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Soil Conservation & Drainage Division
Ministry Of Agriculture

Using waste soil to rehabilitate degraded agricultural lands: Environmental burden as resource

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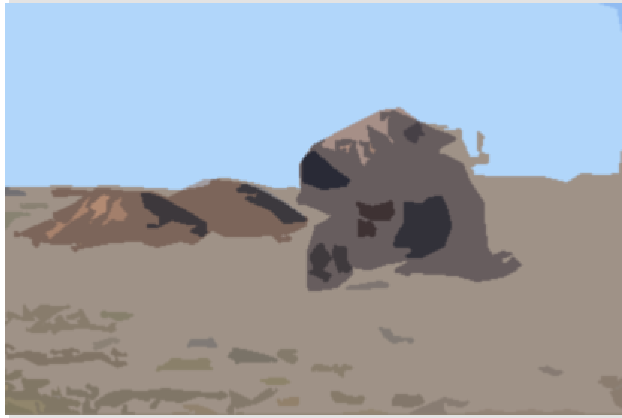

Background

- Global expansion of infrastructures is generating vast amounts of waste soil (soil excavated from construction sites that cannot be used on site).
- The amount of waste soil (WS) accumulated in the European Union (2014) was estimated at 463 x 10^6 tons.
- Piles of WS excavated from construction sites become an environmental nuisance when they are left on site.
- The regulation and management of WS disposal is currently limited to:
  1. Local use for various engineering projects
  2. Stockpiling on site for future use
  3. Transfer to landfills, which are currently overfilled, as padding material or for disposal
  - **Sustainable action are not common or taken for utilizing WS, of good quality, as a resource.**

Background

WS drawbacks

- Despite a number of permitted actions for handling WS, a significant portion of it is disposed of in the area surrounding the construction site, thus raising the risk of pollution and landscape spoilage.
- WS is commonly excavated from deep layers, and are therefore saline, sodic, and lack organic matter, preventing their use without pre-treatment.

WS gains

- Due to the intensification of crop production, one-third of the global agricultural land area is susceptible to soil loss by erosion, constituting ~50% of total estimated soil erosion.
- WS of good agricultural quality are a potential resource

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Background

Current state

- In Israel, the average volume of reusable WS is estimated at ~2x10^{6} m^{3}/year.
- To avoid the transfer costs and fees, large portion of WS is scattered in adjacent agricultural fields without a proper rehabilitation actions.
- Most of these WS are subjected to severe erosion, while accelerating land degradation processes.
- Local and regional environmental costs are nameless.

Objectives

GENERAL

Development of new approach for environmentally, agronomically and economically sustainable use of reclaimed waste soil to rehabilitate degraded agricultural lands.

SPECIFIC

1. Appraisal of national magnitude of waste soil volume, distribution and quality.
2. Estimating the application costs of WS, its environmental impacts and potential implementation strategies in degraded agricultural lands.
3. Utilizing WS as an amendment in degraded agricultural lands.

Results

Obj.1
National magnitude of waste soil volume, distribution and quality

- All national infrastructure projects, where its WS volume was above 100,000 m^3, were considered for the survey.
- 36 sites were surveyed, accumulating a total volume $1.7x10^6$ m^3 of WS.
- WS regulation processes were monitored:
  - Distances and costs of transfer to potential landfills locations
  - Governmental royalty and levy payments
- 16 out of 26 landfill sites were found relevant for this survey (excluding remote uninhibited desert sites)
- A laboratory analysis of WS properties -EC, pH, texture, SAR, OM and aggregate stability indicators was conducted over multiple locations.
- **Results revealed that approximately 25% of the WS fit for potential usage in agricultural degraded lands**

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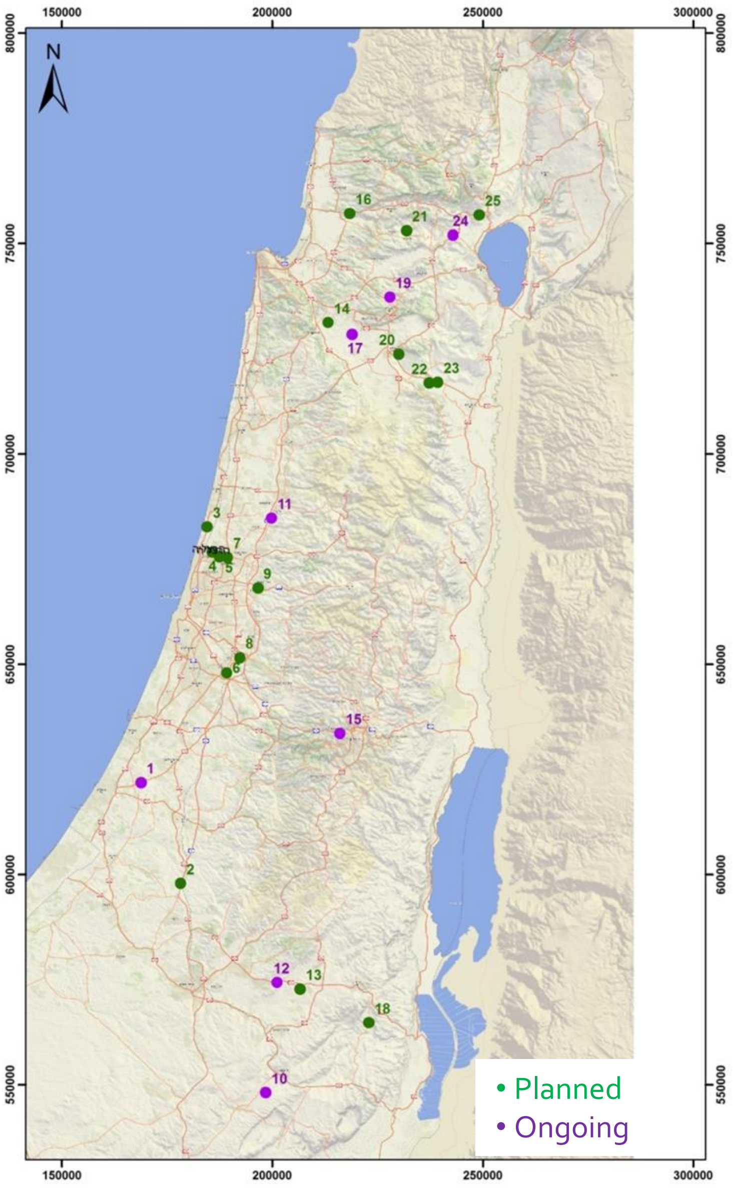
Results

Obj.1
National magnitude of waste soil volume and distribution

- At each site multiple properties were collected:
  - National and local geospatial distribution of WS piles
  - Operating authority
  - Project status
  - Pile construction methods
  - Excavated geological logs
  - Erosion hazard (wind and water)
- The preliminary survey revealed a significant lack of relevant procedures and regulations that prohibit an efficient usage of WS as a potential resource.
- Excavated soil quality was not taken into account while considering local and regional rehabilitation landscape planning, as well as using WS as an agronomic resource

National point of interest map



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Results

Obj.2
estimating the application costs in degraded agricultural fields and its environmental impacts

Off-farm economical impacts (Israel):

- A willingness to pay (WTP) survey, conducted to assess the social (consumer and stakeholders) perception, revealed that:
  - Landscape visibility of WS nuisance is high (67.1%) however it is not considered as and environmental hazardous
  - WTP for WS treatment, locally or remotely, was insignificant.
  - Demographics impacts showed that the total WTP is $85x10^6$ ILS
- The results of a minimum costs optimization model, aimed to minimize total transportation costs showed that the net benefit is estimated at $80.9x10^6$ ILS. An insignificant reduction of 4.8%.
- **These highlight the economical potential usage of WS in degraded agricultural fields, located nearby the excavated sites.**

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Results

Obj.3
Usage of WS as amendment in degraded agric. lands

WS properties vs local soils:

- WS chemical and physical properties are vital for high quality application in relevant fields.
- Susceptibility and applicability of WS to erosion (wind and water) and agronomic potential was tested on preliminary laboratory experiments and on field conditions.

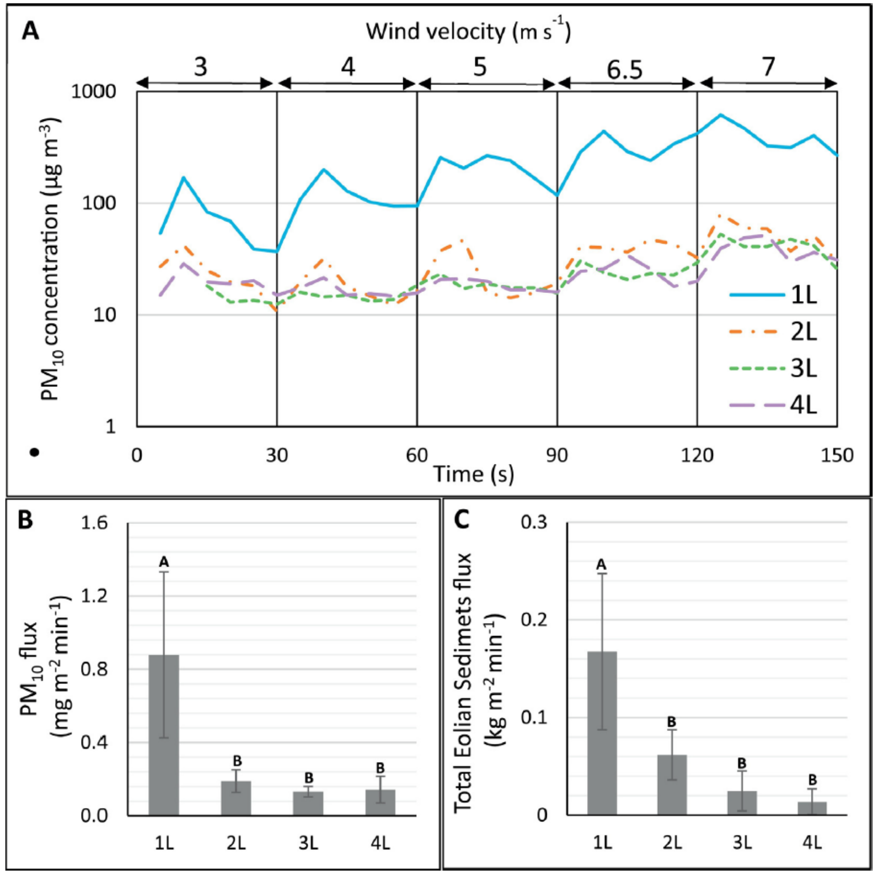
MWD	$CaCO_3$	sand	silt	clay	SAR	pH	EC	Depth	Source	Soil type
[mm]	%						[ds m^{-1}]	[m]		
0.90 (0.10)	18.78 (2.04)	52.3 (3.8)	16.8 (4.4)	30.9 (2.6)	0.56 (0.07)	7.50 (0.27)	0.59 (0.08)	0-0.2	Local soil	Loess
1.7 (0.30)	21.46 (0.04)	43.1 (0.0)	19.8 (1.5)	37.0 (1.5)	10.72 (0.27)	7.65 (0.12)	2.32 (0.04)	1<	WS	
#	41	24.4	24.4	51.3	0.5	6.9	0.2	0-0.15	Local soil	Rendzina
#	12.95 (3.89)	8.78 (2.57)	19.76 (0.34)	71.46 (2.91)	8.77 (1.55)	8.0 (0.0)	3.11 (0.48)	~0.3-0.7	WS	
1.28 (0.19)	11.85 (1.28)	12.64 (3.03)	18.01 (4.11)	69.35 (1.60)	0.57 (0.04)	8.18 (0.02)	0.67 (0.00)	0-0.3	Local soil	Vertisol
1.81 (0.18)	15.82 (1.50)	17.85 (4.11)	18.96 (2.70)	63.19 (1.54)	8.62 (0.24)	7.87 (0.05)	5.76 (0.07)	<2	WS	

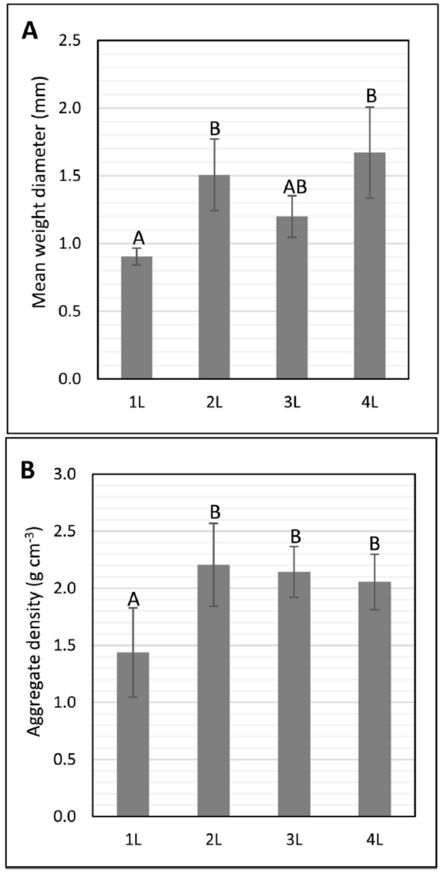
Results

Obj.3
Usage of WS as amendment in degraded agric. lands

Wind erosion:

- A laboratory wind tunnel experiments showed that WS from loess sites are significantly more susceptible for erosion comparing Rendzina and vertisols (Tanner et al., 2018)





1L – local agric. Soil
2-4L – excavated WS

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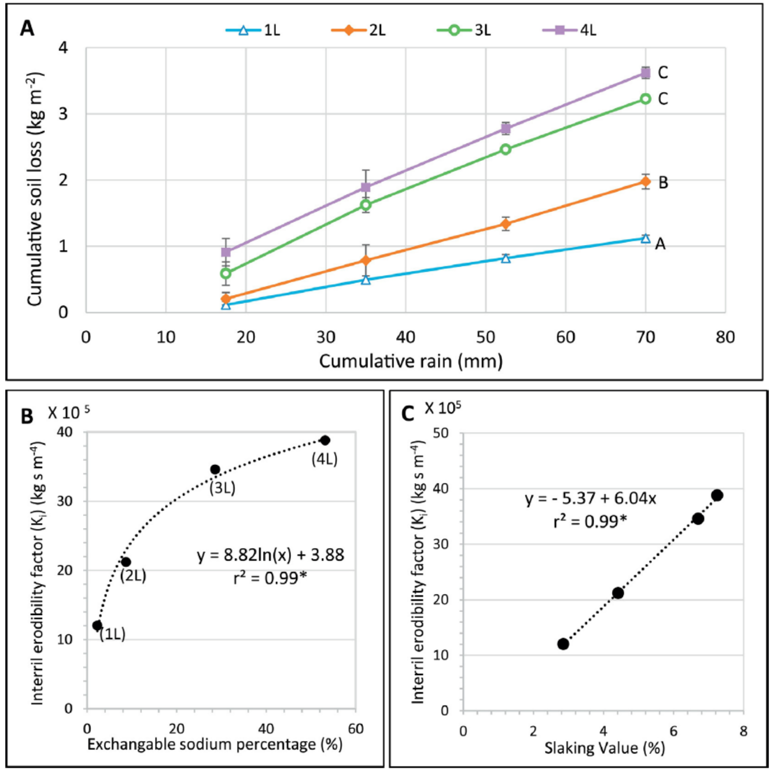
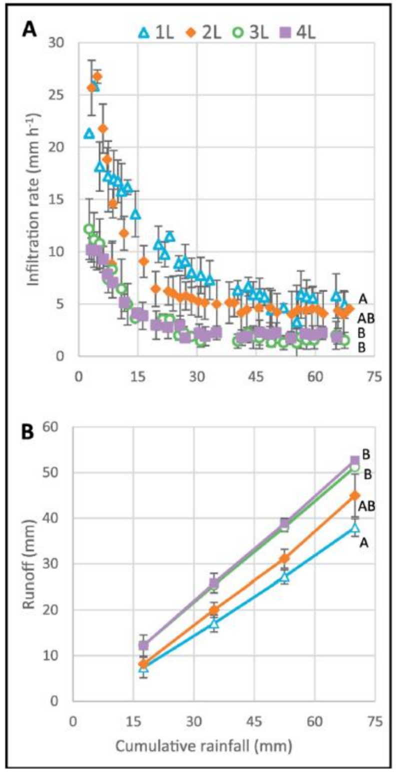
Results

Obj.3
Usage of WS as amendment in degraded agric. lands

Runoff and erosion:

- Laboratory rainfall simulations showed that, without an appropriate conditioning, WS from loess sites is significantly more susceptible to water erosion (Tanner et al., 2018)





1L – local agric. Soil
2-4L – excavated WS

- **Therefore, without preliminary treatment these WS are subjected to a severe erosion potential.**

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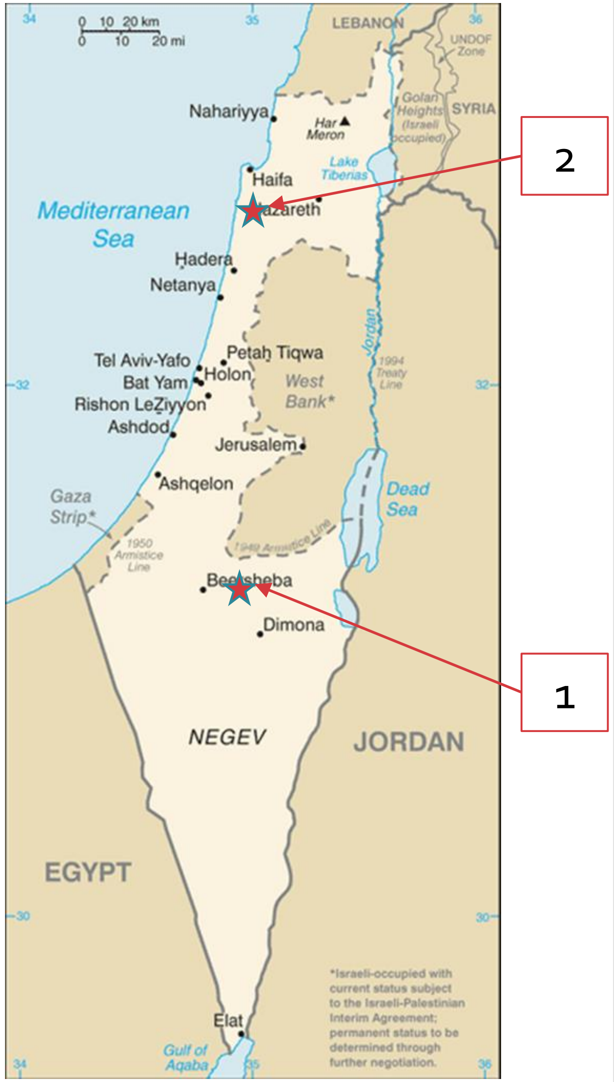
Results

Obj.3
Usage of WS as amendment in degraded agric. lands

On-farm impacts:

- WS chemical and physical properties are vital for high quality application in relevant fields.
- Susceptibility and applicability of WS to erosion (wind and water) and agronomic potential was tested on preliminary laboratory experiments and on-field conditions.
- A field study was conducted in two degraded agricultural locations in Israel, over two common soil types – Loess and Rendzina.
  1. Loess - Semi-arid Northern Negev region. ~ 40% of Israel agricultural lands.
  2. Rendzina - Menashe Heights. <15% of Israel agricultural lands.



Results

Obj.4
Utilizing WS as an amendment in degraded agricultural lands

Field study:

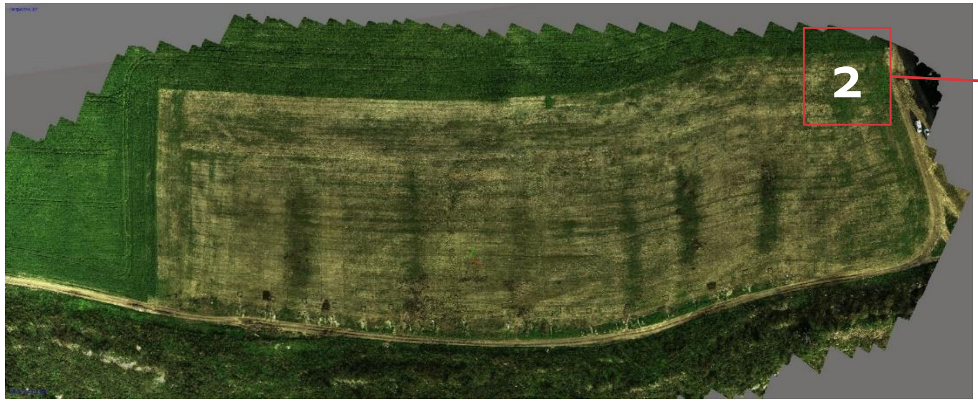
- Manipulations:
  1. **L** - Local soil, without amendments.
  2. **LM** – local soil with manure adding [50 m^3 ha^{-1}]
  3. **LE** – 30 cm of WS mixed with local soil (15+15cm), without amendments.
  4. **LEM** – 30 cm of WS with local soil (15+15cm) with manure adding [50 m^3 ha^{-1}]

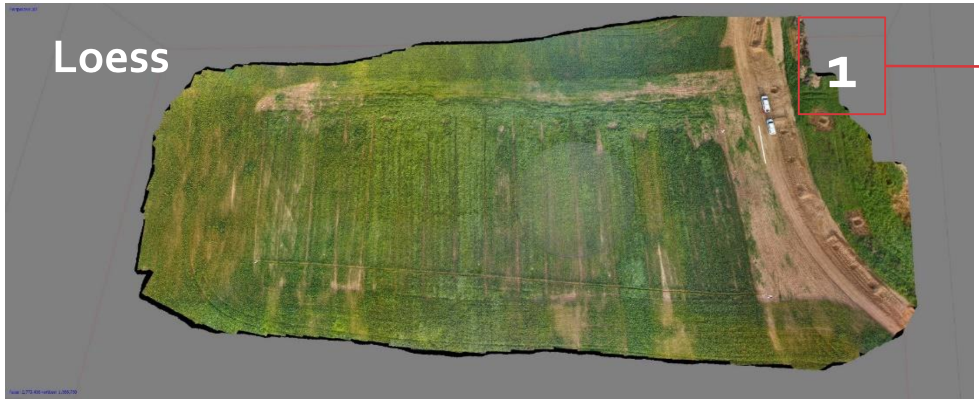
L and LM were considered as lower/upper control manipulations

Results

Obj.4
Utilizing WS as an amendment in degraded agricultural lands

Field study:





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Results

Obj.4
Utilizing WS as an amendment in degraded agricultural lands

WS adding impact on soil EC and SAR

- Mixture of WS with local soil, with and without manure, significantly mitigated EC and SAR values comparing initial rates.
- Post season measurements resulted with further decrease

MWD	$CaCO_3$	sand	silt	clay	SAR	pH	EC	Depth	Source	Soil type
[mm]	%						[ds m⁻¹]	[m]		
0.90 (0.10)	18.78 (2.04)	52.3 (3.8)	16.8 (4.4)	30.9 (2.6)	0.56 (0.07)	7.50 (0.27)	0.59 (0.08)	0-0.2	Local soil	Loess
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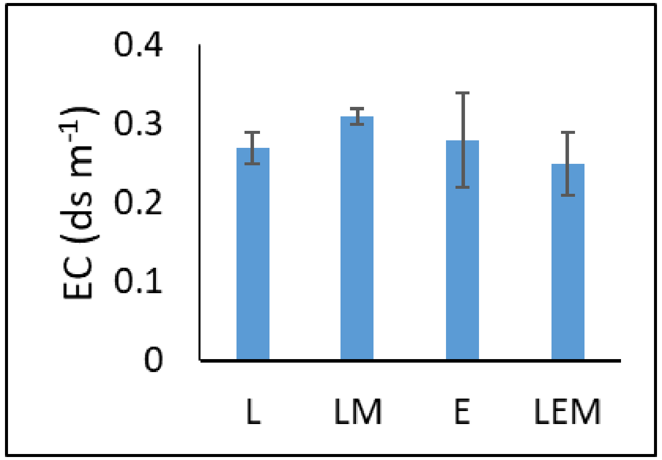
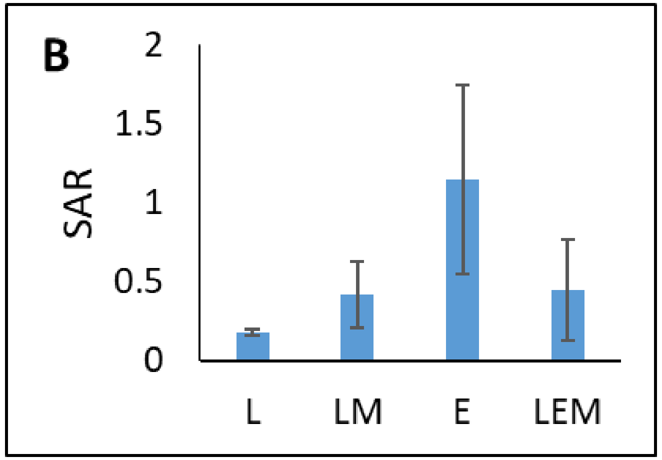
Rendzina





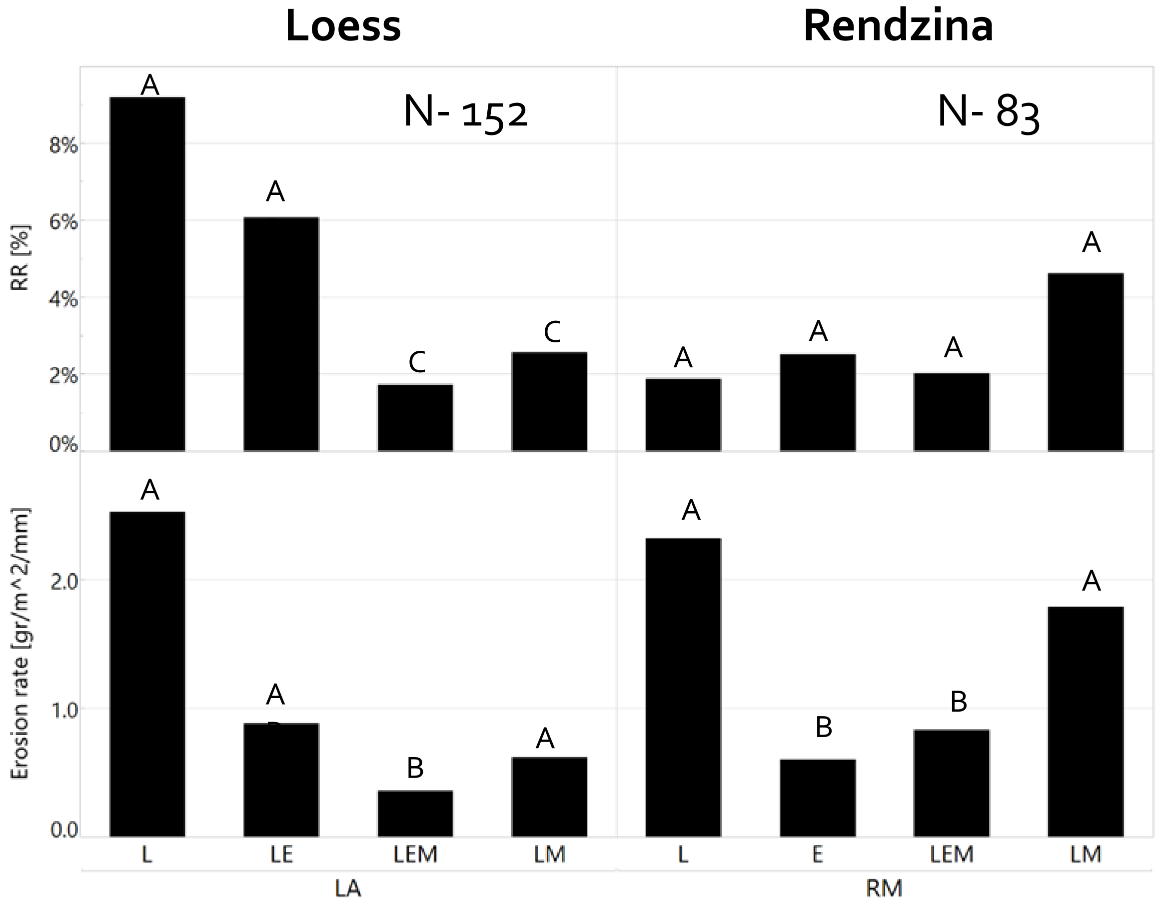
L – local soil; LM – local soil with manure; E – WS; *LEM – local soil mixed with WS and manure*

Results

Obj.4
Utilizing WS as an amendment in degraded agricultural lands

Runoff and erosion rates

RR – runoff-rainfall ratio
N – measured runoff/erosion events



L – local soil; LM – local soil with manure; E – WS; ***LEM – local soil mixed with WS and manure; LE – local soil mixed with WS***

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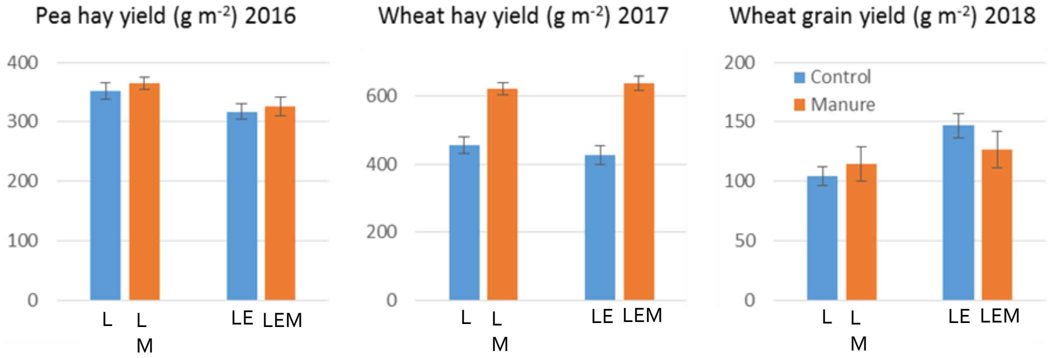
Results

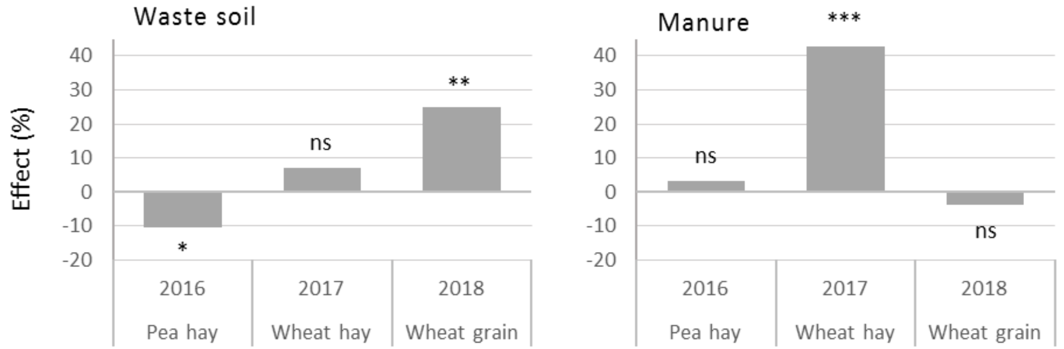
Obj.4
Utilizing WS as an amendment in degraded agricultural lands

Yields

- On both sites the insignificant reduction was observed following the application of WS, related to yield production.
- In loess soils, the accumulative effect of WS adding was positive two years following the application.
- In rendzina soils, a positive impact reached over the first growing year.

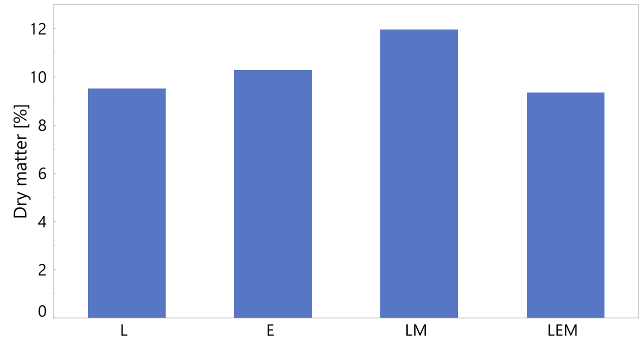
Annual yields comparison





Loess

Rendzina



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Results

Obj.4
Utilizing WS as an amendment in degraded agricultural lands

On-farm economical impacts (Israel):

- WS application costs (once in 20 year)
  - Transportation to a nearby field – 0.0 ILS
  - Waste Soil Scattering and mixture with local soil (30 cm depth) – 9500 [ILS ha^{-1}].
- Manure application costs (a 4-year application)
  - scattering and mixture with local soil at a rate of 50 m3 ha^{-1} (30 cm depth) – 2850 [ILS ha^{-1}].
- Yield production difference costs (ILS ha^{-1}), comparing control [L]
  - Loess soils
    - Y1 – LE – [-] 1200; LM – [-] 200; LEM – [-] 2140 (legume hay)
    - Y2 – LE – [-] 170; LM – [+] 1000; LEM – [+] 1100 (cereal hay)
    - Y3 – LE – [+] 760; LM – [+] 190; LEM – [+] 400 (cereal grain)
  - Rendzina soils
    - Y1 – E – [+] 760; LM – [+] 2160; LEM [+] 1740 (legume hay)

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Summary

Off-site

- A total sum of $1.7x10^6$ m^3 excavated WS were recorded in the current survey (~85% of potential WS on relevant locations).
- Results revealed that approximately 25% of these WS are reusable in degraded agricultural fields.
- An appropriate in-site (infrastructure) management can significantly improve reuse potential in nearby locations.
- A minimum cost optimization model showed:
  - An insignificant net benefit improvement of ~5.0% while considering source-sink enhancement geospatial distribution (Becker et al,. 2020*).
  - Utilizing WS of acceptable agronomical quality can significantly reduce transportation costs by 89%, while shifting these WS to relevant fields.
- Without an appropriate treatment WS are subjected to a severe wind and water erosion (Tanner et al., 2018)

* **Land use policy, Under review**

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Summary

On-site

- Two field site used for WS application, in Israel.
- Many of these were degraded rapidly over the past decades.
- Loess soils
    - Manure adding with WS resulted with the lowest RR and erosion rates comparing local soils
    - WS without manure amendments provided an insignificant lower RR rate.
    - A negative impact of WS adding was observed on the first growing year.
    - Following the third growing year, a significant positive difference was observed comparing the control plots.
    - An economical equilibrium reached by the third growing year
- Rendzina soils
    - Usage of WS with/without manure amendments over a severely degraded agricultural lands significantly reduced erosion rates
    - No impact was observed on RR rates and biomass production
    - An economical enhancement reached at the first growing year

* **Land use policy, Under review**

Thank you

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