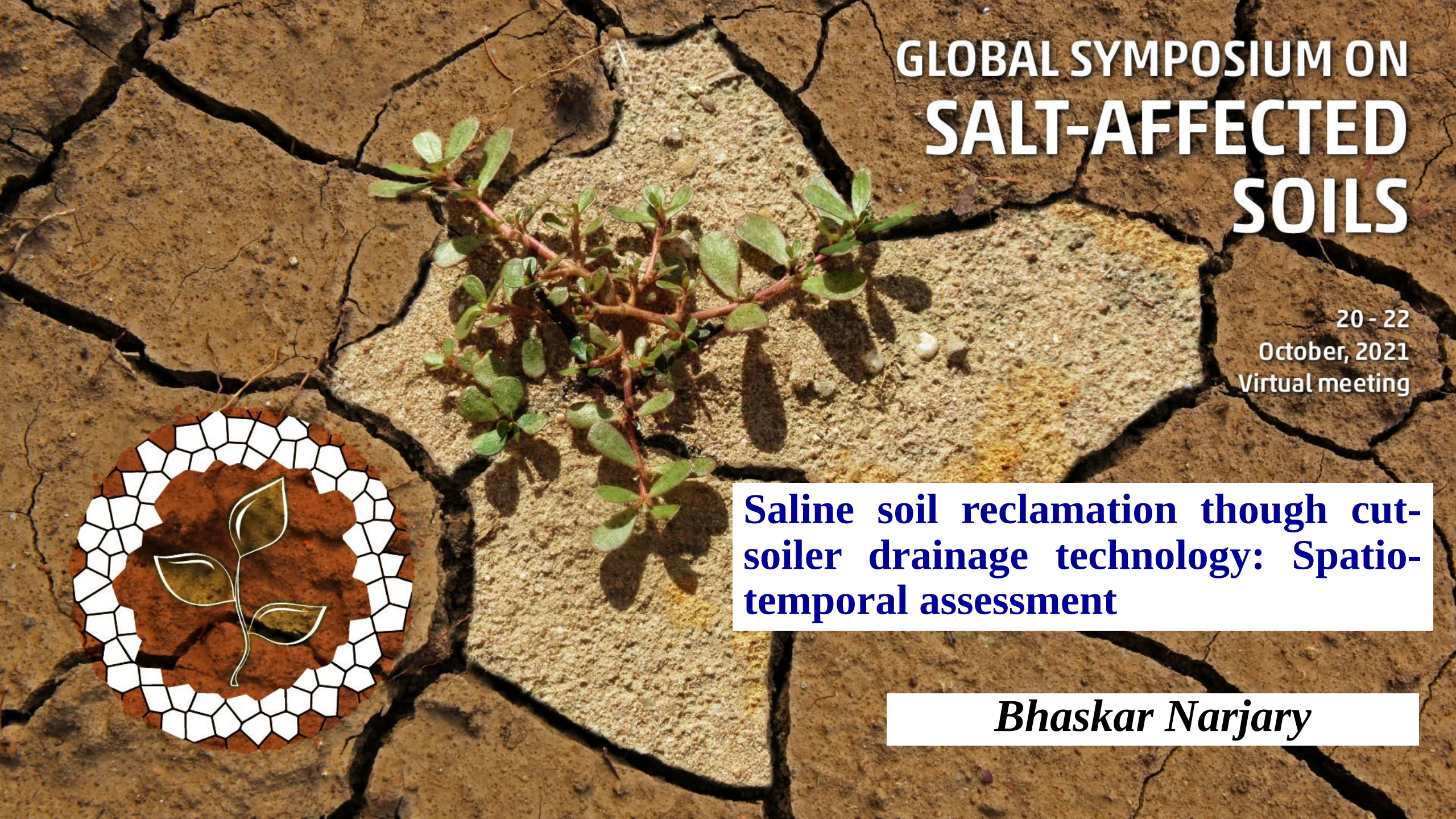


Saline soil reclamation though cut-soiler drainage technology: Spatio-temporal assessment

Bhaskar Narjary

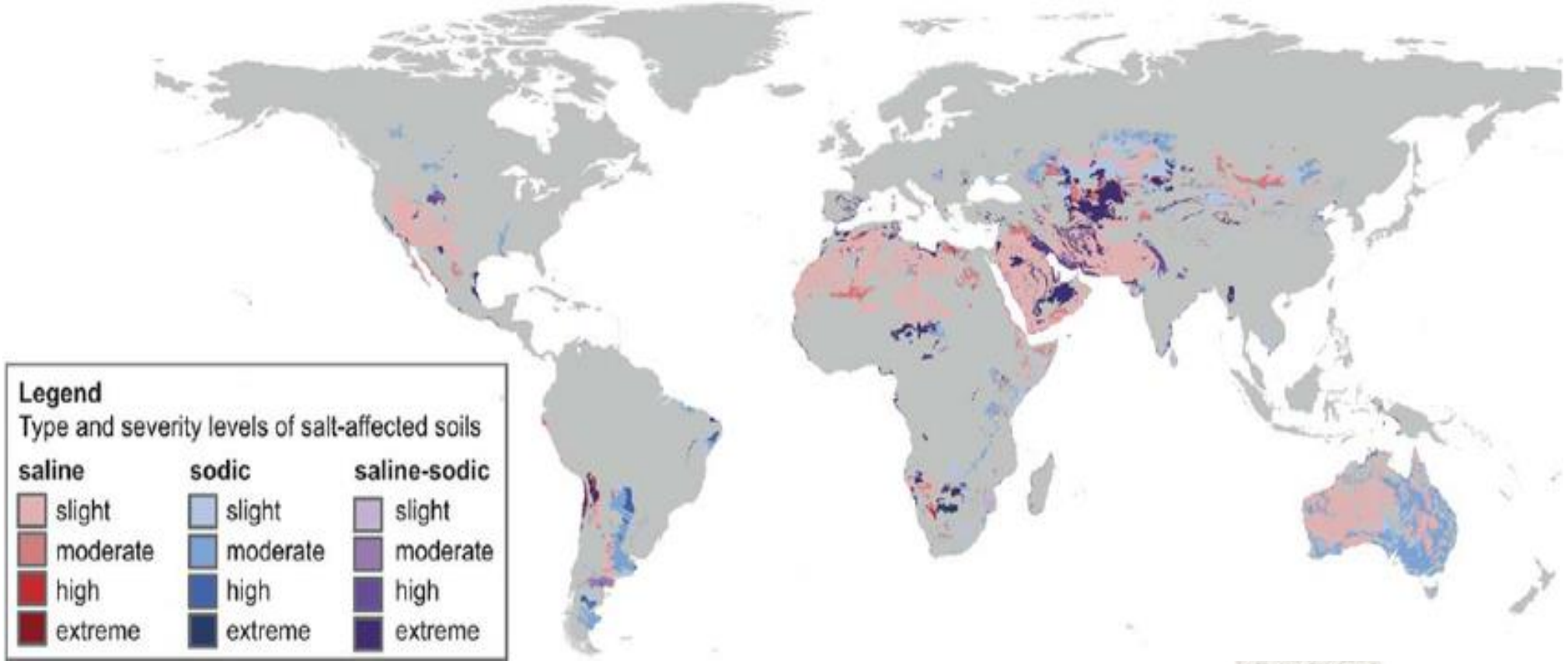
Introduction

➢ **Owing to the semi-arid climate, large areas extensively developed for irrigated agricultural production.**

❑ **Whilst irrigation to has brought prosperity, there have been some isolated environmental impacts.**

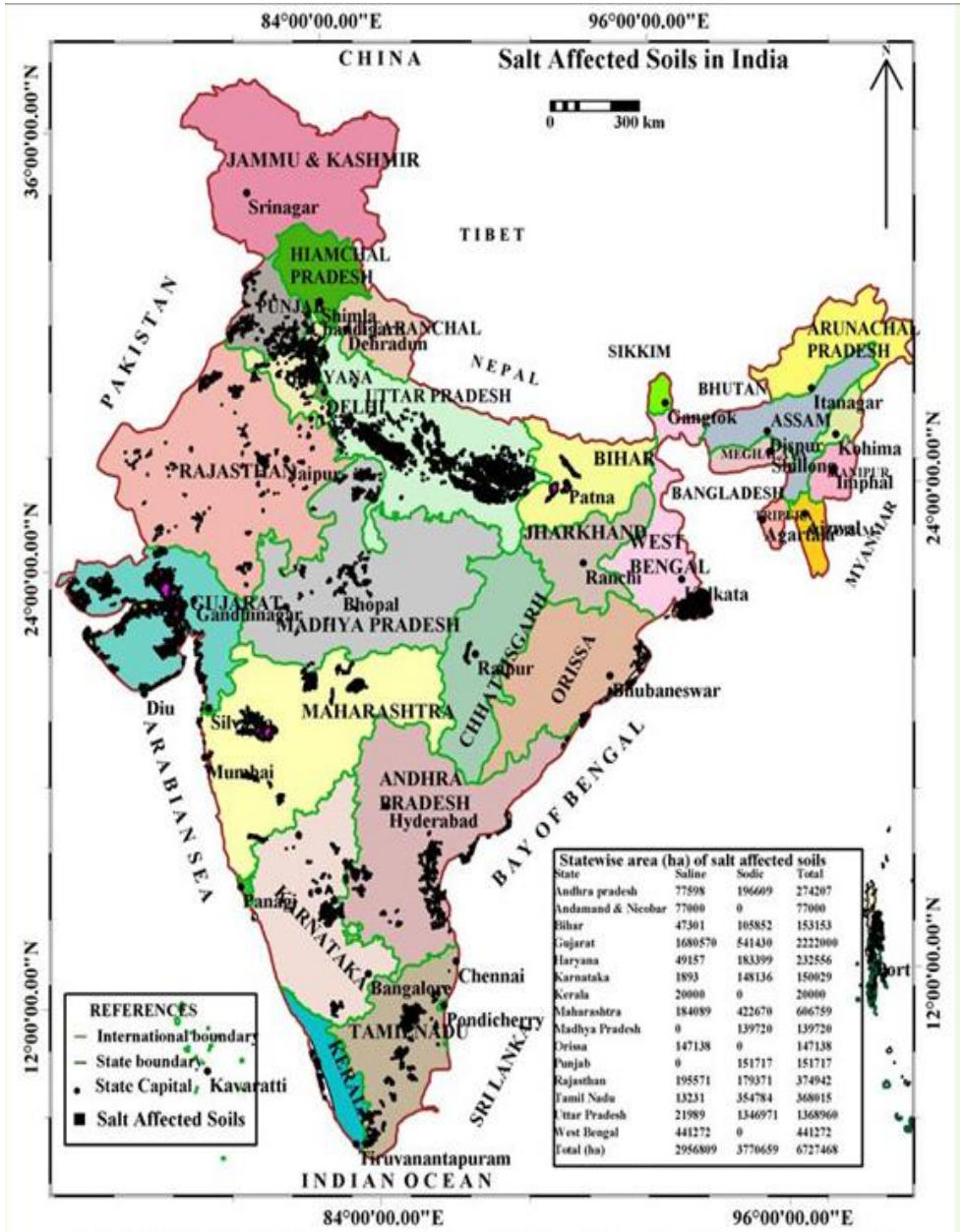
❑ **Soil salinity is serious environmental problems adversely affecting crop yield, soil health and socio-economic conditions for the farming communities.**

Global Extent of Salt Affected Soil



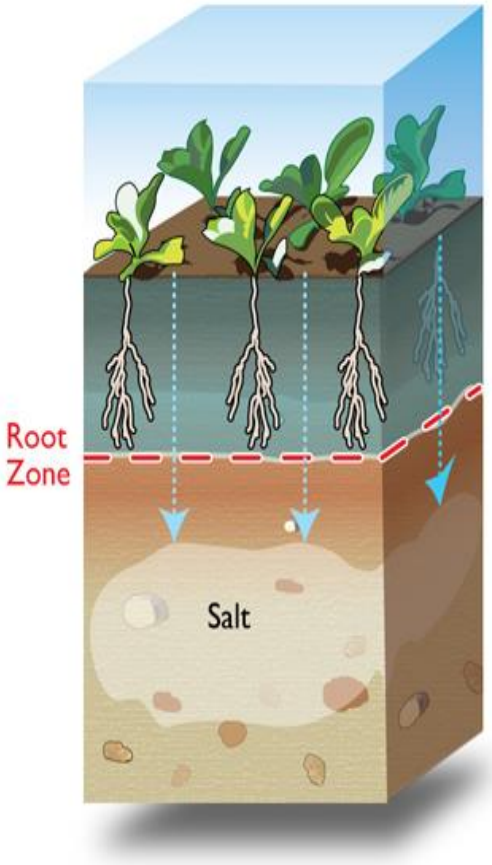
Global extent of SAS: 1 billion ha distributed in > 100 countries across all the continents (Source : *FAO/IIASA/ISRIC/ISS-CAS/JRC, 2008; Wicke et al., 2011; Ivushkin et al., 2019*).

Salt Affected Soil in India



- **Total SAS area in India- 6.73 M ha affected**
- **Sodic-3.77 M ha and saline 2.96 M ha**
- **Expected to increase to 16.25 M ha by 2050**
- **32-84% of groundwater used for irrigation is either saline or alkali**
- **Globally 10 M ha land lost each year due to salinity caused by irrigation (George E. Brown Jr. Salinity Lab, 2006)**
- **India losses ~17 M tonnes of food grains annually**
- **With annual economic loss of USD 230 billion (Sharma et al., 2015)**

Management of Soil salinity



Leaching of Salts
(Groundwater table- deep)

Salt removal through Subsurface Drainage
(Groundwater Table-Shallow)

Creation of stable preferential flow path in subsoil layer for removal of salt water

Cut soiler

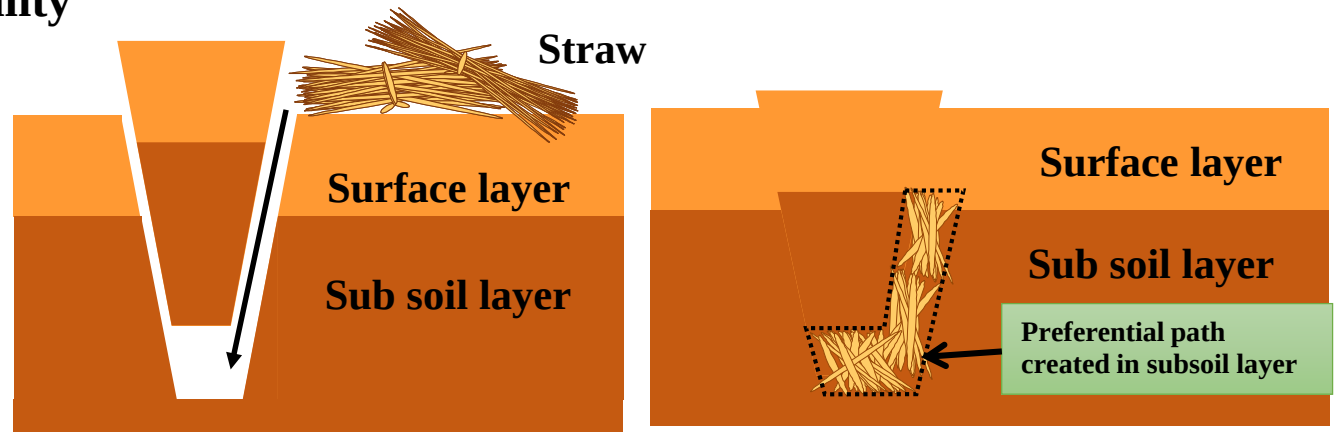
- Cut-soiler introduced in India for management of salinity and seasonal water logging under ICAR-JIRCAS collaborative project.
- Cut-soiler is a machine jointly developed by National Agriculture and Food Research Organization (NARO) and Hokkai Koki Corporation that improves field drainage using surface residue

•The Cut-Soiler collects the surface residue of about one meter width from surface by collector and places into subsurface below 60 cm (adjustable 30-90 cm) with the help of cutter and thus makes residue filled shallow drains at subsoil.

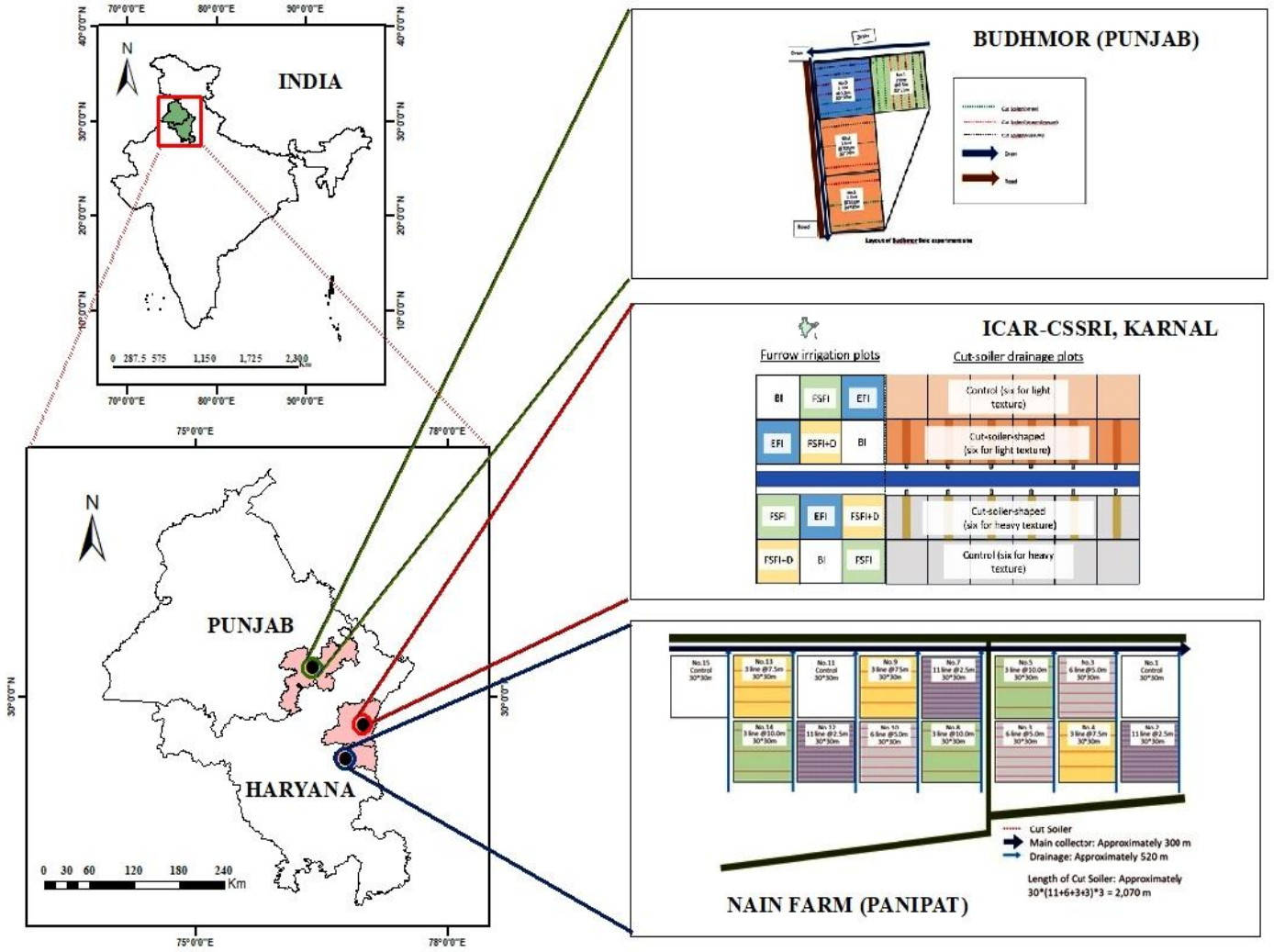
Cut-Soiler: (Preferential path created in subsoil layer)

- **Cut-soiler can make drain hole at 50 cm depth for burying the crop residue by just pulling the tractor attachment**
- **Cut-soiler cuts soil in V-shape and lifts up at the same time, then puts materials on the ground surface into the space.**
- **Applicable to all soils type and high sustainability**

Cut-soiler



ICAR-JIRCAS Collaborative Research Project Experimental Sites



Management of Subsurface sodicity

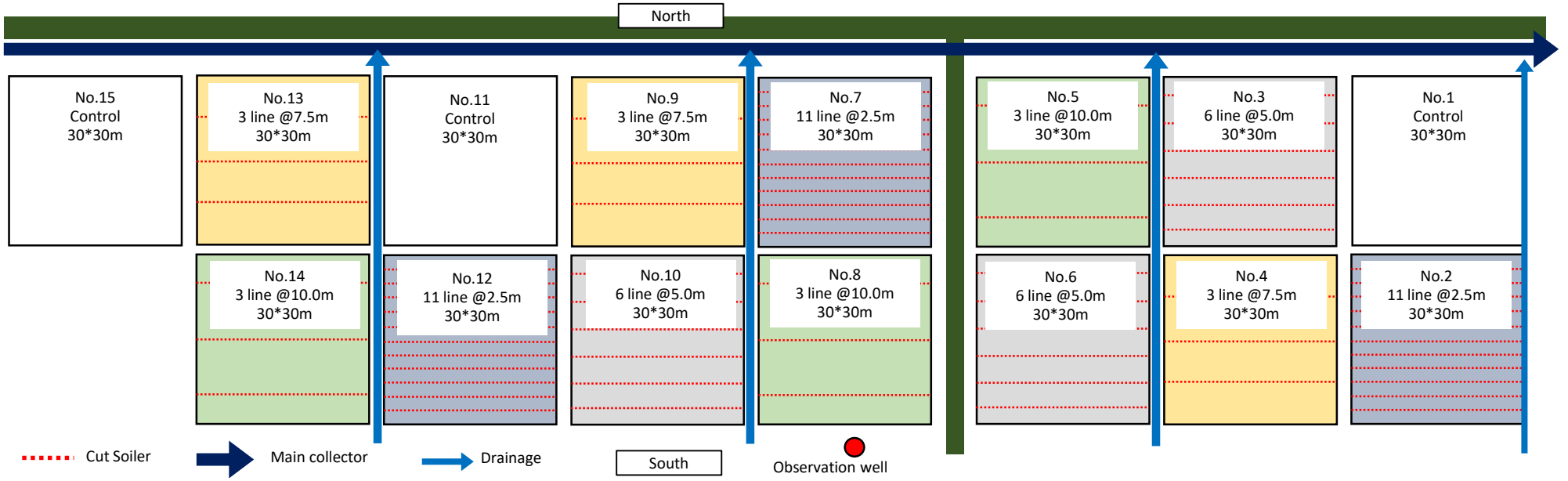
Lysimeter experiment

Management of soil salinity

The research was implemented at salt-accumulated fields in order to standardize optimum spacing of construction line by the Cut-soiler for evaluating salinity removal from the fields.

Research Site: Nain experimental field of ICAR-CSSRI, Panipat, Haryana, India

Layout and Treatment

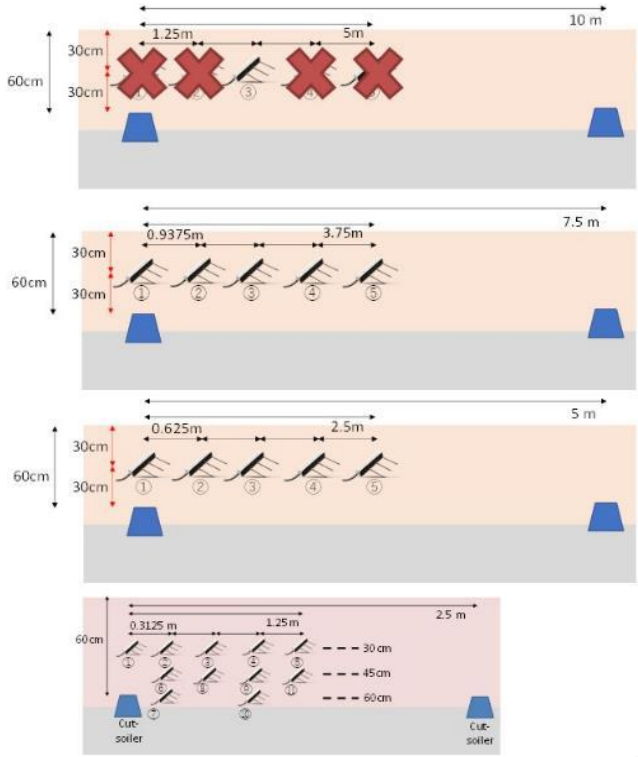


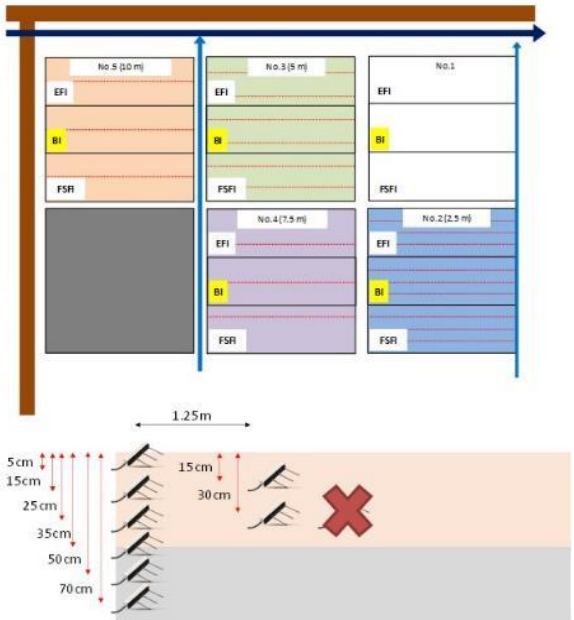
- ✓ 5 patterns of plots (2.5m, 5.0m, 7.5m, 10m spacing Cutsoiler line, and no cutsoiler as control)
- ✓ Depth of Installation : 0.5m in depth,
- ✓ Plot Size : 30m x 30m
- ✓ Total area: 1.35ha
- ✓ Residue Material: Chopped Rice Straw

Sensor's installation in the field

GS3 Greenhouse Sensor (Meter Inc.)
→Soil moisture, Electronic Conductivity (EC), Temperature

GS3 sensors were installed in 2.5 m, 7.5 m spacing
and no-construction of the subsurface drainage.





Weather Condition During the Experiment

- Aridity Index：about 0.32 (2018: 0.44, 2019: 0.20）

Weather condition and irrigation practice

Rainfall

	2018-2019	2019-2020
Pearl millet	201.2 mm	142.6 mm
Mustard	40.6 mm	188.0 mm

Temperature

	2018-2019	2019-2020
Pearl millet	27.6 ℃	17.2 ℃
Mustard	28.7 ℃	15.6 ℃

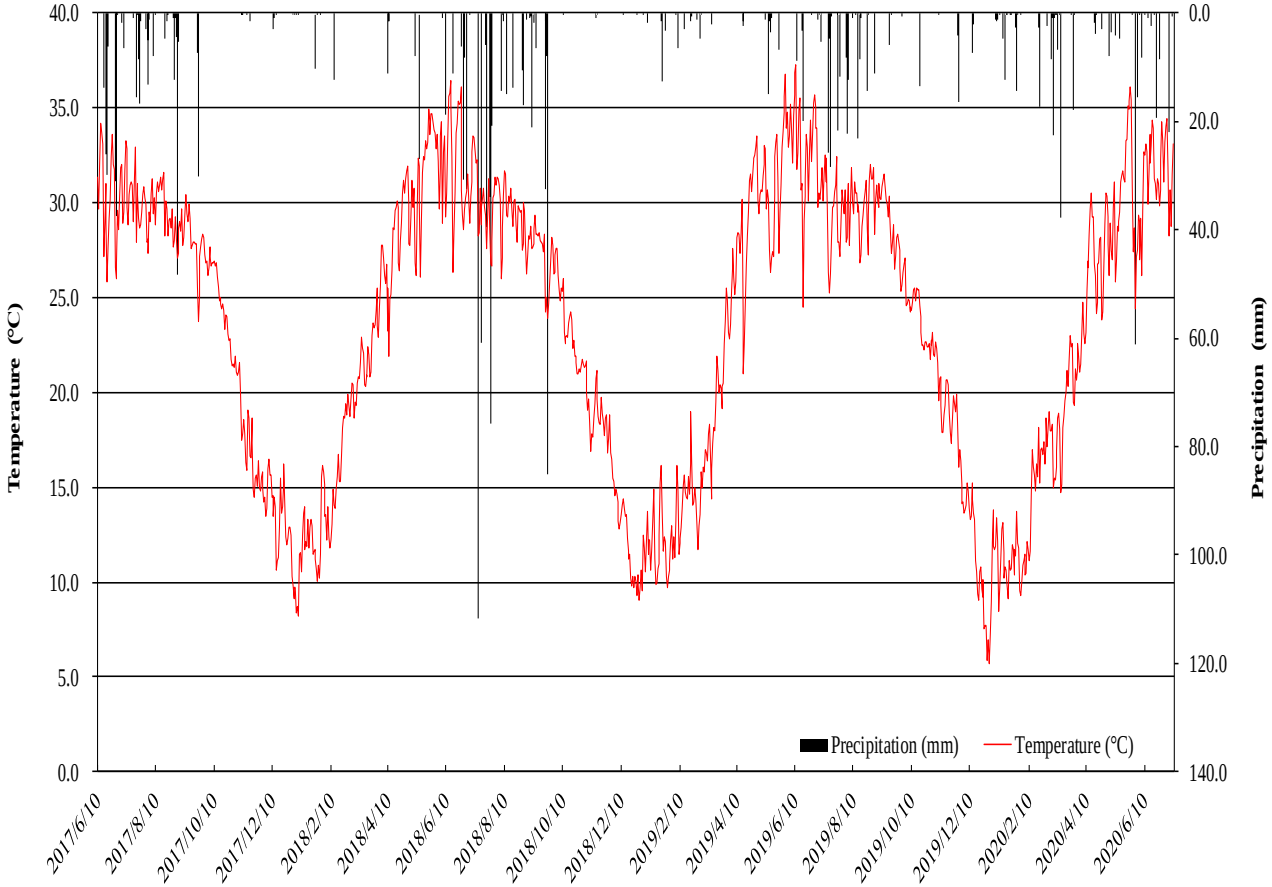
Irrigation

Border irrigation

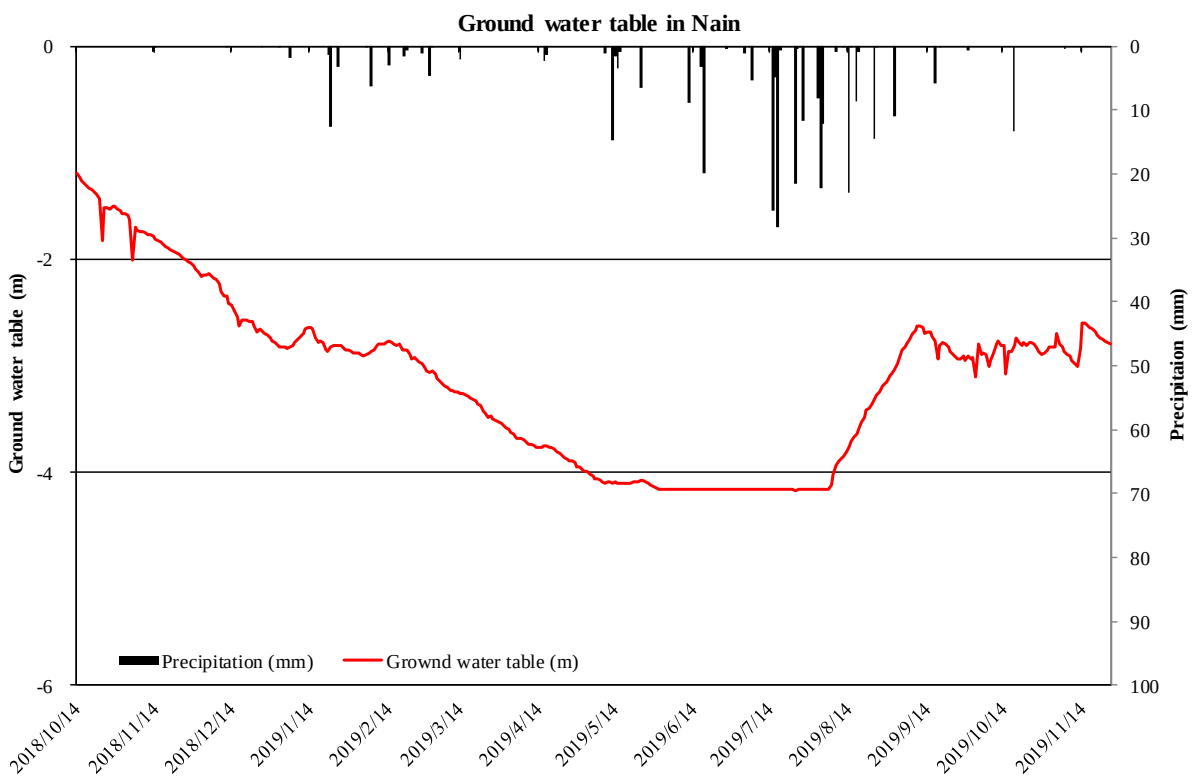
50 mm

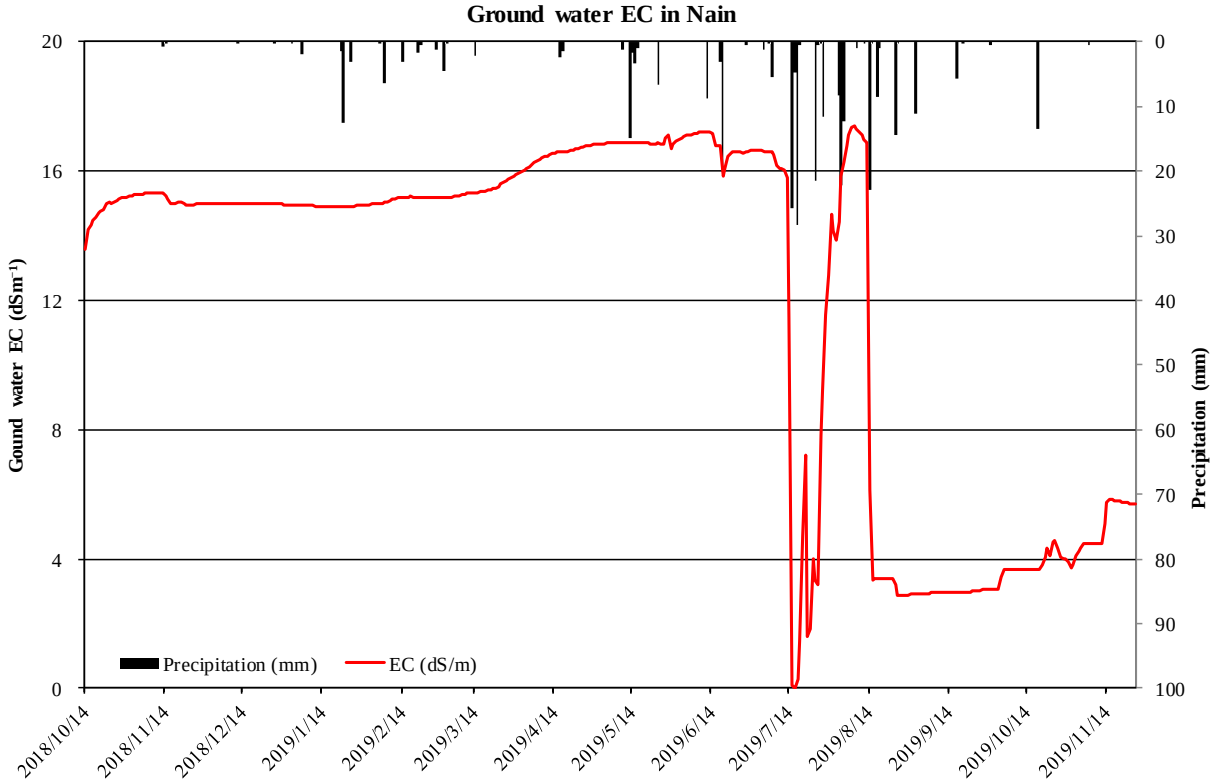
Crop yield

Observation

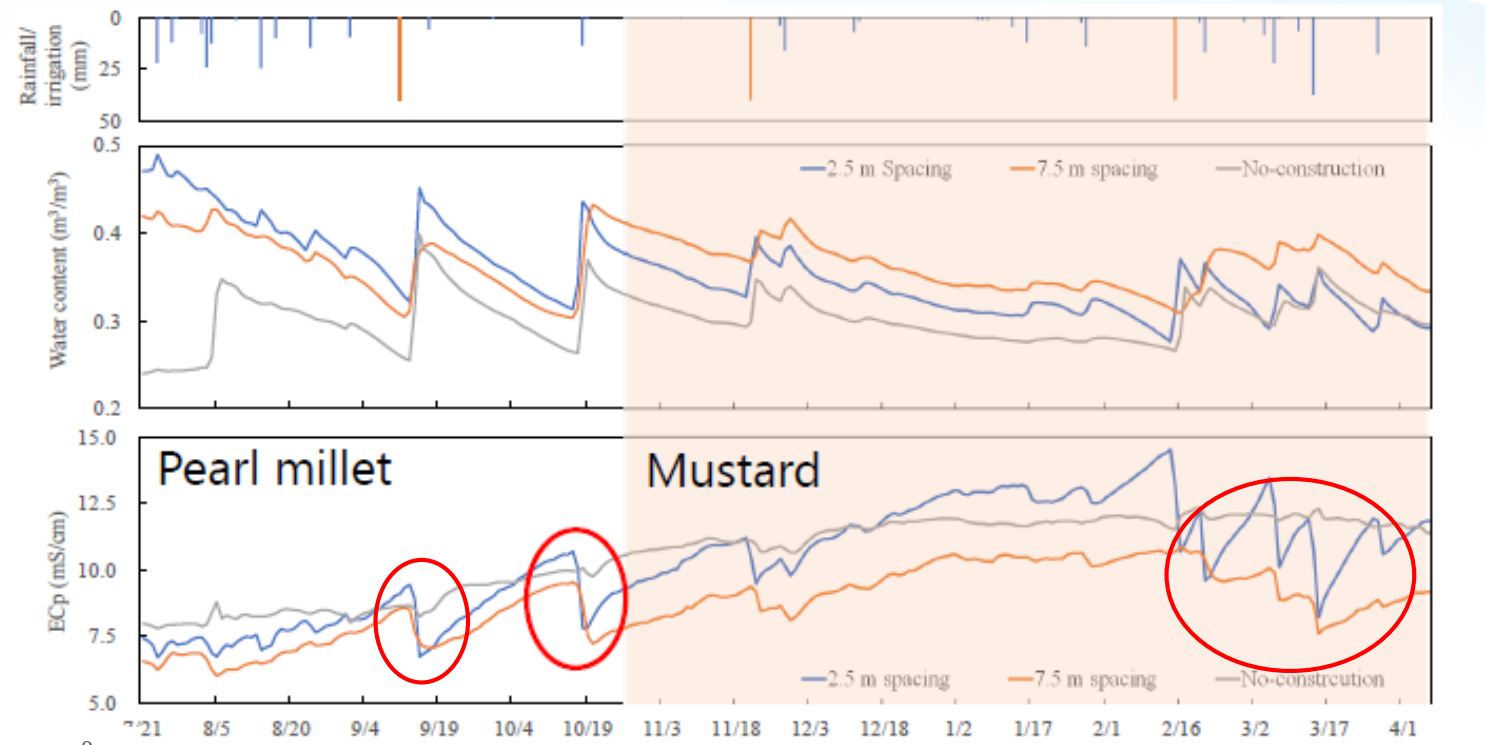


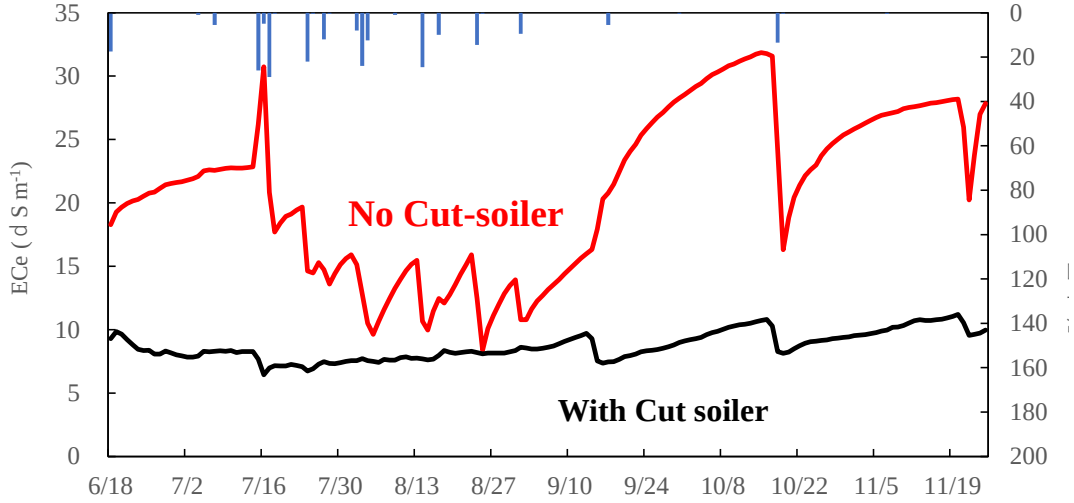
Groundwater table depth and groundwater salinity during experiment





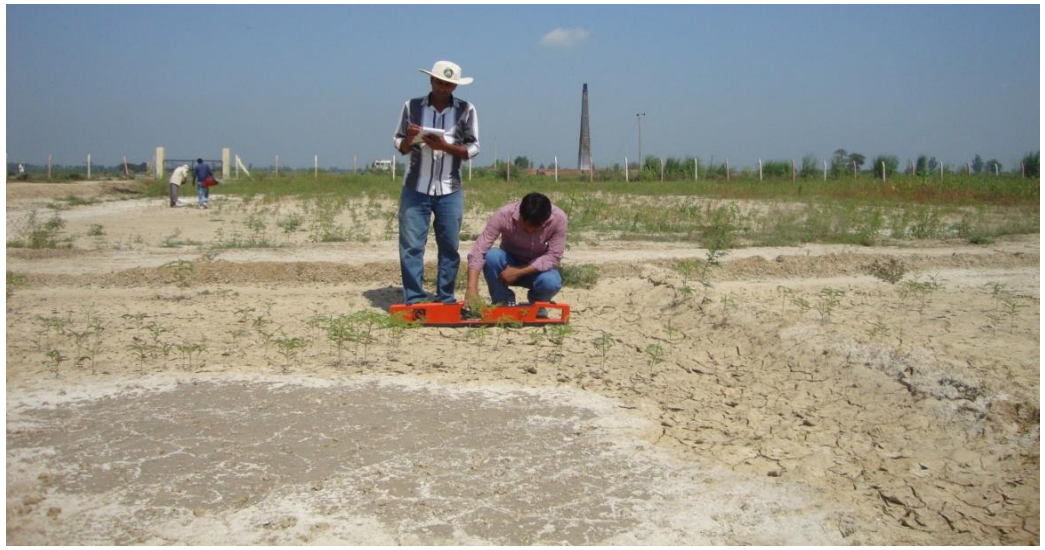
Soil salinity under Cut-soiler





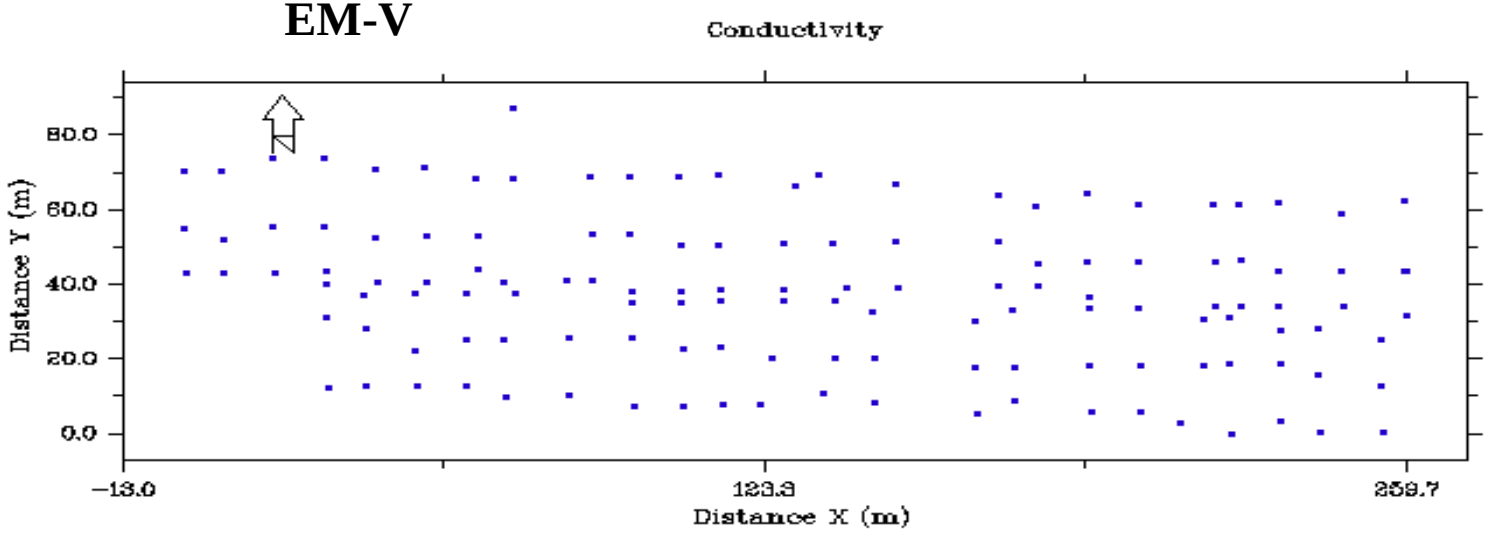
Cut-soiler preferential water outflow reduced soil salinity

Spatial Soil salinity survey through EM-38 (2018-2020)



EM-V

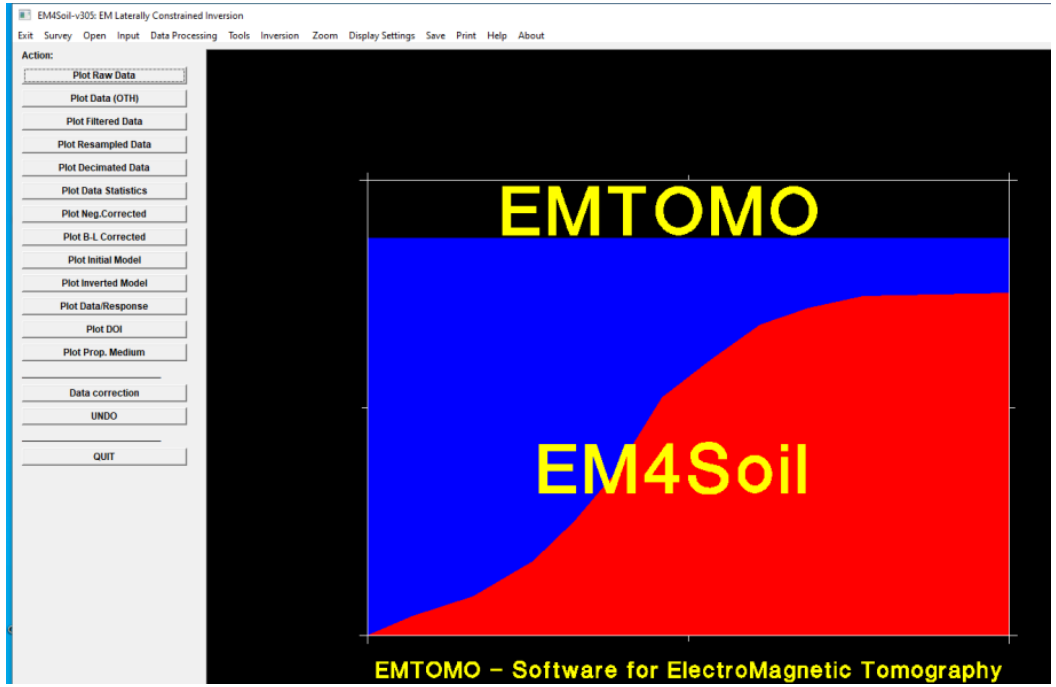
EM-H



Electromagnetic Induction (EMI)Survey location

No of survey points-135
Soil samples – 45
Sampling Depth- 15, 30, 60 and 90cm

EM-38 data modelling using EM4soil inversion software



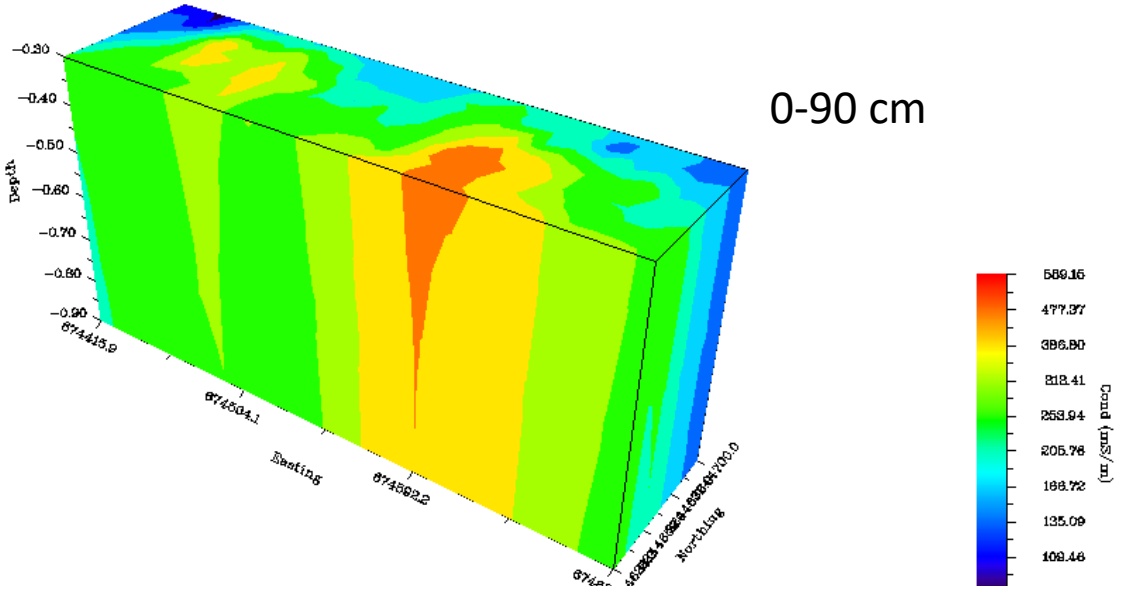
❑ Quasi-3-dimensional inversion algorithm

Modeled parameter

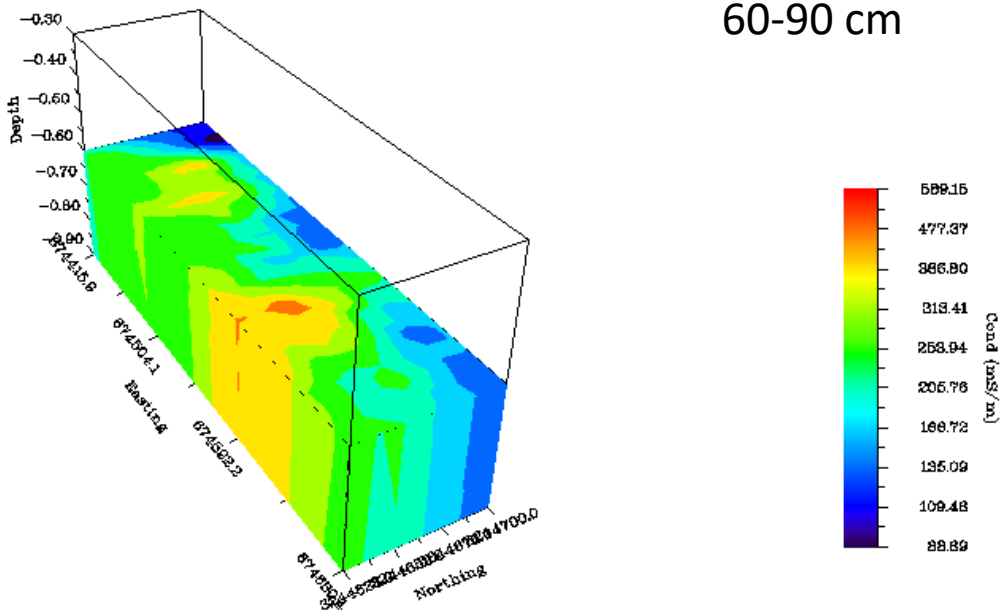
Damping Factor – 2
Liner CF
Algorithm-S2

3D representation of True Apparent Conductivities (ECa) (mS/m) in 2018

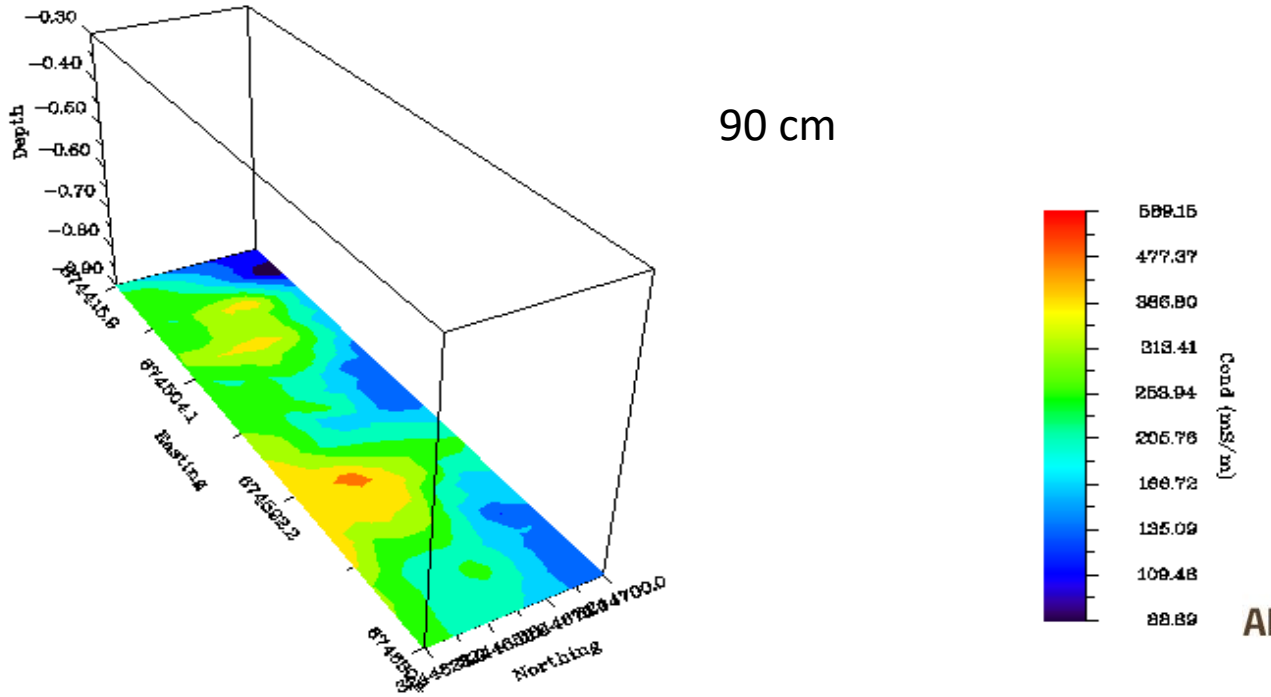
0-90 cm

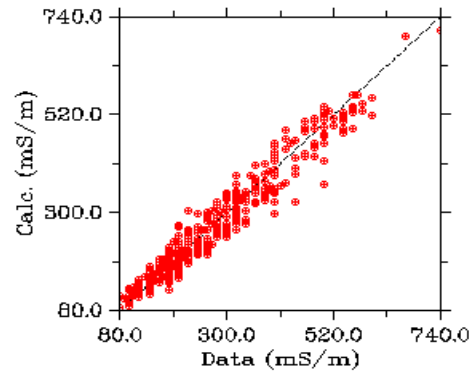


60-90 cm



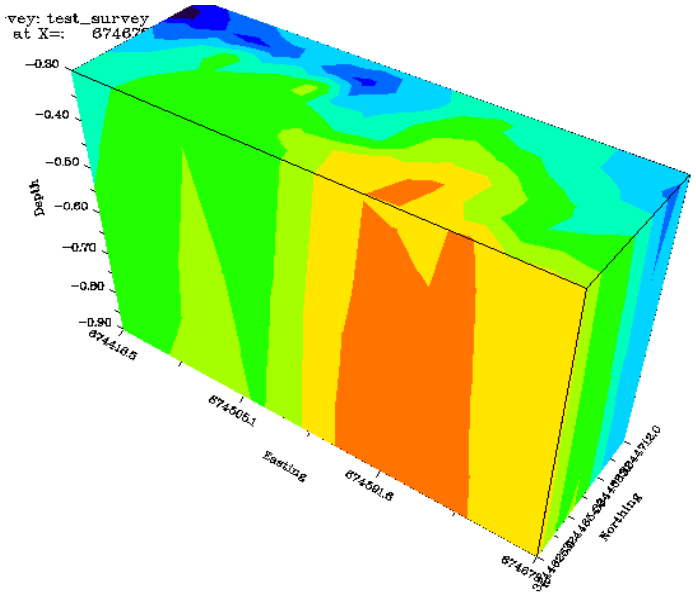
90 cm

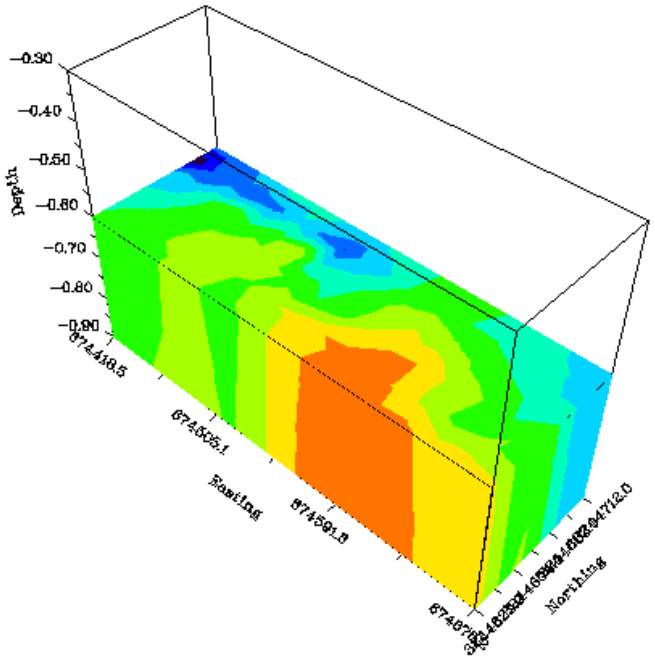


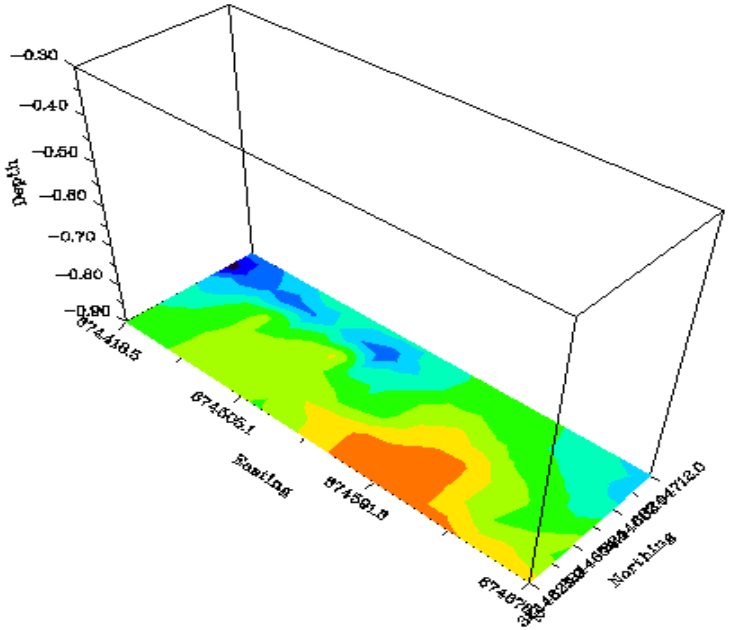


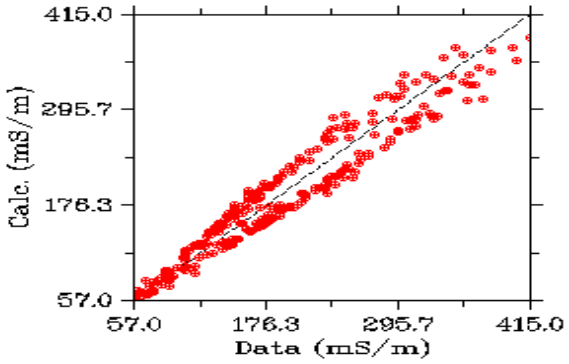
RMSE= 40 mS/m
R2 = 0.979

3D representation of True Apparent Conductivities (ECa) (mS/m) in 2020



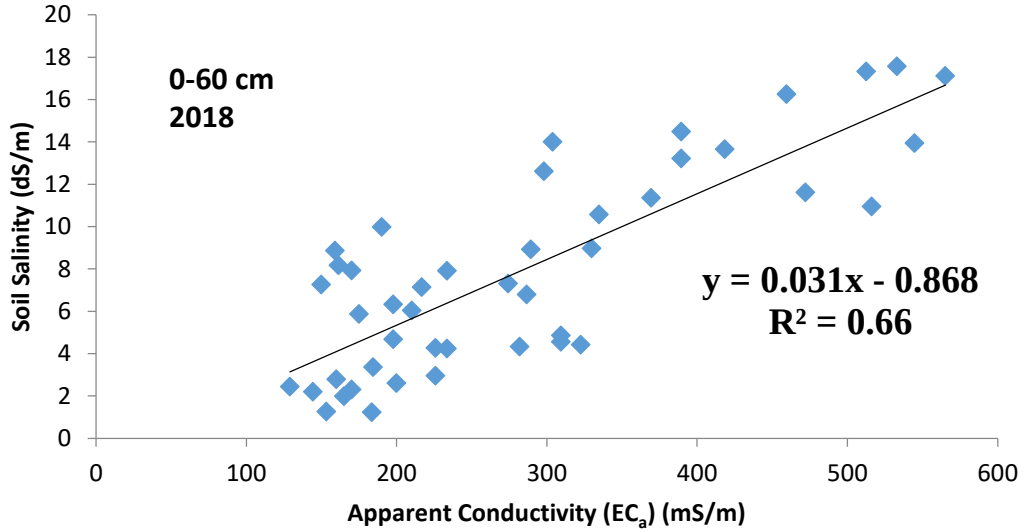


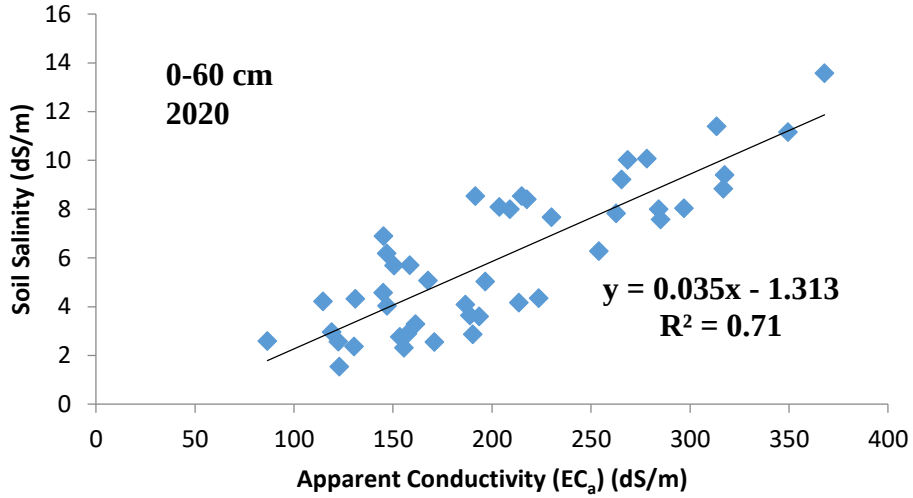


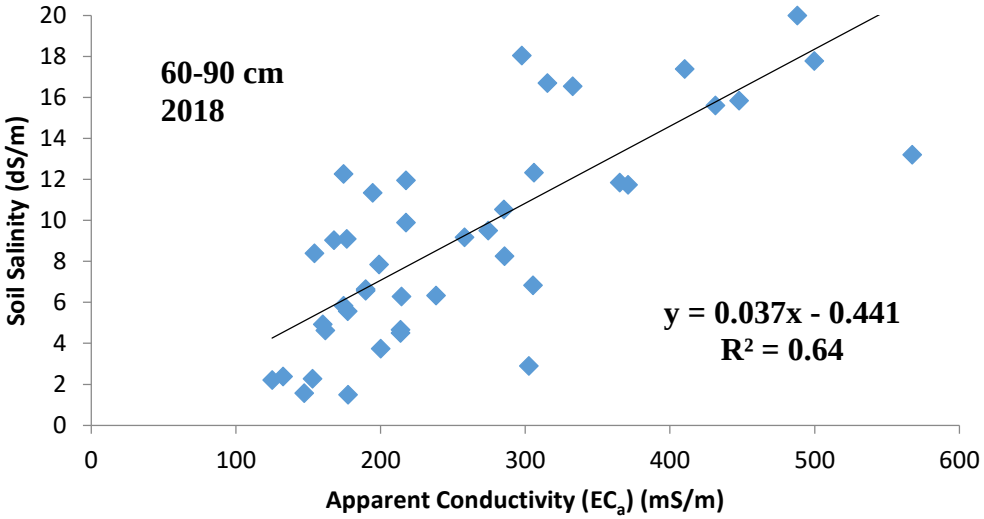


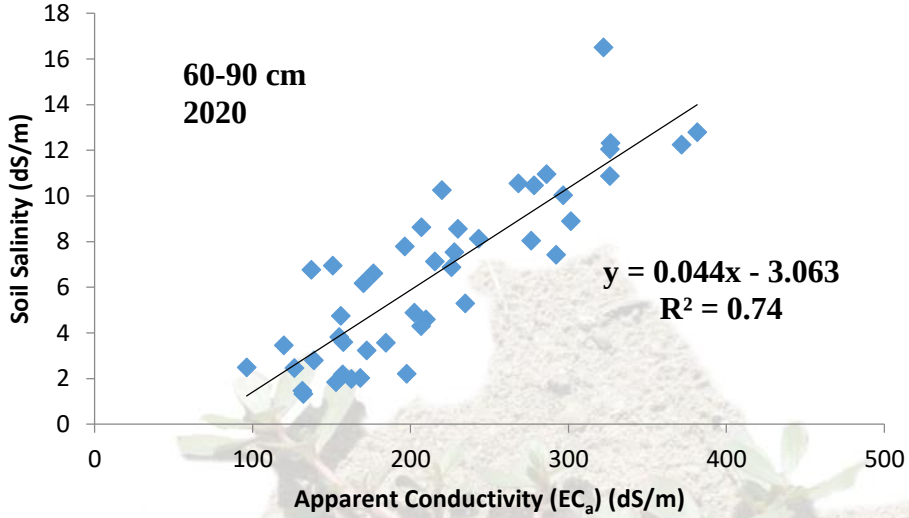
RMSE= 30 mS/m
R2 = 0.995

Model performance with observed Data set



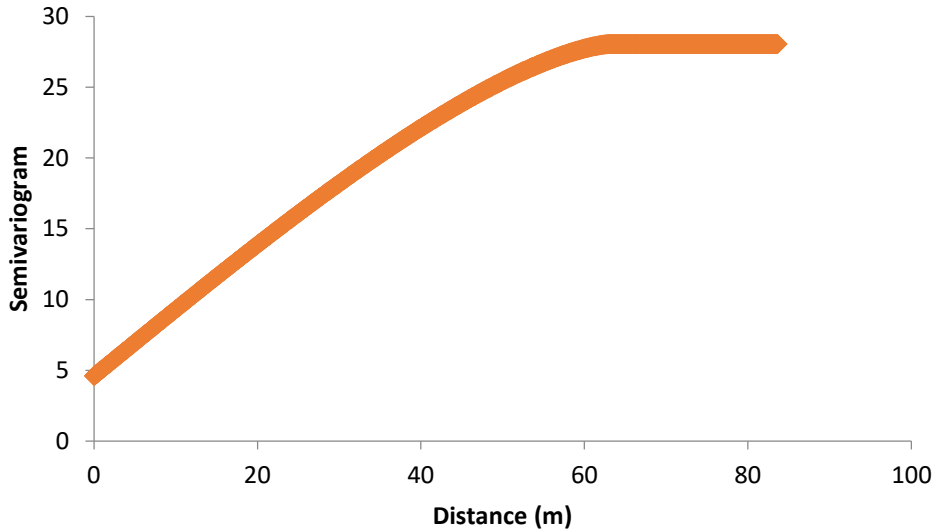




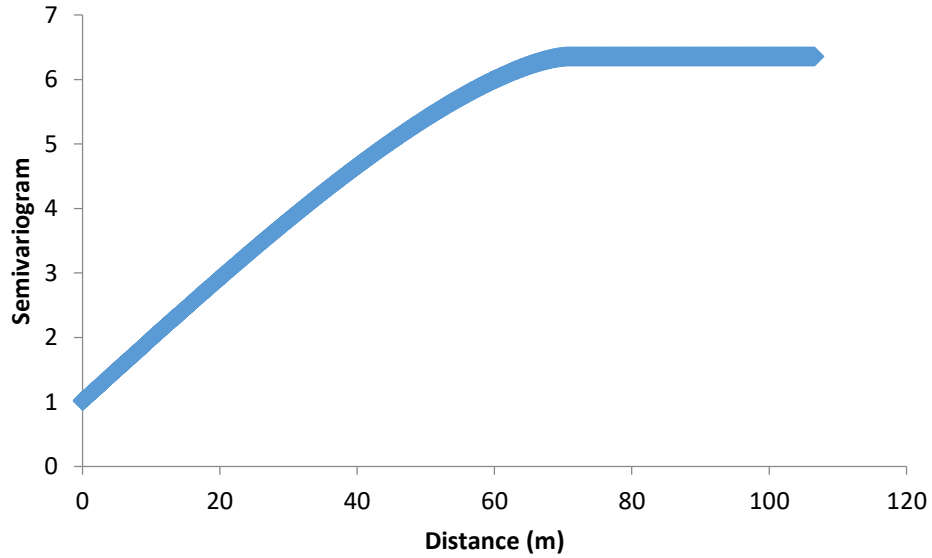


Geostatistics and Mapping Salinity (0-60 cm)

Method – Ordinary Krigging
Semivariogram model- Circular



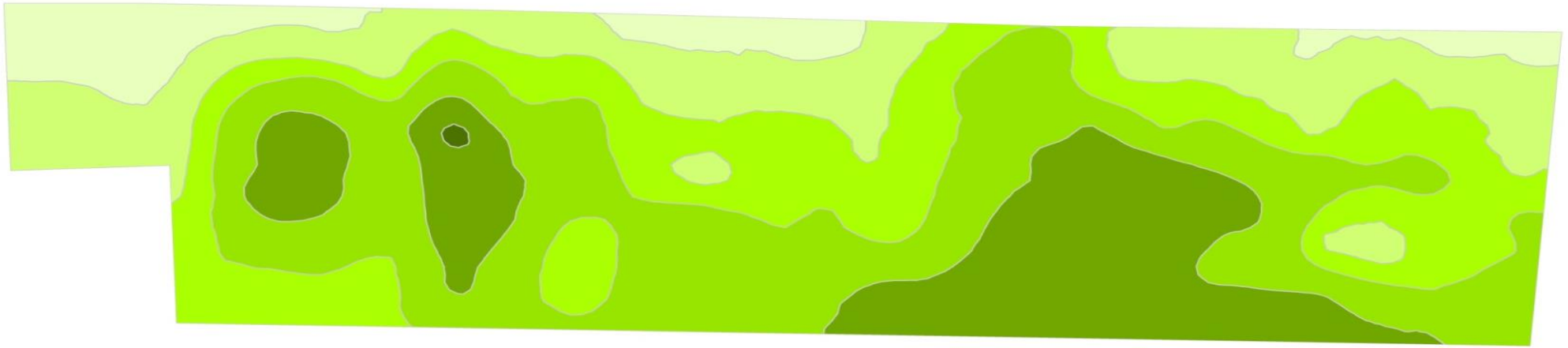
2018



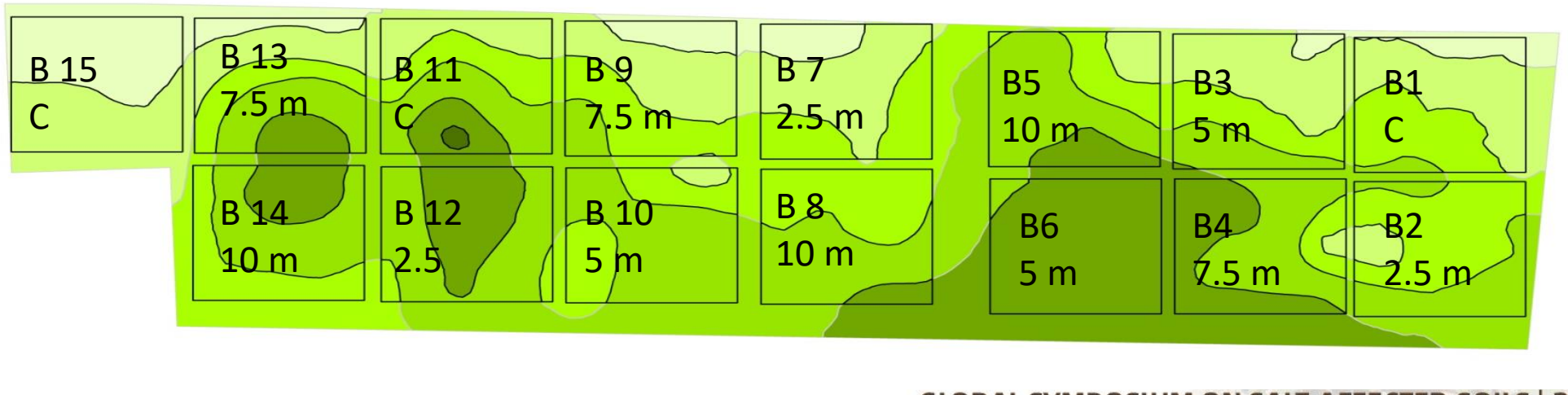
2020

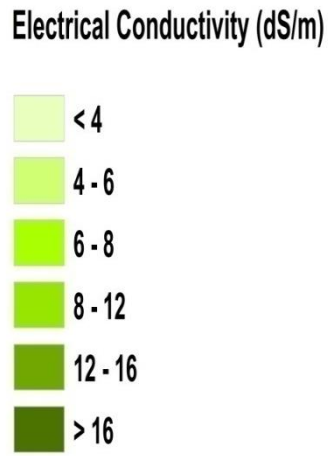
Year	RMSE	RMSSE	ASE	MSE
2018	3.2	1.09	2.9	-0.004
2020	1.48	1.12	1.31	0.004

Spatial map of Soil salinity (0-60 cm) before Cutsoiler(2018)

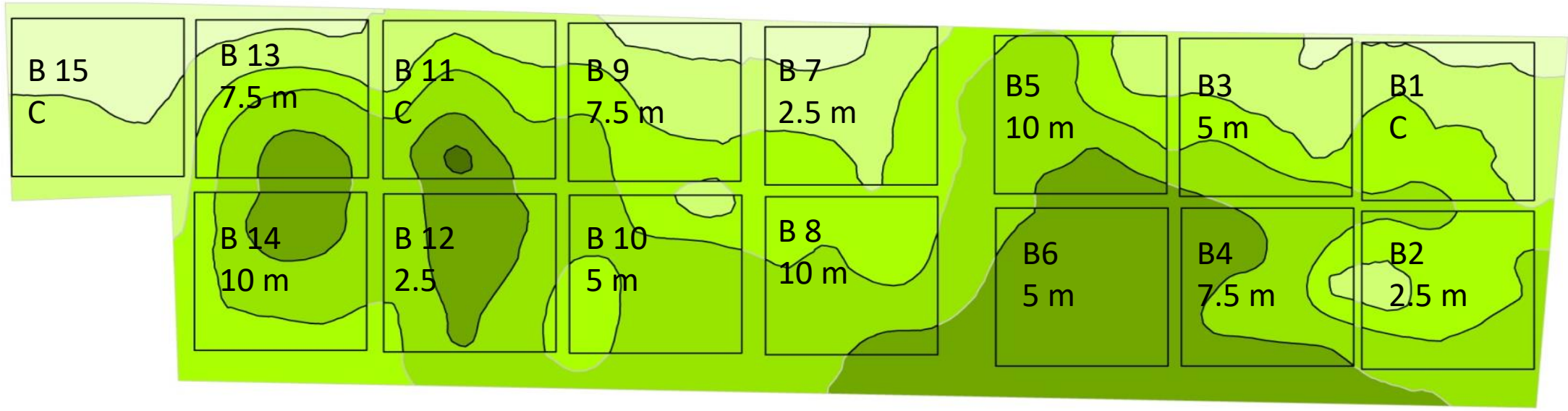


Spatial map of Soil salinity (0-60 cm) before Cutsoiler(2018) plot wise

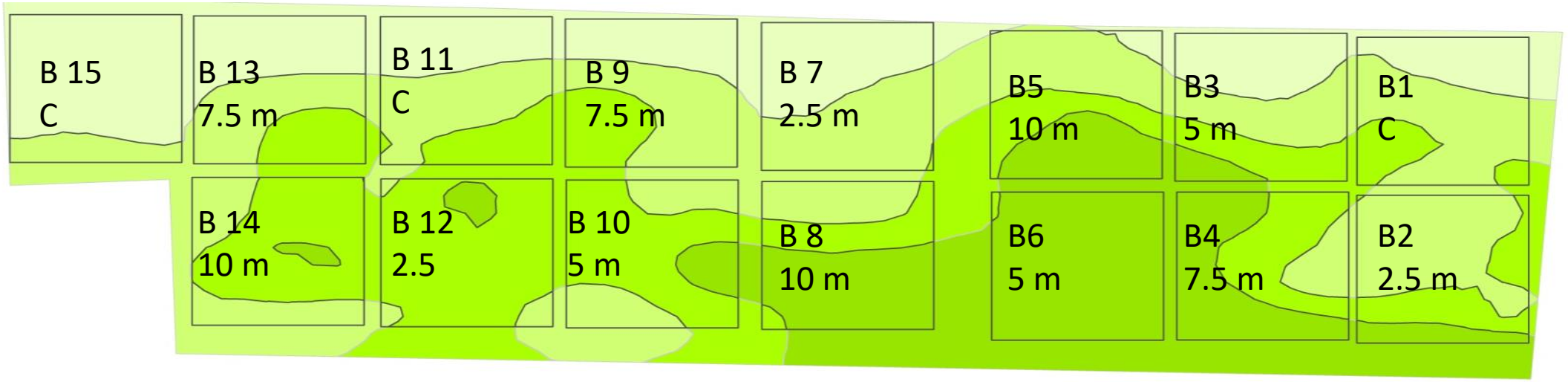


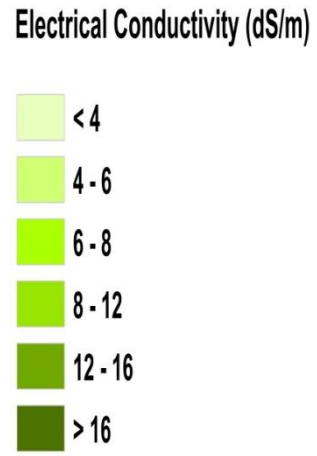


Spatial map of Soil salinity (0-60 cm) before Cutsoiler(2018)

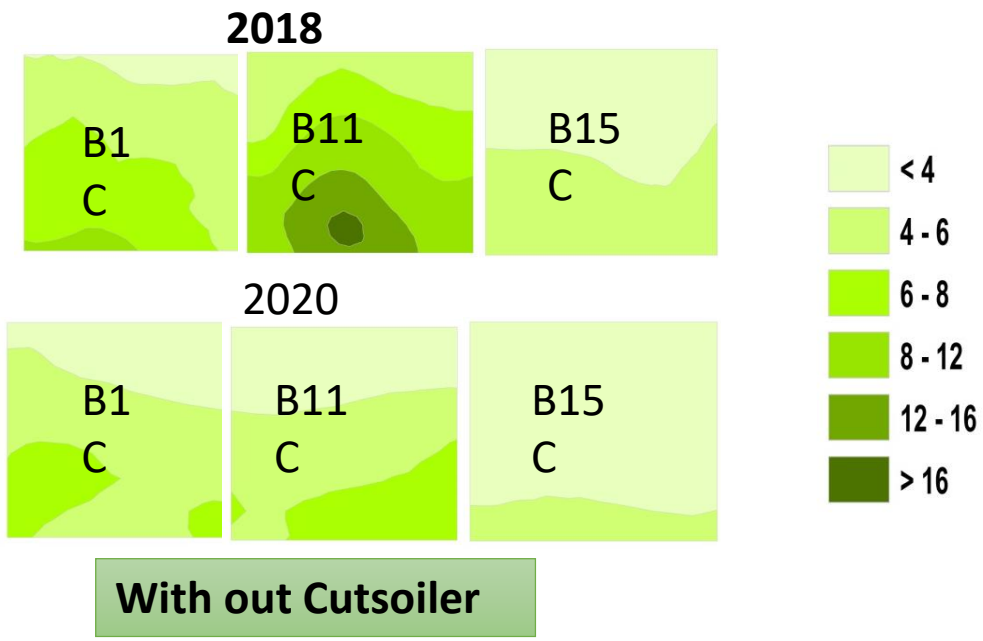


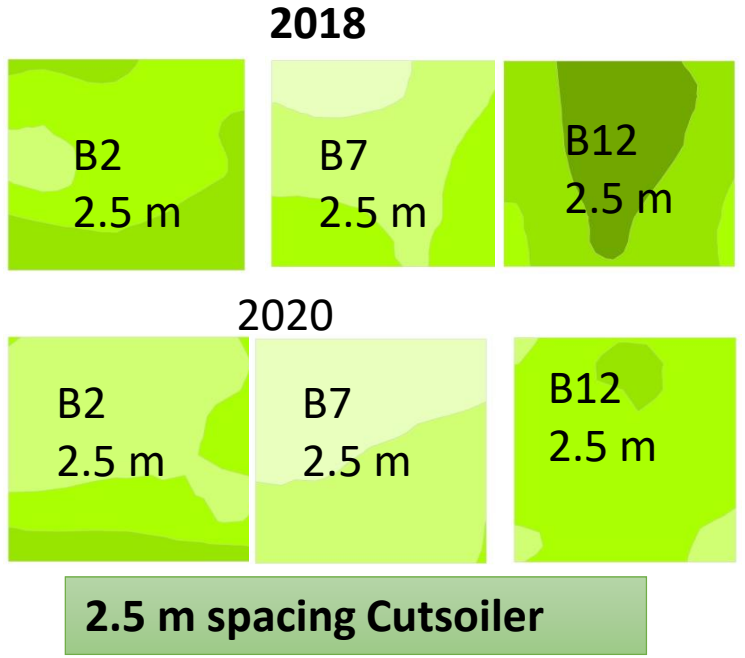
Spatial map of Soil salinity (0-60 cm) after 2 years of Cutsoiler operation (2020)





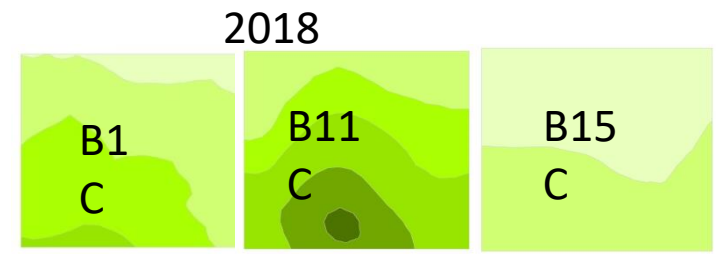
Soil salinity map (0-60 cm) before and after Cut soiler installation

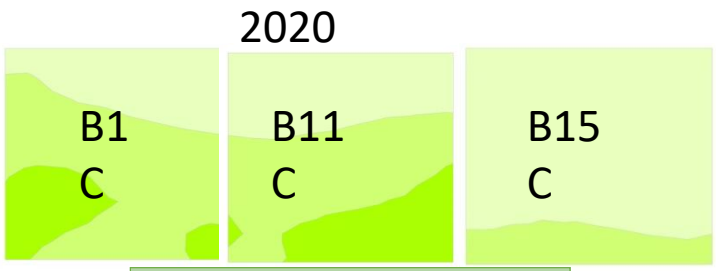




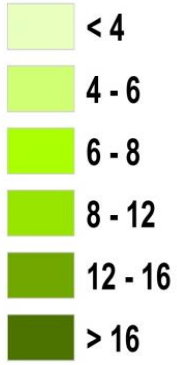
Saline category	Control (2018)	Control (2020)	% area Increase /Decrease	2.5 m (2018)	2.5 m (2020)	% area increase/ decrease
<4	21	49	28	5	16	11
4-6	39	38	-2	20	39	19
6-8	21	13	-8	33	39	6
8-12	13	0	-13	30	6	-24
12-16	5	0	-5	13	0	-13
>16	1	0	-1	0	0	0

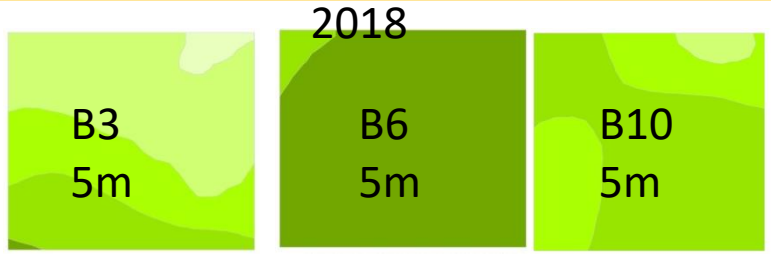
Soil salinity map (0-60 cm) before and after Cut soiler installation

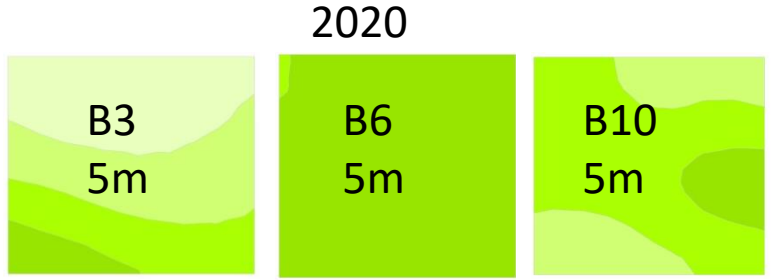




With out Cut soiler



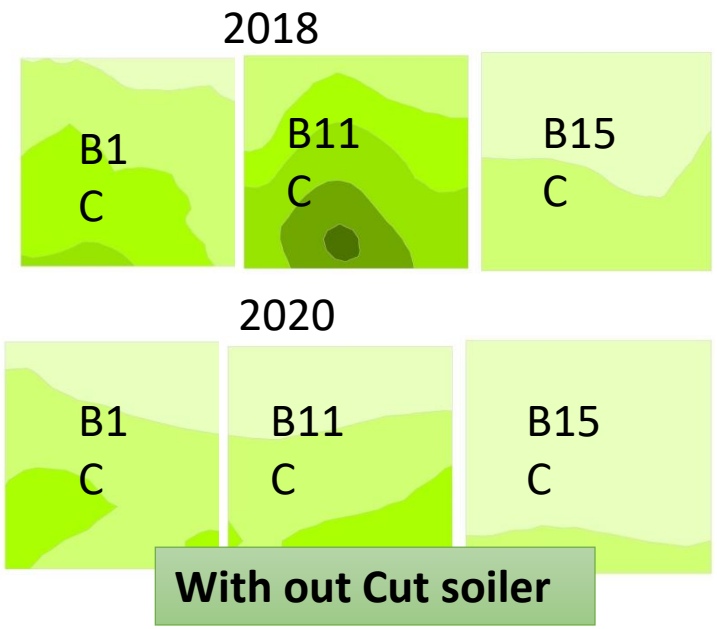


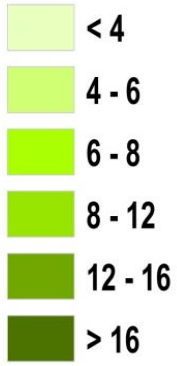


5 m spacing Cut soiler

Saline category	Control (2018)	Control (2020)	% area Increase /Decrease	5 m (2018)	5 m (2020)	% area Increase /Decrease
<4	21	49	28	1	13	11
4-6	39	38	-2	18	20	3
6-8	21	13	-8	19	28	9
8-12	13	0	-13	29	39	10
12-16	5	0	-5	32	0	-32
>16	1	0	-1	0	0	0

Soil salinity map (0-60 cm) before and after Cut soiler installation

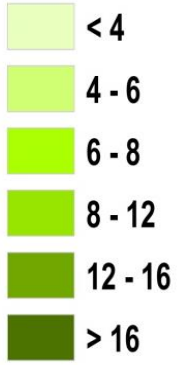


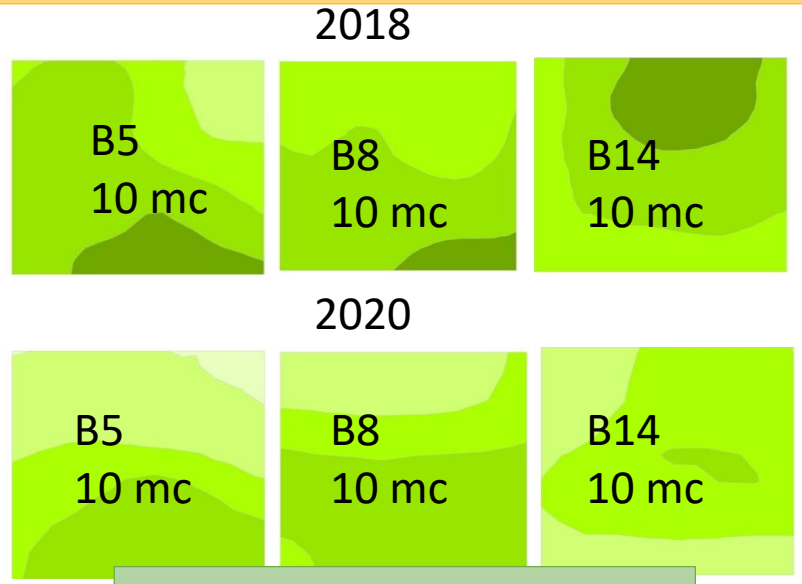


Saline category	Control (2018)	Control (2020)	% area Increase /Decrease	7.5 m (2018)	7.5 m (2020)	% area Increase /Decrease
<4	21	49	28	8	25	17
4-6	39	38	-2	24	31	8
6-8	21	13	-8	22	27	5
8-12	13	0	-13	28	17	-12
12-16	5	0	-5	18	0	-18
>16	1	0	-1	0	0	0

Soil salinity map (0-60 cm) before and after Cut soiler installation

With out Cut soiler





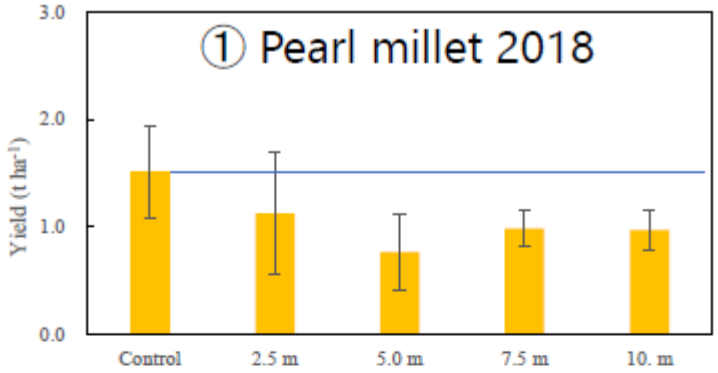
7.5 m spacing Cut soiler

Saline category	Control (2018)	Control (2020)	% area Increase /Decrease	10 m (2018)	10 m (2020)	% area Increase /Decrease
<4	21	49	28	0	1	1
4-6	39	38	-2	4	32	28
6-8	21	13	-8	32	37	5
8-12	13	0	-13	51	30	-21
12-16	5	0	-5	14	0	-14
>16	1	0	-1	0	0	0

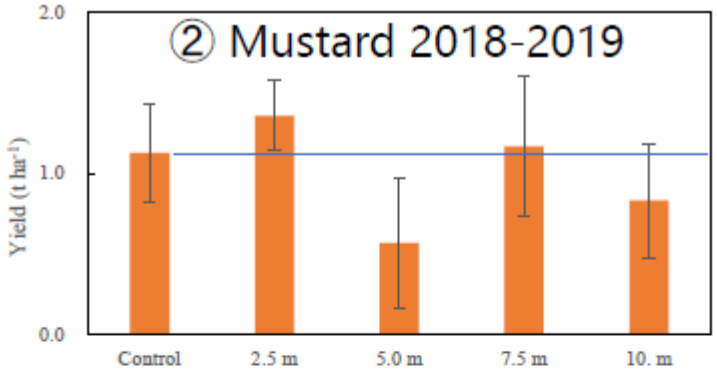
Pearl millet Crop

Mustard Crop

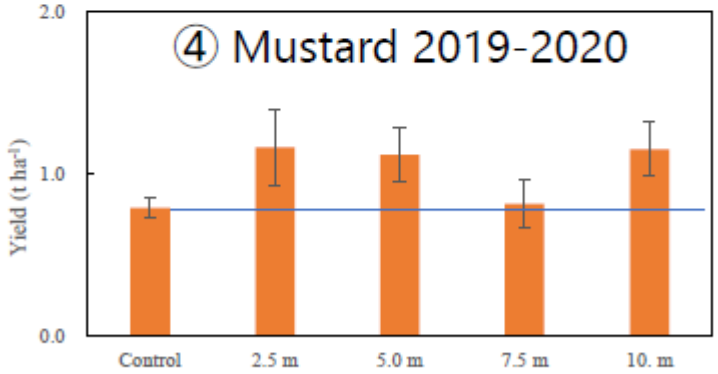
Yield under Cut-soiler



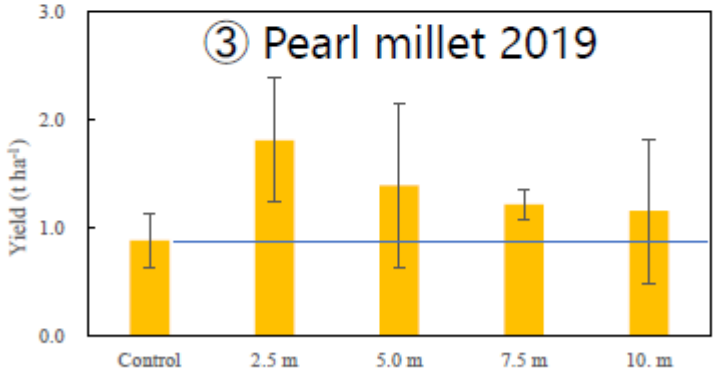
No Cut-soier > Cut-soier



Cut-soier (2.5 m & 7.5 m) > No Cut-soier



Cut-soier > No Cut-soier



Cut-soier > No Cut-soier

- Cut-soiler construction, the yield was improved
- 2.5 m pitch had highest yield

Summary and Conclusion

- **The cut soiler constructed at 2.5, 5.0 and 7.5 and 10.0 m spacing at 50 cm depth with straw as residue incorporation**

- **Spatio-temporal changes in salinity in upper (0-60 cm) and below (60-90 cm) cutsoiler depths was measured trough EM-38 techniques and modeled through quasi-3-dimensional inversion algorithm (EM4Soil)and mapped in GIS.**

- **Increase in non saline area and reduction in high and very high saline area (8-16 dS/m) under different cutsoiler spacing installation mainly be attributed to the draining out more salts through preferential path created by cutsoiler in subsurface layer**

- **Draining out excess salts in addition to natural leaching process improves the land and increase crop yield.**

GLOBAL SYMPOSIUM ON
SALT-AFFECTED
SOILS

THANKS FOR LISTENING

20 - 22
October, 2021
Virtual meeting

Team:

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