-guided land leveling or precision laser land leveling, and it is a process applied for smoothing a land surface up to ±2 cm from its average elevation with the help of a laser-guided drag bucket.

The entire Farm-A was investigated before commencing the actual experiment. Permanent benchmarks were installed, and a detailed topographic map was created using a total station theodolite (*TST*). Next, the features of Farm-A were designated on the map, and detailed information specified about the slope, the elevations of the low and high spots of the fields, the number and sizes of the fields, the number of water inlets, and the available water channels.

The main and secondary water channels were surveyed using the same approach, and their profiles were developed. The water channels were designed for earthen lining, and each field in Farm-A was carefully analyzed to improve the farm's layout. With the new layout, the size of each field was expanded, and regular straight boundaries were created across all the fields. Moreover, the water inlets and control structures were considered as suitable points for the installation of the farm's irrigation system. They were selected based on the irrigation demand.

The cut-and-fill soil ratio of the low and high points was calculated for each field and displayed in the site plan to facilitate field leveling for the machinery operators. Both the irrigation channels and the water inlets were adjusted based on the quantity of water required for the fields. In addition, the water channels were earthen improved, and brick water inlets and a control structure were proposed. Following layout improvements, water channels (contour, unwanted bunds, and water inlets) were removed. In the next stage, rough leveling and LL-leveling were applied. To implement LL-leveling, the maximum elevation difference between the different land points should not be above 12–15 cm. In this study, however, most of the selected fields indicated greater differences in elevation.

In order to solve this problem, another tractor was hired to plow and make the soil soft for leveling. All the fields were laser-leveled, and their sizes increased to at least 0.19 ha. Hence, 12 fields were established instead of 29 (Figs.2 and 3). All unnecessary water channels, undesired field boundaries, water inlets, and ditches were removed, and new straight field boundaries were created. The laser-leveled fields in Farm-A were chosen to observe the impact of LL-leveling, and the un-leveled fields in Farm-B were selected as the controls (Fig.1).

The soil texture of the experimental farms is predominantly sandy loam soil. Crop fields are arranged in a rectangular shape and are about 2054, 2052, 1924 m^2 in LL-leveled Farm-A and nearly 1875, 2000, 1680 m^2 in un-leveled Farm-B. The condition of the crops was kept equal across both farms.

A cutthroat flume was used to determine the water depth (*WD*) applied to the irrigation. The flume was installed in a uniform, straight, and vegetation-free channel. The flume sides were entirely stoppered with dirt to prevent water leakage from the sides and beneath the flume. The flume was installed at appropriate points to maintain free-flow conditions and to facilitate flow calculations. Whenever, the water flow became stable, constant readings were recorded; five to six readings were taken during irrigation periods. The duration of irrigation was recorded, and the area of the fields was measured by TST. Then, the depth of the applied water was calculated for each irrigation line using the hydrologic formula given in Eq.1.

While the number of irrigation bouts were recorded 4, 5, and 8 in the both areas, the *WD* was not equivalent. Farm-A received 283, 334, 570 mm of *WD* while Farm-B received 319, 394, and 650 mm of *WD* in wheat, corn, and eggplant fields, respectively. In the next step, the climate parameters needed for the calculation of the water infiltration and climate data was downloaded from the meteorological station of the National Climatic Data Centre (NCDC) [17]. Missing parameters were calculated with the help of the daily Penman-Monteith evapotranspiration equation (FAO-56 method) [18]. The infiltration for both farms was simulated with the help of the unsaturated water balance Eq. 2.

$$WD = \frac{Q_{si}\,T}{A} \qquad (1)$$

Where Q is the discharge (m^3/s), T is the irrigation duration is seconds, A is the field area (m^2), and WD is the applied (mm).

$$I = P - E_o + 1000\,\frac{Q_{si} - Q_{so}}{A} - \frac{\Delta w_s}{\Delta t} \qquad (2)$$

Where I is infiltration (mm/day), P is precipitation over the time interval Δt (day), E_o is evaporation from the land surface (mm/day), Q_{si} is lateral inflow of surface water into the water balance area (A) (m^3/day), Q_{so} is lateral outflow of surface water from the water balance area (A) (m^3/day), A is the water balance area (m^2), and Δw_s is the change in surface water storage (mm), Lateral outflow of surface water into the water balance area is zero ($Q_{so} = 0$).

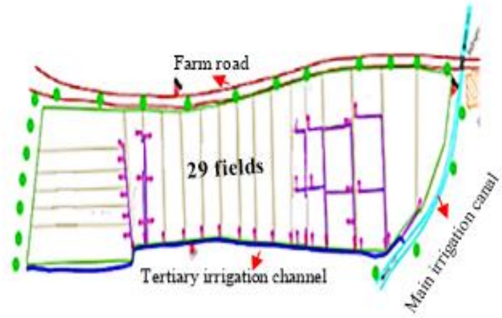

Fig.1 Layout of Farm-A before LL-leveling [12].

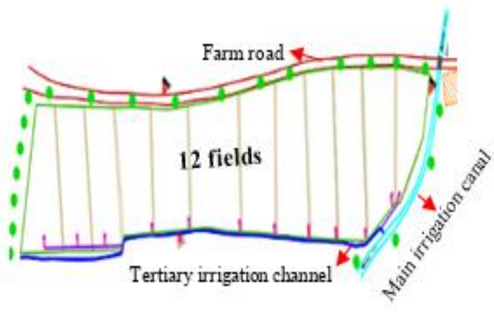

Fig.2 Layout of Farm-A after LL-levelling [12].

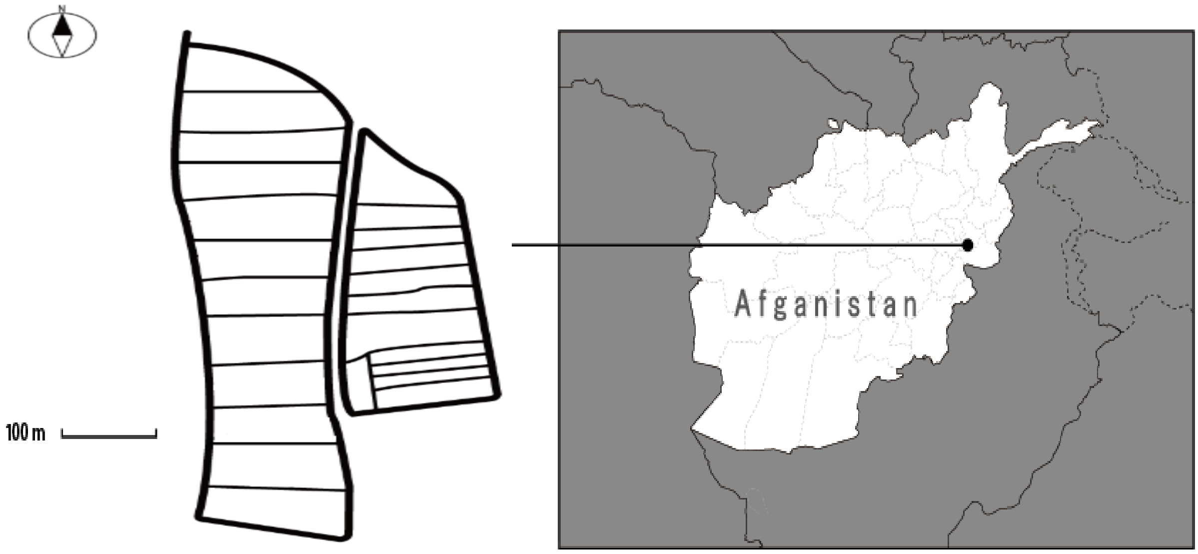

Fig.3 The location of Farm-A and Farm-B, in Nangarhar, Afghanistan (latitude 34. 27° N and longitude 070.24° E; elevation = 572 m; Source: Google maps, 2016 [12].

Table 1 *WD* and mean infiltration from Farm-A and Farm-B

Crop	Farm-A (Leveled)					Farm-B (Un-leveled)			
	Plot area size (m^2)	Irrigation Method	Irrigation number	Used irrigation depth (mm)	Mean infiltration (mm/day)	Plot area size (m^2)	Irrigation Number	Used irrigation depth (mm)	Mean water infiltration (mm/day)
Wheat	2054	basin	4	283	1.6	1875	4	319	2.0
Corn	2052	basin	5	334	0.3	2000	5	394	1.2
Eggplant	1924	furrow	8	570	3.0	1680	8	650	4.0

3. RESULTS

3.1 Cultivation age

Figure 4 represents the vertical movement of water through soil (infiltration) in relation to various times of the year in both the leveled (Farm-A) and in the un-leveled (Farm-B) fields. The infiltration of used-irrigations was observed shortly after the completion of LL-leveling in the wheat, eggplant, and corn fields.

The first infiltration in Farm-A was observed in the wheat field. The infiltration for the very first irrigation, which was applied in November, peaked at about 2.7 mm/day. However, during the next irrigation bout in the following month, the infiltration declined to around 1.4 mm/day. While during the third irrigation bout the infiltration stayed constant, the infiltration dropped substantially to 1.0 mm/day during the last irrigation bout. Whereas, in Farm-B, the infiltration was consistently higher across all crop types than that in Farm-A. In Farm-B, the largest infiltration recorded was around 3.0 mm/day, and the lowest was nearly 1.5 mm/day and occurred in November and December, respectively.

In addition, the infiltration calculated for January and February were 1.6 and 1.9 mm/day, respectively. Hence, in Farm-A, the infiltration was reduced by 17.5% compared to Farm-B.

Next, the eggplant infiltration was computed from May to late July for both farms. The highest infiltration was more than 4.0 mm/day in May. However, during the next irrigation bout in early June, the infiltration declined considerably to 1.0 mm/day and then gradually increased to approximately to 4.0 mm/day by mid-June. After mid-June, the infiltration steadily declined again and reached about 1.0 mm/day in late July. Whereas, in Farm-B, the highest infiltration of 6.0 mm/day was observed in May and the lowest rate of 2.5 mm/day was observed in June.

The last crop that was planted was corn. The highest infiltration observed in the corn field was 1.5 mm/day in July and the lowest was −0.6 mm/day in late June. Over the next months, the infiltration fluctuated throughout the complete season of crops.

In Farm-B, the highest infiltration calculated was 2.6 mm/day in mid-June and the lowest infiltration was −0.7 mm/day in late June. In the other months, the infiltration fluctuated. As a result, the infiltration in Farm-A were 77%, 25%, 18%, in the corn, eggplant, and wheat fields, respectively. lower than in Farm-B. The relation of cultivation age to infiltration was not significant and R^2 equal to 0.0006 and P-value equal to 0.8915.

Across crop types, the infiltration was highest in the initial month and then fluctuated throughout the remainder of the growing season in both farms. As shown in Fig.4, the infiltration of the Farm-B during the cultivate age was greater than that of the Farm-A. But, no correlated to infiltration.

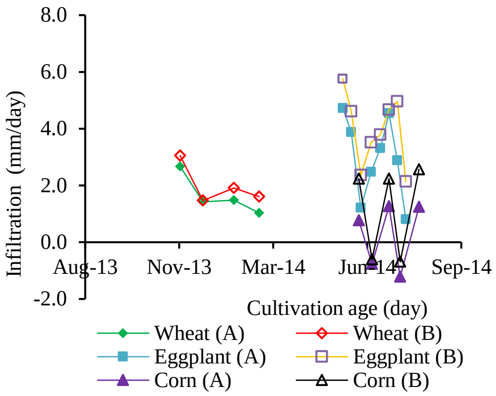

Fig.4 Cultivation age vs infiltration (mm/day).

3.2 *WD*

Figure 5 illustrates the relationship between infiltration and *WD* in both farms. The colored and uncolored solid shapes of the diamond, square, and triangle markers, represent the infiltration relative to water intake over the whole growing season for wheat, corn, and eggplant in Farm-A and Farm-B, respectively.

Across all crop types, with an increase in water intake, the infiltration increased. For instance, the highest observed infiltration of the eggplant in Farm-B was 6.0 mm/day concurrent with a peak *WD* at nearly 90 mm. Likewise, in Farm-A, a similar relation was observed, however, the measured water intake and infiltration was 15 mm and 2.0 mm/day lower than in Farm-B, respectively.

In Farm-A, the highest infiltration for wheat was determined to be 2.4 mm/day concurrent with a *WD* of 90 mm. While, in Farm-B, the highest infiltration was around 3.0 mm/day with the *WD* being almost 100 mm. During the next irrigations, the applied *WD* in Farm-A were computed as about 64, 77, and 55 mm with concurrent infiltration of 1.5, 1.4 and 1.0 mm/day, respectively. Whereas in Farm-B, the calculated infiltration was around 2.0, 1.7, and 1.5 mm/day concurrent with *WD* of 75, 80, and 70 mm, respectively.

In contrast, the corn crop displayed the lowest infiltration throughout the complete season compared to the other two crops in both farms. In Farm-A, the infiltration for the *WD* of 80 mm was calculated as 2.0 mm/day, and for the lowest *WD* of about 60 mm the infiltration was calculated as −0.6 mm/day. Whereas in Farm-B, the equivalent lowest and highest *WD* were 65 and 98 mm, respectively. The concurrent highest and lowest infiltration was 2 mm/day and −0.60 mm/day, respectively. The overall *WD* and infiltration of the remaining irrigation bouts were considerably lower in Farm-A than in Farm-B.

Hence, in Farm-A, the infiltration was reduced by an average of 77%, 25%, and 18% in the corn, eggplant, and wheat fields, respectively. The infiltration was, however, found to be directly linear to water intake (R^2 = 0.2281 and P- value = 0.004). Further the relation of *WD* to infiltration was indicated significant relation.

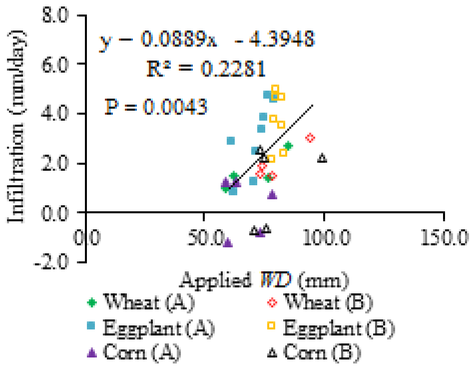

Fig.5 Relationship between infiltration (mm/day) and applied *WD* (mm).

3.3 Irrigation Interval

Figure 6 indicates water infiltration relative to the duration (in days) of the irrigation interval over the period of growing season of wheat, eggplant, and corn in both farms. The duration intervals between irrigations were maintained equivalent across all crops.

In general, the most and the least number of days between irrigations among crops were noted for the wheat and eggplant crops as 33 days and 9 days, respectively. Conversely, the lowest infiltration measured was less than 1.0 mm/day for an 11-day interval and the highest was about 6.0 mm/day for a 10-day interval in corn and eggplant fields in Farm-A and Farm-B, respectively. Overall, the highest infiltration per number of interval days were always observed in Farm-B.

In the wheat field in Farm-A, the lowest irrigation interval was 24 days and the highest 33 days. However, the lowest infiltration of 1.0 mm/day was observed in the 26-day irrigation interval. On the other hand, the highest rate of 2.7 mm/day was observed in the 24-day irrigation interval. Whereas, in Farm-B, the lowest infiltration of 3.0 mm/day, was observed in the 33-day irrigation interval.

During other irrigation bouts, the interval between irrigations and the infiltration either remained equal or fluctuated slightly In Farm-A.

Similarly, in the corn fields of both farms, the number of irrigations were five and the highest and lowest irrigation intervals were 20 days and 11 days, respectively. Remarkably, the infiltration did not remain equal. In Farm-A, the highest infiltration was 1.27 mm/day and occurred in the 12-day irrigation interval, and the lowest rate of −1.22 mm/day was observed in the 20-day irrigation interval. Nonetheless, for the 11-day irrigation interval, the infiltration was 1.25 mm/day. Whereas, in Farm-B, the highest infiltration discovered was 2.6 mm/day and occurred in the 11-day irrigation interval and the lowest as −0.6 mm/day and occurred in the 18-day irrigation interval. In both farms, for the next irrigation bouts, the irrigation intervals, and the infiltration did not remain stable. In Farm-A, the infiltration was lower than in Farm-B.

The number of irrigations counted in the eggplant field was eight. The highest irrigation interval recorded was 12 days and the lowest recorded was 9 days in both farms. In Farm-A, the lowest infiltration of 0.8 mm/day occurred in the highest irrigation interval, and the highest infiltration of 4.7 mm/day occurred in the lowest irrigation interval.

Whereas, in Farm-B, the highest infiltration of 5.8 mm/day occurred in the 9-day interval and the lowest rate of 2.1 mm/day occurred in the 12-day irrigation interval. During the remaining irrigations, the interval days were all similar, while the water infiltration differed. R^2 was 0.2398 and P-value was 0.003. in brief, association between irrigation intervals and infiltration was a very significant relation. Hence, in Farm-A, the infiltration was decreased by an average of 77%, 25%, and 18% in the corn, eggplant, and wheat fields, respectively.

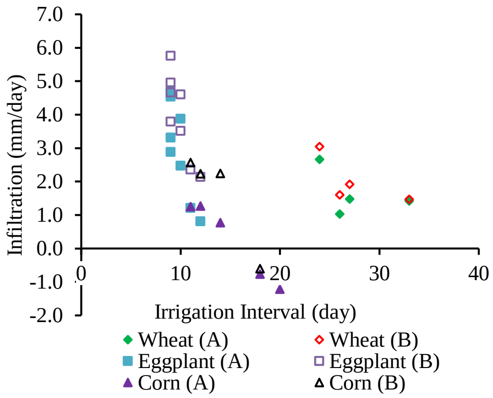

Fig.6 Duration of irrigation interval (days) vs infiltration (mm/day).

3.4 Land area size

Figure 7 depicts the effect of different land areal size on infiltration in fields for three different crops, namely wheat, corn, and eggplant across both farms. The field size is shown in m^2 and the water infiltration in mm/day.

The lowest infiltration (1.0 mm/day) was observed in the larger sized field (2000 m^2) and the highest infiltration (6.0 mm/day) was observed in the smallest sized field (1680 m^2).

In Farm-A the highest infiltration (2.7 mm/day) was observed in the smallest sized field (1900 m^2) of the eggplant crop. In addition, the lowest infiltration (1.31 mm/day) was found in the biggest sized field (2054 m^2).

Similarly, in Farm-B, the highest infiltration (3.7 mm/day) was recorded in the smallest sized field (1680 m^2) and the lowest infiltration (0.9 mm/day) was observed in the largest sized field (2000 m^2).

The R^2 was found to be 0.3672 and P- value was showed as 0.0001. Hence, the areal land size has significant relation to infiltration, with increasing field size corresponding to lower infiltration. Consequently, in Farm-A, the infiltration was smaller by an average 77%, 25%, and 18% in the corn, eggplant, and wheat fields, respectively.

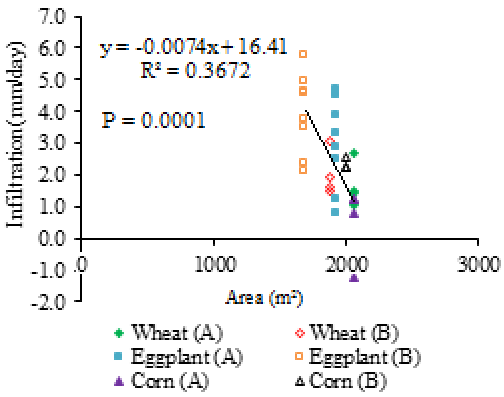

Fig.7 Relation between land area (m^2) and infiltration (mm/day).

4. DISCUSSION

The simulation results of this study provide information regarding the losses of water through infiltration from irrigated wheat, corn, and eggplant fields of both farms. These results highlight important aspects of infiltration relative to temporal changes, seasonal fluctuations of *WD*, different field sizes, and the variation in the duration interval between irrigation bouts. The findings of this research indicate that infiltration could differ with *WD* in the fields affected by seasonal fluctuations in the field water content (Fig.5).

Consequently, the same field may lose different volumes of water at different times of the year; strong, dry soil conditions could rapidly increase water infiltration in the field, and conversely, strong, wet soil conditions can cause very low, even negative, infiltration. In our data, across all crop types, the infiltration was higher just after LL-leveling and then quickly decreased during the following irrigations. We think that this fast reduction in infiltration may be due to high antecedent water content in the soil from the previous irrigation. Before LL-leveling, the fields were not irrigated for more than three months nor was there any rainfall, hence, the soil was very dry.

In addition, the infiltration in Farm-A were consistently lower than those in Farm-B, across all crop types. It could be suggested that this may have resulted from a positive effect of LL-leveling because in the laser-leveled field, moisture was more uniform and lasted for a longer time than in Farm-B (Fig.4). Moreover, it may also be a result of the development of a hardpan layer under the plow layer in the laser-leveled fields (Fig.6).

Further, as the LL-leveling increased the size of each field in Farm-A the water intake and the infiltration decreased. The infiltration dropped with increasing field size in both farms (Fig.7). In our results, the intake of water declined, and the irrigation duration became shorter because of LL-leveling. There were understandable variations between the two operations at the time of irrigation and after irrigation. These changes, even though small, may be an indication of the advantages brought by LL-leveling. We could purpose that with an increase in field size, water intake and water infiltration may become lower.

Furthermore, seasonal *WD*, that was measured separately, resulted in a difference in the amount of irrigation water applied in both farms. Farm-A received 283, 334, and 570 mm *WD*, while, the Farm-B received 319, 394, and 650 mm *WD* in wheat, corn, and eggplant fields, respectively. We believe that these reductions in water intake could be a result of the leveled land surface in Farm-A, which provided a more appropriate environment for water to flow across the surface and to reach all corners of a field equally. The total number of irrigation bouts used for the crops were considered the same (4, 5 and 8) in both farms because the farmer did not separate out the irrigations. By comparing this variation, we could verify both the smaller *WD* in Farm-A and the linearity of *WD* to the infiltration that was measured in both farms (Table 1).

Toward the end of the experiment, reports from the farm's irrigator indicated that the water was becoming difficult to manage in Farm-B, despite the small visual changes in, for instance, plant growth, plant height, canopy cover, tillers, and grain sizes. This may also be attributed to LL-leveling. Since the same varieties were sown in both places, differences in yield are most likely due to the optimal crop soil moisture in laser-leveled fields. At the same time, it could be suggested that the order of the infiltration is affected by both land cultivation practices and the choice of crop types. For example, the water infiltration for wheat, corn, and eggplant were, on average, 1.6, 0.3, and 3.0 mm/day in Farm-A, respectively. Whereas, in Farm-B, the rates were 2.0, 1.2, and 4.0 mm/day, respectively (Table 1).

Therefore, it has become clear that the LL-leveling contributes to increased water savings and can decrease infiltration through the soil by maintaining slow infiltration, small water inputs, and longer soil moisture conditions.

5. CONCLUSION

This study has investigated the relation of infiltration to field size, water inputs, the durations of the irrigation interval, and cultivation age of crop types. The results, showed a significant association between field size and irrigation interval. Infiltration was reduced with increasing field size and irrigation interval in days. But, fairly a positive correlation was depicted between *WD* and infiltration. By increasing *WD*, infiltration was grown.

Furthermore, the findings were evaluated for both Farms; In Farm-A, infiltration of applied *WD* was by an average 3.0 mm/day, 1.6 mm/day, and 0.3 mm/day, in the eggplant, wheat, and corn, fields, respectively. While, in Farm-B, it was 4.0 mm/day, 2.0 mm/day, and 1.2 mm/day.

Hence, in Farm-A, the infiltration was decreased by an average 77%, 25% and 18%, respectively. LL-leveling plays a substantial role in decreasing the loss of water in soil due to infiltration, by manipulating the high-water input. In addition, LL-leveling can precisely level land and allow for the establishment of larger fields than usual in those areas. The larger field size can help reduce irrigation duration and the amount of water required, by slowing the infiltration in the soil. Additionally, LL-leveling can distribute water more uniformly in soil, which can support moisture in the soil for longer periods of time.

Moreover, in the laser-leveled field a crop can resist a longer period without water than in an un-leveled field. This implies that the duration of the irrigation interval in days between irrigations can be longer, which can assist farming communities, especially where water intensive practices last for extended periods of time. Furthermore, in a laser-leveled field, the infiltration can decrease with an increase in crop cultivation age, which is not clear for an un-leveled field. However, the application of traditional land practices can adversely affect water inputs, irrigation duration, cultivation age, and infiltration.

The results of the present study indicate that, from a water balance perspective, infiltration was lowered across crop types in the leveled fields. Such practices can, further result in increased water savings, the tackling of water shortage problems, the delivery and access to adequate and reliable water, and increased water productivity. More importantly, it could provide an opportunity to downstream farmers to have access to irrigation water.

6. ACKNOWLDGEMENTS

The authors appreciate the tireless support from the technical team of On-Farm Water Management Project and the Ministry of Agriculture Irrigation and livestock of Afghanistan for giving chance for conducting this study.

7. REFERNCES

[1] Azimi, A. & McCauley, D. Afghanistan natural Resources comprehensive need assessment final Report. Published by Asian Development Bank. No.010103. Afghan Digital Libraries, 2002, pp. 9.

[2] Qureshi, A.S. Water resources management in Afghanistan. The issues and options. International water resource institute. Working paper 49, Pakistan country series No. 14, IWMI, 2002.

[3] Qureshi, A.S. Water resources management in Afghanistan. The issues and options. International water resource institute. Working paper 49, Pakistan country series No. 14, IWMI, 2002.

[4] National Development Strategy Article No. 114, Afghan water law, 2005.

[5] Wolf, P., & Stein, T. Improving on farm water management. A never-ending challenge. Journal of Agriculture and Rural Development in the tropic sand and sub tropic. Vol. 104, No. 1, 2003, pp. 34.

[6] Asif, M., Ahmad, M., Gafoor, A. & Aslam, Z. Wheat productivity, land and water use efficiency by traditional and LL-levelling techniques. Online Journal of Biological Sciences (Pakistan), Vol. 3, No. 2, 2003, pp. 141-164.

[7] Rana, M., Arshad, M., & Mausd. Effect of basin, furrow and rain gun sprinkler irrigation system on irrigation efficiencies, nitrate-nitrogen leaching and yield of sunflower. Pakistan Journal of water resources. Vol. 10, No.2, 2006, pp. 1.

[8] Gill, M. water for life. Proceeding of seminar on world food day. Directorate of Agriculture Information. Dept. Agric. Govt. Panjab, India.

[9] Islamic Republic of Afghanistan Agricultural Sector Review Report. Published by The World Bank. Report No. AUS9779. June 2014, pp. 23, 9.

[10] Rout, B. Water management, livestock, and the opium economy. How the water flow: A typology of irrigation systems in Afghanistan Research and Evaluation Unite (AREU). Synthesis paper series. Kabul, Afghanistan, 2008.

[11] Prepared by New Mexico State University final report of Afghanistan water, agriculture, and technology transfer, 2011, pp. 13.

[12] Shakerullah Hashimi, Homayoon Ganji, Kondo, Ryoei Ito and Takamitus kajisa, Laser land levelling for crop yield and water efficiency in eastern Afghanistan. International Journal of GEOMATE, Tsu, Mie, Japan. Vol. 13, Issue. 36. 2017, pp. 116-121.

[13] Wickham, T.H., Singh, V.P. Water movement through wet soils. Soils and rice. IRRI, Los Banos, Philippines, 1978, pp. 337-357.

[14] Sharma, P.K., De Datta, S.K. Effects of puddling on soil physical properties and processes. Soil physics and Rice. IRRI, Los Banos, Philippines, 1985, pp. 217-234.

[15] Anbumozhi, V., E., Tabuchi, T. Rice crop and yield as influenced by changes in ponding water, water depth, water regime and fertigation level. Water manages. 1998.37, pp. 241-253.

[16] Khaurin, E. Trees and Bushes of Afghanistan. Forest National Coordination Office, FAO, Kabul, 2003, pp. 9-13.

[17] National Climate Data Centre (NCDC), country Afghanistan, Jalalabad station No. 691166.https://www.ncdc.noaa.gov/CDO/cdosubqueryrouter.cmd).

[18] FAO Irrigation and Drainage Paper No. 56, Chapter 2, Equation 6, pp. 24.