Thesis of Joint Master's Degree Program on Integrated Drylands Management

Effect of micro-catchment water harvesting on soil moisture condition in Jordan's Badia

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NIEER NATIONAL INSTITUTE FOR EARLY EDUCATION RESEARCH

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ICARDA Science for resilient livelihoods in dry areas

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- Introduction
- Objective
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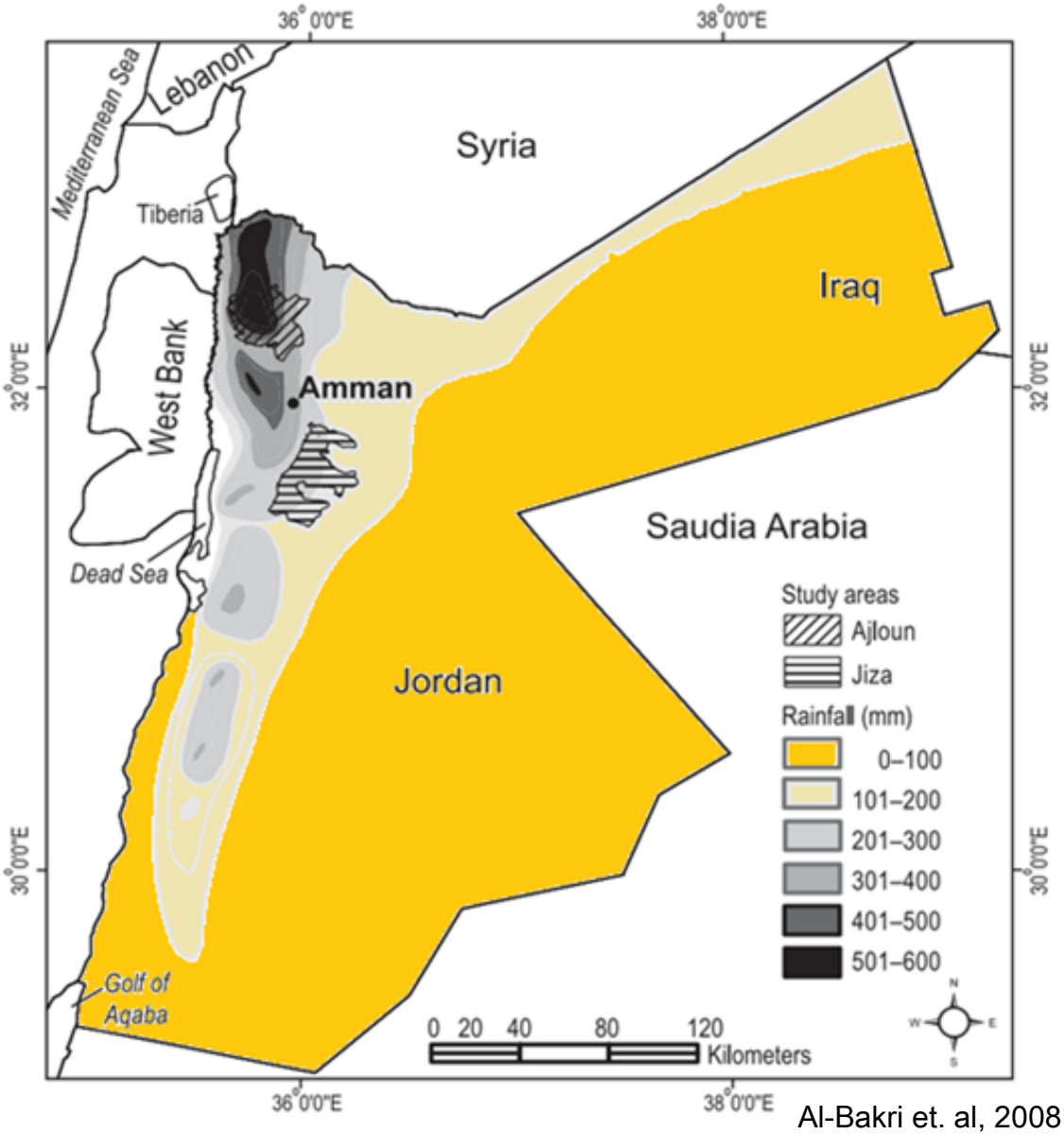
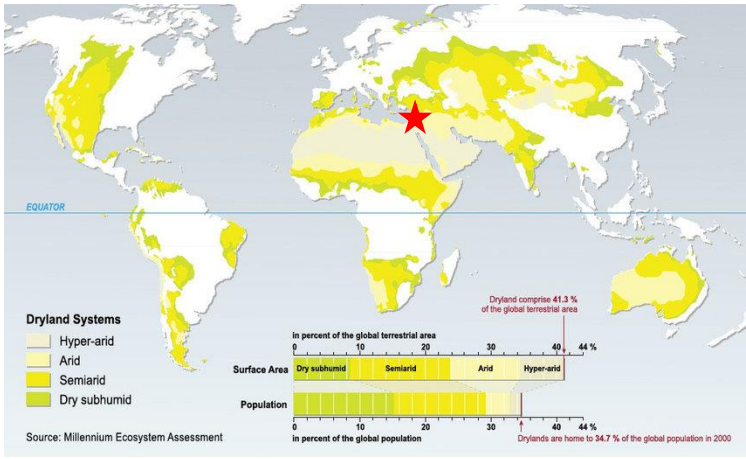
- Conclusion

Jordan is one of the dryland country



Al-Bakri et. al, 2008



Graciela et. al., 2015

80-90% area is below 200mm annual rainfall (desert area) called Badia

Jordan Badia is faced serious land degradation

- Political restrict
- Nomadic life change
- Increasing population

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→Vegetation change; Genus *Anabasis* subshrubs dominant vegetation)

- Inappropriate management

→Soil degradation

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- Soil erosion by wind and water

Crusts that decrease infiltration and increase runoff, further induced the soil erosion (Rawaijih et. al., 2015)

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Ecosystem service exploited, which affects negatively to the landscape and community resilience.

Solution for breaking through downward spiral

If this situation leave for several years, it will be worse…

For breaking through downward spiral,
it is important to control runoff and keep the water in land

◆ Leading to the recovering vegetation
- people can graze using plant
- Soil erosion decrease

◆ The condition that ecosystem services express easily

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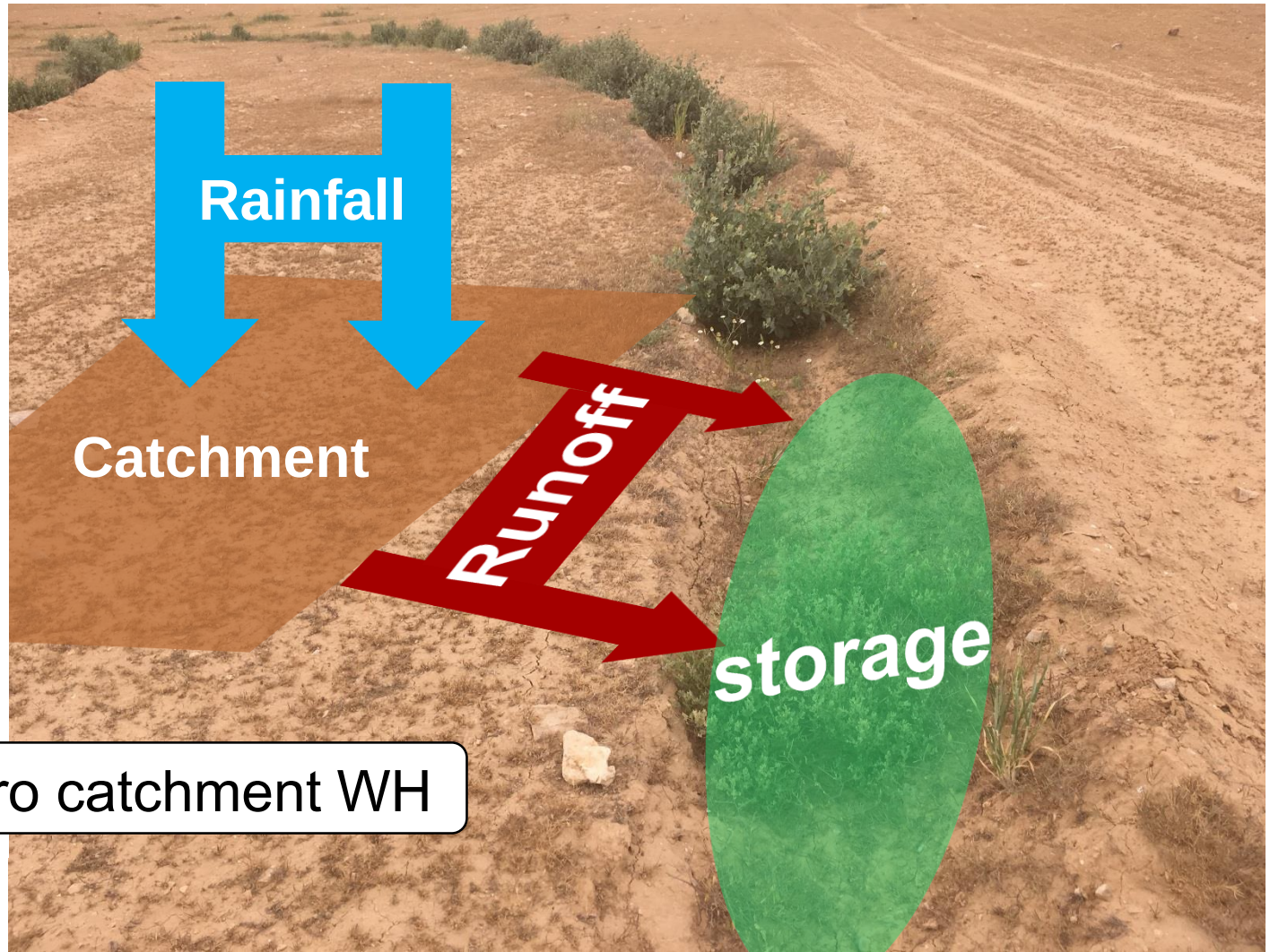
◆ The conditi that ecosystem services express easily

Water Harvesting (WH) is one of the solution

Decrease soil erosion and rehabilitate degraded lands Gatot (1999)

Q. What is Water harvesting (WH)?

”The process of concentrating rainwater over catchment through runoff to be stored and beneficially used”” Oweis et. al, 2012



Micro catchment WH

Mechanized (Vallerani) micro WH, (V-WH)

The system used of Vallerani tractor plough for making the pit, which is the storage part for collecting water.

Advantage

- Quick performance
- Economical when Large scape application
- Deep depth of pit compared to human
- Durable structure of the pit

Jordanian Badia condition and it is possible to significantly increase the machine's effective efficiency (Gammoh and Oweis 2011a.b)

For breaking through downward spiral,
it is important to control runoff and keep the water in land

Potential of WH for recovering the degraded land

Previous studies

- VWH was adapted to the site conditions, mounted on the tractor, and tested, under actual field conditions (Gammoh and Oweis 2011b)
- The effect of micro-catchment WH on soil-water storage and shrub establishment in Syria(Ali and Yazar, 2007).

Few studies that scientifically verified that VM-WH effect on the soil moisture condition in spatial temporally

- Soil moisture contents in the pit
- Effect and adaptation of vegetation in the pit

To gain various knowledge about soil moisture

Objective

To gain various knowledge for the condition of soil moisture, which was utilized by out-planted shrub seedlings grown in the VWH pit, in accordance with time and space in Jordan's Badia.

- Local rainfall characteristics
- Soil moisture content
- Growth of the out-planted shrub seedlings

The research was carried out with ICARDA

ICARDA
Science for resilient livelihoods in dry areas

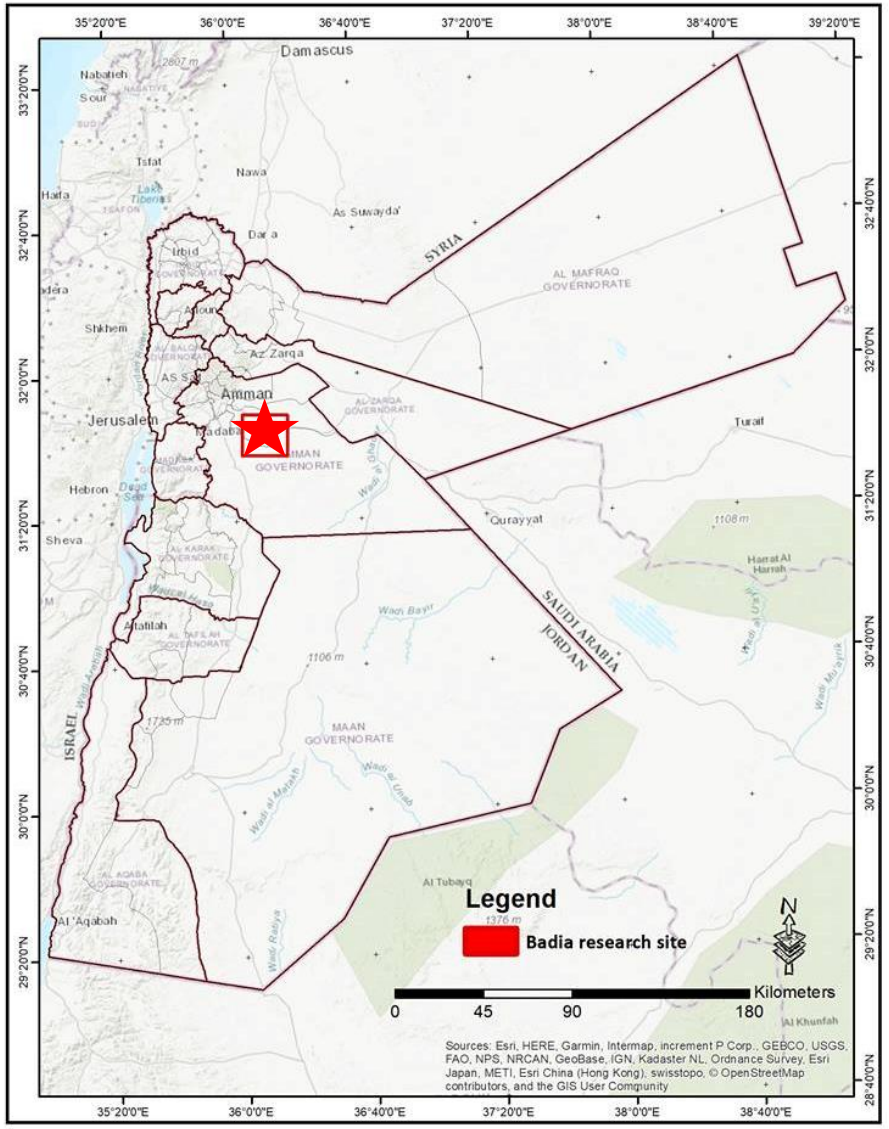
Site description

- 30km south-east from Amman
- Two season

Rainy season in winter (Oct-May)
Dry season in summer (Jun-Sep)

- Avg. Ann. rainfall 141mm

(1996 to 2017; Queen Alia international airport) (QAIA)



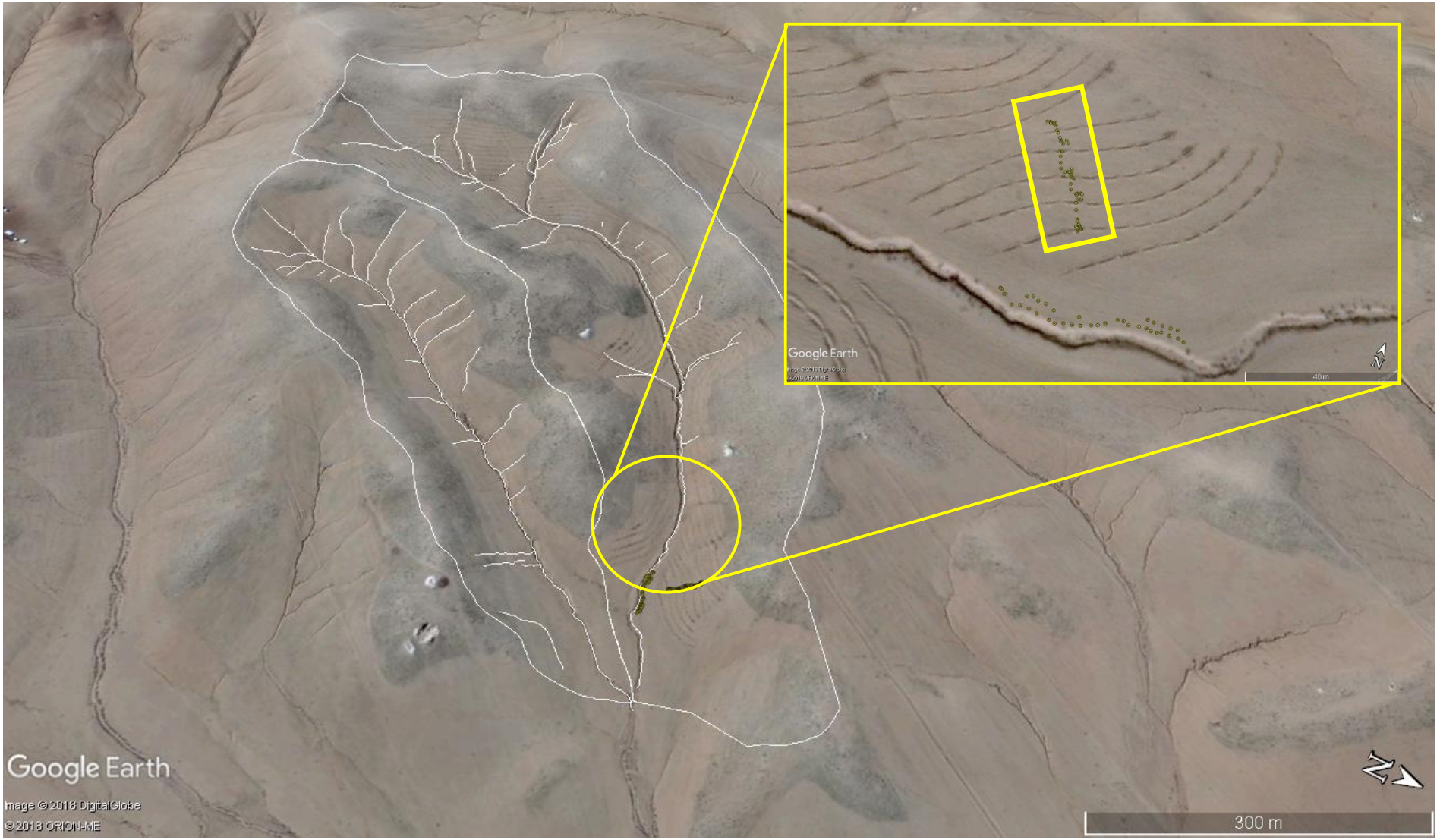
(Haddad, 2018)

Current land situation

- Genus *Anabasis* subshrubs dominant vegetation
- Avg. height 850m
- Slope Avg. 9.9°
- Rock pan developed
- Soil depth: 0.3~1.5 m deep
- Clay loam, Bulk density: 1.48

  (NARC: national Agricultural Research Center)
- Calcisols (WRB by FAO)

Experiment site



30 ha were amended by Vallerani plough in Majidyya (Haddad, 2018)

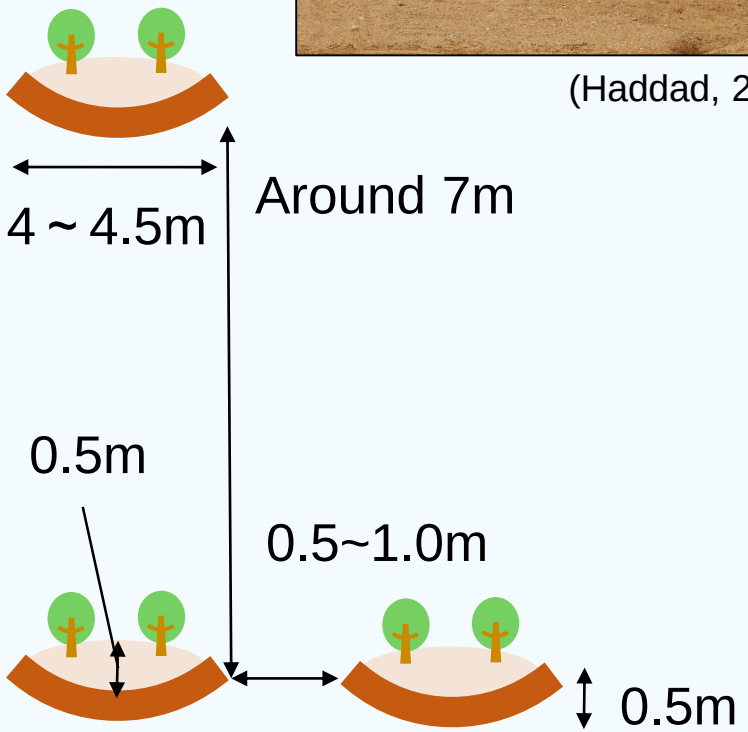
(Yamanaka, 2018)

Experiment site

Installation MWH and its structure

- Settled begin of Nov to Dec 2016

(Haddad, 2016)



Shrub (*Atriplex halimus*)

- 2 shrub out-planted / plot at End of Dec 2016
- 1 time pesticide at Apr 2017
- Seed is came from US forest service SEED project, Sabha station

SEED
Sustainable Environment and Economic Development

(Haddad, 2016)

Description of *Atriplex halimus* (*A. halimus*)

Atriplex halimus

- Native species in this region
- Drought resistance shrub
- Saltbushes / the C4 metabolic pathway (Mart`Inez et. al., 2003)
- Covering 80,000ha in Syria, Jordan, Egypt, Saudi Arabia, Libya, and Tunisia (Mart`Inez et. al., 2003)
- Good source for livestock during the dry summer and autumn period (Mohammad Tabieh et. al., 2015).

Contents of measurement

Local rainfall characteristic

- To gain the amount of entering water to the land.

Soil moisture content

- To monitor the moisture contents in soil

Soil pH and EC

- To monitor the moisture contents in soil

Plant diameter and height

- To monitor the moisture contents in soil

Experiment design

Local rainfall characteristic

- To gain the amount of entering water to the land.

Place: at just 500 m far from the study site
Period: Sep 2017 to May 31st

Soil moisture content

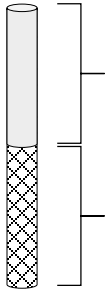
- To monitor the moisture contents in soil

Device: Time Domain Reflectometry (TDR)

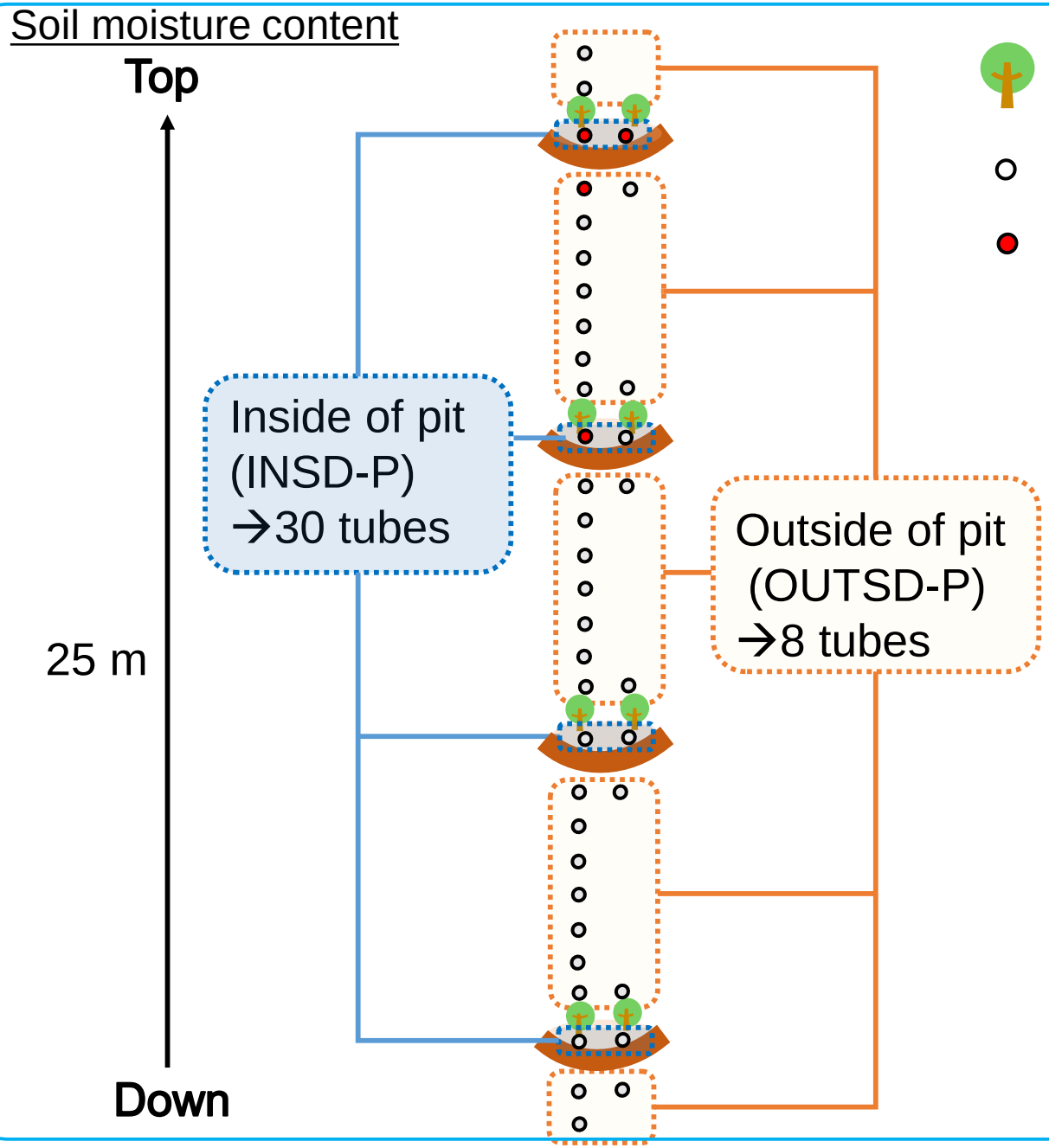
Period: Dec 19th 2017 to Sep 26th 2018
Weekly measurement + after rainfall

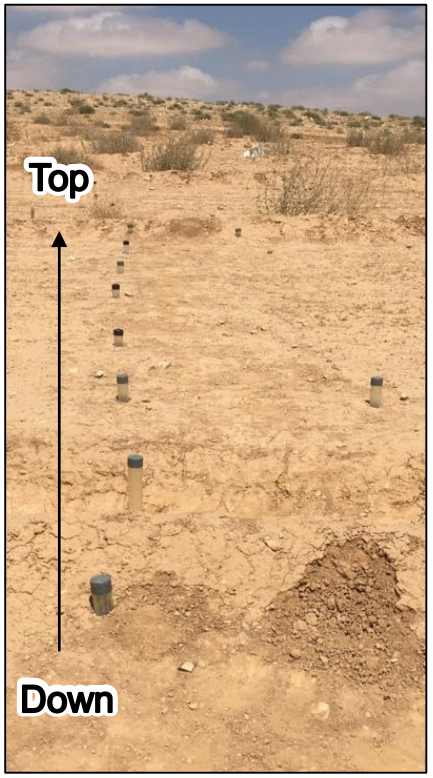
Community people, Mr. Mohammad

2 depth: Surface layer (0-20 cm)
Deeper layer (20-40 cm)



Design for soil moisture measurement





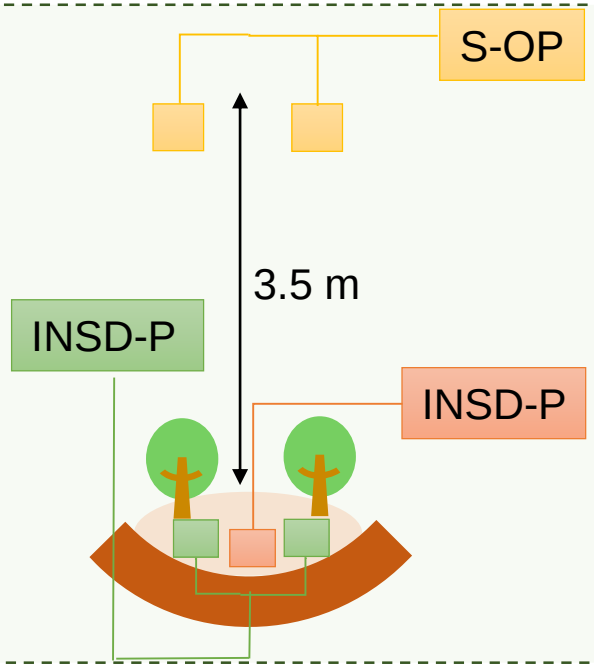
Design for plant growth

- To confirm that the plants use water for growth

Soil pH and EC

- To confirm that soil sodicity is suitable for plant

Device: pH, EC meter



Plant diameter and height

Height: Wooden ruler
Diameter: Electronic caliper

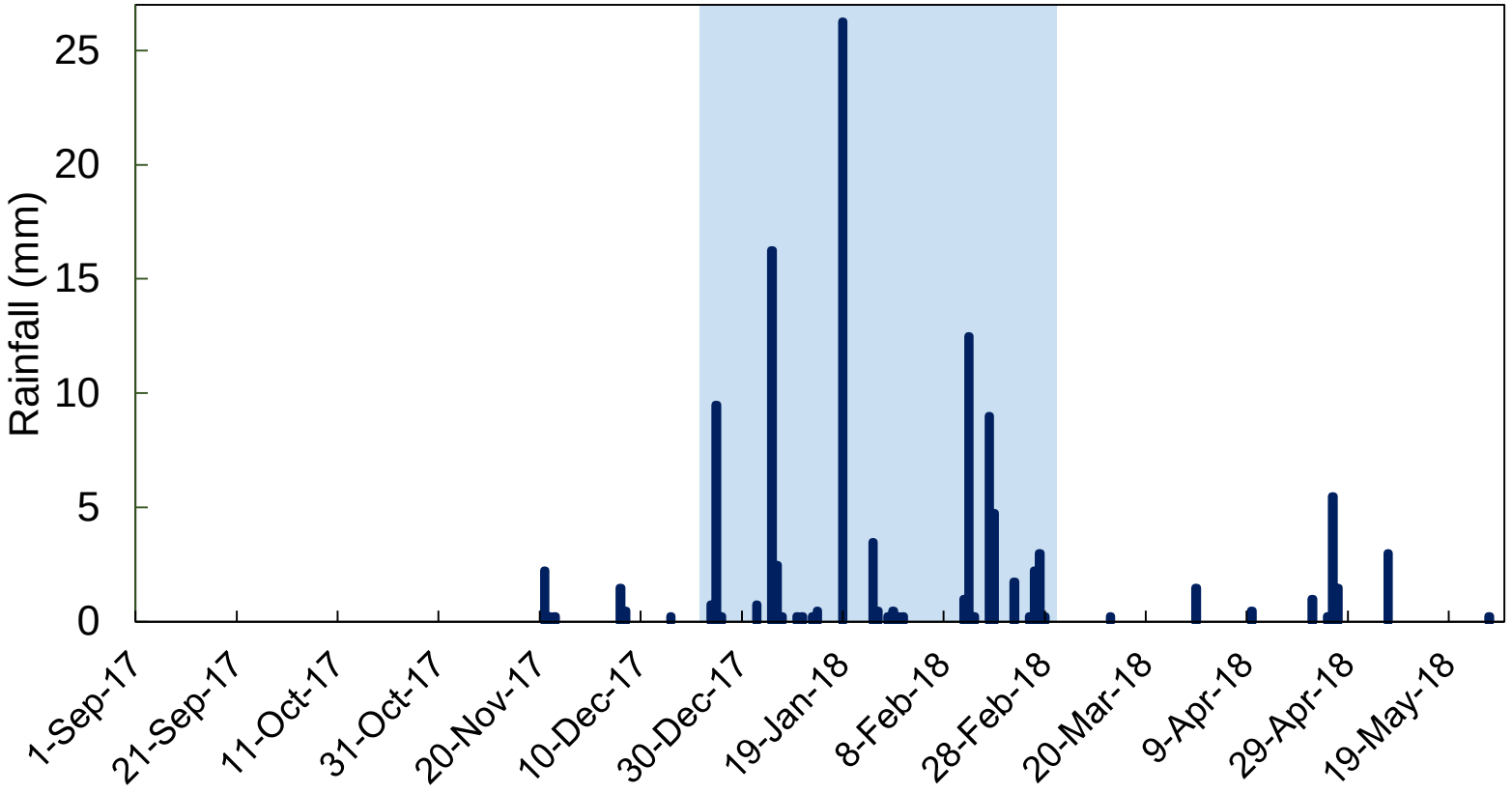
- 94 shrub was monitored

Measured by Community people, Mr. Issa and Mr. Menuwe

Period: Rainy season 2016 to dry season 2018

- Monthly measurement

Local rainfall characteristic



43days rainfall event during Nov 2017 to 2018

→Total rainfall : 115mm (Avg. 141 mm annual rainfall at QAIA)

Maximum single rainfall: 26.3mm (19th Jan 2018)

→Actually, heavy rainfall happened in end of December to end of February

WH pit after rainfall

(Menuwe, 2018)

(Issa, 2018)

Calculation

- To convert the following values…

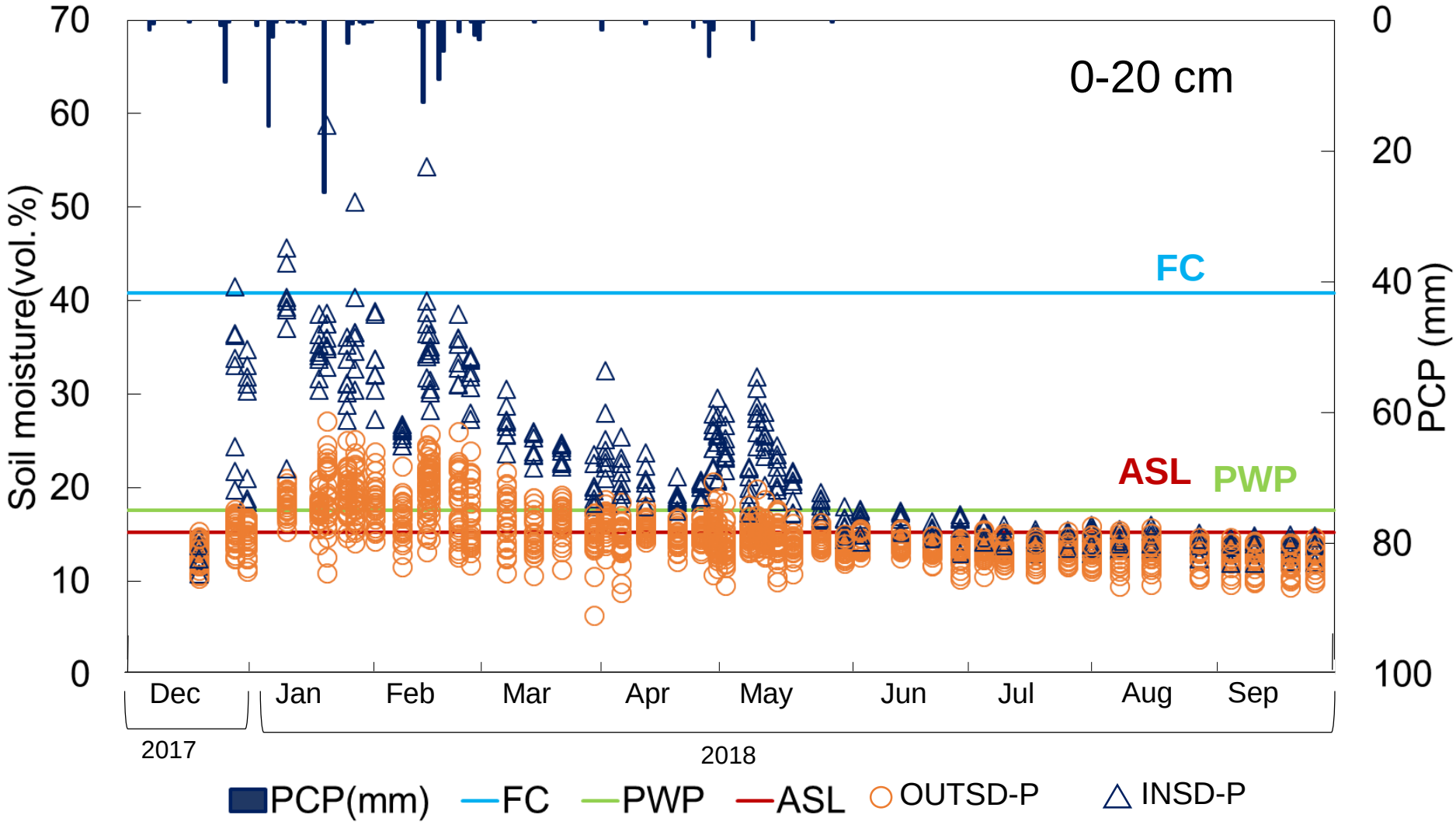
Field Capacity (FC) : - 0.33 bar
Permanent Wilting point (PWP): -15 bar
Atriplex. halimus stress level (ASL): 3.02 Mpa (Martinzez et al., 2003)

$$\theta(\psi) = \theta r + \frac{\theta s - \theta r}{\left[1 + (\alpha|\psi|)^{n}\right]^{1-\frac{1}{n}}}$$

Van Genuchten water retention model equation (1980)
by Rosetta, Clay loam condition

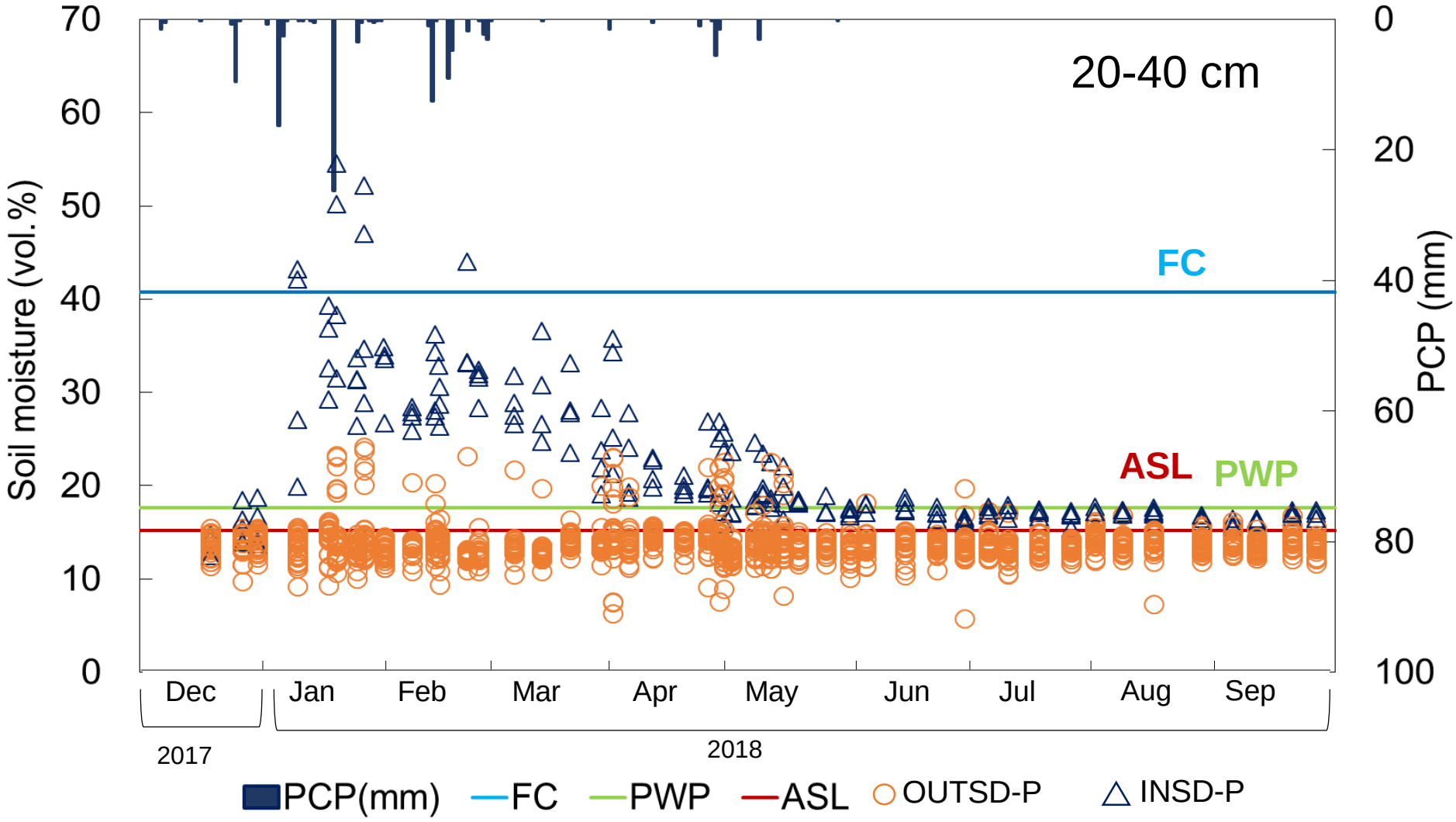
FC : 40.8 (vol.)%
PWP: 17.6 (vol.)%
ASL: 15.2 (vol.)%

Soil moisture contents in surface layer



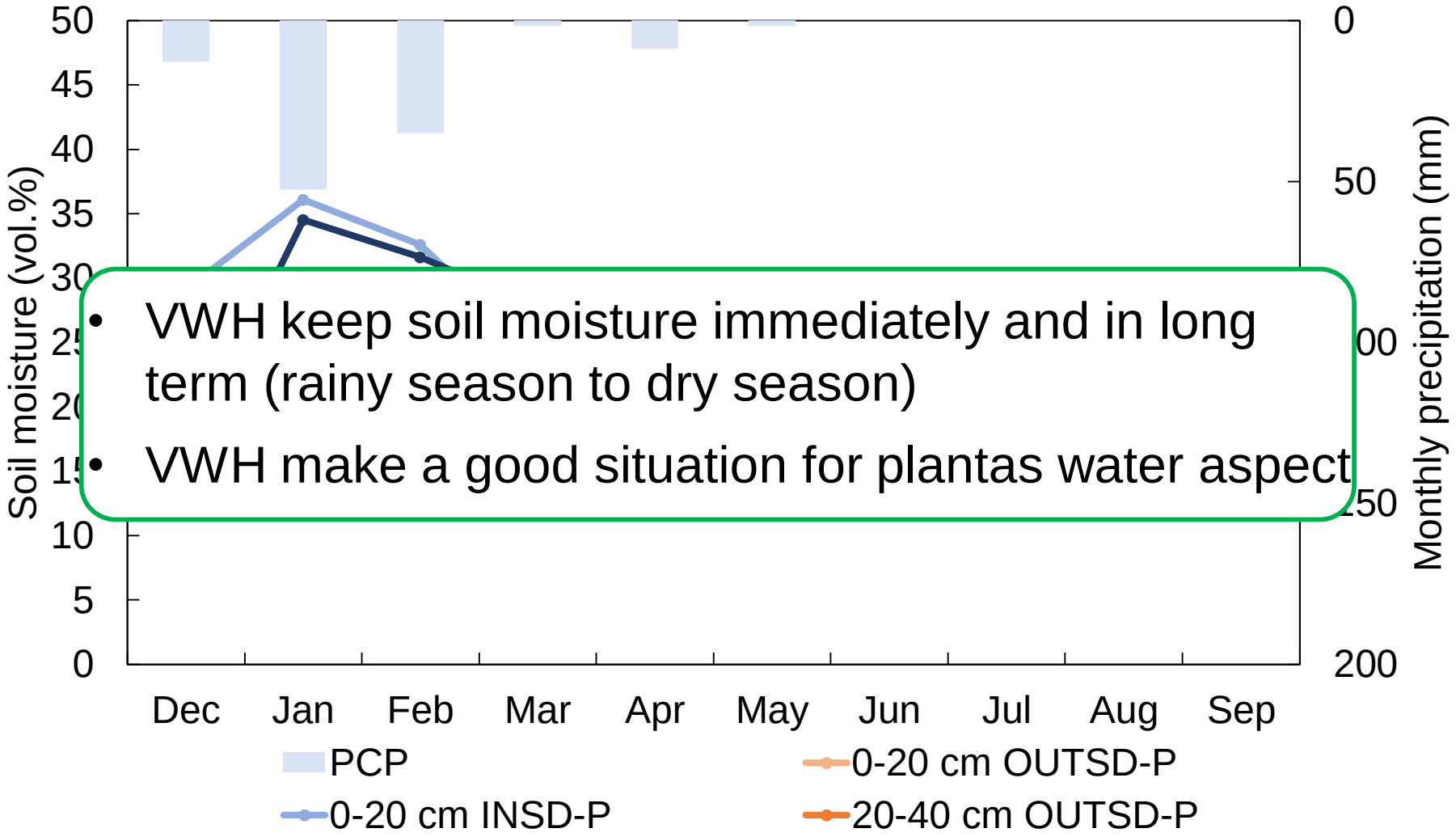
- Immediately increased at the surface layer on INSD-P after rainfall
- Dispersion of data was not connected with pit location → Crack

Soil moisture contents in deeper layer



- In December, Soil moisture was no differences INSD-P → It took time for infiltrate deeper layer
- Some INSD-P were over FC → Slight possibility of FC recharge

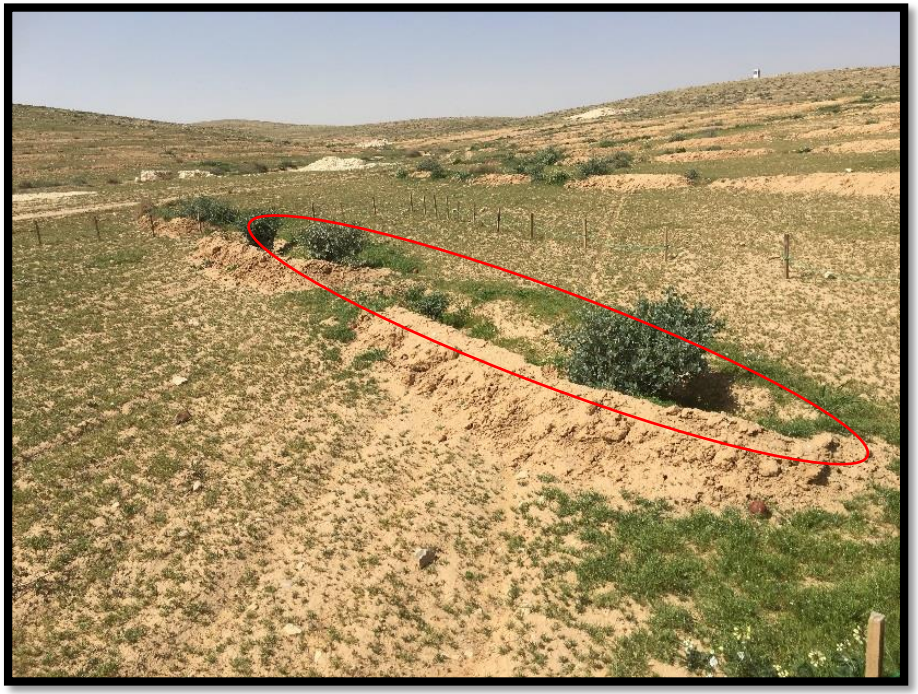
Monthly soil moisture average with rainfall

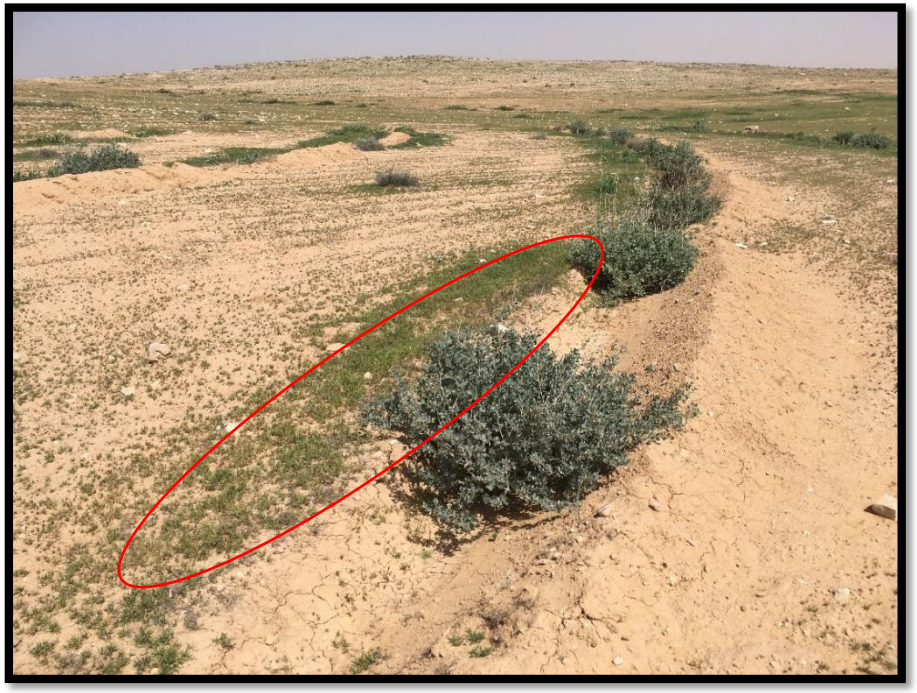


- VWH keep soil moisture immediately and in long term (rainy season to dry season)
- VWH make a good situation for plantas water aspect

- Soil moisture of OUTSD-P hovered around 13.8 % in deeper layer
- Soil moisture INSD-P did not reached

Possibility of expanding wet zone

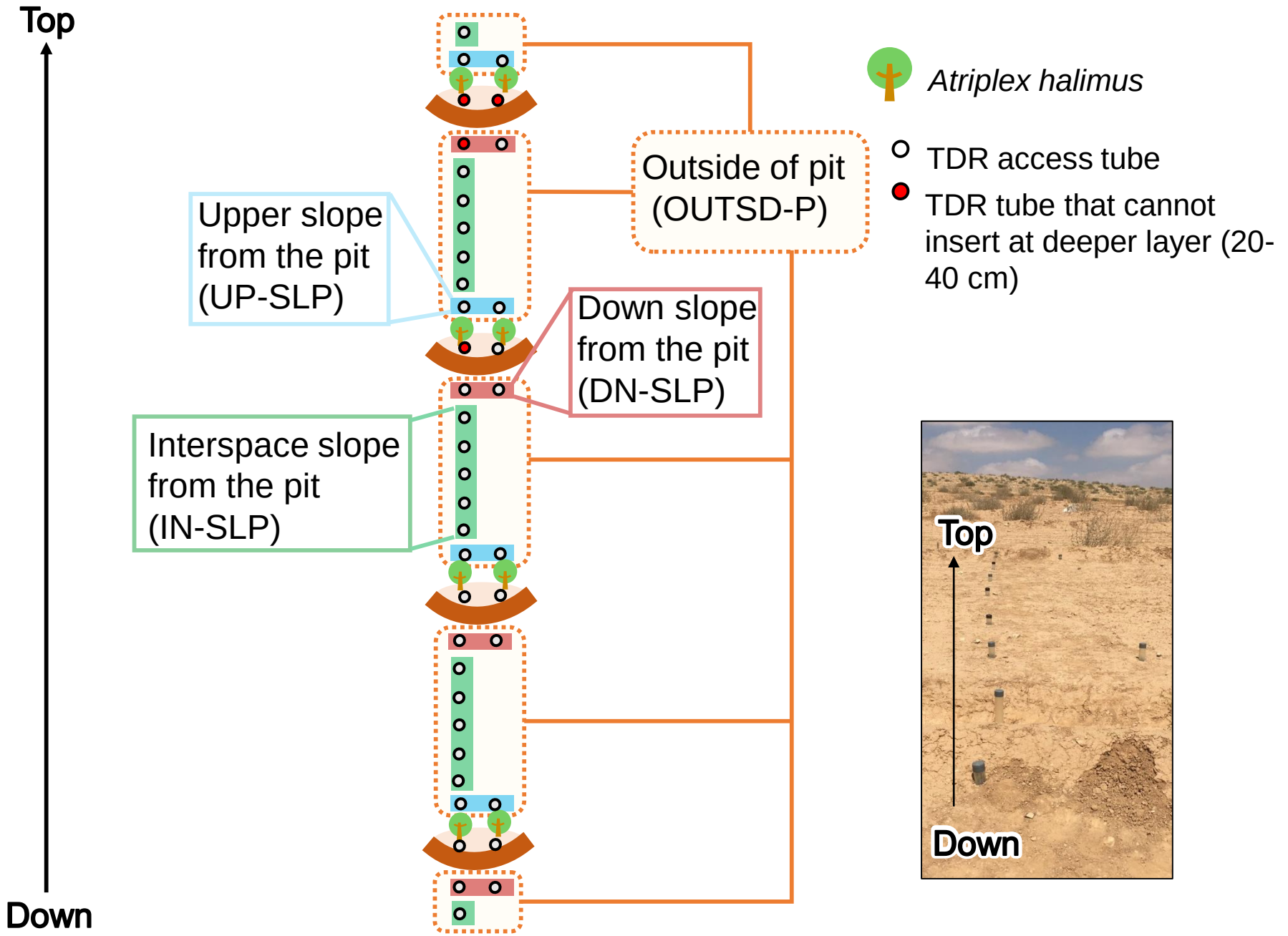




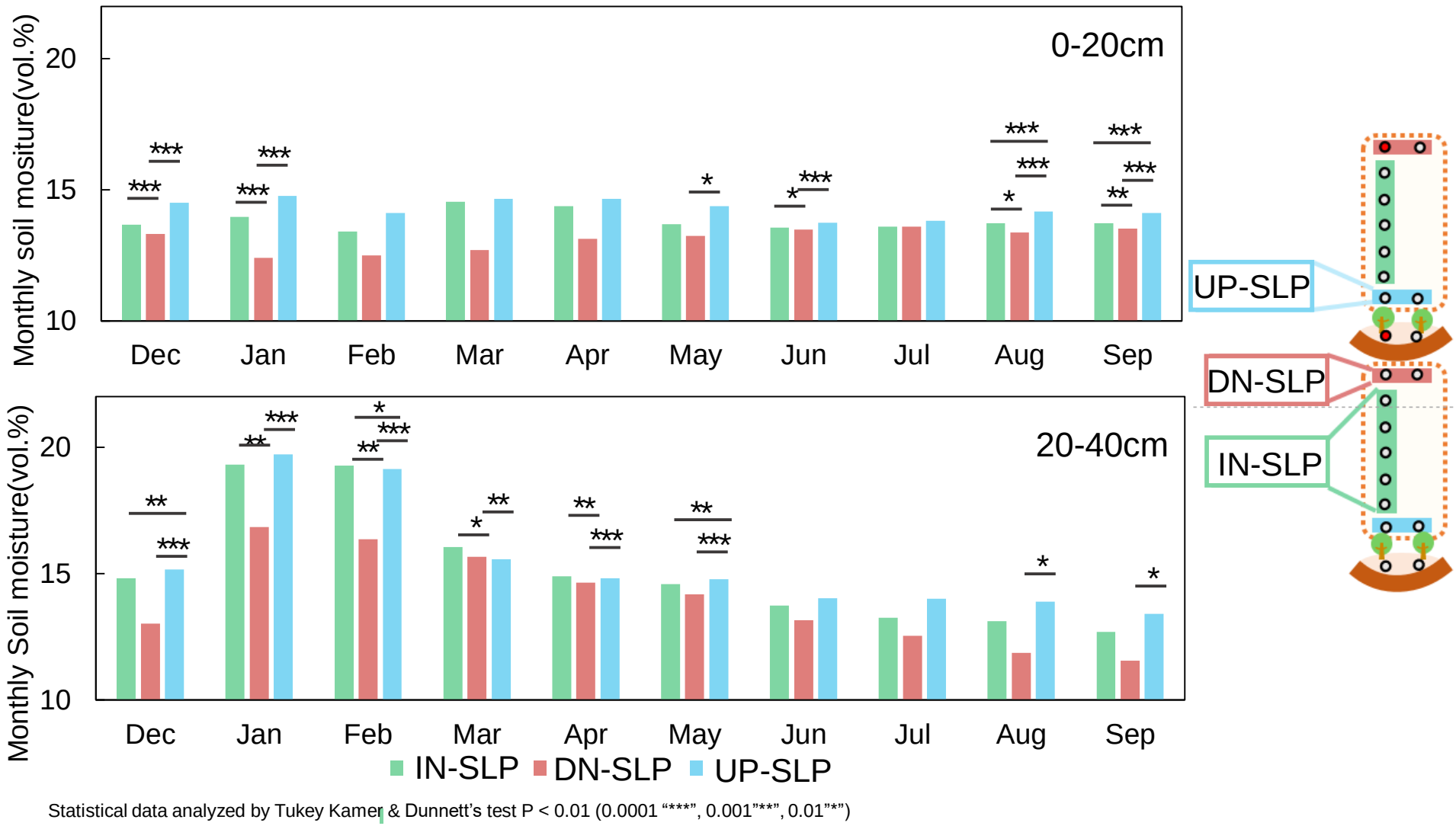
Soil moisture may expand to the upper slope side..?

If wet zone expand to the upper slope area from the pit, it will be linked to vegetation recovering including weed

Transect layout at hill slope site



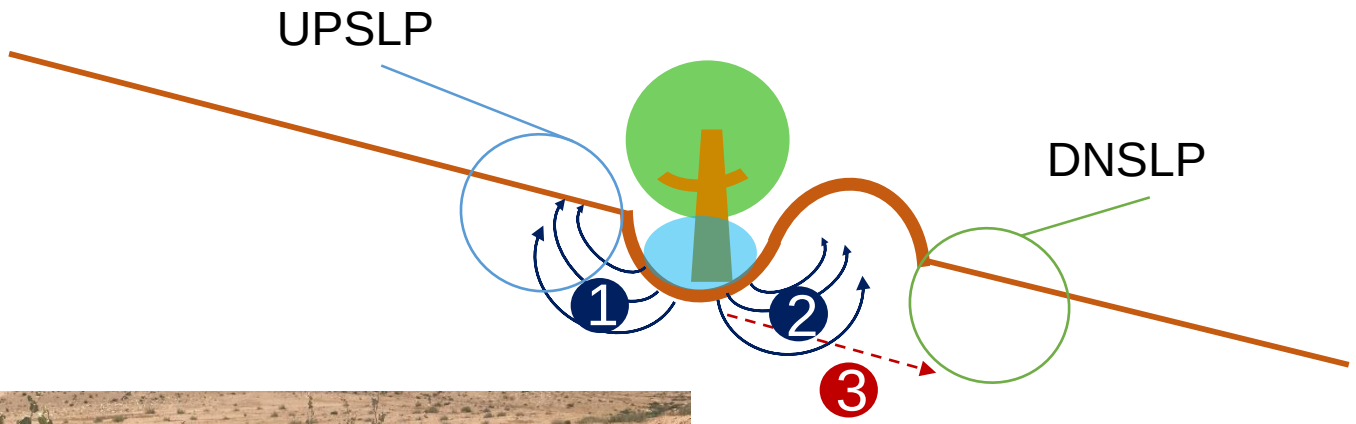
Soil moisture differences in OUTSD-P



Statistical data analyzed by Tukey Kamer & Dunnett's test P < 0.01 (0.0001 "***", 0.001"**", 0.01"*")

- DN-SLP is lower than UP-SLP and IN-SLP
- Significant differences in dry season between UP-SLP and DN-SP

New generation could observed in UPSLP



- Temporally work as fodder area
- Plant residue will make the fertilize soil in the pit
- Lead to the next step of vegetation recovering

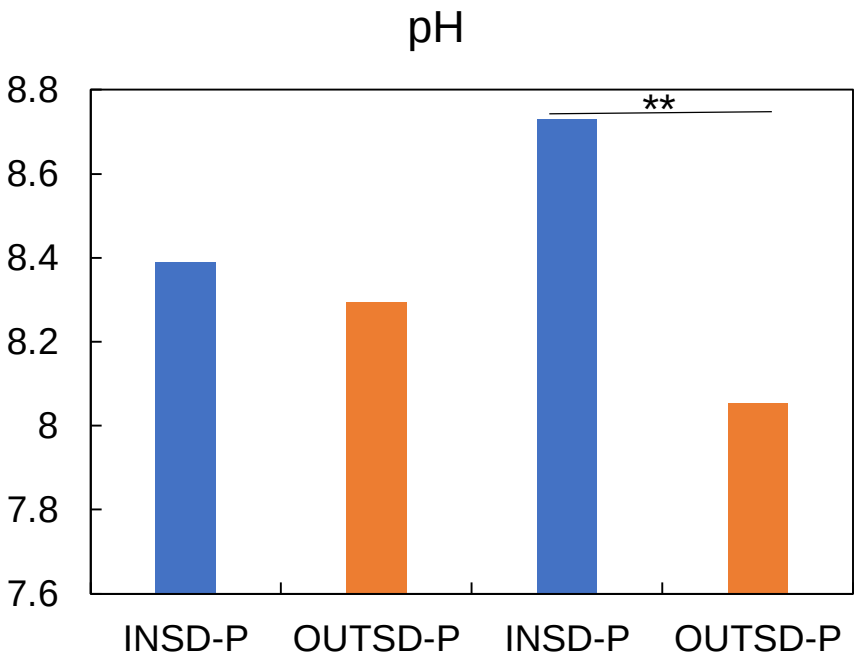
- Soil moisture might increase expanded around UP-SLP
- Young natural generation could observed around UP-SLP

Soil pH and EC as place for *A. halimus*

Soil pH (1:5) and EC (1:5)

	0-20 cm		20-40cm	
	INSD-P	OUTSD-P	INSD-P	OUTSD-P
pH	8.39	8.30	8.73**	8.05
EC (ds/m)	0.185	0.233	0.223	0.567

t test ($p<0.05$) (0.0005 “***”, 0.005”**”, 0.05”*”)



t test ($p<0.05$) (0.0005 “***”, 0.005”**”, 0.05”*”)

A. halimus is salt bush, can live alkaline soils (pH 7.0 – 11.0)

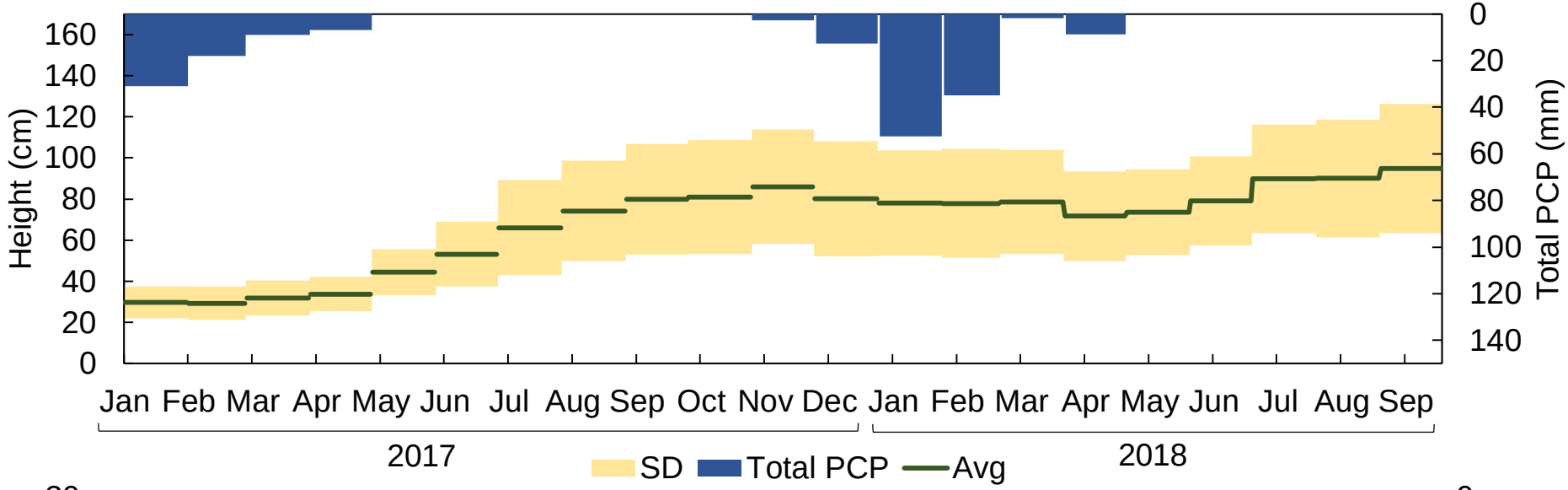
EC: Loam soil; EC > 0.4 (ds/m): saline soil

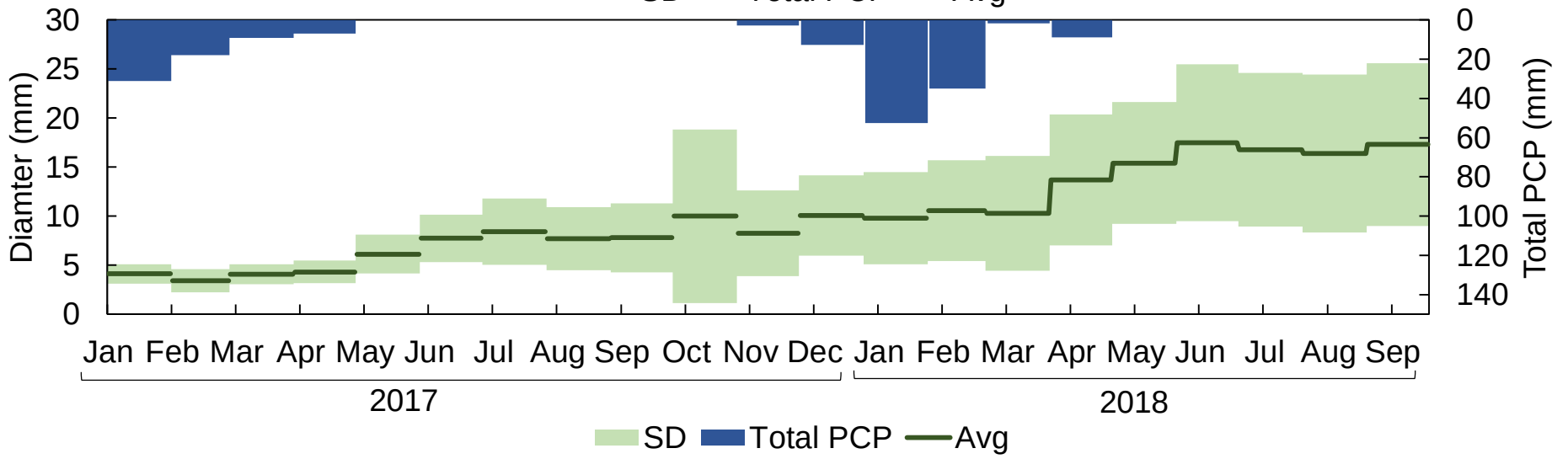
- INSD-P was higher than OUTSD-P

→There is no-damage for A. halimus at this time

◆ It is important to monitor pH and EC for long term.

Plant height and diameter





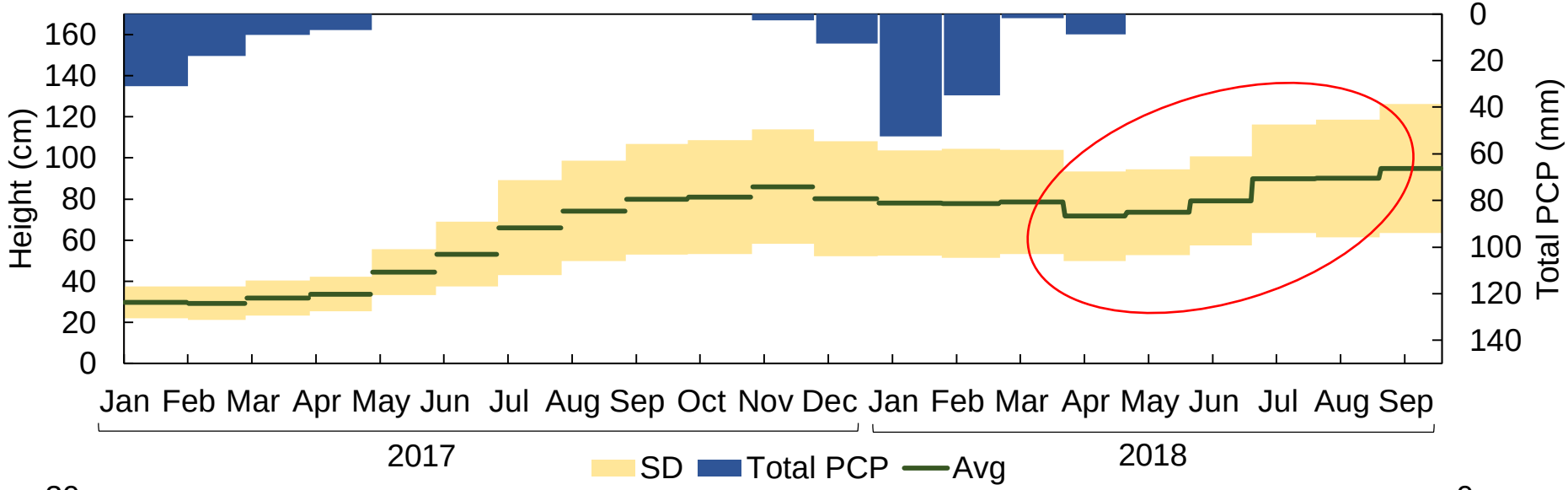
- Out-planted shrub in the pit survive smoothly

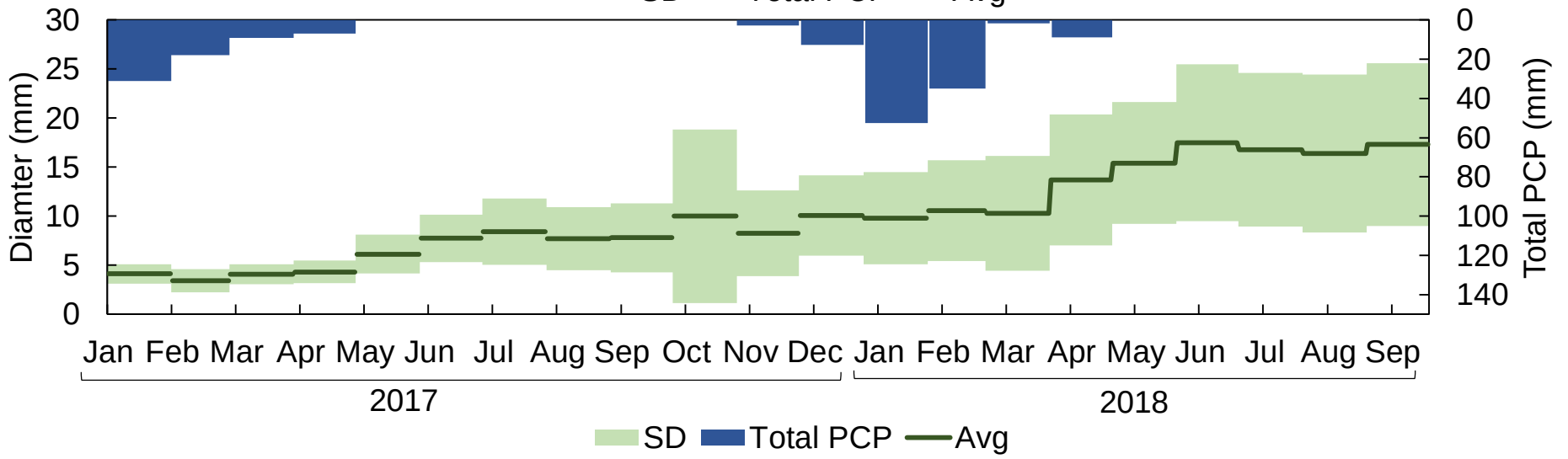
Soil moisture contents in deeper layer

- In August, natural young plant were grown in OUTSD-P were dying

→ OUTSD-P is severe situation for *A. halimus* growth

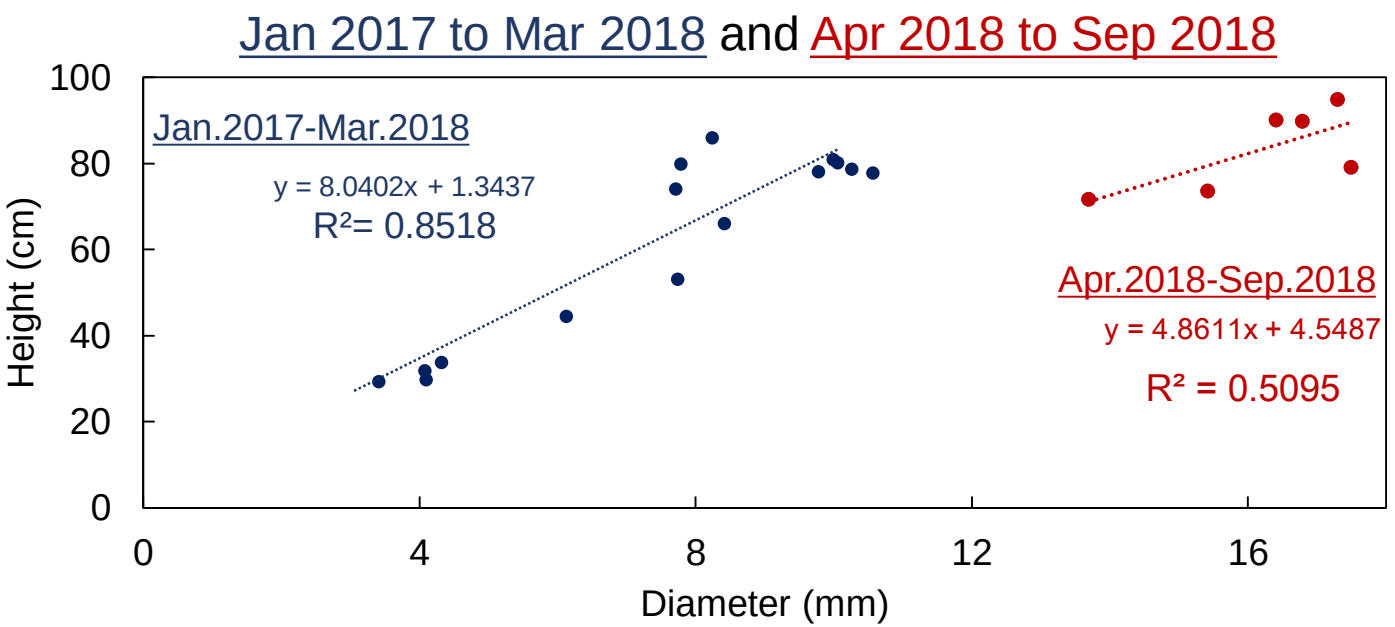
Plant height and diameter





- Out-planted shrub in the pit survive smoothly

Correlation of height and diameter



- From April, correlation of height and diameter was not good
- →wild animal grazed the shrub in the site..?

Summary of the result

This research proved that

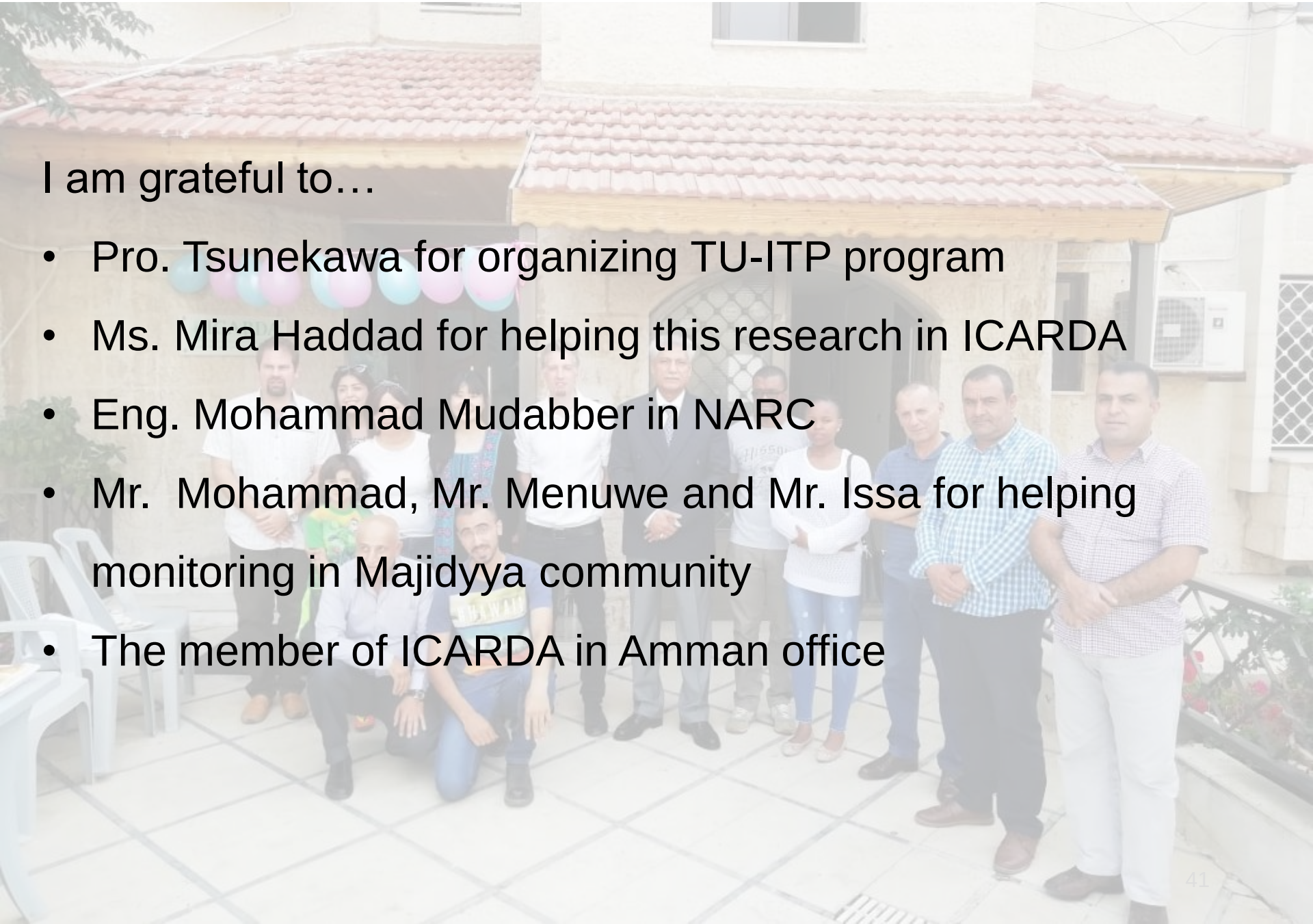
- After rainfall, immediately VWH keep soil moisture in the pit
- VWH kept soil moisture in long term (rainy season to dry season)
- VWH make wet zone not only pit, but also the upper slope
- VWH support *A. halimus* growth from the water aspect

Future work

- Depend on catchment area, amount of soil moisture change
  →To find the number of *A. halimus* for utilizing soil moisture

- The situation of the inside pit will be change
→It needs to be monitored that soil environment (such as pH, EC, sediment accumulation) influence on plant

- MWH performance will be change (after several years)
→Then, Can plant prevent runoff through the root?
(Monitoring or modeling research)



I am grateful to…

- Pro. Tsunekawa for organizing TU-ITP program
- Ms. Mira Haddad for helping this research in ICARDA
- Eng. Mohammad Mudabber in NARC
- Mr. Mohammad, Mr. Menuwe and Mr. Issa for helping monitoring in Majidyya community
- The member of ICARDA in Amman office

Thank you for your attention!