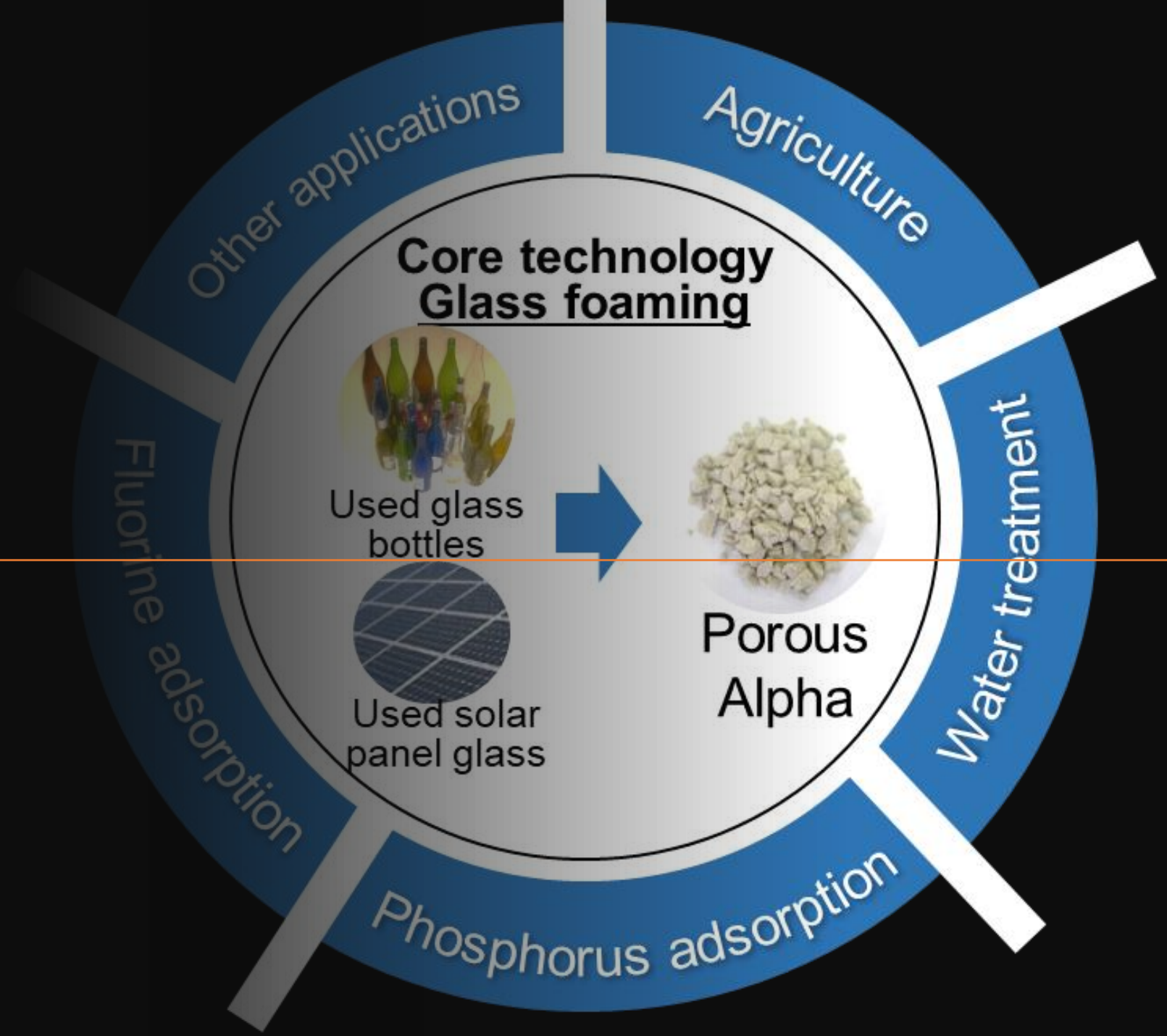
Porous Alpha

ONE SOLUTION

MULTIPLE APPLICATIONS

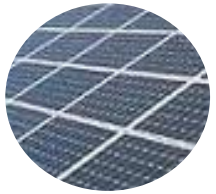
SOIL CONDITIONING



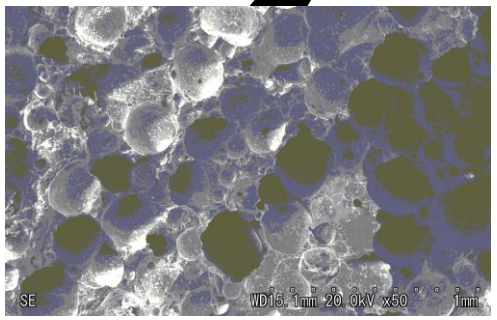
Our technology is centered at foamed glass “Porous Alpha” from used glass, developing its application

Used Glass bottles

Glass in outdated solar panel



Porous Alpha



Electron microscope image of Porous Alpha

Transformed for each application

Application

- Air treatment as biofilter media
- Water treatment: Adsorption and recovery of fluorine
- Water treatment: Adsorption and recovery of Phosphorus ion
- Water treatment: Biofiltration
- Soil conditioning: improving water retention capacity and aeration capacity
- Weed prevention for solar park
- Rooting media for hydroponics
- …etc.

Porous Alpha is made by burning of mixture of pulverized glass and foaming agent

Glass waste

Production line of Porous Alpha (Illustrative)

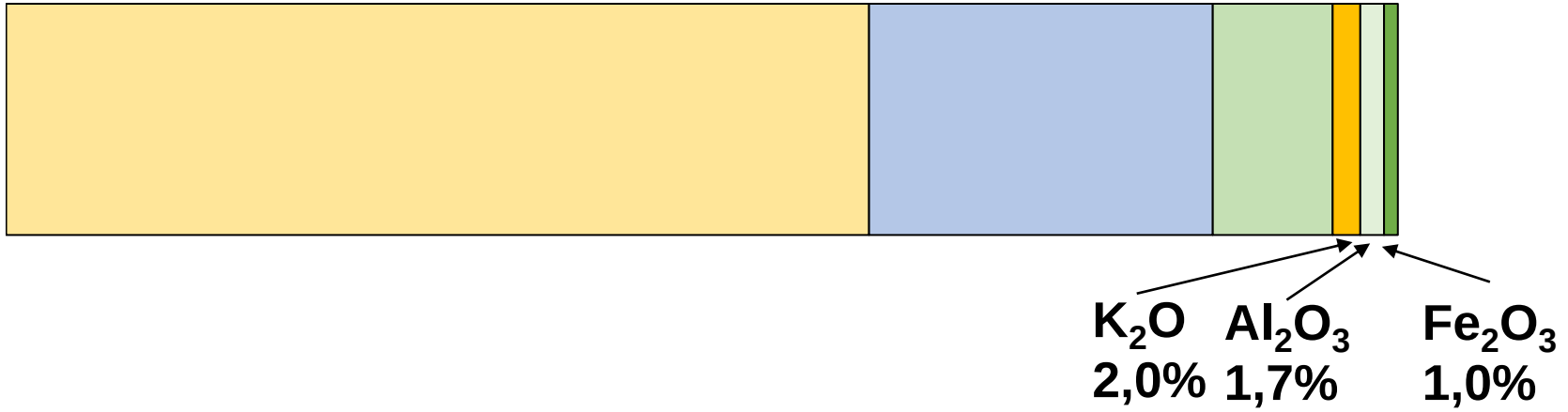
Crushed glass

Powder glass

Foamed glass
= Porous Alpha

Porous Alpha is mainly composed of silica and calcium oxide, similar to the chemical composition of natural sand

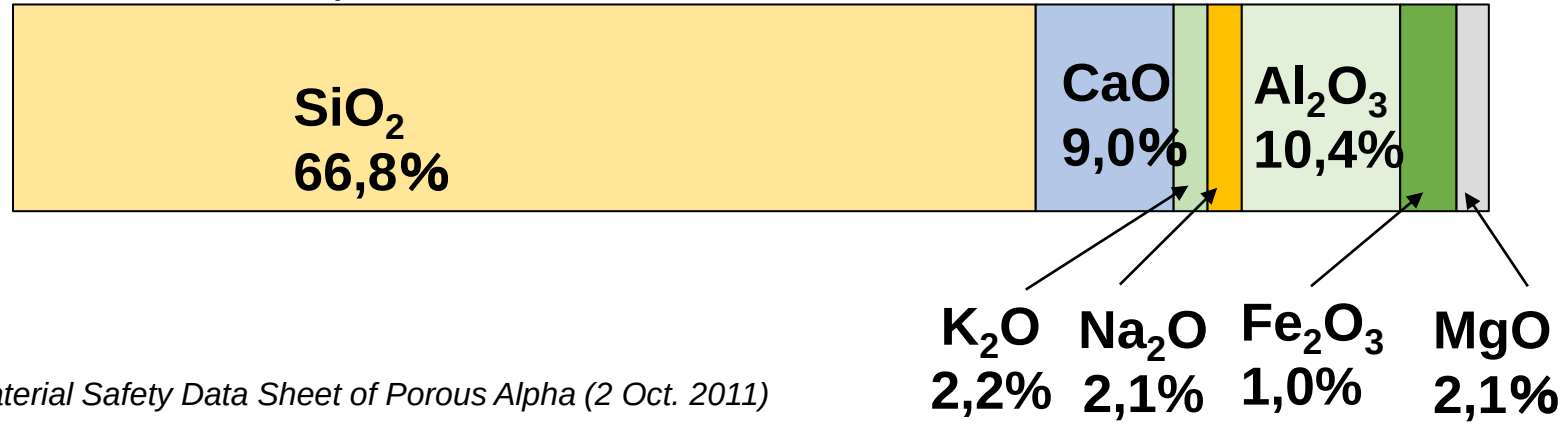
Main chemical composition of Porous Alpha*



Other minor components (less than 1%)

Ti, Cr, Mn, Ni, S, etc

Chemical composition of natural sand in Taklamakan Desert in China



** Material Safety Data Sheet of Porous Alpha (2 Oct. 2011)*

Physical characteristics is as follows

Based on Material Safety Data Sheet of Porous Alpha , Oct 2011

- Visual appearance: Achroma or light green etc.
- Odor: Odorless
- True density: ca 2,5 g/c㎥
- Size density: 0,9 ≈ 1,2 g/c㎥
- Grain size: 50 ≈ 2.000 μm (Median 700μm)
- Grain shape: Abrasive infinite shape
- pH: Max. pH 10,3 or pH 7(after water washing)
- Solubility: Not identified
- Softening temperature: 720 ≈ 730℃(unresolved)
- Volatile: not identified

Porous Alpha has three uniqueness which are the base for our diversified applications

Uniqueness	Competitors' products	Merit by the uniqueness
1 No-elution of heavy metal	Heavy metal elution is not avoidable	▸ Range of acceptable raw material (glass) is wider than competitors' products ▸ Widen range of application by safety nature - Usable for agriculture as soil conditioner - Not contaminating the treated water when used as water treatment agent
2 Coexistence of Interconnected and closed pore	Only closed pores	▸ Possible to contain diversified matter and microbes - Diversified microbes for deodorizing - Water and air for soil conditioner ▸ Air and water are permeable - Perform as water treatment agent by sinking in water
3 Adjustable specific gravity and pore size	Constant specific gravity	▸ Adjustable to the requirement by application and environment

Under the Japanese regulation, Porous Alpha can be used as a soil for agriculture without environmental impact

Result of leaching test based on the “Environmental regulation regarding the soil pollution”, 23 August 1991, Ministry of Environment, analyzed by Tottori Health Association

No.	Item	Result	Criteria
1	Alkyl mercury	Not detected	Not detected
2	Total mercury	< 0,0005 mg/l	0,0005mg/l
3	Cadmium	< 0,001 mg/l	0,01mg/g
4	Lead	0,001 mg/l	0,01mg/l
5	Organophosphorus	Not detected	Not detected
6	Hexavalent chromium	0,014mg/l	0,05mg/l
7	Arsenic	< 0,001mg/l	0,01mg/l
8	Total cyanogen	Not detected	Not detected
9	PCB	Not detected	Not detected
10	Trichloroethylene	< 0,03 mg/l	0,03mg/l
11	Tetrachloroethylene	< 0,01 mg/l	0,01mg/l
12	Dichloromethane	< 0,02 mg/l	0,02mg/l
13	Carbon tetrachloride	< 0,002mg/l	0,002mg/l
14	1,2 – Dichloroethane	< 0,004 mg/l	0,004mg/l

No.	Item	Result	Criteria
15	1,1 – Dichloroethane	< 0,02mg/l	0,1mg/l
16	Cis1,2 – Dichloroethylene	< 0,04 mg/l	0,04mg/l
17	1,1,1 – Trichloroethane	< 0,3 mg/l	1mg/l
18	1,1,2 – Trichloroethane	< 0,006 mg/l	0,006mg/l
19	1,3 –Dichloropropene	< 0,002 mg/l	0,002mg/l
20	Thiuram	< 0,006 mg/l	0,006mg/l
21	Simazine	< 0,003 mg/l	0,003mg/l
22	Thiobencarb	< 0,02 mg/l	0,02mg/l
23	Benzene	< 0,01 mg/l	0,01mg/l
24	Selenium	< 0,001 mg/l	0,01mg/l
25	Fluorine	< 0,08 mg/l	0,8mg/l
26	Boron	< 0,1 mg/l	1mg/l
27	Copper	< 0,5 mg/kg	125mg/kg

The global food production should be significantly increased with limited expandable arable land

Required food increase by 2050

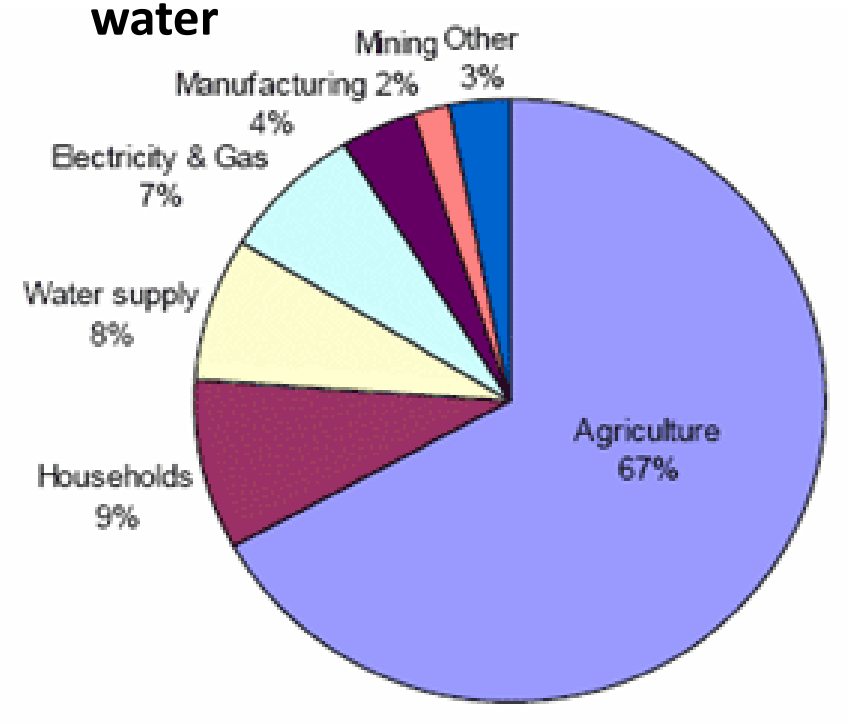
Expandable arable land for agriculture

Yield-increase and transformation of arid-zone into agriculture area are part of the keys to achieve increase of food production

Source: How to Feed the World in 2050, FAO

Though the increase of yield normally means the increase of water consumption, the available water is limited

- **Agriculture consumes lots of water**



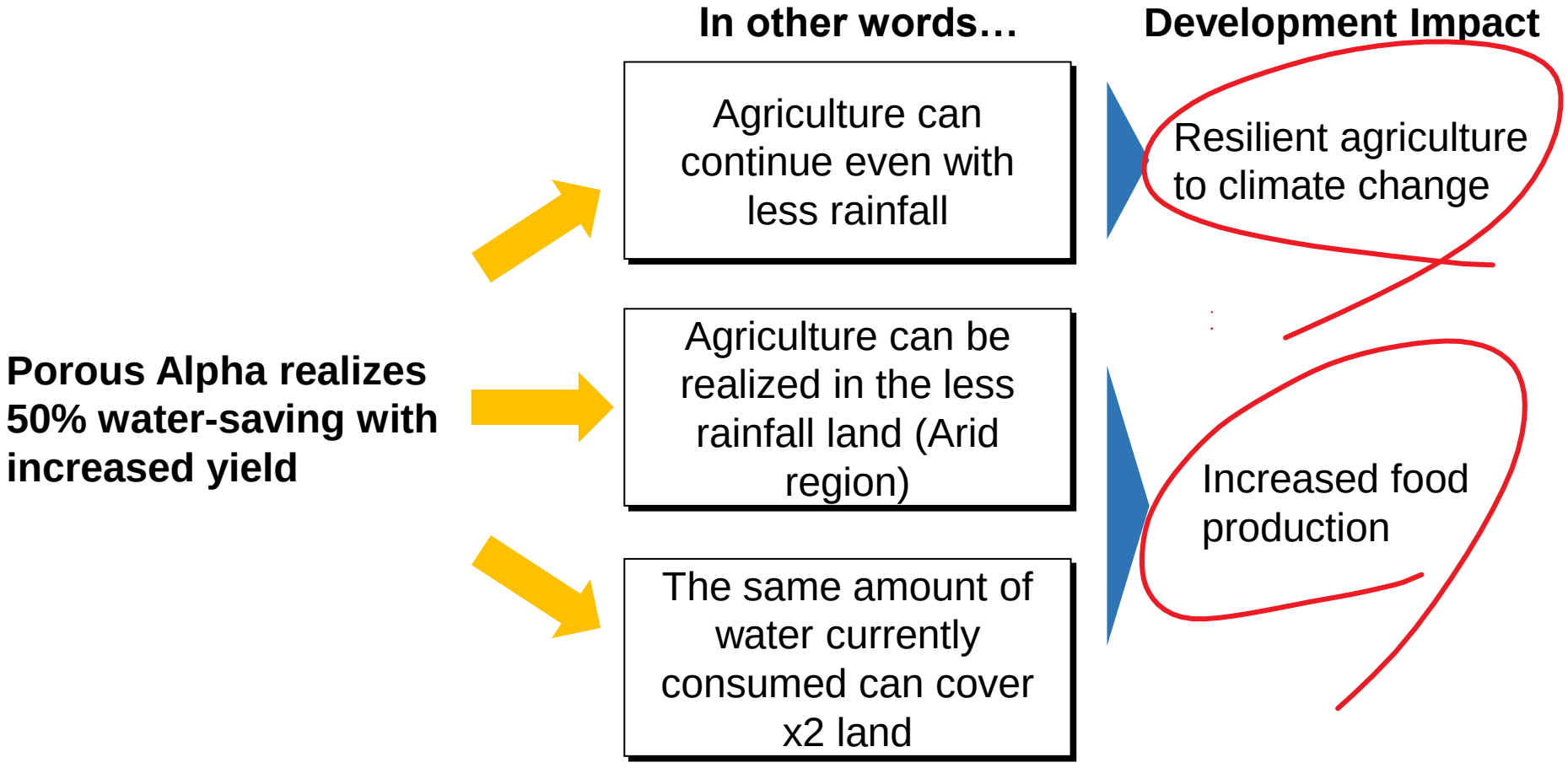
Utilisation of water all over the world(2005)*

- The precipitation is decreasing in some areas
- Recent droughts
  - Horn of Africa
  - South Africa
  - Mozambique

There’re limitation on the available land and the available water

* http://www.climate.org/topics/water.html

Water-saving contribute increased food demand under climate change



Mixing Porous Alpha for sandy soil or argillaceous soil realize improved yield with less water consumption

- Water saving is critical issue for agriculture in arid zone mainly in Middle East and Africa where
  - Morocco, no.4 biggest exporter of tomato, has their production base in arid zone close to Sahara desert
  - Without effective water utilization, agriculture cannot be sustainable

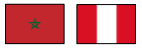
- Water scarce can be the direct cause of conflict

- Drip irrigation is good solution for water saving, but not enough
  [Case in Morocco]
  - Most of export tomato farmers in Morocco use drip irrigation
  - Nevertheless, groundwater level is getting deeper every year. Currently many farmers pump up the water from 200 – 250 m below surface.
  - Water related cost for agriculture is now 10 – 15%, which has been increasing

- Utilization of Porous Alpha as soil conditioner can realize water saving with increased yield

Porous Alpha realizes various value propositions

List of example development challenges where Porous Alpha can contribute to solve

Problems	Values realized by Porous Alpha (Countries with our project)
Farmers' income needs to be improved. Water and/or soluble fertiliser cost is high and/or scarce. 	**Increased profit for farmers** Farmers can realise more profit with increased yield and/or reduced cost by water-saving and fertilizer saving
Mitigation to shortage of rainfall or drought is required 	**Increased resilience to climate change (shortage of rainfall)** Farmers can continue the agricultural activity during shortage of rainfall and/or mitigate the impact by drought
Too much water is now pumped up at unsustainable level. 	**Water resource conservation** If farmers are using underground water too much, the usage of Porous Alpha can conserve the underground water resource by reducing required water quantity
Though arable land exists, the restriction or limitation to water resource prevents the expansion 	**Farm expansion without increase of water consumption** Arable but uncultivated land due to the shortage of water resource can be converted without increasing water consumption
Land exists. The rainfall is too short for agriculture	**Conversion of dry / arid non-arable land into arable land** Dry / arid area where the available water resource is too low for existing irrigation method can be converted into arable land because the required irrigation water volume can be half
Water reservoir is required. However the construction and maintenance cost of the reservoir is too high.	**Reduction of reservoir construction cost** To cover same land area, as the required water volume can be half, the required size of reservoir, operating cost and maintenance cost can be smaller
Too much time and effort are consumed to secure the water for agriculture.	**Reduction of workload to secure the water** As the required water volume can be reduced, the workload to secure the water can be half, by which the saved time to secure the water can be used for other activities
Soil aeration is so limited due to clay soil, which causes low productivity 	**Improvement of aeration and infiltration in clay soil** Improved aeration and infiltration realize the increase of productivity.
There's risk of soil salinization due to the high usage of soluble fertilizer.	**Prevention of soil salinization** If farmers are using liquid fertiliser (fertigation), the reduction of fertilizer can contribute to prevent or mitigate the risk of soil salinization

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26	Boron	< 0.1 mg/l	1mg/l
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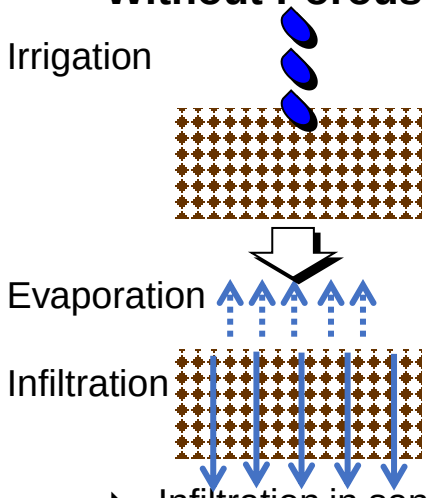
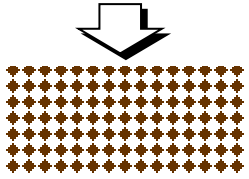
The pores of Porous Alpha increases water retention capacity of the soil, especially of sandy soil

Without Porous Alpha

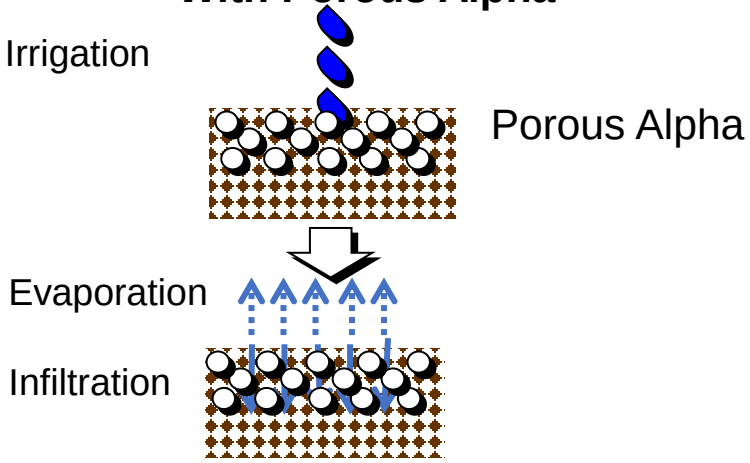


- Infiltration in sandy soil is very high
- A lot of irrigated water and liquid fertilizers are not absorbed by plants

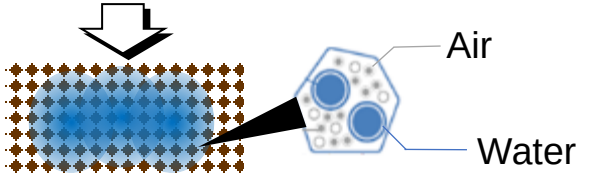


- Soil humidity in sandy soil is low, which requires frequent irrigation

With Porous Alpha



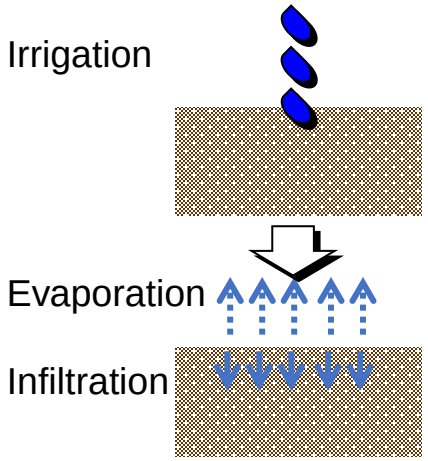
- Porous Alpha capture the irrigation water and liquid fertilizer
- Plants can absorb more water and liquid fertilizer



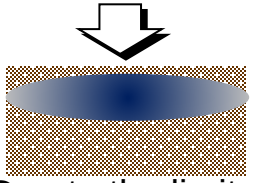
- The soil with Porous Alpha has higher humidity
- As Porous Alpha is inorganic material it can work for more than 10 years

Porous Alpha use allows better aeration in compacted soil to facilitate rooting and water circulation

Without Porous Alpha

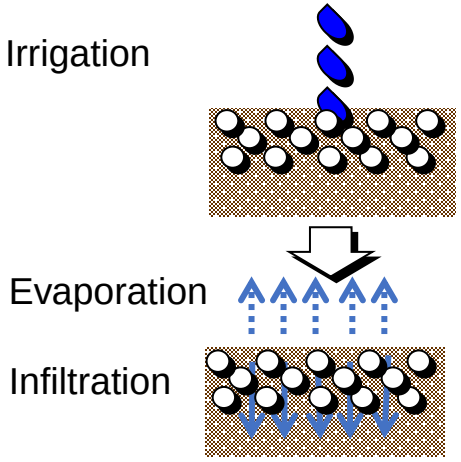


- Infiltration in clay soil is quite limited
- The soil hardness negatively impacts root development

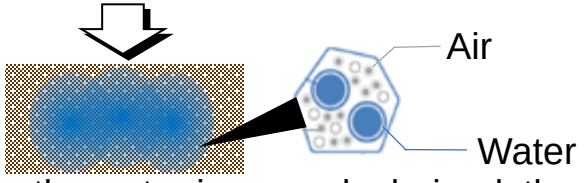


- Due to the limited infiltration, the water is retained too long in soil, which degrades roots

With Porous Alpha



- Porous Alpha gives space in the soil
- The soil compaction is also mitigated



- As the water is properly drained, the retained water is limited
- Better aeration realizes better yield
- As Porous Alpha is inorganic material it can work for more than 10 years

Thanks to the product safety, Porous Alpha works as substrate as well

100% Porous Alpha as growing media

By replacing coco-peat into Porous Alpha, the duration of the media is extended
- Coco-peat: 3 years
- Porous Alpha: 10+ years

Porous Alpha is mixed with other growing media such as peat moss

By mixing Porous Alpha, the growing media can keep the aeration for long term
(The growing media after several years lose aeration capacity by compaction)

Porous Alpha has two types of product for agriculture: granule product (P310) and powder product (P03)

	Granule product (P310)	Powder product(P03)
		
Particle size	3mm ~ 10mm	0mm ~ 3mm
Density	± 0.375 g/L	± 1 g/L
Installation dosage	10% of rooting zone	5% of rooting zone
Track record as soil conditioner	Tomato, Cherry Tomato, Green beans, Hot pepper, Bell pepper, Spinach, Lettuce, Melon, Watermelon, Citrus, Grass	Tomato, Grape, Kiwi, Dates*, Citrus*, Tomato, Sweet potato, Wheat, Sweet Pepper, Melon, Grass
Track record as substrate	Blue berry	Cucumber, Chili Pepper, Strawberry

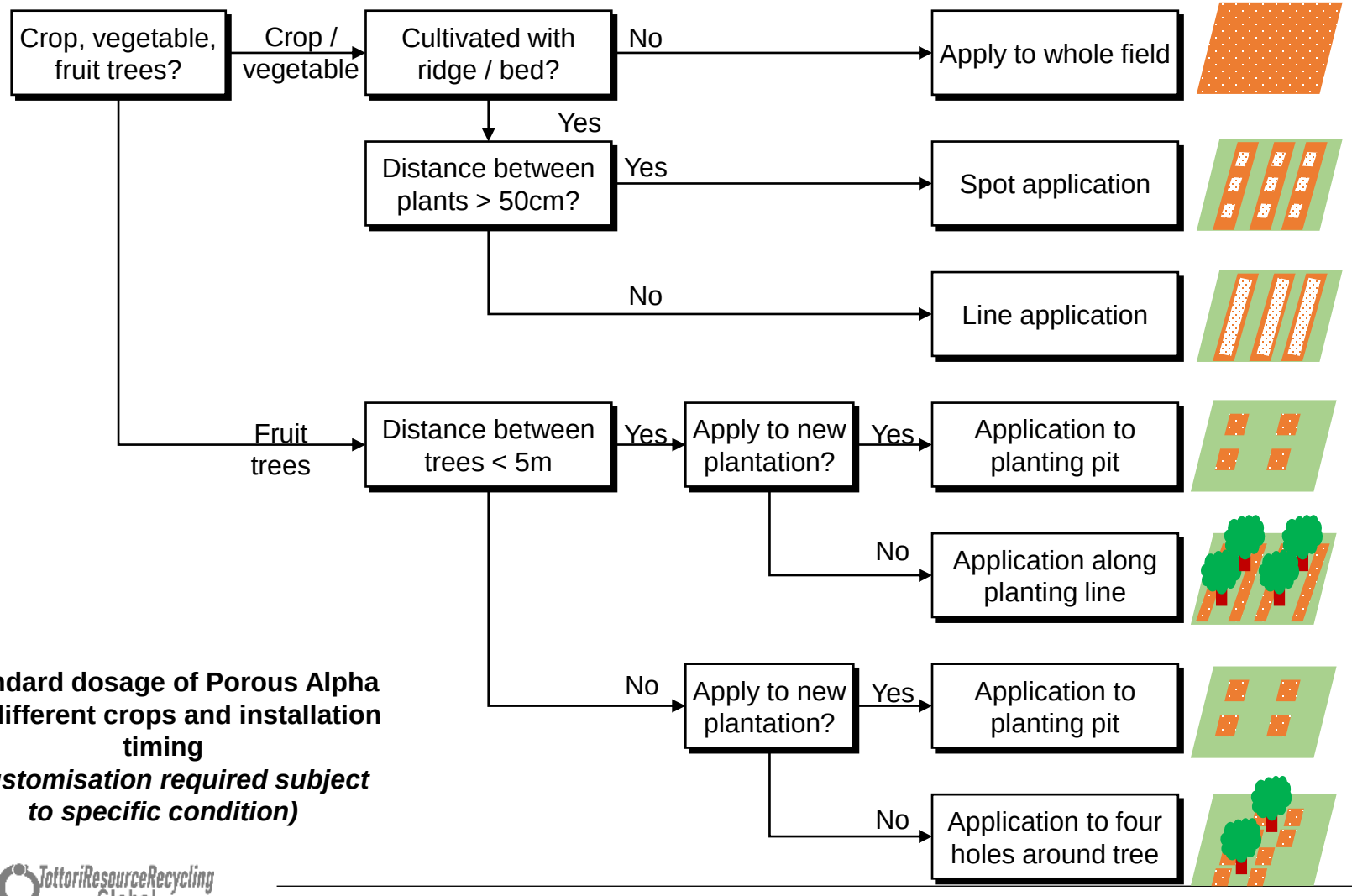
Installation is quite simple: mixing Porous Alpha with soil by tractor

Installation in Morocco

Installation in Senegal

Lay the Porous Alpha on the field and mix it by tractor | No special skills required

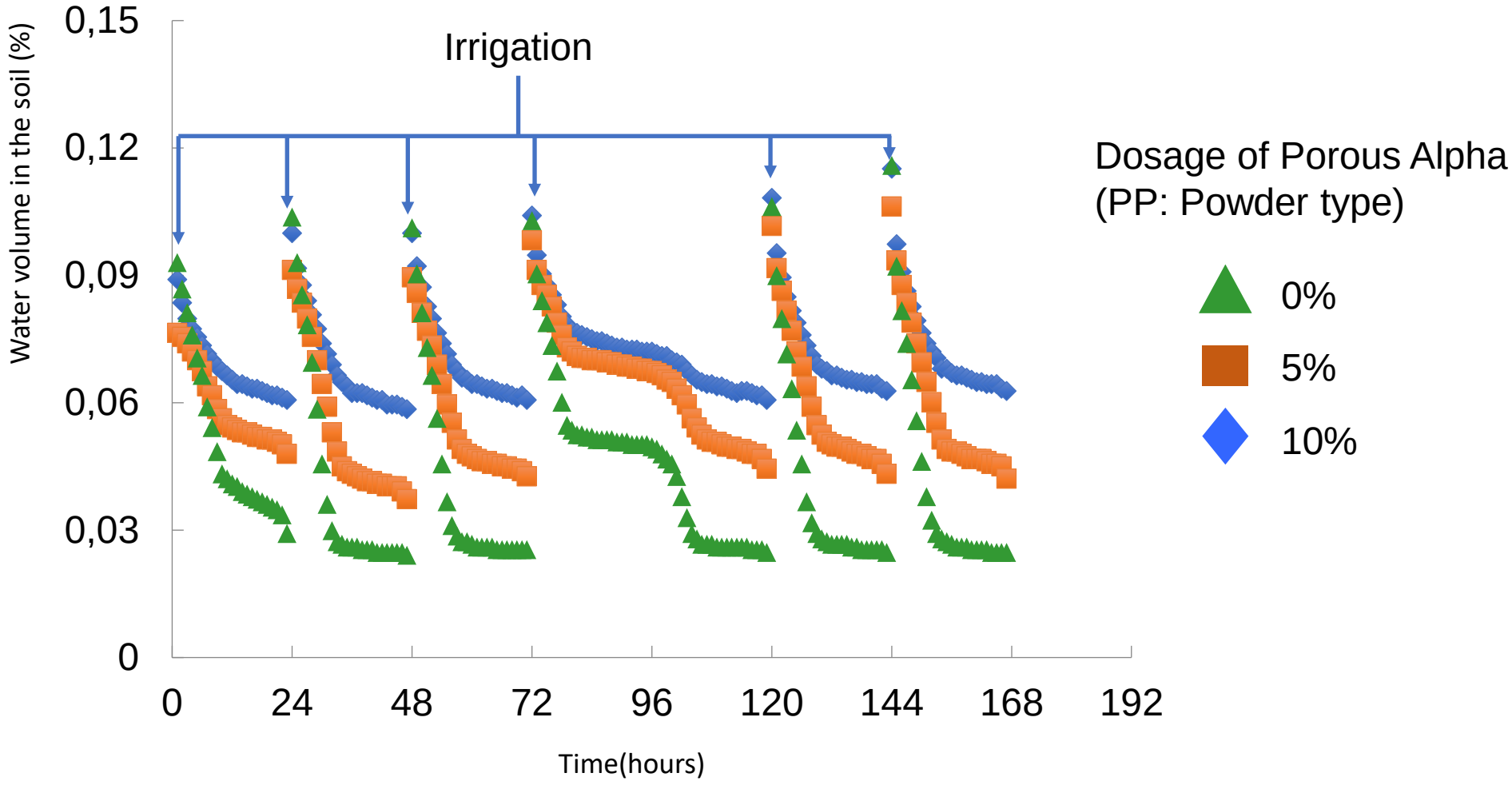
Depending on cultivation method, the mixing area/points varies for optimized return on investment



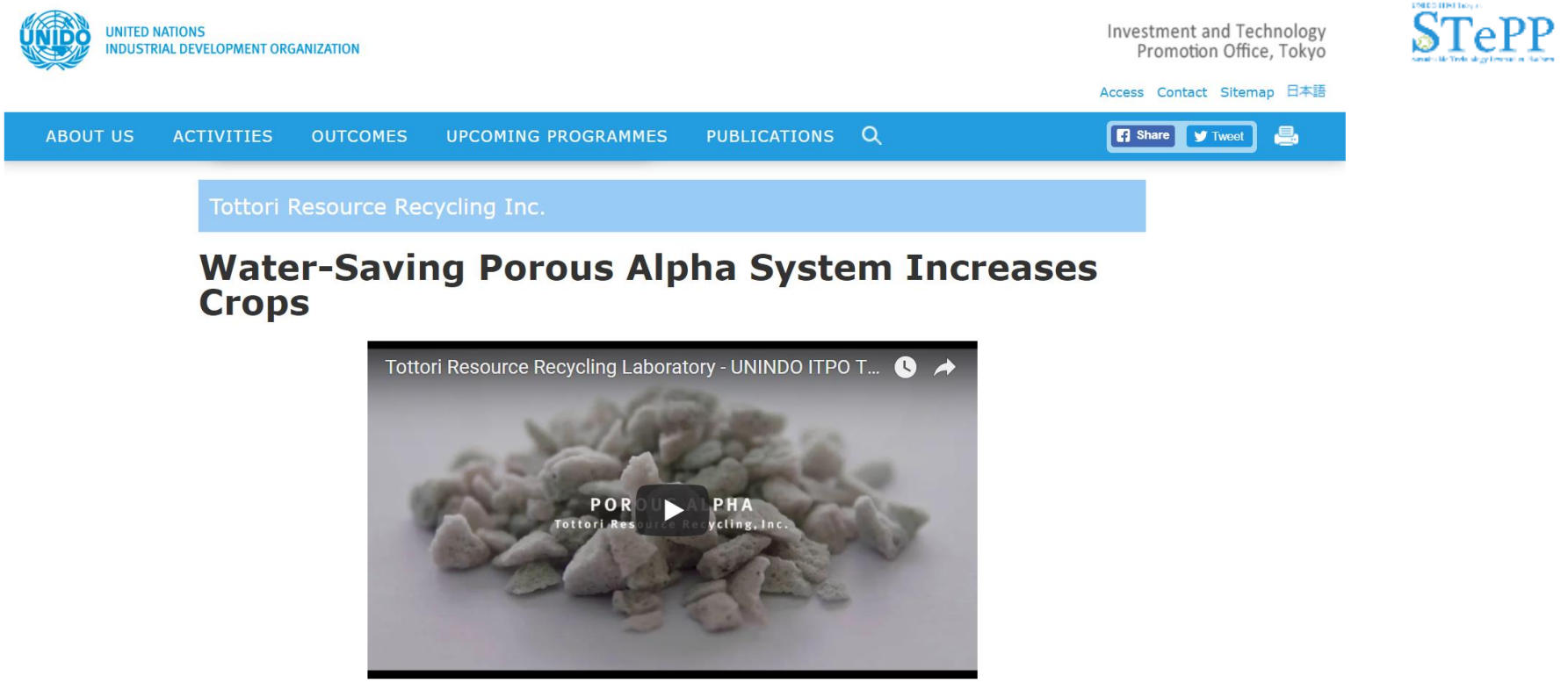
Example	Dosage P310	Dosage P03
Wheat, Sweet potato, Grass	300m3/ha	150m3/ha
Melon, Watermelon	0.75L/spot	0.25L/spot
Tomato, Cherry tomato, Pepper, Lettuce, etc.	5L/m	2.5L/m
Orange, Grape, Apple, Peach, Kiwi, Nectarine	15~20L/tree	7.5-10L/tree
	20L/tree	10L/tree
Date palm, Avocado	50L/tree	25L/tree
	72L/tree	36L/tree

Standard dosage of Porous Alpha for different crops and installation timing
(Customisation required subject to specific condition)

Water retention by Porous Alpha (powder) in sand is verified in Arid land research center, Tottori University



Our technology is registered as environmental technology by UNIDO, United Nations Industrial Development Organization



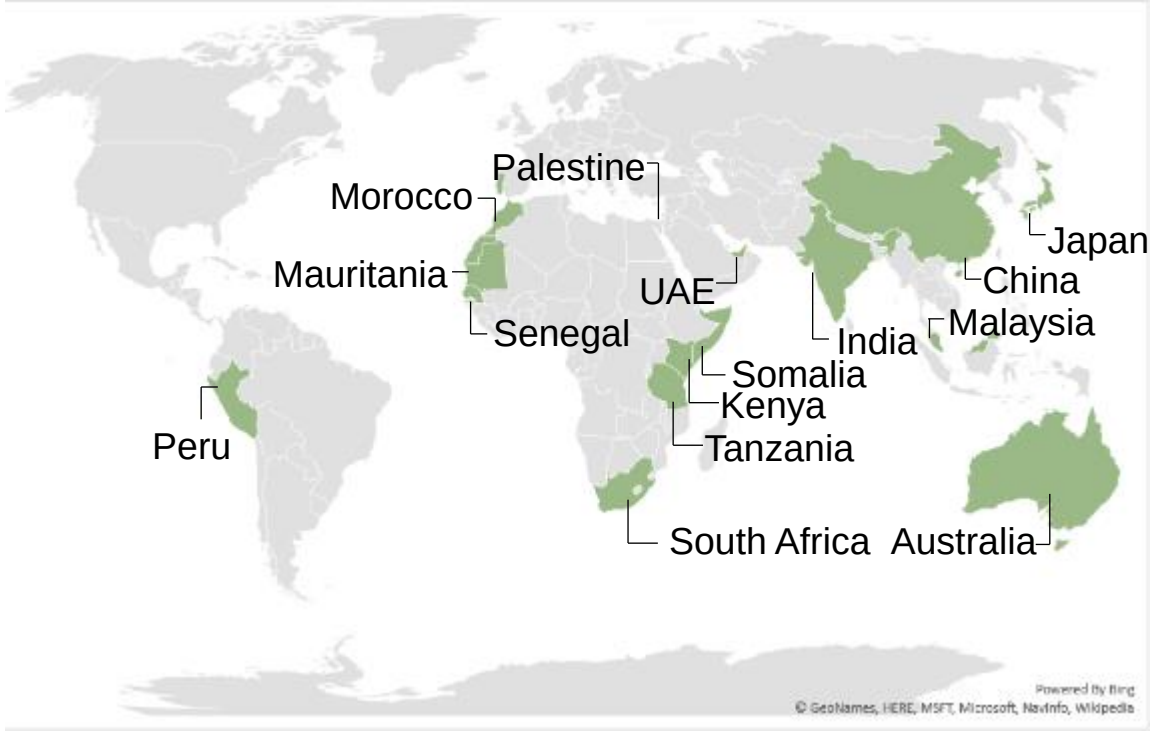
http://www.unido.or.jp/en/technology_db/1659/

Porous Alpha has the advantage mainly in duration

Competitors	Superabsorbent polymer	Expanded vermiculite	Diatomite	Peat moss
Characteristic	▸ High absorbing capacity ▸ Degradable ▸ After degradation, it's required to remove from the soil because it's petrochemical product. However, it's not easy to remove it because it's mixed with soil ▸ Expensive	▸ Produced by burning hydro-mica in 600-1000℃ ▸ Porosity is more than 90%, which is suitable to improve water permeation ▸ 20% of the soil is required ▸ Vermiculite product can contain asbestos as the mining site is close	▸ Unstable quality ▸ Expensive	▸ Strong acidity ▸ Depending on the raw material, water retention capacity get lost once dried up ▸ Fragmented peat moss has quite limited capacity of permeation
Advantage of Porous Alpha	▸ Usable more than 10yrs, not degradable ▸ Porous Alpha is not required to remove from soil as it's harmless to the soil and the composition is very close to the soil itself.	▸ Less quantity; Porous Alphas is used for 10% of soil ▸ It takes time for extended vermiculite to retain the water. No such characteristics for Porous Alpha	▸ Less expensive than diatomite	▸ No need to adjust pH ▸ Porous Alpha keep the capacity of retention of water and aeration ▸ Larger aeration

Thanks to the product safety and impact, Porous Alpha is installed in various countries & crops for various users

Countries where Porous Alpha have been installed



Crops to which we've been applying Porous Alpha

Vegetables
- Tomato
- Cherry tomato
- Green beans
- Hot pepper
- Bell pepper
- Spinach
- Cucumber
- Lettus
- Melon
- Watermelon
- Sugar beet*
- Chive*

Fruit trees
- Kiwi fruit
- Date palm
- Oil Palm (nursery)
- Orange*
- Peach*
- Apricot*
- Grape
- Olive*
- Blue berry

Cereal
- Sweet potato
- Wheat

Others
- Grass
- Flower (Poinciana)*

**: Under pilot usage in farmers' field*

Customers, business partners, project partners

Private: Export-oriented large-scale private farmers, Export-oriented cooperatives, Agri-input distributors
State-owned agency: Japan International Cooperation Agency (JICA), Ministry of Agriculture, Fisheries, Rural Development, Water and Forests of Morocco, Ministry of Agriculture and Irrigation of Peru
International Organization: International Organization for Migration, United Nations High Commissioner for Refugees, United Nations Industrial Development Organization

Case study of Porous Alpha for agriculture

- Tomato & Beans production in green house (Morocco)
  - Line Application for water saving and yield increase
- Watermelon production in open field (Morocco)
  - Spot Application for water saving
- Melon production in open field (Morocco)
  - Spot Application for water saving and yield increase
- Grape production in open field(Peru)
  - Application along planting line for yield increase
- Kiwi production in open field (China)
  - Application along planting line for yield increase
- Date palm production in open field(Morocco)
  - Application to planting pit for new plantation and four spots for adult trees for water saving
- Various vegetable in open field (Somalia)
  - Line Application for yield increase
- Blueberry production with substrate (Morocco)
  - Usage as substrate for yield increase
- Others

For vegetable production on ridge, Porous Alpha is mixed in a ridge. Installation can be done before or after setting ridge

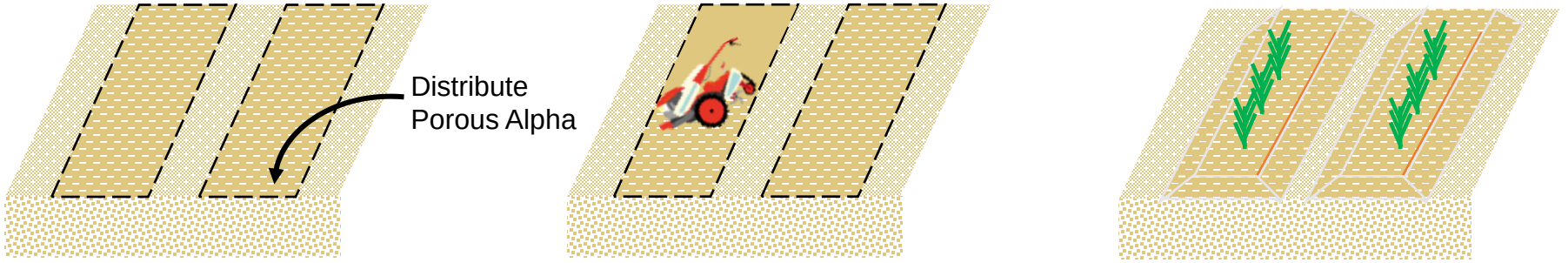
Two options of installing Porous Alpha for vegetable production with on ridge

Option 1: Installation of Porous Alpha before setting ridge

Step1: Put Porous Alpha for the location where ridge is set

Step2: Mix Porous Alpha with soil by hand or tractor

Step3: Setting up ridge and plantation

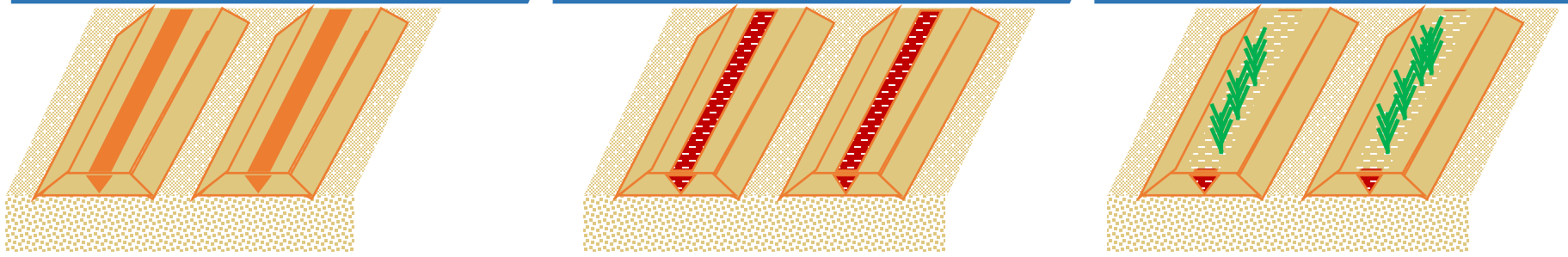


Option 2: Installation of Porous Alpha after setting ridge

Step1: Open the ridge

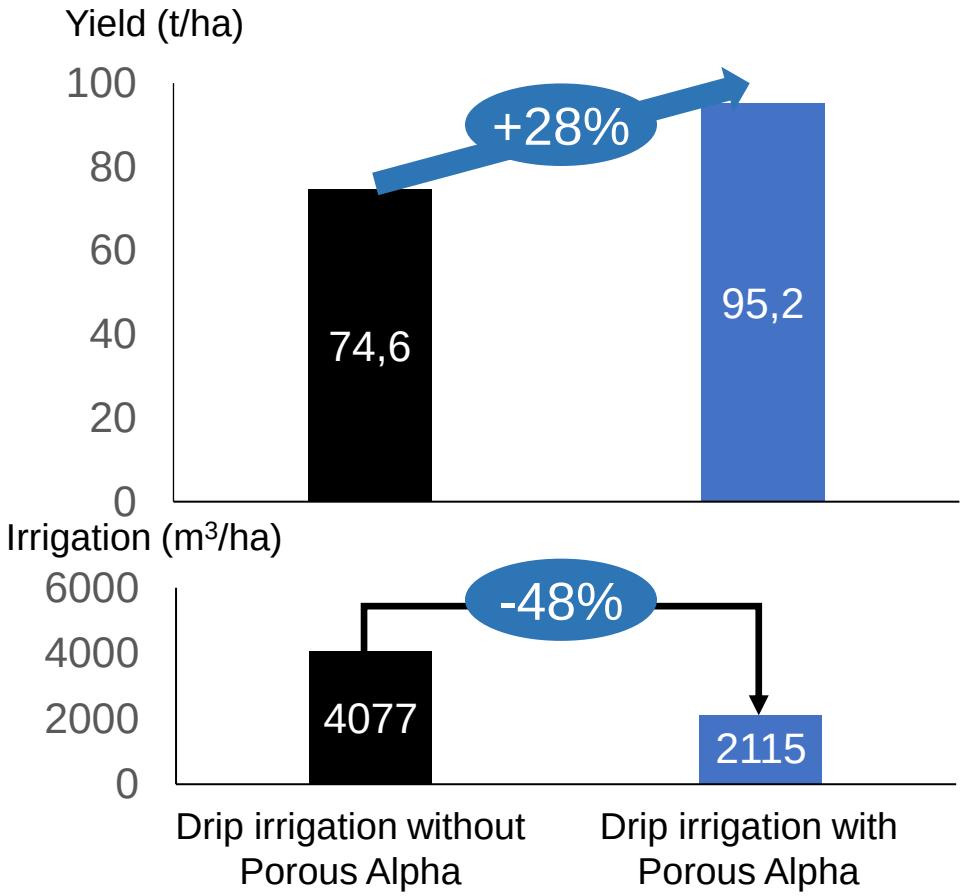
Step2: Pour & mix Porous Alpha in the ridge

Step3: Reshape ridge and plantation

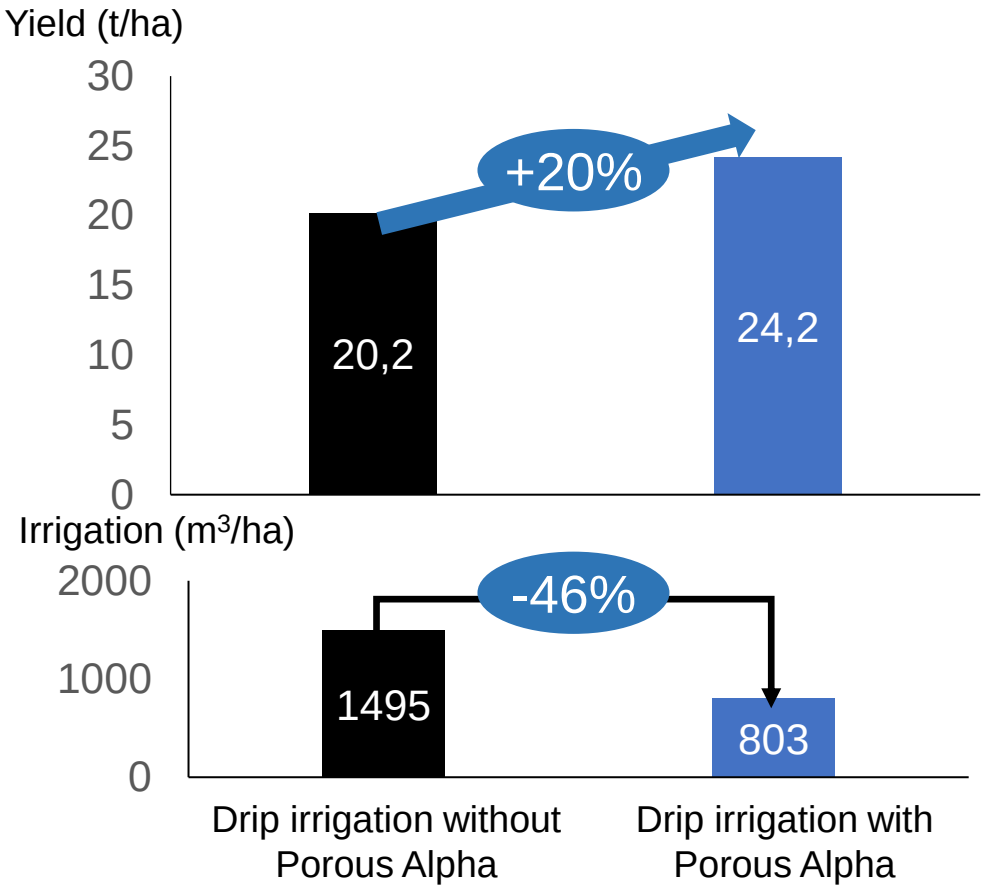


In Morocco, Porous Alpha realized 50% water saving alongside with yield increase by 20+% for tomato

The comparison of the yield of tomato in the 1st season

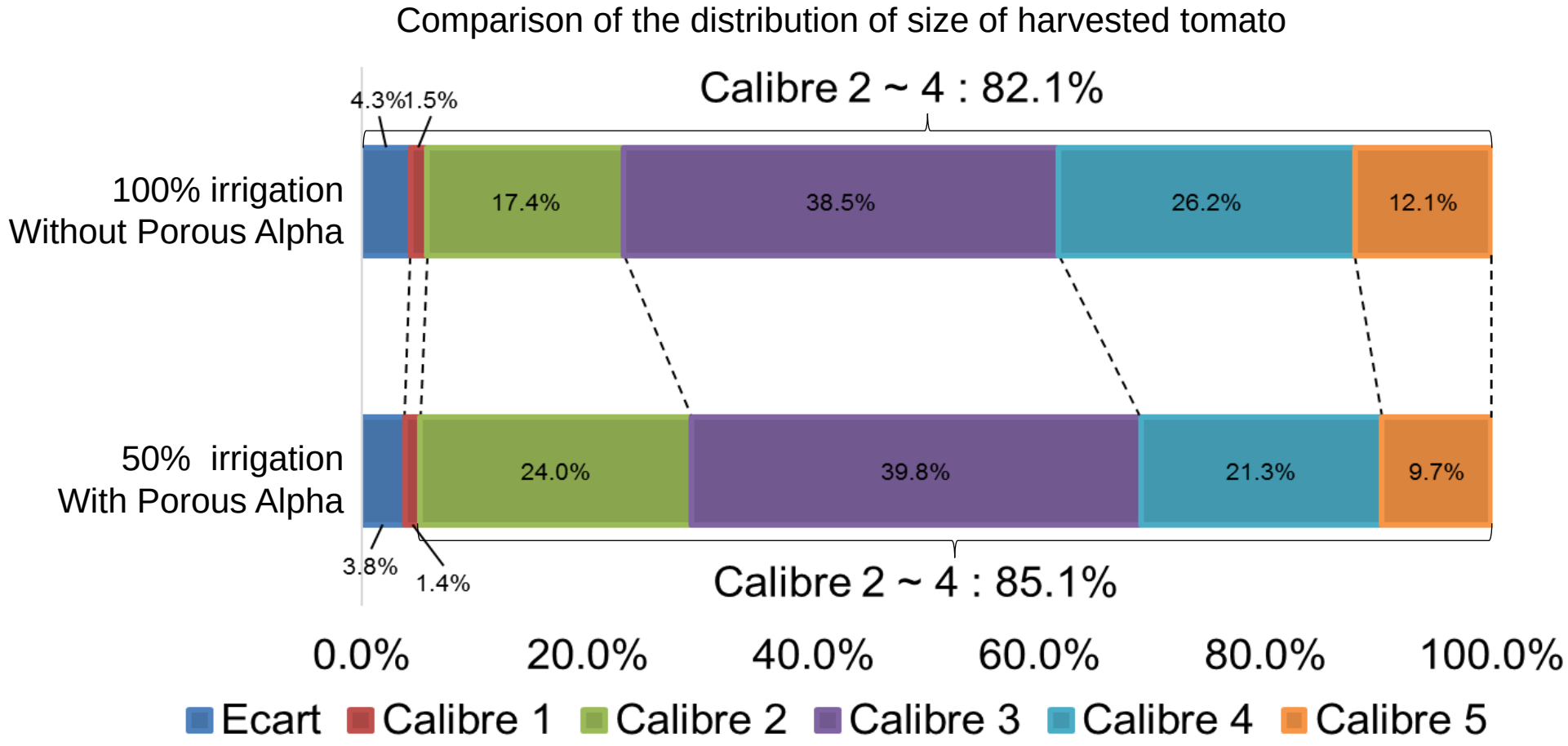


The comparison of the yield of tomato in the 2nd season



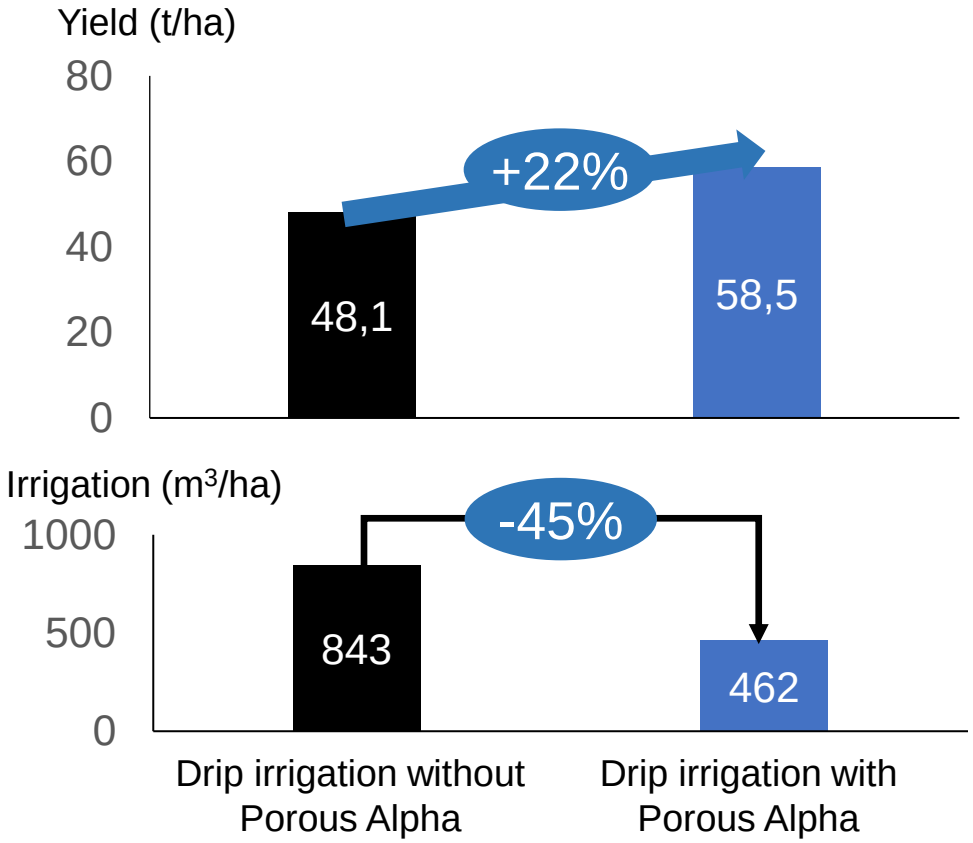
* *The harvest of 2nd season was terminated at the end of March due to the damage by Tuta Absoluta*

No negative impact was identified on the size distribution of tomato by using Porous Alpha with less water in Morocco

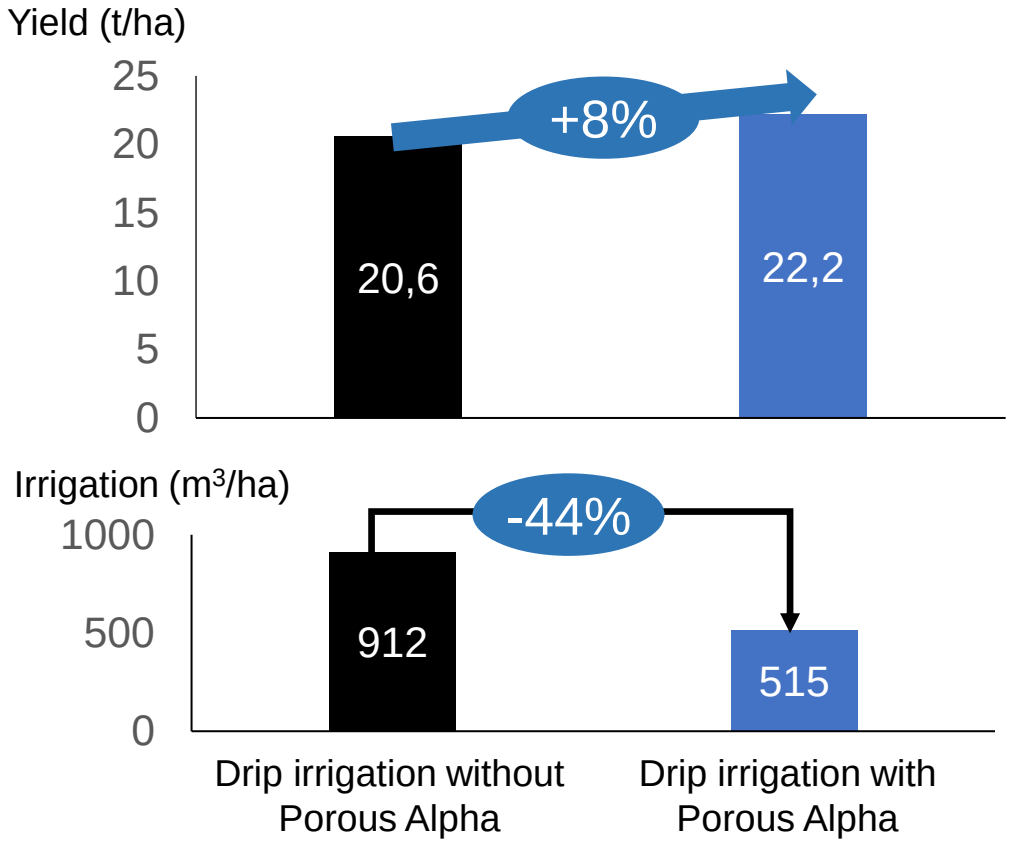


For green bean, Porous Alpha realized also increased yield in the condition of 50% reduced irrigation

The comparison of the yield of green beans in the 1st season

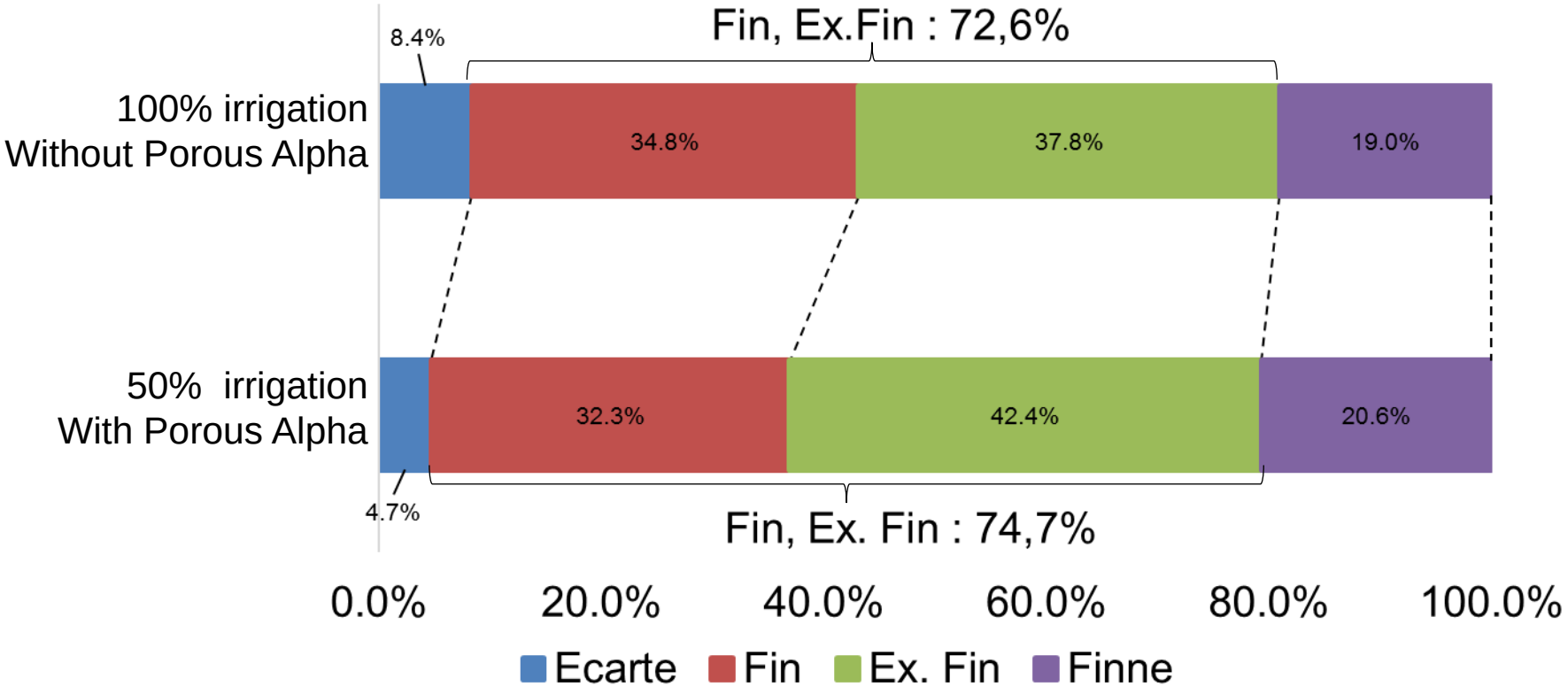


The comparison of the yield of flat beans in the 2nd season



No negative impact was identified on the size distribution of green bean by using Porous Alpha with less water in Morocco

Comparison of the distribution of size of harvested green bean



No negative impact on the soil was identified by Porous Alpha

The comparison of the maximum content of heavy metals in the soil according to the Directive of EU and the result of the experimentation

No.	Items	Maximum values defined in the directive of EU* (mg /kg)	Maximum content in the soil after the 1st season		Maximum content in the soil after the 2nd season	
			Without Porous Alpha	With Porous Alpha	Without Porous Alpha	With Porous Alpha
1	Cadmium	3	0.29	0.28	0.32	0.3
2	Copper	140	7.93	7.35	21.4	20.78
3	Nickel	75	11.48	11.37	6.54	6.9
4	Lead	300	3.43	3.38	5.67	3.8
5	Zinc	300	61.49	56.09	64.61	79.25
6	Mercury	1.5	< 0.02	< 0.02	0.15	0.11

** Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture*

No negative impact on the fruit was identified by Porous Alpha as well

The comparison of the maximum content of heavy metals between the CODEX* and the result of the experimentation

Comparison for tomato

		1st season		2nd season	
Regulated heavy metal	Standard (mg/kg)	Without Porous Alpha	With Porous Alpha	Without Porous Alpha	With Porous Alpha
Cadmium	0.05	< 0.01	< 0.01	< 0.02	< 0.02
Lead	0.1	0.06	0.04	< 0.06	< 0.06

Comparison for green beans

		1st season		2nd season	
Regulated heavy metal	Standard (mg/kg)	Without Porous Alpha	With Porous Alpha	Without Porous Alpha	With Porous Alpha
Cadmium	0.20	0.11	0.12	<0.06	< 0.06
Lead	0.05	< 0.01	< 0.01	< 0.02	< 0.02

**The standard of CODEX is based on CODEX GENERAL STANDARD FOR CONTAMINANTS AND TOXINS IN FOOD AND FEED (CODEX STAN 193-1995)*

Tomato producers also experienced the water saving, fertilizer saving and yield increase by Porous Alpha

Result of pilot installation by private producers in Morocco*

No.	Producer	Crop	Water consumption	Fertilizer consumption	Yield with Porous Alpha	Yield without Porous Alpha	Yield increase (%)
1	AS (1/4 ha)	Tomato	50%	50%	65 t/ha	62 t/ha	+5%
2	M (1/4 ha)	Tomato	70%	70%	80 t/ha	74 t/ha	+8%
3	S (1/4 ha)	Cherry tomato	57%	57%	85 t/ha	83 t/ha	+3%
4	T (PP) (0.1 ha)	Tomato	50%	50%	387 kg	360 kg	+8%
5	T (P310) (1/4 ha)	Tomato	50%	50%	102 t/ha	87 t/ha	+17%

** All the producers were affected by "Tuta absoluta" more or less, which makes the yield less than the other years*

Our project in Morocco is featured in the white paper of Japanese Ministry of Foreign Affairs

匠の技術、世界へ 1

持続可能な節水型乾燥地農業をモロッコで

～独自の技術が乾燥地域の節水と土壌改良に一役～

モロッコにてポーラスαの節水型農業技術に取り組む竹内農章さん（中央）とスス・マッサ地域農業開発公団のメンバー（写真：鳥取環境資源化研究所）

アフリカ大陸の北西端に位置し、北は地中海、西は大西洋に面したモロッコでは農業が重要な産業であり、GDPの13%、輸出の11%、就業労働人口の25%（約300万人）を占めています。しかし、乾燥地域が多く慢性的な水不足に悩まされ、干ばつ時には収穫量が通常の50%程度にまで落ち込むこともあります。気候変動による降水量の減少も予想されることから、農業用水を確保するための経費が年々上昇するなど、水の持続的な利用が課題となっています。

野菜の生産が盛んなモロッコ中部のスス・マッサ地域では、少量の水を効果的に使う点滴灌漑が普及しているものの、水不足の解消には至っていません。こうした中、同地域の節水型農業に期待がかかるのが、株式会社鳥取環境資源化研究所が開発した「ポーラスα（アルファ）®」です。ポーラスαは廃ガラスと貝殻（炭酸カルシウム）を原料とする同社が独自に開発した多孔質発泡ガラス素材です。開発当初は、土木資材の軽量盛土材や防犯砂利[※1]としての利用を想定していましたが、鳥取大学乾燥地研究センターとの共同研究の結果、土壌に混ぜて使用すると多数の細かい孔に水が蓄えられて土壌の保水性が高まり、土壌改良材として優れた効果を発揮することが分かりました。その上、ポーラスαは環境に与える影響（負荷）も小さいなどの特徴もあり、2010年には乾燥地向け節水型農業技術として国連工業開発機関（UNIDO）[※2]の環境技術データベースにも登録されています。

同社がモロッコの農業が抱える水問題と接したのは2008年のこと。既に確立していたポーラスαの節水型農業技術をモロッコで開かれた学会で紹介したときに、モロッコの政府機関から実証実験についての打診を受けました。このときは、モロッコ政府との間で役割分担や費用負担などで合意に至らず実現しませんでしたが、その後、JICAの民間技術導入可能性調査という制度を利用してセネガルでポーラスαの実証実験を行いました。

スス・マッサ地域農業開発公団の研究施設で行われた試験栽培でインゲンを収穫している様子（写真：鳥取環境資源化研究所）

そこで成果を上げ、さらに農業が大規模に行われている国を検討したところ、同社は再度モロッコに思い至り、2015年6月から2年半の予定で、ODAを活用した中小企業海外展開支援[※3]の普及・実証事業[※4]を行うこととなりました。

2015年9月から2016年4月にスス・マッサ地域農業開発公団の研究施設で行われた第1回試験栽培では、トマトとインゲンを栽培しました。その結果、従来と比べて半分の水の量で、トマトは28%増、インゲンは22%増の収穫量がありました。節水効果、収穫量増大、土壌・作物への安全性など、ポーラスαの有効性の高さを示す結果が得られたのです。

「ポーラスαを入れた畑がそうでない畑よりも生育が良いということが分かり、農業開発公団の現場責任者も手応えを感じたようです。2015年12月に現地で開催された農業展示会で、彼が来場者にポーラスαを売り込む姿を見たときには、当社製品を信頼してくれていることが実感できうれしく思いました」と竹内義章社長は振り返ります。

こうした結果を受け、2016年8月からは大規模農家での試験導入も始まっています。竹内社長は、「農業開発公団の試験栽培は0.06ヘクタールでしたが、大規模農家の総面積は2ヘクタール以上です。また、生産者ごとに農法や農地の環境が微妙に異なるため、どのような結果が出るのか期待と不安があります」と話します。

2016年8月、ケニアの首都ナイロビで開催された第6回アフリカ開発会議（TICAD VI）に出展し、ポーラスαを活用した節水型農業技術を紹介しました。乾燥地を多く抱えるアフリカ諸国の関係者からも、大いに注目を集めました。

「モロッコの乾燥地域では水の需要量が供給量を上回り、地下水位が年々下がっています。ポーラスαの利用で水の使用量を半減できれば、地下水位の低下を食い止め、気候変動による少雨化、干ばつにも不安を抱くことなく、安心して農業に取り組めると考えています」と竹内社長。

今後は対象作物を果樹などに拡大するとともに、ポーラスαの現地での製造・販売体制を構築していく計画です。

※1 「防犯砂利」は、踏むと音が出て、侵入者の足音に気づかせる用途がある。
※2 United Nations Industrial Development Organization
※3 ODAを活用した中小企業等の海外展開支援事業は、中小企業等の優れた製品・技術等を途上国の開発に活用することで、途上国の開発と、日本経済の活性化の両立を図る事業。
※4 普及・実証事業は、中小企業等からの提案に基づき、製品・技術等に関する途上国の開発への現地適合性を高めるための実証活動を通じ、その普及方法を検討する事業。

Master Techniques from Japan to the World 1

Introducing Sustainable Water Saving Agriculture Technology in Arid Areas of Morocco

Unique technology helping to save water and improve soil quality in arid regions

Mr. Yoshiaki Takeuchi (center) works on the Porous Alpha water-saving agriculture technology, with members of the Souss Massa Regional Agricultural Development Corporation in Morocco. (Photo: Tottori Resource Recycling, Inc.)

Situated in the northwest corner of the African continent, Morocco borders the Mediterranean Sea to the north and the Atlantic Ocean to the west. Agriculture is a key industry for Morocco, accounting for 13% of GDP, 11% of exports, and 25% of the workforce (approx. 3 million people). However, there are many arid areas in the country troubled by chronic water shortages and harvests can fall by 50% in times of drought. Given that rainfall is expected to decrease due to the effects of climate change, the cost of securing a sufficient volume of water for agricultural purposes continue to rise each year, making sustainable use of water resources a major challenge.

The Souss-Massa region in central Morocco is a major vegetable producing region. Although, drip irrigation, which uses small volumes of water effectively, is prevalent in this region, water shortages still remain an issue. It is in the face of this situation that the hopes for the water saving agriculture of the Souss-Massa region are resting on Porous Alpha®. Porous Alpha developed by Tottori Resource Recycling Inc. is a porous foamed glass material made from waste glass and sea shells (calcium carbonate). At the initial stages of the development, the company anticipated that the material could be used as a lightweight filling material for civil engineering works or as crime prevention gravel.[1] However, in joint research with the Arid Land Research Center of Tottori University, it became apparent that the material had excellent properties as a soil conditioning material. If mixed with soil, water accumulates in the many tiny holes in the material, thus helping to improve soil water retention capacity. Moreover, Porous Alpha with its low environmental impact was registered in the Environmental Technology Database of the United Nations Industrial Development Organization (UNIDO) in 2010 as water saving agriculture technology for arid areas.

Tottori Resource Recycling Inc. first became aware of the water issues, facing the agricultural industry in Morocco in 2008. When the company made a presentation to an academic meeting in Morocco about its established water saving agricultural technology using Porous Alpha, Moroccan government agencies approached the company about launching a Verification test project. The project did not materialize at that time, as an agreement was not reached between the Government and the company on the role played and costs shared. Meanwhile, the company conducted a verification test project on Porous Alpha in Senegal using JICA's Feasibility Survey with the Private Sector for introducing Japanese Technologies. When the project in Senegal produced good results, the company started looking for other countries with large scale agricultural industries where the technology could be used, and recalled their past exchange with Morocco. It was decided that, from June 2015 a two-and-a-half year Verification Survey[2] for disseminating Japanese technologies would be conducted, under JICA's support for Japanese Small and Medium-sized Enterprises (SMEs) Overseas Business Development[3] using ODA.

Green beans are harvested as part of a trial cultivation by the Regional Agricultural Development Office of the Souss Massa. (Photo: Tottori Resource Recycling, Inc.)

Tomatoes and green beans were planted in the first experiment, conducted in a research facility of the Regional Agricultural Development Office of the Souss-Massa from September 2015 to April 2016. The result was 50% reduction in water used, and 28% increase in tomatoes yielded and 22% increase in green beans yielded. The result demonstrated the high effectiveness of Porous Alpha, in realizing water saving, increasing yields, and improving soil and crop safety.

"I think the field manager of the Regional Agricultural Development Office could see for himself that the crops planted in the field with Porous Alpha demonstrated better growth than the one without. I was delighted to see him promoting Porous Alpha to the visitors to an agricultural exhibition held in Morocco in December 2015. I realized and appreciated that he trusted our product" says Mr. Yoshiaki Takeuchi, President of Tottori Resource Recycling Inc., looking back.

On the basis of these results, Porous Alpha was experimentally introduced to large-scale farms from August 2016. Mr. Takeuchi says "The experiment will cover an area of over two hectares whereas the project at the Regional Agricultural Department Office covered 0.06 hectares. Also, farming methods and field condition differ slightly from producer to producer. So I await the result with mix feeling of anticipation and anxiety."

In August 2016 the company participated in an exhibition held on the occasion of the Sixth Tokyo International Conference on African Development (TICAD VI) in Nairobi, Kenya, introducing its water saving agricultural technology using Porous Alpha. The technology drew considerable attention from representatives of African countries with vast arid regions.

Mr. Takeuchi notes, "In the arid regions of Morocco demand for water outstrips that of supply and underground water levels are dropping each year. If the introduction of Porous Alpha could contribute to halving the amount of water used, it could halt the decreasing of the underground water level and could enable people to engage in agriculture activities without worrying about less rainfall and drought caused by climate change."

The company plans to expand the use of Porous Alpha to other crops, such as fruit trees, and also to set up local production and sales systems.

*1 "Crime prevention gravel" is designed to make a loud noise when walked over, alerting people to the footsteps of intruders.
*2 A survey to verify ways to enhance a product and technology's compatibility with a developing country and thereby disseminate the product and technology, based on a proposal from Japanese SME.
*3 Projects aiming to achieve both the development of developing countries and the activation of the Japanese economy by utilizing Japanese SMEs' excellent products and technologies through ODA.

White Paper on Development Cooperation 2016, Ministry of Foreign Affairs, Japan

Case study of Porous Alpha for agriculture

- Tomato & Beans production in green house (Morocco)
  - Line Application for water saving and yield increase
- Watermelon production in open field (Morocco)
  - Spot Application for water saving
- Melon production in open field (Morocco)
  - Spot Application for water saving and yield increase
- Grape production in open field(Peru)
  - Application along planting line for yield increase
- Kiwi production in open field (China)
  - Application along planting line for yield increase
- Date palm production in open field(Morocco)
  - Application to planting pit for new plantation and four spots for adult trees for water saving
- Various vegetable in open field (Somalia)
  - Line Application for yield increase
- Blueberry production with substrate (Morocco)
  - Usage as substrate for yield increase
- Others

To realize 50% of water and fertiliser saving, Porous Alpha was installed for each planting spot

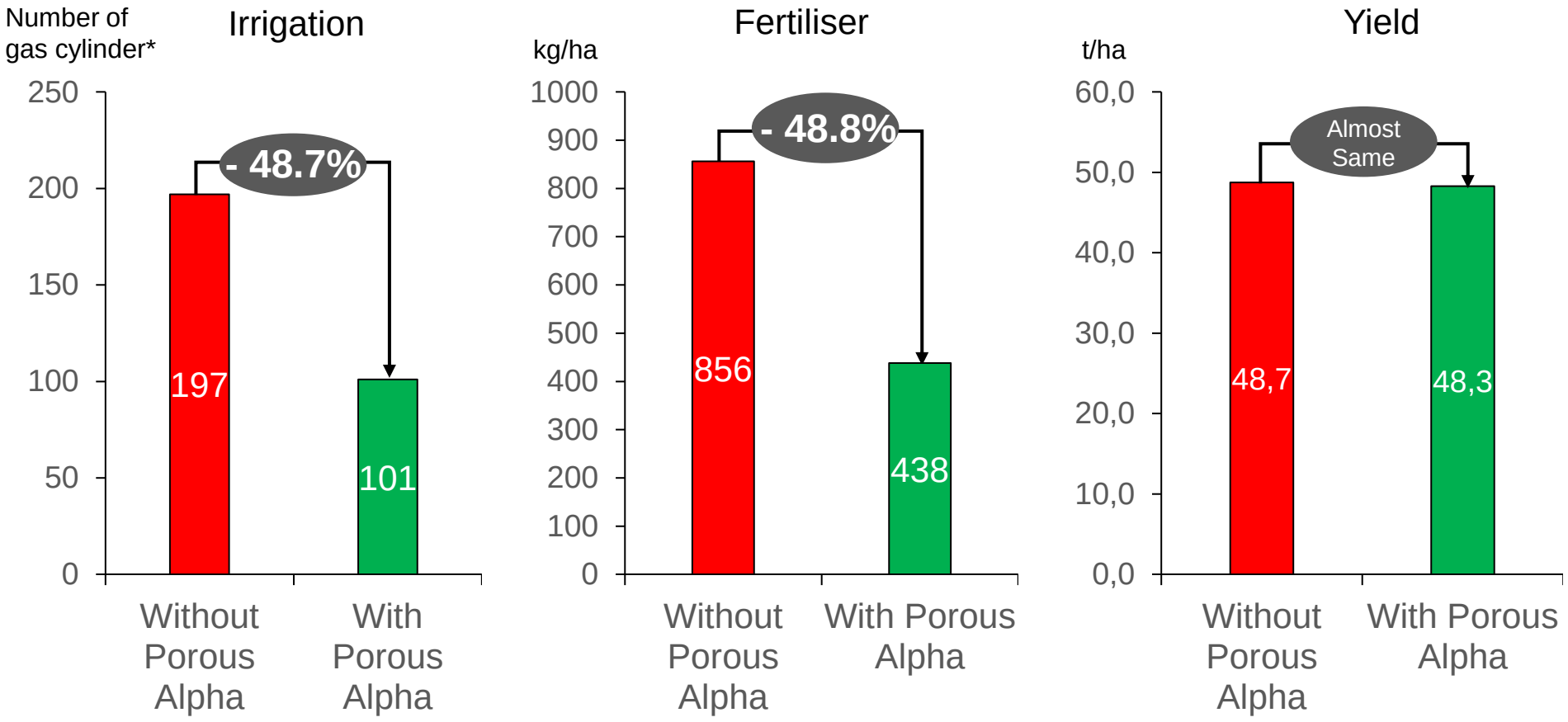
- Location: Zagora, Morocco
- Objective: To save water and fertiliser by 50%
- Irrigation method: Drip irrigation
- Fertiliser application: Fertigation
- Installation method: Spot Application (P310: 750 ml/spot)
  - One plant was planted in one spot

1) Make small pit to apply Porous Alpha

2) Pour Porous Alpha

3) Cover the soil

We have realised 50% water and fertiliser saving for the same yield



*: Irrigation volume was calculated based on the consumed gas cylinder to pump up water from borehole

Case study of Porous Alpha for agriculture

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  - Application along planting line for yield increase
- Kiwi production in open field (China)
  - Application along planting line for yield increase
- Date palm production in open field(Morocco)
  - Application to planting pit for new plantation and four spots for adult trees for water saving
- Various vegetable in open field (Somalia)
  - Line Application for yield increase
- Blueberry production with substrate (Morocco)
  - Usage as substrate for yield increase
- Others

To realize yield increase with less input for melon production in Chtouka in Morocco, Porous Alpha was installed for each spot

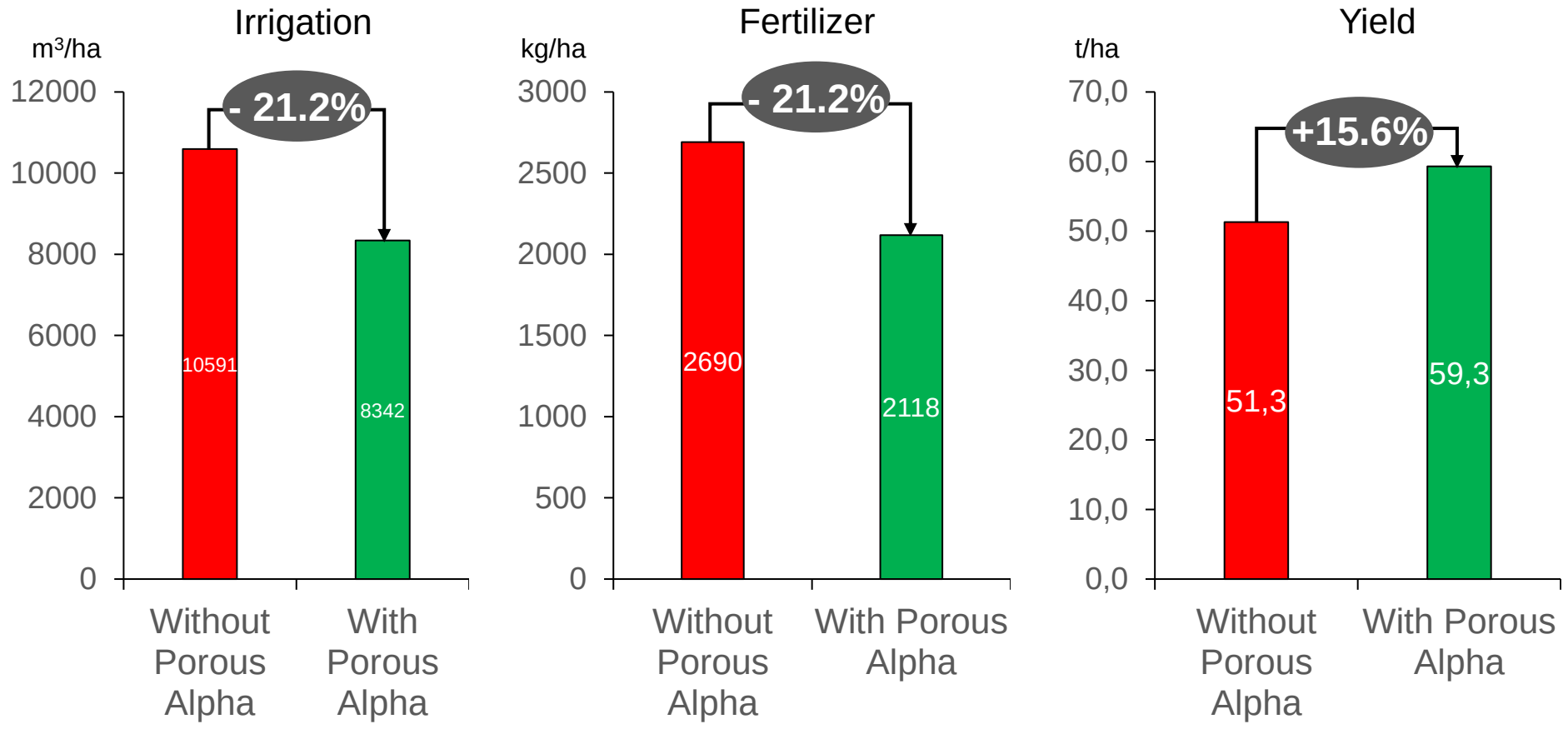
- Location: Chtouka, Morocco
- Objective: To increase the yield with less water and fertiliser
- Irrigation method: Drip irrigation
- Fertiliser application: Fertigation
- Installation method: Spot Application (P310: 750 ml/spot)
  - Two plants were planted in one spot

1) Make small pit to apply Porous Alpha

2) Pour Porous Alpha

3) Plant seedling

Porous Alpha realised 20% less input alongside with 15% yield increase



Case study of Porous Alpha for agriculture

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  - Spot Application for water saving
- Melon production in open field (Morocco)
  - Spot Application for water saving and yield increase
- Grape production in open field(Peru)
  - Application along planting line for yield increase
- Kiwi production in open field (China)
  - Application along planting line for yield increase
- Date palm production in open field(Morocco)
  - Application to planting pit for new plantation and four spots for adult trees for water saving
- Various vegetable in open field (Somalia)
  - Line Application for yield increase
- Blueberry production with substrate (Morocco)
  - Usage as substrate for yield increase
- Others

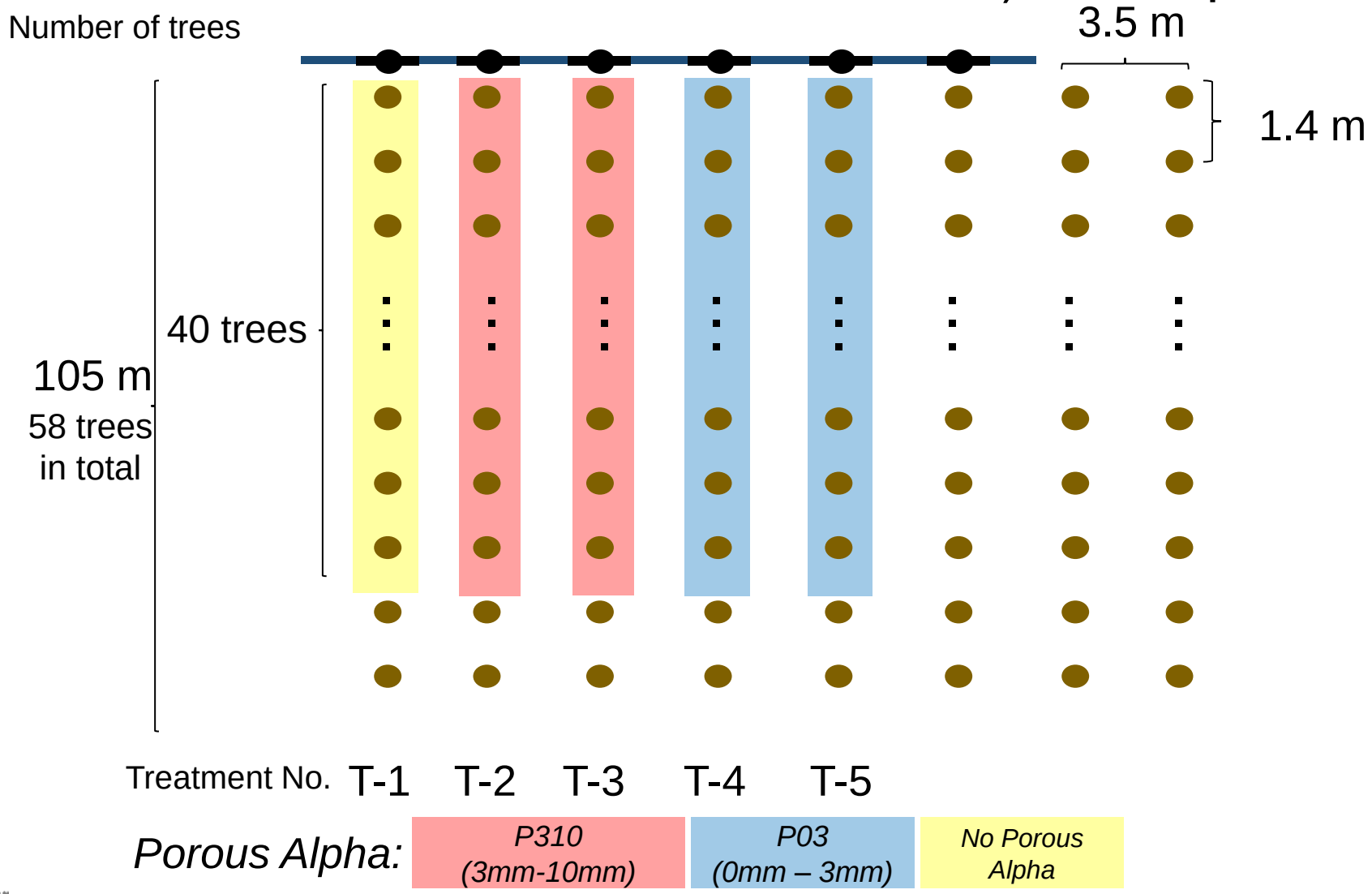
Water-saving is the key for the sustainability of large-scale agriculture in Ica, Peru

Facts on water resource in Ica, Peru	Implications	Impact by water-saving
The perforation of new wells and to deepen existing ones are prohibited in Ica by National Water Authority (ANA)	No additional source available	Company can use the existing well for longer period and/or expand land with same water source
Against the input of 253 mil. m^3 to aquifers, 563 mil. m^3 is consumed in Ica	Decrease of existing water resource	The industry has chance to avoid depletion of aquifers

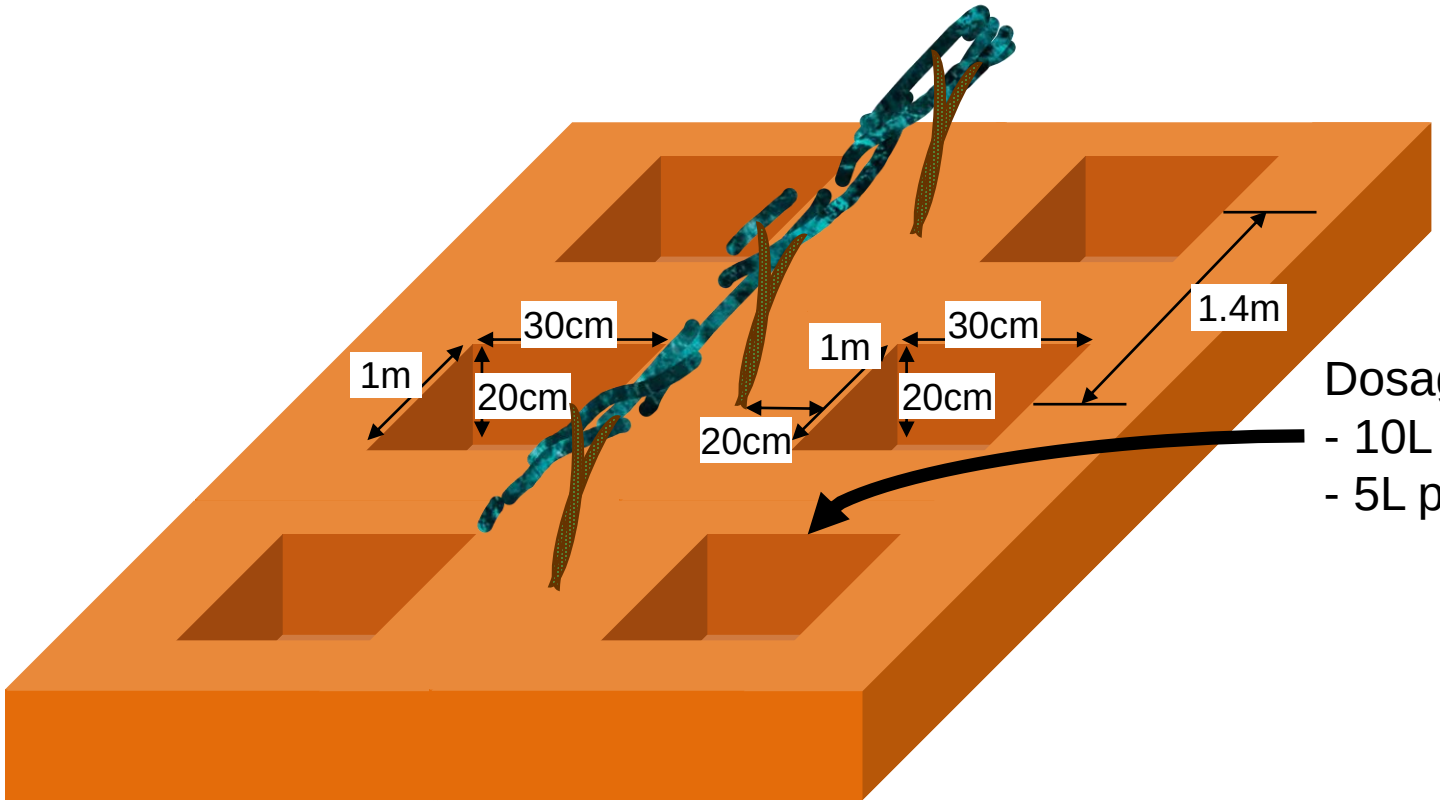
We installed Porous Alpha for table grape adult trees to increase the yield with same input

- Main objective of pilot test: Yield increase
- Age of target tree at the commencement: 2 years old
  - Planted in 2016
- Input
  - Water consumption: 14000 m3/ha/year
    - pH: 7.5 ~ 8.5
    - EC: 2 mS/cm
    - Chemical acid is added to reduce pH
  - Water cost: 500 Eur/ha/year
  - Liquid fertilizer cost: 2000 Eur/ha/year
- Current yield: 30 tons/ha/year

Porous Alpha was installed for 160 trees (80 trees for P310, 80 trees for P03) to compare the yield



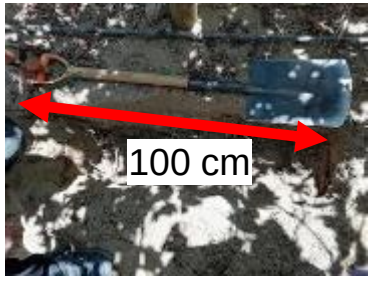
Porous Alpha was installed in two sides of each tree



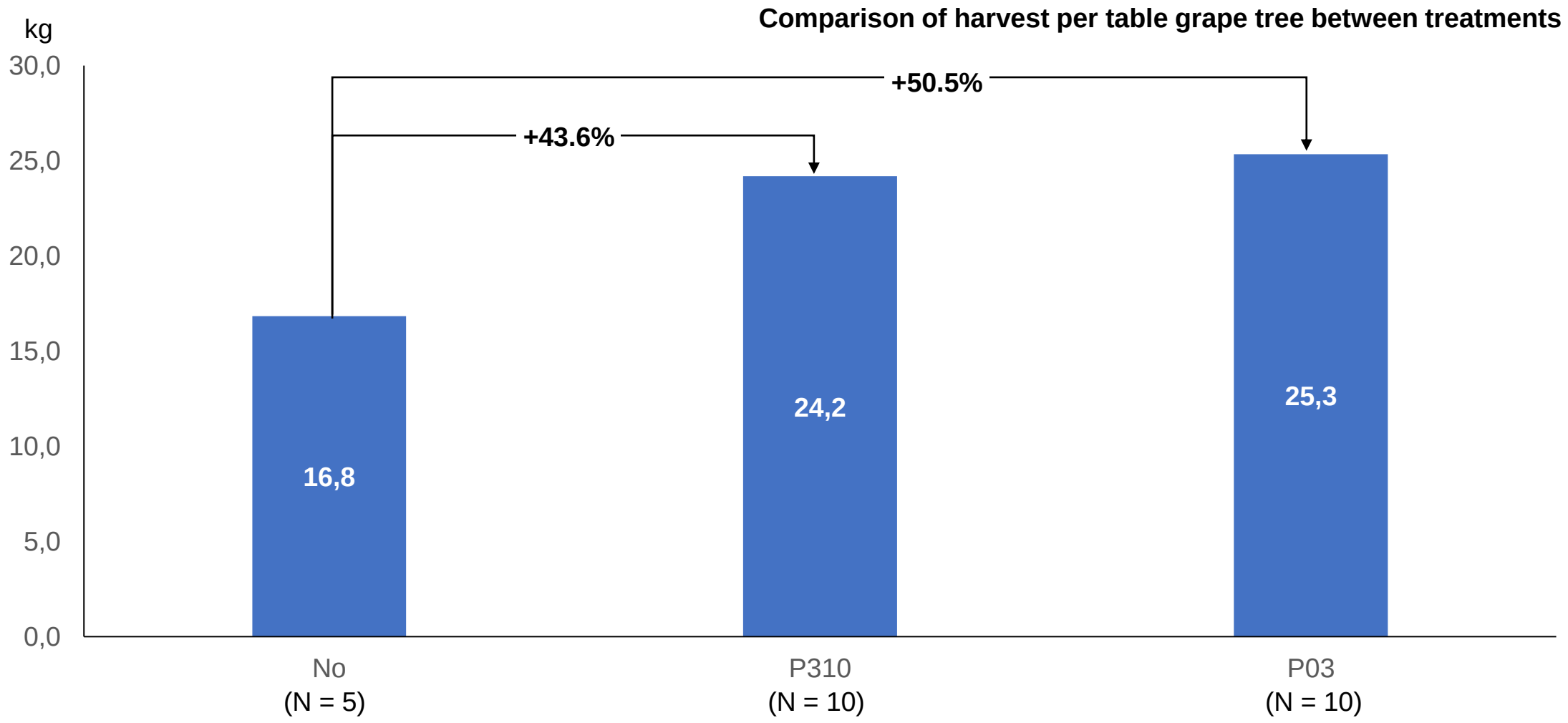
Dosage of Porous Alpha
- 10L per hole (P310)
- 5L per hole (p03)

Installation process of Porous Alpha for adult grape tree

Make holes of 100cm x 30cm x 20cm → Place bags of Porous Alpha → Measure the volume of Porous Alpha → Mix Porous Alpha with soil and recover



The yield of table grape trees with Porous Alpha was higher than the tree without Porous Alpha by 40 ~ 50%



(Harvest per tree raw data (kg per tree))

No Porous Alpha	With P310	With P03
15	22	23
14.1	20.4	22.8
20.4	20.8	23.6
20	25	28.25
14.7	21.2	28
	29	23.68
	27.5	23.2
	20.4	23.6
	29.5	28.25
	26	29

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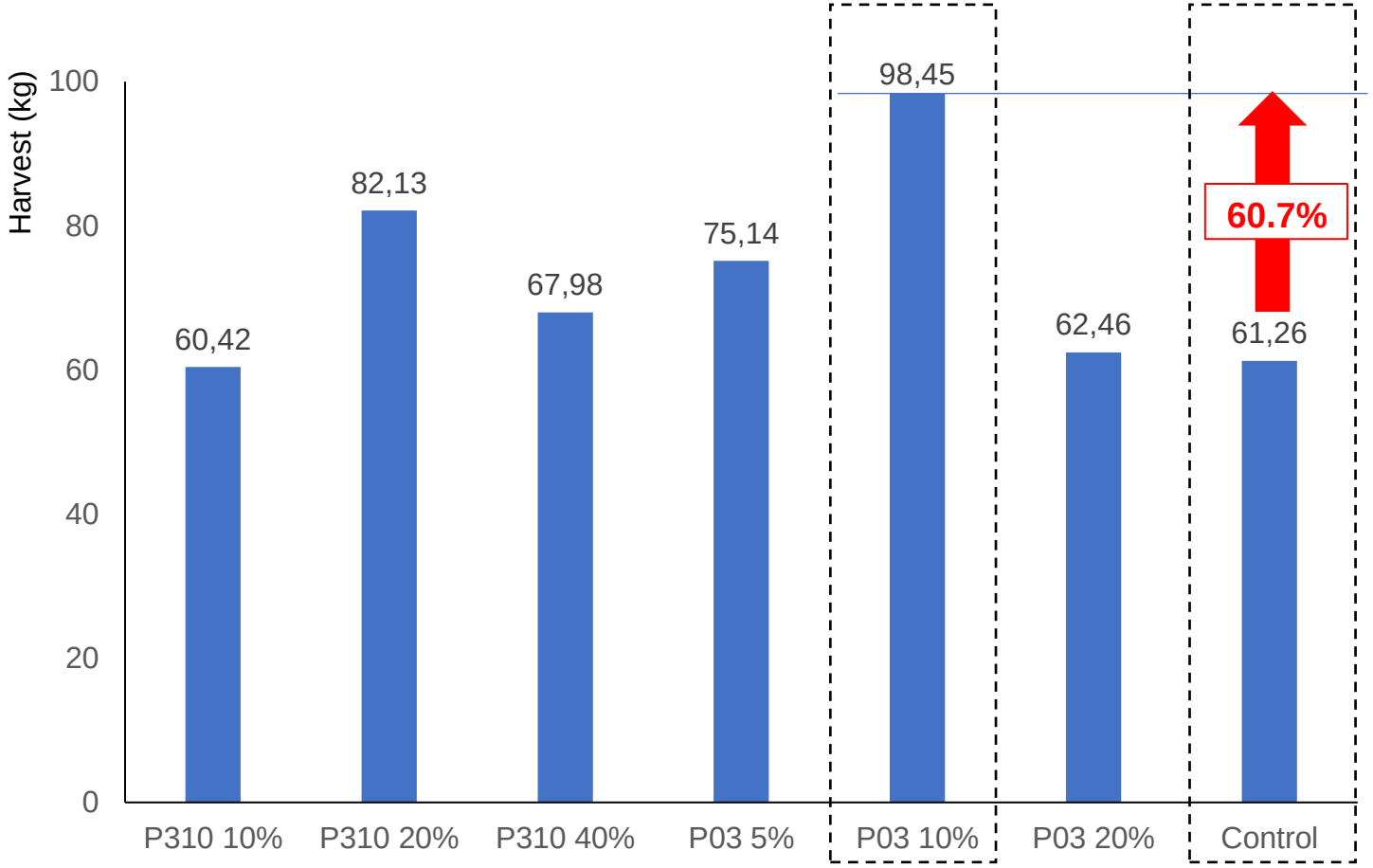
  - Line Application for yield increase
- Blueberry production with substrate (Morocco)
  - Usage as substrate for yield increase
- Others

For kiwi production in clay soil, Porous Alpha realized more than 60% yield increase

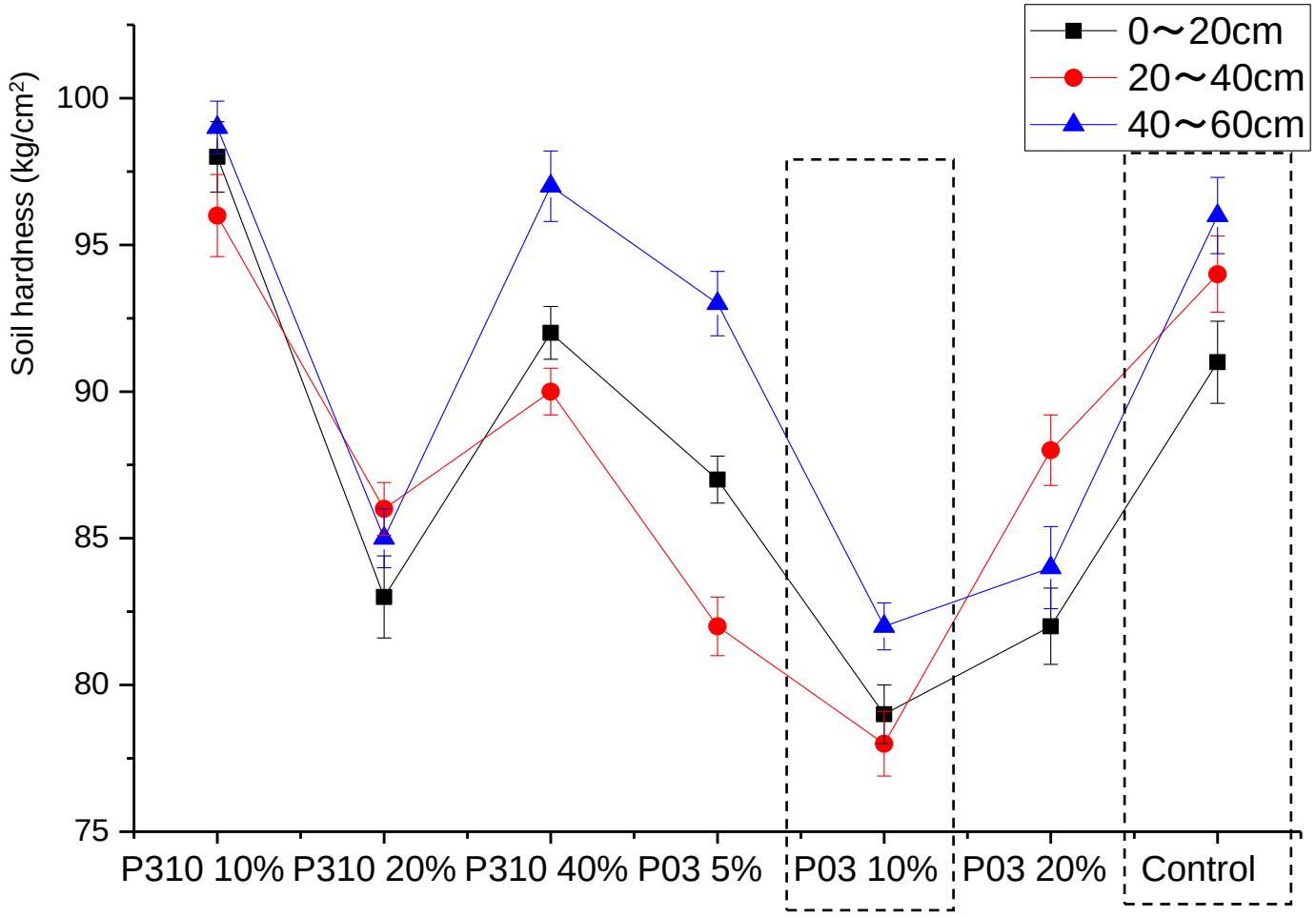


Soil with 10% of Porous Alpha (P03, powder type) has realized significantly higher yield than the soil without Porous Alpha. What is behind this?

(Kiwi experimentation result with quality data)

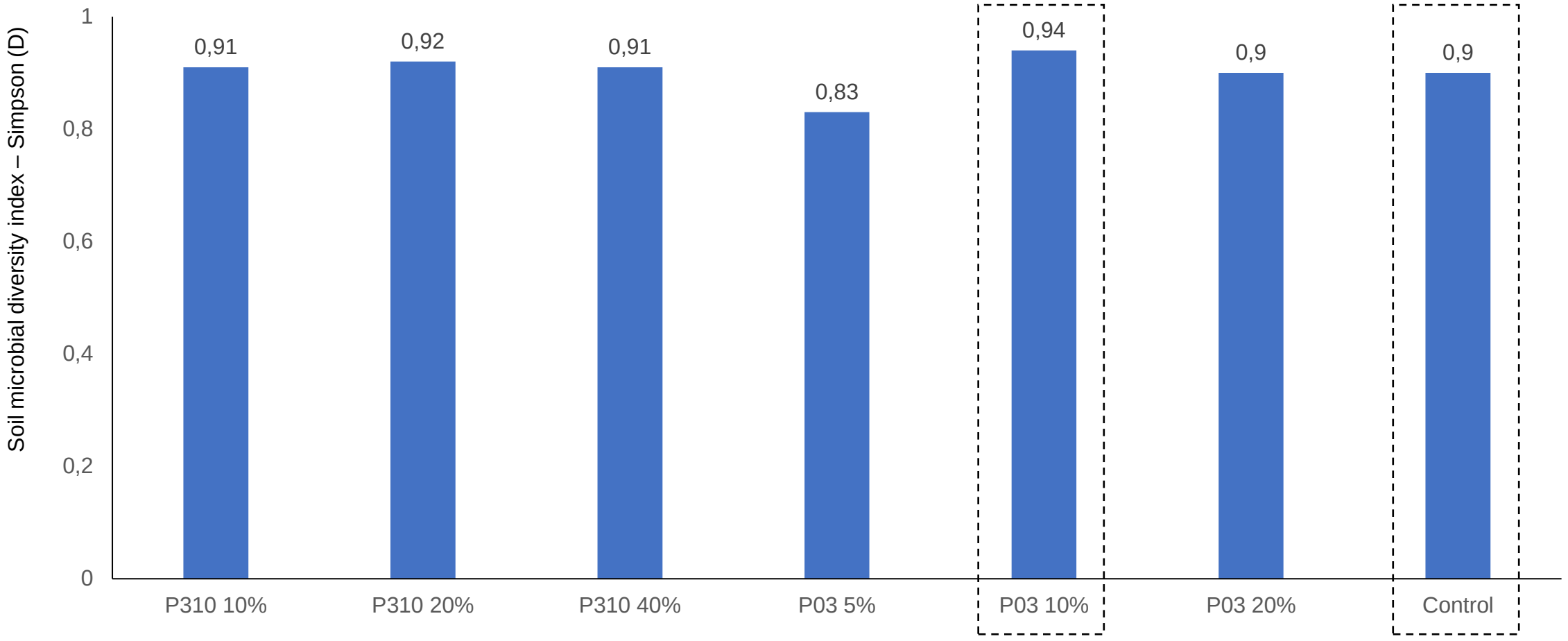
Treatment	Yield (kg)	The commodity rate (%)	Hard fruit soluble solids (%)	Soft fruit soluble solids (%)	Hardness (kg/cm²)	Total sugar (%)	Total acid (%)	Sugar-Acid ratio	Vc (mg/100g)
I 10% P_{310}	60.42±2.36	80.52	10.83	16.34	14.32	4.80	1.11	4.32	164.34
II 20% P_{310}	82.13±4.55	87.14	11.03	16.87	15.89	4.93	1.02	4.83	170.34
III 40% P_{310}	67.98±2.87	85.47	10.93	15.89	15.21	4.72	0.93	5.06	169.32
IV 5% P_{03}	75.14±3.23	84.43	10.45	16.49	14.58	4.48	1.13	3.96	168.24
V 10% P_{03}	98.45±5.28	93.48	11.23	17.00	16.02	4.78	1.00	4.78	168.49
VI 20% P_{03}	62.46±2.65	77.85	10.69	16.61	15.25	4.42	1.12	3.95	165.89
VII CK	61.26±1.03	82.35	10.71	16.48	15.59	4.59	1.04	4.41	166.67

The soil with Porous Alpha has softened the clay soil hardness



Soil with 10% of Porous Alpha (P03, powder type) is significantly softer than the soil without Porous Alpha

The better aeration also realized better activation of microbes in soil



Soil with 10% of Porous Alpha (P03, powder type) has higher soil microbial diversity than the soil without Porous Alpha

Case study of Porous Alpha for agriculture

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- Various vegetable in open field (Somalia)
  - Line Application for yield increase
- Blueberry production with substrate (Morocco)
  - Usage as substrate for yield increase
- Others

In a new plantation, Porous Alpha will have same growth even with half of the inputs compared to normal condition

- Objective: Better growth & 50% water reduction and fertilizer
- Installation method
  - Digging planting holes
  - Mix the product on the ground in the upper 50cm
  - Plantation

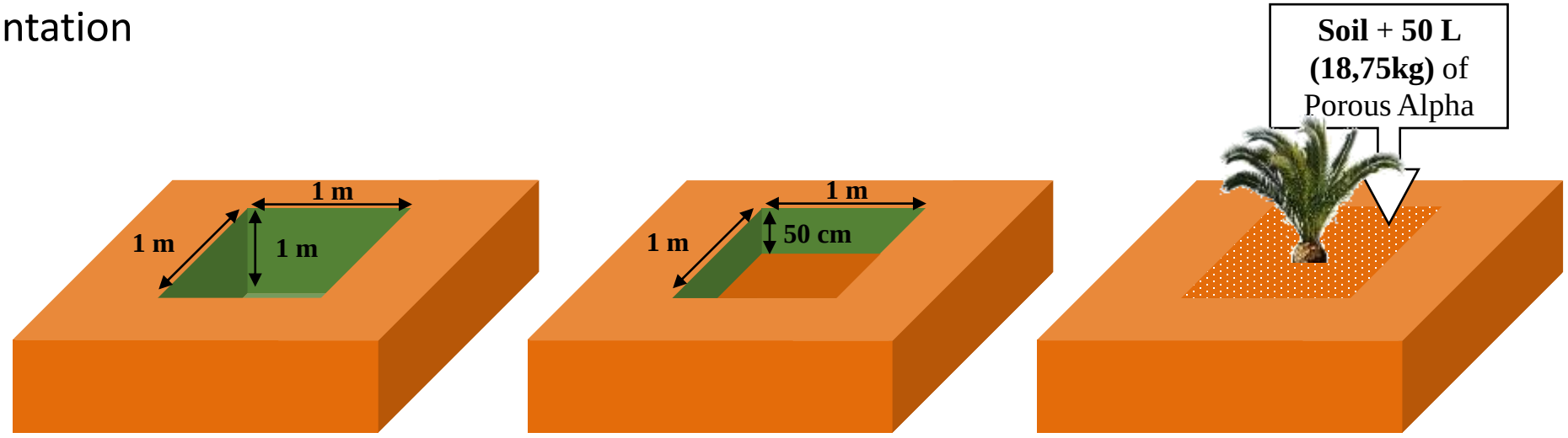


Image of installation for new date palm plantation

1) Digging

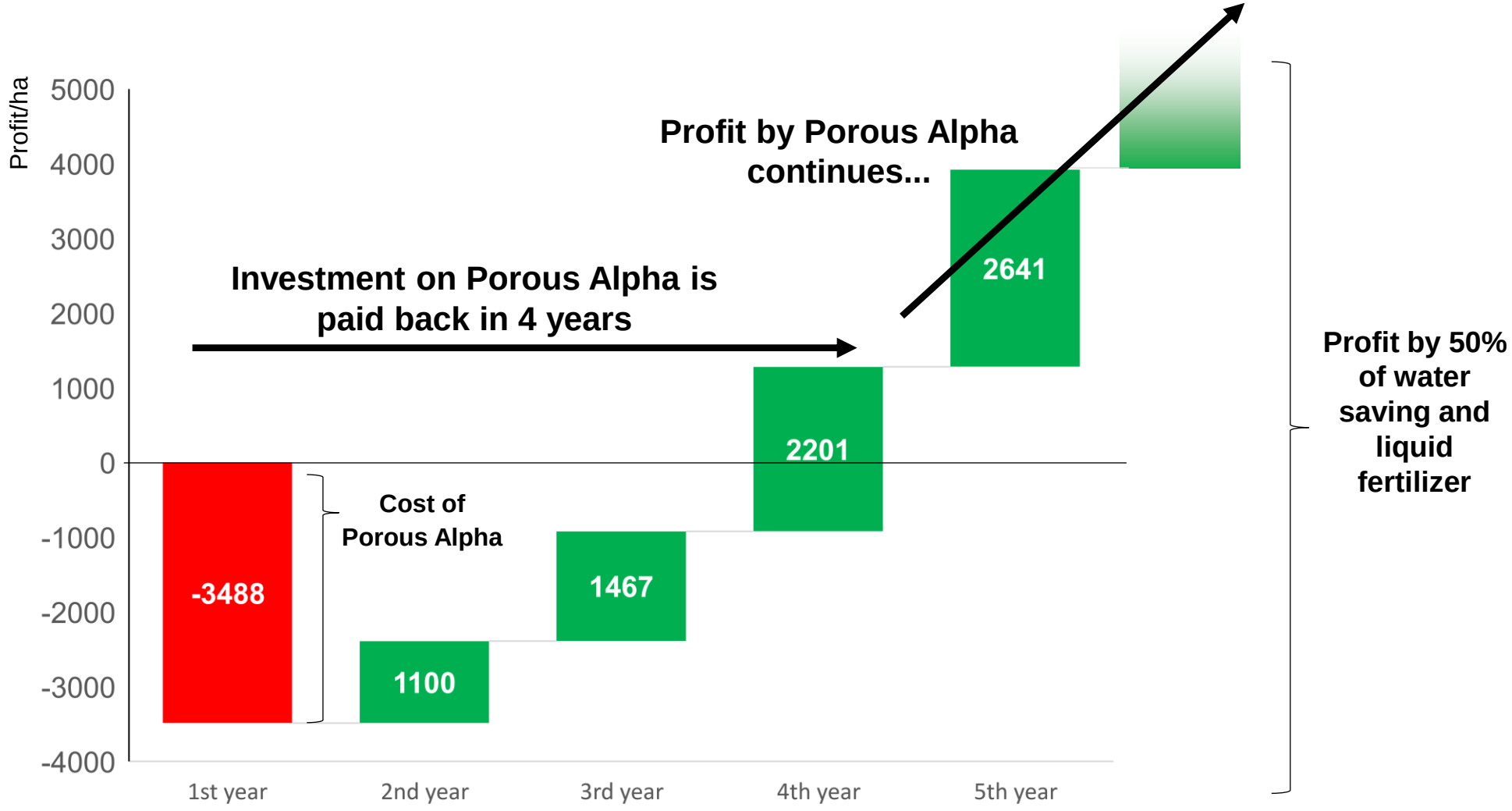
2) Mix

3) Prepared for planting

With porous alpha, the expenses of your planting project are reduced by 3800+ Eur/ha before the start of production

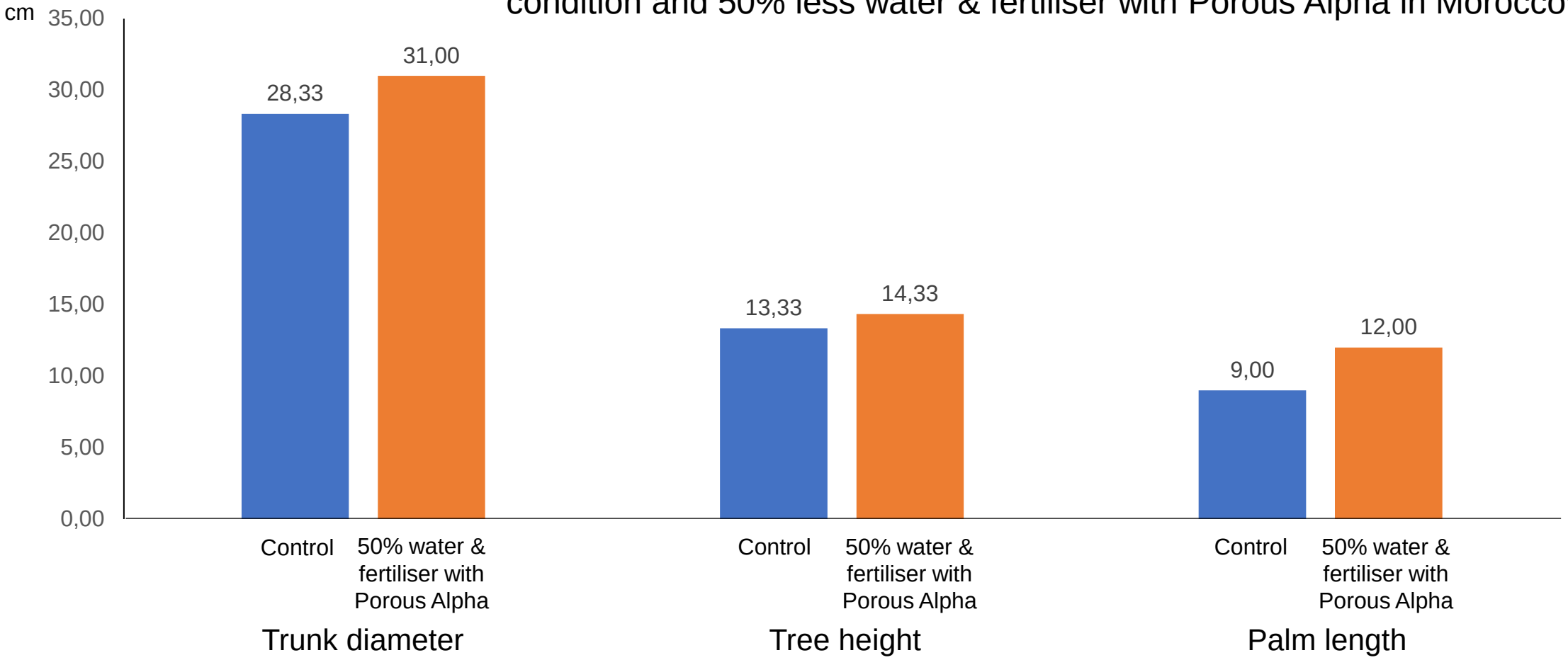
	1st year (Plantation)	Expense of water and fertilizer for 5 years	5th year (Production)
Planting without Porous Alpha		**14800 Eur/Ha**	
Planting with **Porous Alpha**		**11000 Eur/Ha**	

The investment in Porous Alpha at plantation is paid back in 4 years, with the following annual profit of + 2600 Eur/ha/year



The growth of palm tree with half water and fertiliser with Porous Alpha was same with the normal condition

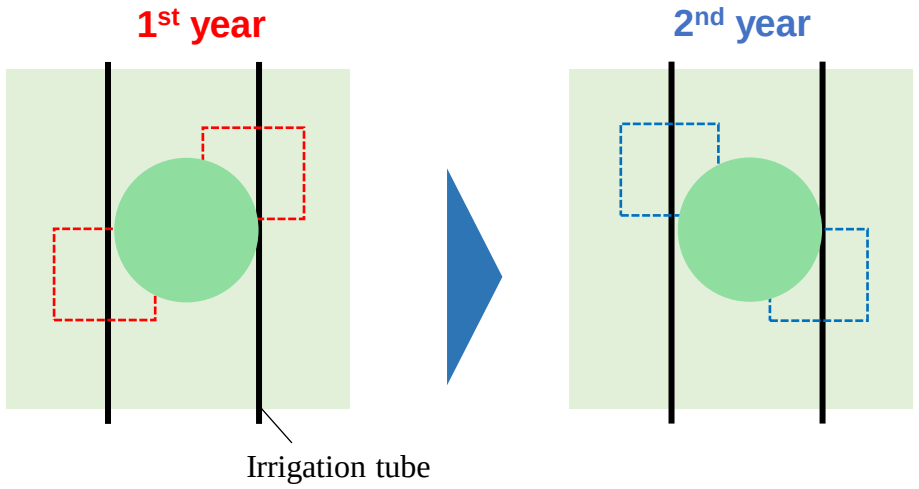
Comparison of growth of date palm (3 years old tree) in 7 months between normal condition and 50% less water & fertiliser with Porous Alpha in Morocco*

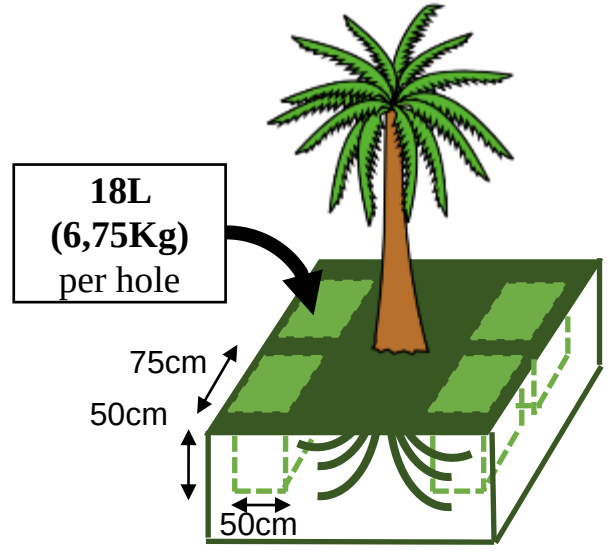


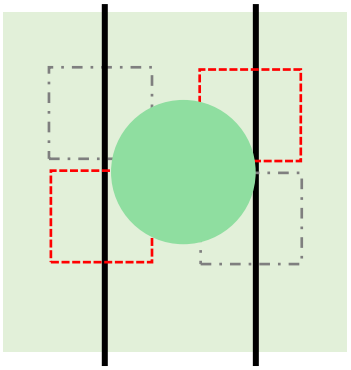
** March 2019 ~ October 2019 in Errachidia Morocco, Each treatment has three trees*

On adult Palm, Porous Alpha will allow to earn half of the expenses over 10 years

- Objective: Save **50%** of water and fertilizer
- Installation method
  - Divide the application of the product over two years
  - Install the product on 2 holes each year during the winter
  - Dimensions of each hole: 75cm * 50cm * 50cm

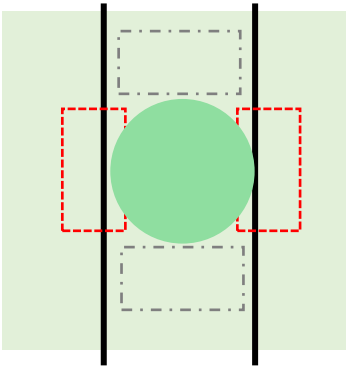




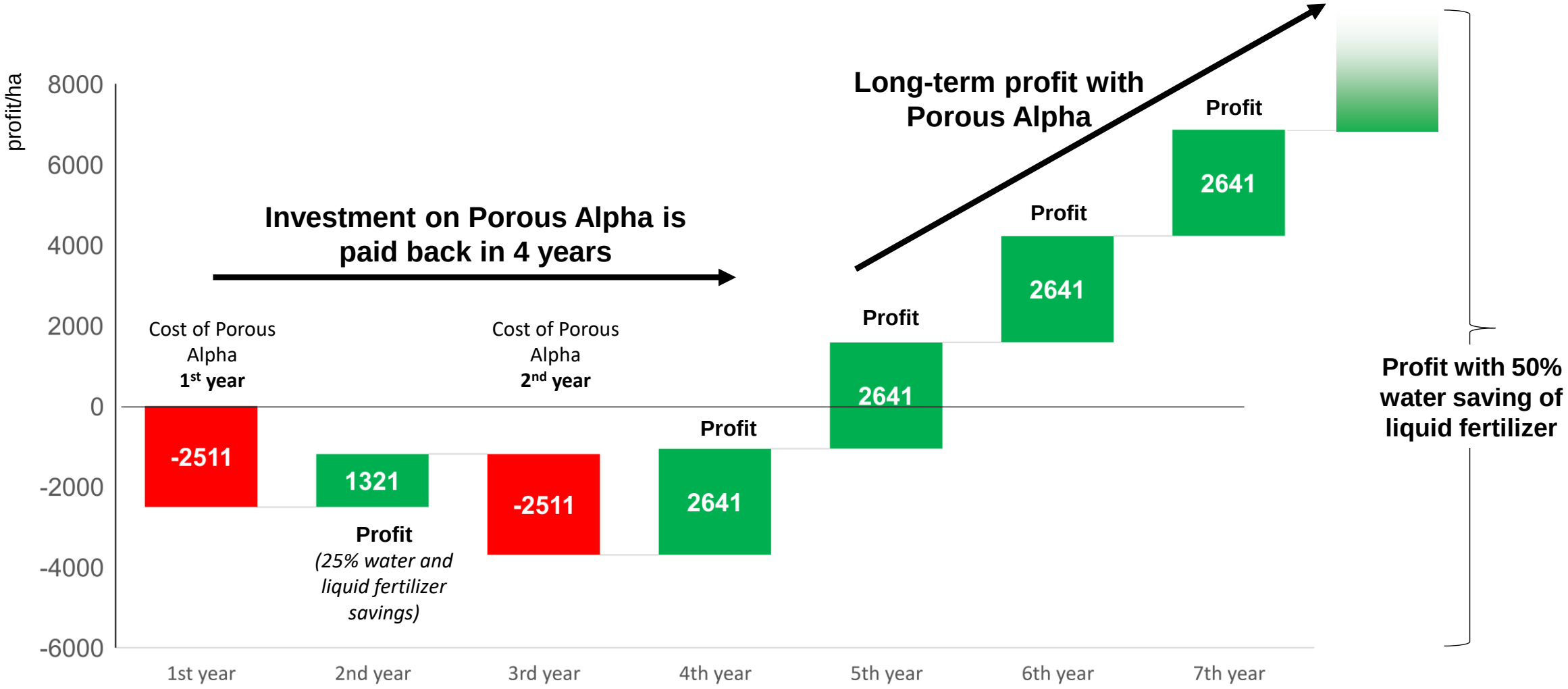


Date palms in Boudnib (aged + 12 years)

A Errachidia (aged 3 years)

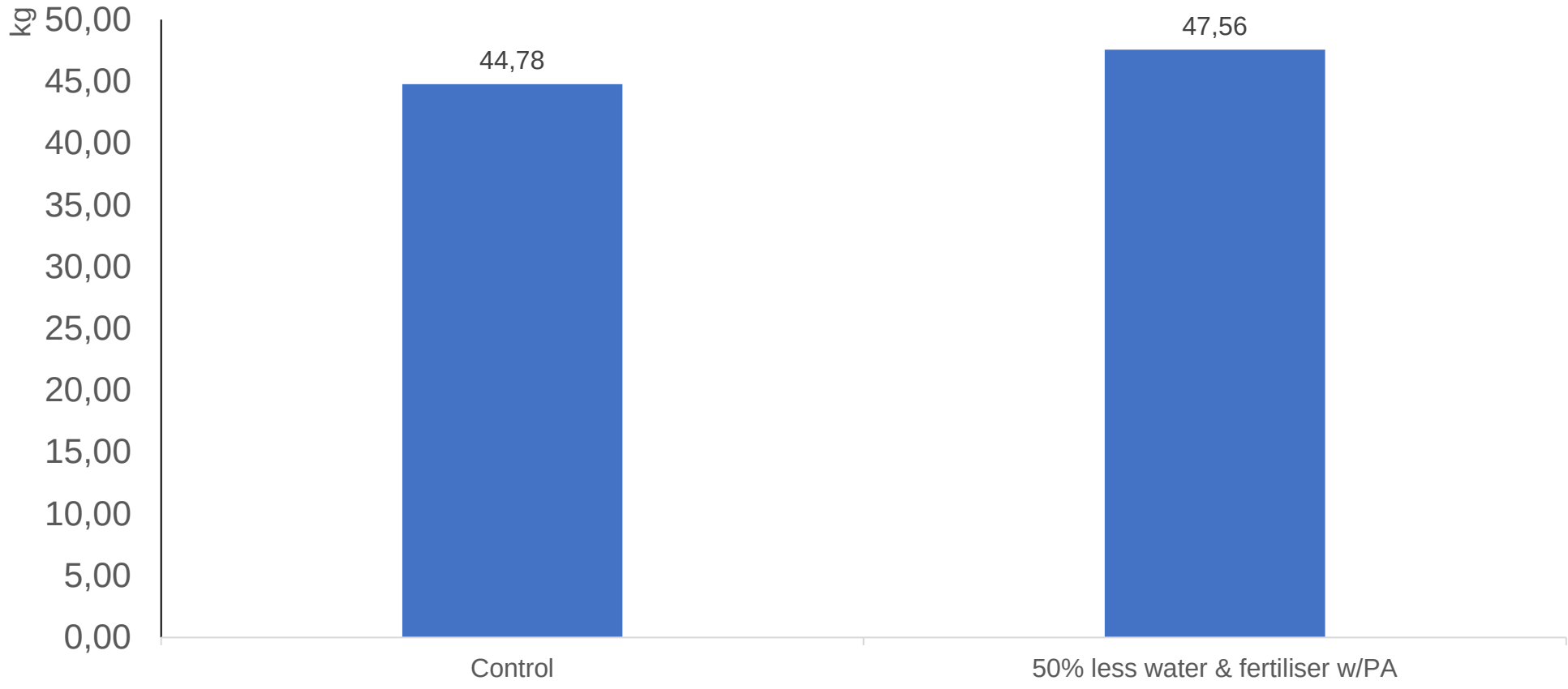


The investment in Porous Alpha on adult palms is paid back in 4 years, with an annual gain of 2600 Eur/ha



Date palm tree in Morocco with 50% less water & fertiliser with Porous Alpha gave harvest with control condition

Comparison of average harvest of 9 trees of date palm between normal condition and 50% less water and fertilizer with Porous Alpha*



* *Harvest recorded in September in Errachidia Morocco*

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  - Line Application for yield increase
- Blueberry production with substrate (Morocco)
  - Usage as substrate for yield increase
- Others

We carried out pilot project in Somlia for the verification of the performance of Porous Alpha

- Timeline
  - Date of agreement for the project: November 2016
  - Training for Teachers at JKUAT: November 2016
  - Season 1 in Baidoa: April 2017 – September 2017
    - Collaboration with IOM and READO (Rural Education and Agriculture Development Organization)
  - Season 2 in Bossaso: October 2017 – March 2018
    - Collaboration with IOM and Ministry of Agriculture of Somalia
- Objective
  - Confirm the Porous Alpha's performance on water-saving and yield increase
  - Confirm the non-existence of negative impact on soil and crop
- Crops
  - Orange fleshed sweet potatoes (OFSP) for Baidoa
  - Tomato, Spinach, Lettuce, Hot pepper, Bell pepper for Bossaso

Lecture session on Porous Alpha and the Installation training in the field of JKUAT

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The expected impact is so significant that the food security of internally displaced people are improved

As-Is

Persistent food insecurity fragile to climate change*
- Severe climate
- Scarce water resource
- Few experience on agriculture

This project

Verification of simple agriculture technology with 50% less water

If this project succeeds…

Increased food security with resilience to climate change *
- Less water consumption for agriculture
- Increased and resilient food production to climate change
- Adoptable by many Internally displaced people

* *http://humanitariancompendium.iom.int/somalia/2016*

TRR and IOM shared the cost and effort

List of roles and responsibilities for the realisation of the project in Somalia

No.	Role	TRR	IOM
1	Identification of project needs, project site and vegetables to be tested	-	✓
2	Setting experimental conditions and layout	✓	-
3	Production of Porous Alpha (3m^3 in total)	✓	-
4	Cost of manufacturing of Porous Alpha	✓	-
5	Transport arrangement from factory to port of Kobe, Japan	✓	-
6	Transport arrangement from port of Kobe, Japan to the project site	-	✓
7	Transport cost from factory to the project site	-	✓
8	Preparation of pilot farm including setting drip irrigation equipment	-	✓
9	Preparation of installation manual of Porous Alpha	✓	-
10	Cost for business trip for Training for trainers (ToT) in Nairobi	✓	✓
11	Location, materials, schedule organisation for the arrangement of ToT in Nairobi	-	✓
12	Lecture and demonstration in ToT	✓	-
13	Installation of Porous Alpha in the project site	-	✓
14	Plantation, production and harvest	-	✓
15	Data collection & analysis (pH & EC of soil, irrigation, harvest, photo)	-	✓
16	Chemical analysis on soil and crop and its cost	-	✓
17	Cost for business trip for the review and evaluation after the experimentation in Nairobi	-	✓

Training session in JKUAT with IOM Somalia Mission and Somali Ministry of Agriculture

Lecture session on Porous Alpha the experimenation plan in JKUAT

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Installation training in the field of JKUAT

© IOM / Miski Mohamed 2016

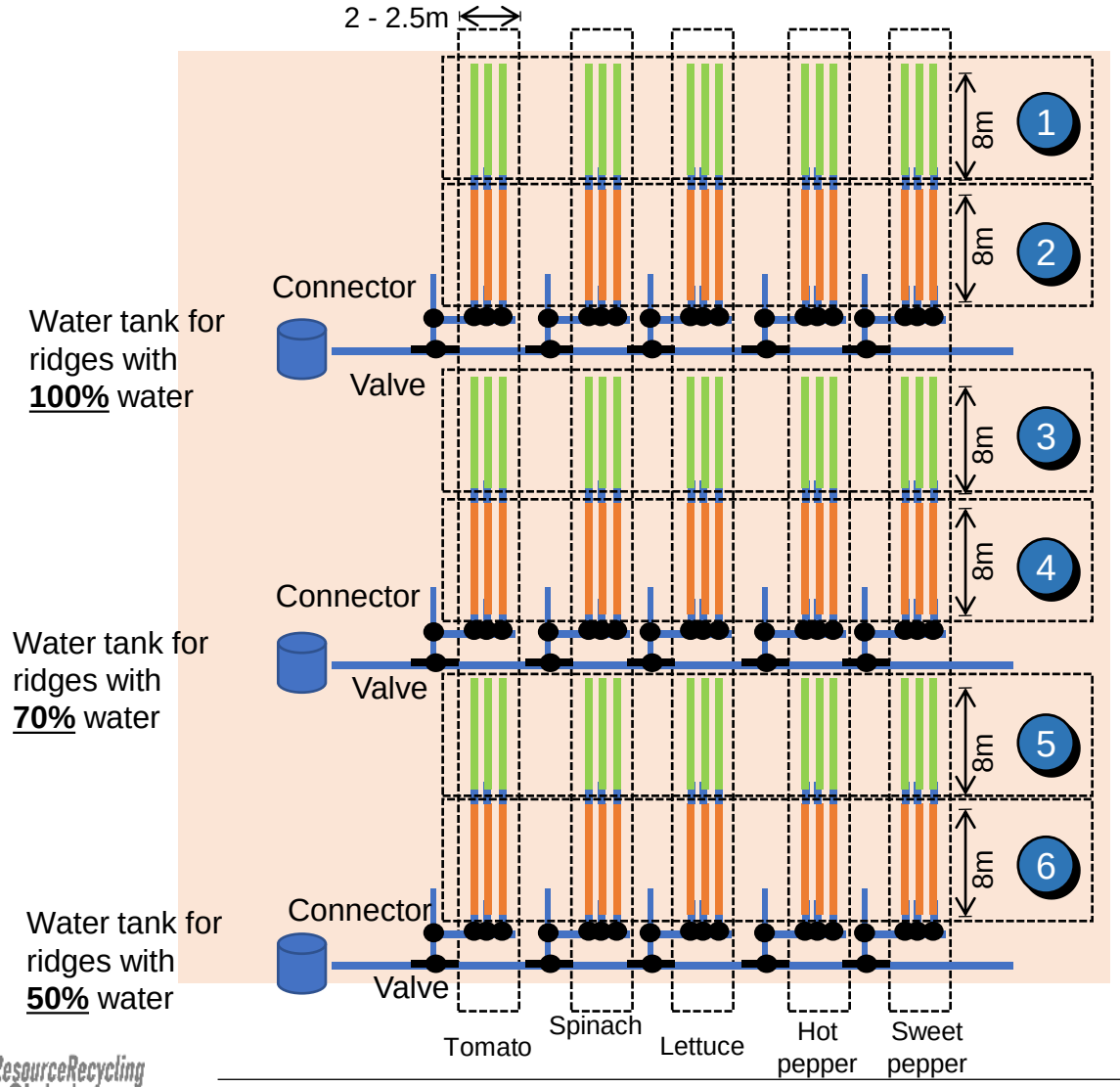
In the preliminary test in Baidoa, the water-saving effect was identified

- Soil texture: Silt loam
  - Farmers avoid heavy clay soil for Orange fleshed sweet potato (OSPF) production due to the risk of insufficient root development
- Irrigation method: Flooding
- Result
  - 50% water reduction was realized by Porous Alpha
    - Four times a week without Porous Alpha
    - Twice a week with Porous Alpha
  - Harvest was observed to be good under water-saving condition, but was not recorded quantitatively

Checking the harvested OSPF

Mixing Porous Alpha with soil

The other experiment in Bossaso was carried out to qualitatively verify the effect of Porous Alpha



Ridges with Porous Alpha

Ridges without Porous Alpha

Irrigation tube

1 ~ 6 Experimentation condition No.

Condition #	Irrigation	Porous Alpha
1	100%	Without Porous Alpha
2	100%	With Porous Alpha
3	70%	Without Porous Alpha
4	70%	With Porous Alpha
5	50%	Without Porous Alpha
6	50%	With Porous Alpha

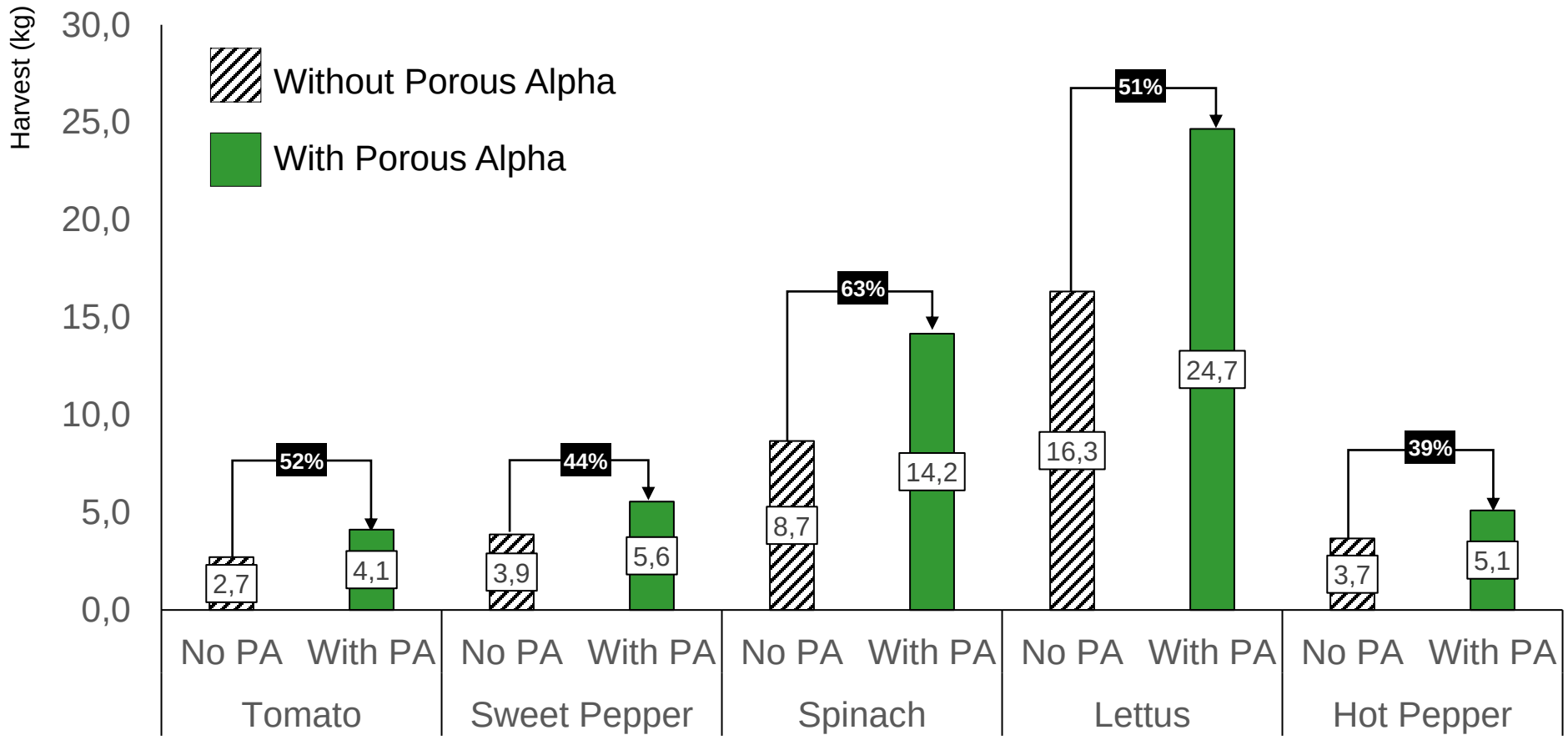
Soil in Bossaso is clay-loam alkali soil

- Soil texture
  - Sand: 30%
  - Clay: 32%
  - Silt: 38%
- Soil alkali level
  - pH: 7.97
  - EC: 0.93 mS/cm

Experimentation field in Bossaso

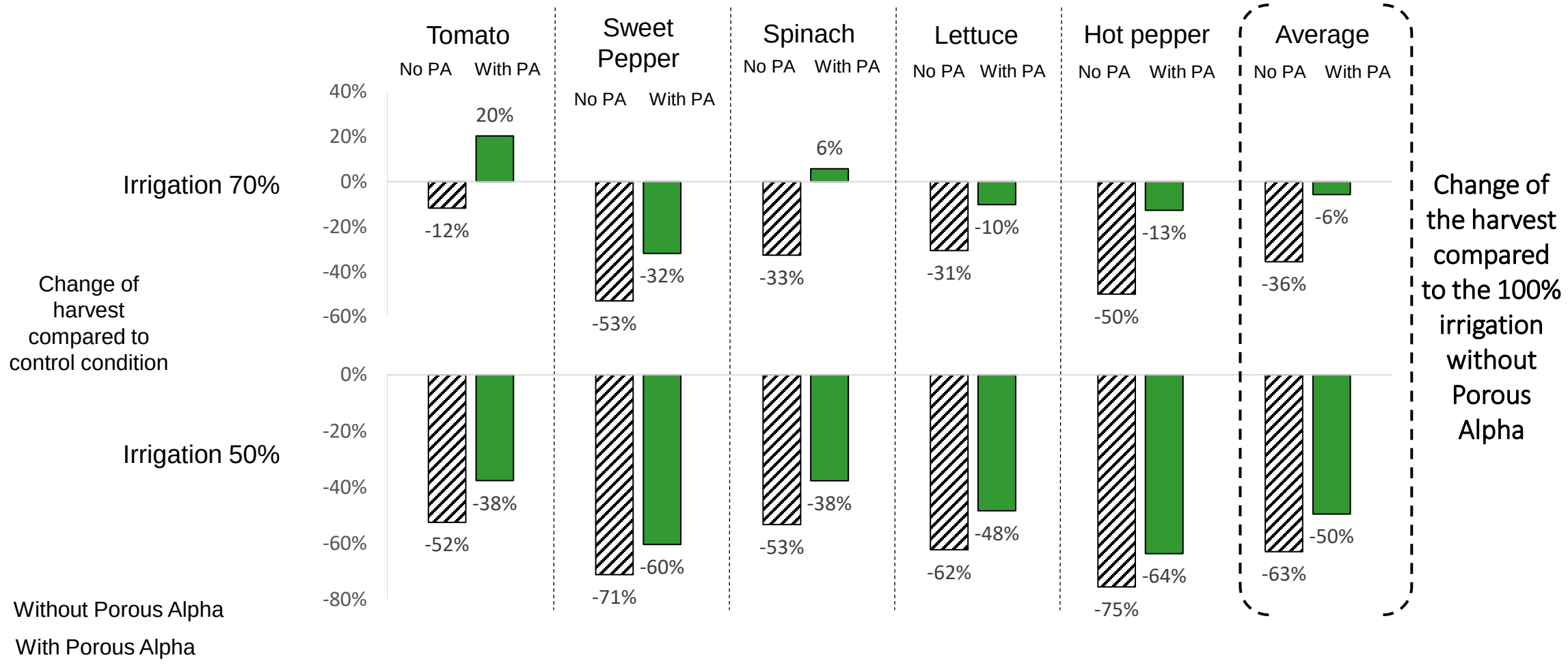
The harvest with Porous Alpha under 100% irrigation increases by 39% ~ 63%

Average harvest (8m ridge) of each vegetable with 100% irrigation



Porous Alpha has proved its effect to increase the yield without increasing any other input

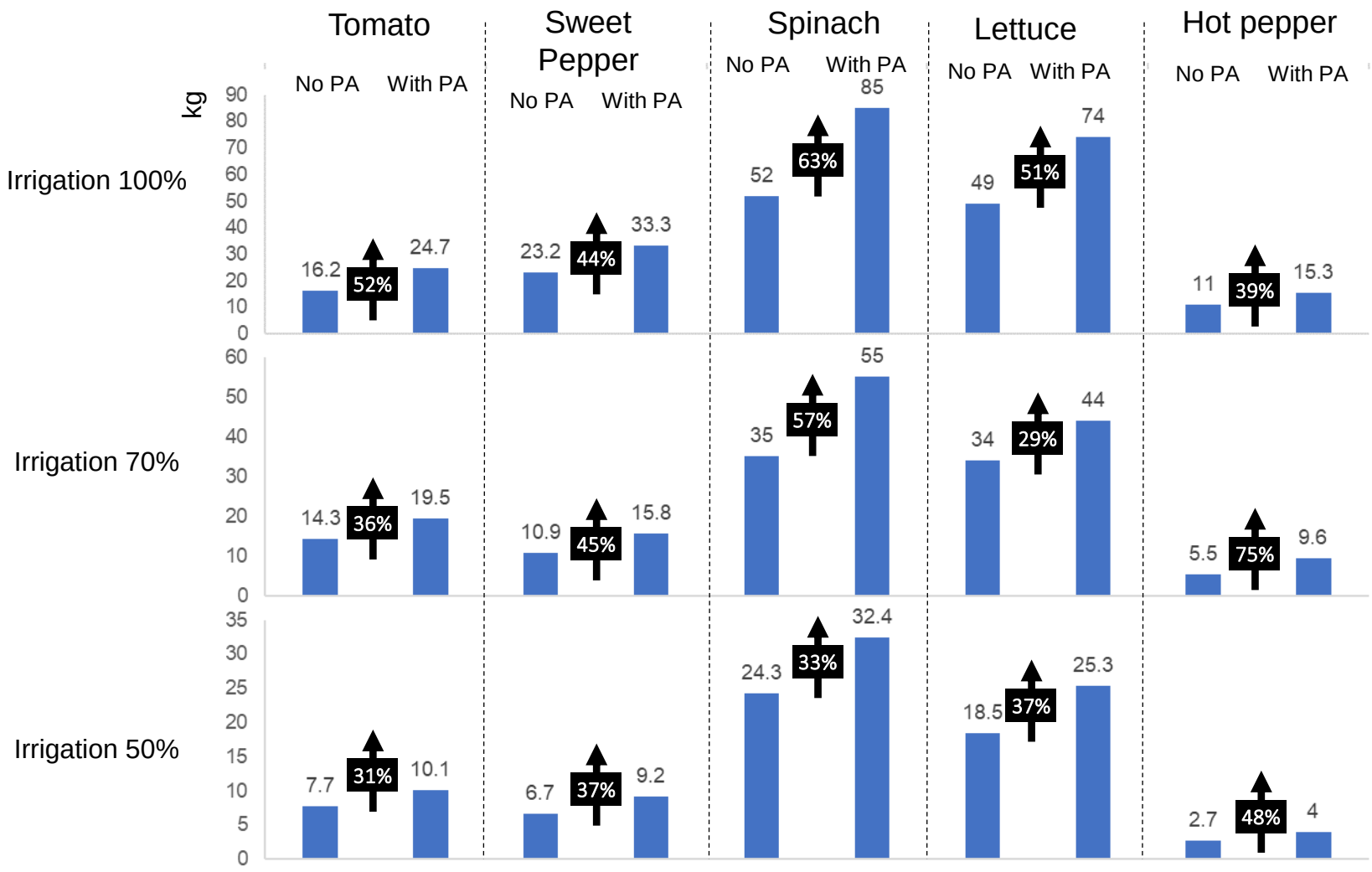
The decrease of harvest due to the limited water is smaller with the installation of Porous Alpha



Porous Alpha mitigates the harvest decrease caused by the water-shortage

Annex: Harvest of 3 ridges for all the conditions in Bossaso

Total harvest of each vegetable under each irrigation and Porous Alpha condition



Project in Somalia implies that Porous Alpha can improve the food safety and mitigate the impact by water shortage

- Increase of food production under normal climate
  - With Porous Alpha, food production can be increased by more than about 30% without additional input

- Mitigation of the impact by short rain-fall
  - The reduction of the harvest by water shortage can be mitigated with Porous Alpha
    - If Porous Alpha is not installed, the harvest reduction of the water shortage of 30% is -36%.
    - However, if the Porous Alpha is installed, that reduction compared to the control condition is limited to -6%
    - In case of the water shortage of 50%, the decrease of harvest is 63% without Porous Alpha and 50% with Porous Alpha

- One-time installation of Porous Alpha realizes food security improvement for 10 years

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Blueberry production requires soft but long-standing substrate

Current issues of blueberry production

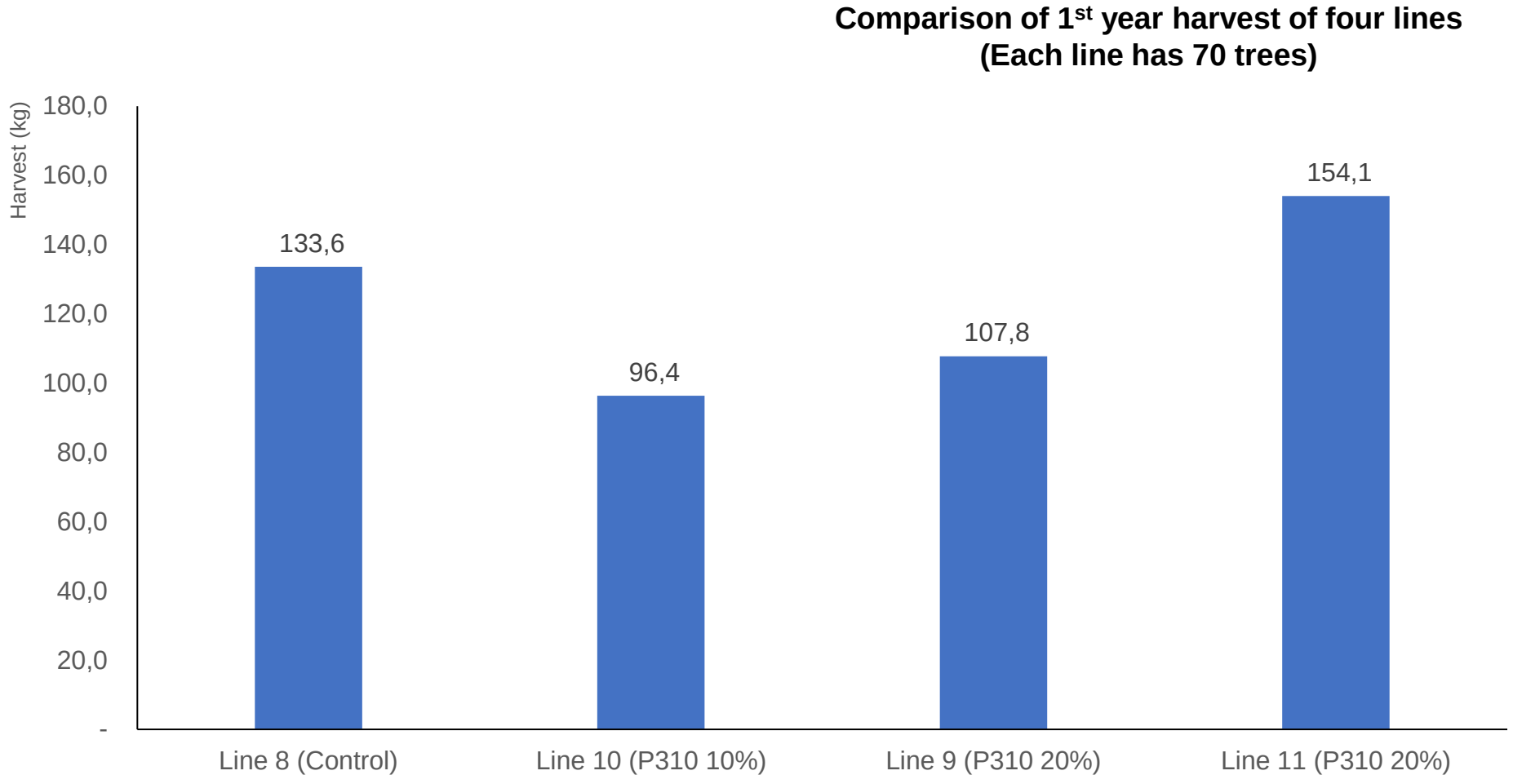
- Blueberry is produced with mixture of substrate such as coco-peat and peat-moss
- Blueberry production continues around 8 years
  - Production starts from 1st year with quite limited quantity
  - The maximum production volume realize from 4 to 8 years
- For high blueberry production, it requires soft rooting media with high aeration
- Currently, the mixture of substrate is compacted after some years

Solution by Porous Alpha

- By mixing Porous Alpha into the mixture of substrate, it is expected to alleviate the compaction

The result of 1st year harvest didn't provide conclusive result

In general, 1st year harvest is quite limited compared to later stage. We continue to monitor the production



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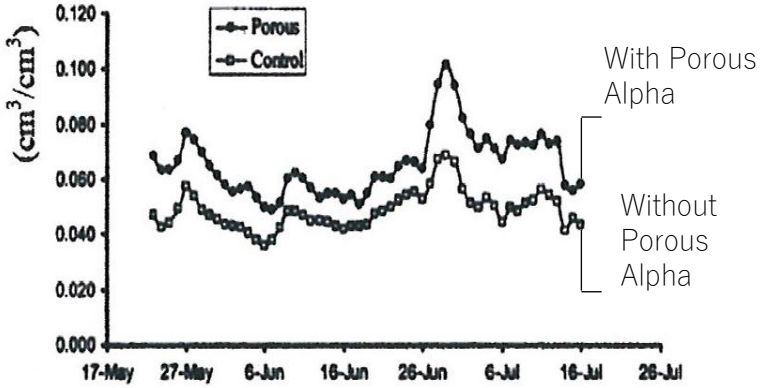
In Mauritania, Porous Alpha set as layer in the soil almost doubled the yield with higher moisture in the soil

With Porous Alpha

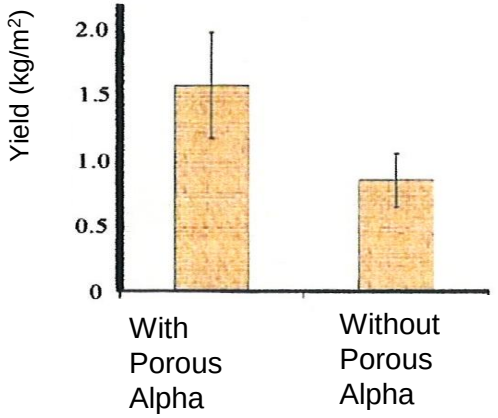
Case in Mauritania

Without Porous Alpha

Historical trend of soil moisture (15cm below surface)



Comparison of the yield



Nov. 2008 Plantation of tomato

Feb. 2009 Harvesting

In the test in Senegal, Porous Alpha mixed with the clay soil improved the yield of green beans by 70%+

Harvest of green beans in the field of 10m x 10m

Condition	1st harvest 6/1/2014	2nd harvest 12/1/2014	3rd harvest(*) 21/1/2014
With Porous Alpha	73 kg	57 kg	4kg
x 1.88 (In average)	x 1.26	x 2.38	x 2.0
Without Porous Alpha	58 kg	24 kg	2kg

* 3rd harvest is only calculated for one of the six ridges for each condition

With Porous Alpha

Comparison: Two months after seeding

Without Porous Alpha

Specification and applicable conditions of soil conditioning by Porous Alpha

- Applicable soil texture: Sandy soil and clay soil
- Application method

	Crops cultivated with ridges	Crops cultivated without crops	Trees: Porous Alpha applied at plantation	Trees: Porous Alpha applied for planted trees
Method	Before setting ridge, distribute Porous Alpha on the location of ridge. Mix Porous Alpha with soil by hand tractor or tractor. Then set up ridge Porous Alpha	Spread Porous Alpha in the field and mix Porous Alpha with soil by hand tractor or tractor	Mix Porous Alpha with the soil for planting pit	Ditch around the terminal of lateral root. Mix the Porous Alpha with the soil from ditch. Then recover the soil with Porous Alpha to the ditch
Dosage	10% of rooting zone (Porous Alpha Φ:3mm – 10 mm) or 5% of rooting zone soil (Porous Alpha in powder) * Rooting zone: Ridge volume x Root depth (e.g. For the ridge with width of 30cm and root depth is 15cm, the dosage is 5L/m (Φ3mm-10mm) or 2.5L/m in powder))	10% of rooting zone (Porous Alpha Φ:3mm – 10 mm) or 5% of rooting zone soil (Porous Alpha in powder) * Rooting zone: Field area x Root depth (e.g. For the crop with root depth of 15cm, the dosage is 15L/m^2 (Φ3mm-10mm) or 7.5L/m^2 (in powder))	10% of rooting pit (Φ3mm-10mm) or 5% or rooting pit (in powder)	10% of ditched soil (Φ3mm-10mm) or 5% of ditched soil (in powder)
Choice of spec.	If high soil pH is acceptable, the powder product is applicable. (e.g. The crop is resistant to alkaline soil or the soil pH is originally so high that the pH of irrigation water is lowered by acid additive) For the other case, the product of Φ3mm-10mm should be used			

- Durability: More than 10 years (If Porous Alpha is applied to crops with ridge and the tillage is done horizontally to the ridge, the Porous Alpha can be scattered out of the zone of ridge. In that case, the Porous Alpha needs to be installed again)
- Our expert supports the best application method customized for each situation

How can we help?

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