Identification of the best cultivars based on fruit characteristics and adaptability (organic and conventional system)

DELIVERABLE 1.2

PulpIng

Developing of **Pu**mpkin Pu**lp** Formulation using a Sustainable **In**te**g**rated Strategy

Index

Document Information

Deliverable Number	1.2
Deliverable name	Identification of the best cultivars based on fruit characteristics and adaptability (organic and conventional system)
Contributing WP	WP1: Defining agronomic conditions for pumpkin production
Contractual delivery date	M36, August 2023
Actual delivery date	M36, August 2023
Dissemination level	Public
Responsible partner	UTH
Reviewers	UT, CBBC/ISACM, BU
Version	1

1. Scope of the document

In this WP, selected pumpkin germplasm was evaluated under field conditions in three different countries, e.g. Greece, Egypt and Tunis.

2. Methodology

2.1. Experiments in Greece

The experiment was conducted at the experimental farm of the University of Thessaly, Greece during the growing period of 2021 and 2022 (e.g., April-November). Seeds from ten genotypes (V1-V10; Table 1) were directly son in the soil on 19-05-2021 and 21-04-2022. The genotypes included 8 local landraces collected from the respective regions, while two commercial genotypes were also included (e.g., F1 Fytro FS-243, Fytro seeds S.A., Greece; and Big Max, GenikiFytotechniki S.A., Greece). Moreover, for the growing period of 2022 crop rotation was implemented dividing the field in two halves were one half was cultivated with a legume spieces(*Pisumsativum*L.) before pumkin and the otherhalf was laid fallow. Seeds were sown in rows at distances of 1.6 m within each row and 2.0 m between the rows. Each row consisted of 32 plants, with three rows for each genotype being used (96 plants for each genotype in total), while rows were laid out according to the completely randomized design (n=3).

For the 2021 growing period, before sowing a complex fertilizer (18-9-18, N-P-K; Complex Haifa Turbo K + Mg +S + Fe and Zn; Haifa Group, Israel) was applied as base dressing at a rate of 250 kg/ha and was evenly distributed with a rototiller. Irrigation was applied via a drip irrigation system (one emitter per plant with water supply of 6 L/h) at regular intervals based on the environmental conditions during the experimental period. Irrigation was scheduled based on the recordings of soil moisture content taken at regular intervals aiming to retain 100% of field capacity. Soil moisture content was recorded with PR2 Profile Probe (Delta T PR2/4 +HH2; Delta-T devices Ltd., Burwell, UK) using access tubes 40 cm long, while measurements were taken at soil depths of 10, 20, 30 and 40 cm. Access tubes were established with Delta-T augering and extraction kit (PR-ASK1-S, Delta-T Devices Ltd., Cambridge, UK), using one access tube per genotype (15 tubes in total).

After crop establishment, fertilization was applied via the drip irrigation system (fertigation). In particular, on 16-07-2023 plants received ammonium nitrate (34.5% nitrogen; 80 kg/ha), Solusop (0-0-52, N-P-K; Agri.fe.m Ltd., Greece; 40 kg/ha) and Disper bloom (Disper Bloom; Agrofarm S.A., Greece; 1.5 kg/ha). On 26-07-2023, plants were foliary sprayed with Disper bloom (100 g/100 L of water) and Root & leaf (20-20-20, N-P-K +TE; 200 g/100 L of water). On 28-07-2023, plants were fertigated with 80 kg of ammonium nitrate and 40 kg of Solusop. On 12-08-2023, plants were treated with 50 kg of ammonium nitrate, 50 kg/ha of Solusop and 15 kg/ha of Mannitol 3 GR (Agrofarm S.A., Greece). Weeds were controlled chemically with pre-emergence herbicides, as well as manually with a hand hoe during the growing period and until crop establishment. Pests and pathogens were chemically controlled based on the recommended practices of the crop.

Harvest took place when fruit reached maturity from 25-08-2021 to 22-11-2021, depending on the genotype. After harvest, fruit yield was calculated by as the sum of the weight all the fruit from each cultivar extrapolated to the harvested area of one hectare.

For the 2022 growing period, crop rotation was implemented dividing the field in two halves were one half was cultivated with a legume species (*Pisumsativum* L. was sown 23/11/2021) before pumkin and the otherhalf was laid fallow.*Pisumsativum*plants were cut and integrated as green manure in the soil on March 2022.This regime was applied for three selected genotypes (V1, V4 and V7) based on their performance and the preliminary results of the quality features of fruit collected from the 2021 growing period. The rest of the genotypes were cultivated in the same conditions as in 2021 (no crop rotation).

Before sowing, the part of the field where green manure was added received base dressing with Kalisop (0-0-51; N-P-K) at a rate of 88 kg/ha and 0-46-0 at a rate of 49 kg/ha. The other half which remained fallow received 250 kg/ha of a complex fertilizer (18-9-18, N-P-K; Complex Haifa Turbo K + Mg +S + Fe and Zn; Haifa Group, Israel); 15 kg/ha of 15-15-15 (N-P-K); Kalisop (0-0-51; N-P-K) at a rate of 88 kg/ha; and ammonium nitrate at a rate of 125 kg/ha. All vertilizers were integrated in the soil with a rototiller.

During cultivation, plants received fertilizers through the irrigation system (fertigation) as follows: on 06/07/2022 and 22/07/2022 140 kg/ha of ammonium nitrate and 70 kg/ha of Solusop (0-0-52, N-P-K; Agri.fe.m Ltd., Greece); on 12/08/2022 70 kg/ha of ammonium nitrate and 70 kg/ha of Solusop. Weeds were controlled chemically with pre-emergence herbicides, as well as manually with a hand hoe during the growing period and until crop establishment. Pests and pathogens were chemically controlled based on the recommended practices of the crop.

Harvest took place when fruit reached maturity from 28-07-2022 to 07-10-2022, depending on the genotype.

Table 1. Genotype names of pumpkin cultivated in Greece in 2021-2022.

Pumpkin Genotype
V1 (Fytro FS-243) UTH
V2 (Landrace from the region of Trikala)
V3 (Big Max)
V4 (Local landrace “Nychaki”)
V5 (Local landrace “LeukaMelitis)
V6 (Local landrace from the region of Lakonia)
V7 (Local landrace from the region of Lakonia)
V8 (Local landrace from the region of Lakonia)
V9 (Local landrace “Makedonikaprasina")
V10 (Local landrace from the region of Laconia)

The descriptors regarding the fruit shape are presented in the following figure (Figure 1).

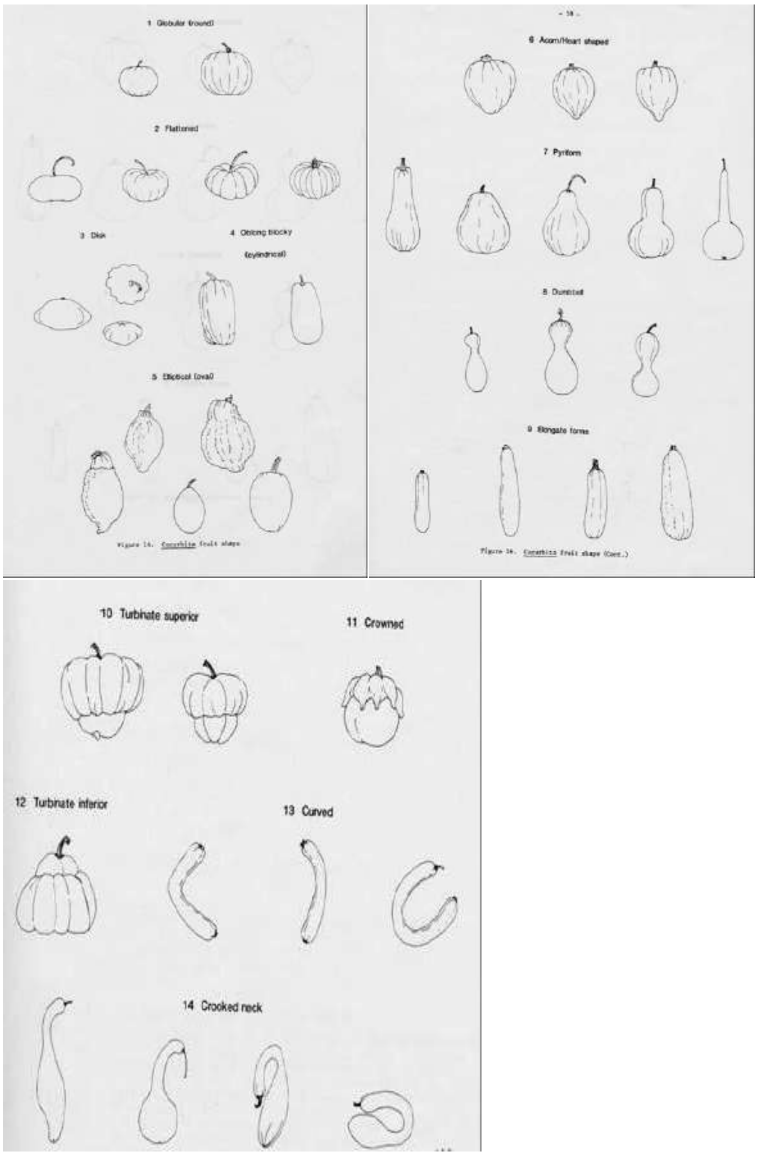
1) 

Figure 1. Fruit shape characterization according to ECPGR descriptors for Cucurbita sp.

2.2. Experiments in Tunisia

Trial 1: Conventional farming

The experiment was conducted at the experimental farm of the High Agronomic Institute of Chott Mariem (Sousse – Tunisia) under greenhouse conditions during the growing period of 2022 and 2023 (e.g., February - May). Based on the response of 15 landraces to salt stress, four landraces were selected (Table 2) and planted into 2 L pots containing peat, soil and gravel to ensure good drainage and prevent water logging.

Table 2. Description of morphology of fruit from local squash accessions

Landrace	Accession number	Governorate	Description
Batati yellow	NGBTUN752	Siliana	Globular fruit, yellow skin, light orange flesh
Galaoui small seeds	NGBTUN1005	Ariana	Fruit turbinate inside with a large basal point, green skin, green-white flesh
Karkoubi pink	NGBTUN748	Sousse	Flattened fruit, dark yellow skin, yellow flesh
Bjéoui green	NGBTUN753	Siliana	Flattened fruit, dark green skin, light green flesh

The physico-chemical characteristics of the substrate used are shown in the table below (Table 3).

Table 3. Physico-chemical characteristics of the substrate

	Clay (%)	Silt (%)	Sand (%)	O.M. (%)	pH	Carbon (%)	Nitrogen (g/Kg)
Substrate	38.27	27.19	34.54	57.33	7.07	33.87	11.31

Planted seedlings were transferred to the greenhouse under controlled conditions and watered regularly. Once a week, plants were fertilized with four fertilization rates. In particular, plants received fertilizers through manual irrigation as follows (i) low fertilization rate (standard fertilization rate – 10%), (ii) standard fertilization rate (144 U N, 75 U P_2O_5, 321 U K_2O and 60 U MgO), (iii) average fertilization rate (standard fertilization rate + 10%) and (iiii) high fertilization rate (standard fertilization rate + 20%). After 45 days, the plant response to different fertilization rates was assessed on the basis of agro-morphological parameters.

Harvest took place when fruit reached maturity at the beginning of May, depending on the genotype. Pests and pathogens were chemically controlled based on the recommended practices of the crop (Table 4).

Evaluated parameters

- ✓ Yield/Plant
- ✓ Fruit weight
- ✓ Fruit number/Plant
- ✓ Peel thickness
- ✓ Flesh thickness

Table 4. List of pesticide treatments carried out

Trade name	Active ingredient	Type	Doses	Enemies
Proplant	Propamocarbechlorydrate	Fungicide	200cc/hl	Mildew
Saprol	Triforine	Fungicide	100ml/100l	Oïdium
Sherap-EC	Cypermehtrine	Insecticide	100cc/l	Aphids
Bazooka	Imidacloride	Insecticide	50cc/hl	White flies
Decis EC25	Deltaméthrine	Insecticide	100cc/hl	Aphids

Trial 2: Organic farming

This experiment was carried out in open field using approximately 1000 m². Sixty seeds/landrace for three landraces (Galaoui large seeds, Galaoui small seeds and Bejaoui green) were cultivated on the experimental site of the technical centre for organic farming (Sousse – Tunisia)**.**

Sowing took place in February 2023 in honeycombed trays placed in a greenhouse. The soil was ploughed and 3.5 tonnes of compost were spread, followed by several passes to break up and loosen the soil with a Canadian plough. A rotavator was used to break up the large clods, and planting of seedlings took place in March 2023 at the 3-leaf stage.

During the germination period, the greenhouse was aerated every day and phytosanitary treatment was carried out as required, in particular against damping-off. The first irrigation was carried out immediately after planting. Irrigation was then carried out regularly and evenly.

Hoeing was repeated 2 or 3 times during the crop development to eliminate weeds, loosen the soil and integrate the manure into the soil before the plants covered the soil surface. This practice was carried out when the plants reached the 4 to 5 leaf stage and before the appearance of flowers.

The fertilization programme was based on the use of different types of solid compost and different concentrations of compost tea.

Evaluated parameters

- ✓ Seed weight
- ✓ Skin thickness
- ✓ Flesh thickness
- ✓ Floral scar
- ✓ Fruit size

- ✓ Flesh color
- ✓ Skin color

Experimental design

The experiment was conducted on completely randomized blocks (CRB) with three replications. Data were analysed using ANOVA tests ($p<0.05$), means were compared using the Duncan Multiple Range test. Statistical analysis wer performed by SAS software V9.

3. Results

3.1. Experiments in Greece

The results of the description of fruit based on the ECPGR descriptors for Cucurbita sp. are presented in Table 5.

Table 5. Traits for the morphological characterization and proportion of the accessions in each class of the tested pumpkin genotypes.

Descriptor Name	Descriptor State	Percentage (%)	Varieties
Plant Growth Habit (PGH)	3 (Bushy)	0.00	
	5 (Intermediate)	0.00	
	7 (Prostrate)	100.00	All
Peduncle Transectional Shape (PTS)	1 (Round)	30.00	V2, V5, V6
	2 (Smoothly angled)	70.00	V1, V3, V4, V7, V8, V9, V10
	3 (Sharply angular)	0.00	
Fruit Shape (FS)	1 (Globular, round)	50.00	V3, V4, V6, V9, V10
	2 (Flattened)	10.00	V5
	3 (Disk-shaped)	0.00	
	4 (Oblong blocky, cylindrical)	0.00	
	5 Elliptical (oval)	0.00	
	6 Acorn (heart-shaped)	10.00	V2
	7 (Pyriform)	20.00	V1, V7

	8 (Dumbebell with neck)	0.00	
	9 (Elongated)	10.00	V8
	10 (Turbinate superior)	0.00	
	11 (Crowned)	0.00	
	12 (Turbinate inferior)	0.00	
	13 (Curved)	0.00	
	14 (Crooked neck)	0.00	
	99 (Other)	0.00	
Fruit Ribs (FR)	0 (Absent)	20.00	V1, V7
	3 (Superficial)	40.00	V4, V5, V6, V10
	5 (Intermediate)	20.00	V2, V3
	7 (Deep)	20.00	V8, V9
Predominant Fruit Skin Color at Maturity (PFSC)	1 (White)	0.00	
	2 (Green)	30.00	V8, V9, V10
	3 (Blue)	0.00	
	4 (Cream)	20.00	V1, V7
	5 (Yellow)	10.00	V4
	6 (Orange)	40.00	V2, V3, V5, V6
	7 (Red)	0.00	
	8 (Pink)	0.00	
	9 (Brown)	0.00	
	10 (Grey)	0.00	
	11 (Black)	0.00	
	99 (Other)	0.00	
Secondary Fruit Skin Color (SFSC)	0 (No secondary skin)	80.00	V2, V3, V4, V5, V6, V7, V8, V10
	1 (White)	0.00	
	2 (Green)	20.00	V1, V9

	3 (Blue)	0.00	
	4 (Cream)	0.00	
	5 (Yellow)	0.00	
	6 (Orange)	0.00	
	7 (Red)	0.00	
	8 (Pink)	0.00	
	99 (Other)	0.00	
Secondary Fruit Skin Color Pattern (SFSCP)	0 (No secondary skin)	50.00	
	1 (Speckled)	20.00	V9
	2 (Spotted, blotchy)	10.00	
	3 (Striped)	10.00	V1
	4 (Streaked)	0.00	
	5 (Bisectional)	0.00	
	99 (Other)	0.00	
Fruit Skin Texture (FST)	1 (Smooth)	100.00	All
	2 (Grainy)	0.00	
	3 (Finely wrinkled)	0.00	
	4 (Shallowly wavy)	0.00	
	5 (Netted)	0.00	
	6 (With warts)	0.00	
	7 (With spines)	0.00	
	99 (Other)	0.00	
Flesh Color (FC)	1 (White)	30.00	V3, V8, V9
	2 (Green)	0.00	
	3 (Yellow)	0.00	
	4 (Orange)	70.00	V1, V2, V4, V5, V6, V7, V10
	5 (Salmon)	0.00	
	99 (Other)	0.00	

Flesh Color Observation Stage (FCOS)	1 (Market stage)	100.00	All
	2 (Physiological maturity)	0.00	
Flesh Texture (FT)	1 (Smooth-firm)	100.00	All
	2 (Grainy-firm)	0.00	
	3 (Soft-spongy)	0.00	
	4 (Fibrous-gelatinous)	0.00	
	5 (Fibrous-dry)	0.00	

According to **Table 5**, all the genotypes had a prostrate plant growth habit. The peduncle transectional shape was round in three genotypes (V2, V5 and V6), while the rest of the genotypes had a smoothy angled peduncle transactional. Most of the genotypes (V3, V4, V6, V9 and V10) formed round fruit, two genotypes formed pyriform fruit (V1 and V7) and the rest of the genotypes formed flattened, heart-shaped and elongated fruit (V5, V2 and V8, respectively). Regarding the fruit ribs, four genotypes had superficial ribs (V4, V5, V6 and V10), while two genotypes had intermediate (V2 and V3), deep ribs (V8 and V9) or no ribs (V1 and V7). The predominant fruit color was orange in four genotypes (V2, V3, V5 and V6), three genotypes had green color (V8, V9 and V10), two genotypes had cream color (V1 and V7) and one genotype was yellow (V4). However, the green color observed in three genotypes should be confirmed in the following growing period since harvesting was defined by the growing season and the climate conditions (growing period in the summer-autumn of 2020). Most of the genotypes (8 genotypes) had no secondary fruit skin color, while the rest of them (two genotypes) formed green stripes (V1) or green speckles (V9). Finally, all the genotypes formed fruit with smooth skin and smooth-firm flesh texture, while the skin color was either purple (in seven genotypes) or white (in three genotypes).

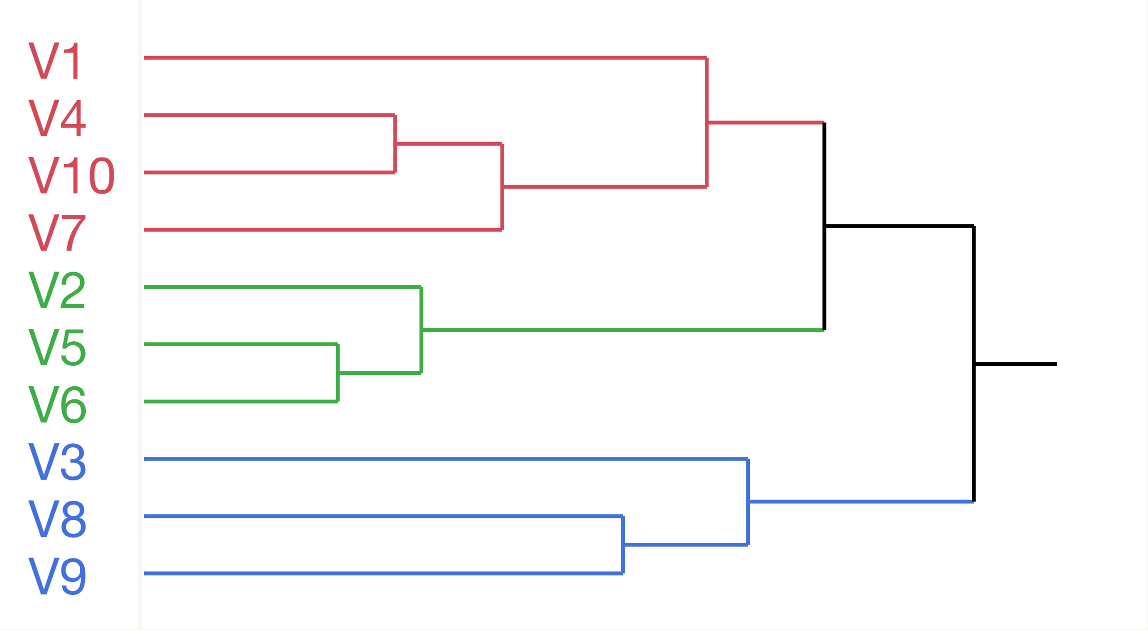


Figure 2. Cluster analysis of the pumpkin accessions through UPGMA method according to their morphological traits.

The cluster analysis of the selected germplasm based on the morphological traits of plants and fruit identified three groups of genotypes, namely the first group that includes genotypes V1, V4, V7 and V10, the second groups which includes genotypes V2, V5 and V6 and the third groups which consists of genotypes V3, V8 and V9 (Figure 2). The crop performance results (fresh and dry weight of plants) are presented below. Fruit weight was recorded at harvesting, while stem and leaves were weighed when plants reached the largest size and before senescence.

Table 6. 100-Seed weight (g) of the tested genotypes.

	100-Seed weight (g)
V1	10.4h
V2	28.3b
V3	28.5b
V4	16.4f
V5	31.6a
V6	25.5c
V7	12.7g
V8	23.6d
V9	24.2c
V10	28.3b

Means in the same column followed by different letters are significantly different according to Duncan Multiple Range test at p=0.05

The highest 100-seed weight was recorded for V5 genotype, followed by V2, V3 and V10, whereas the lowest weight was recorded for the seeds of V1 genotype (Table 6).

The results regarding the yield parameters are presented in the following Tables.

Table 7. Yield of pumpkin genotypes cultivated in Greece in 2021.

Pumpkin Genotype	Yield (kg/ha)
V1 (Fytro FS-243) UTH	19638
V2 (Landrace from the region of Trikala)	24469
V3 (Big Max)	29938
V4 (Local landrace “Nychaki”)	28738
V5 (Local landrace “LeukaMelitis)	13313
V6 (Local landrace from the region of Lakonia)	20617
V7 (Local landrace from the region of Lakonia)	25438
V8 (Local landrace from the region of Lakonia)	21700
V9 (Local landrace “Makedonikaprasina")	14946
V10 (Local landrace from the region of Laconia)	19629

Table 8. Yield of pumpkin genotypes cultivated in Greece in 2022.

Pumpkin Genotype	Yield (kg/ha)	
	No crop rotation	Crop rotation
V1 (Fytro FS-243) UTH	76016	91230
Voutirato	40795	
V3 (Big Max)	39669	
V4 (Local landrace “Nychaki”) Cylindrical	53916	61398
V5 (Local landrace “LeukaMelitis) Round	56342	
V6 (Local landrace from the region of Lakonia)	35687	
V7 (Local landrace from the region of Lakonia)	89638	102032
V8 (Local landrace from the region of Lakonia)	31727	
V9 (Local landrace “Makedonikaprasina")	13510	
V10 (Local landrace from the region of Laconia)	33066	

Table 9. Fresh biomass distribution in different plant parts.

	FreshWeight (kg/ha)		
	Fruit	Stem	Leaves
V1	25930e	9782e	4267e
V2	28200d	4263h	2208h
V3	32899c	8667g	2570g
V4	40000a	17057d	5418d
V5	14487g	9088f	4533e
V6	21460f	3230i	1518i

V7	35919b	9250f	3620f
V8	26342e	18475c	6039c
V9	15990h	27847b	7916b
V10	13291i	31000a	9762a

Means in the same column followed by different letters are significantly different according to Duncan Multiple Range test at p=0.05

A significant variation was observed among the tested varieties in relation to fresh biomass distribution in the various plant parts (Table 9). The highest fruit yield was recorded for genotype V4, whereas the lowest yield was observed for genotype V10. Moreover, the highest biomass of stem and leaves was determined for genotype V10, whereas the lowest values for the same parameters were recorded for genotype V6.

Table 10. The distribution of fresh biomass in different fruit parts

Cultivar	Fruit mean weight (g)	Rind (%)	Fiber (%)	Seeds (%)	Flesh (%)
V1	1500	15.7	1.2	0.7	82.4
	1243	24.5	1.6	1.4	72.6
V2	6476	23.8	3.2	0.8	72.2
V3	7641	18.9	7.8	0.6	72.7
V4	5041	37.2	10.8	2.6	49.4
V5	11790	19.7	2.5	0.6	77.1
V6	8090	19.2	6.0	0.7	74.2
V7	1730	27.3	3.3	3.4	66.0
	1599	32.7	2.8	4.0	60.5
V8	3941	33.2	6.5	1.9	58.4
V9	4771	38.7	3.8	4.9	52.6
V10	2008	21.1	1.4	2.1	75.5

Flesh constituted the highest portion of fruit biomass for all the tested cultivars with values that ranged between 49.4% and 82.4%, while rind was the second heaviest fruit part (15.7%-37.2) (Table 10). Fruit shape affected the distribution of fresh biomass, as well as the volume of the internal fruit cavity. Fibers and seeds constituted low portions of fruit biomass.

Table 11. Dry matter distribution in different plant parts.

	Dry Weight (kg/ha)		
	Fruit	Stem	Leaves
V1	1571f	1076e	896e
V2	1272h	341h	530h
V3	2375b	650g	591g
V4	2299c	1194d	921d
V5	2130d	727f	680f

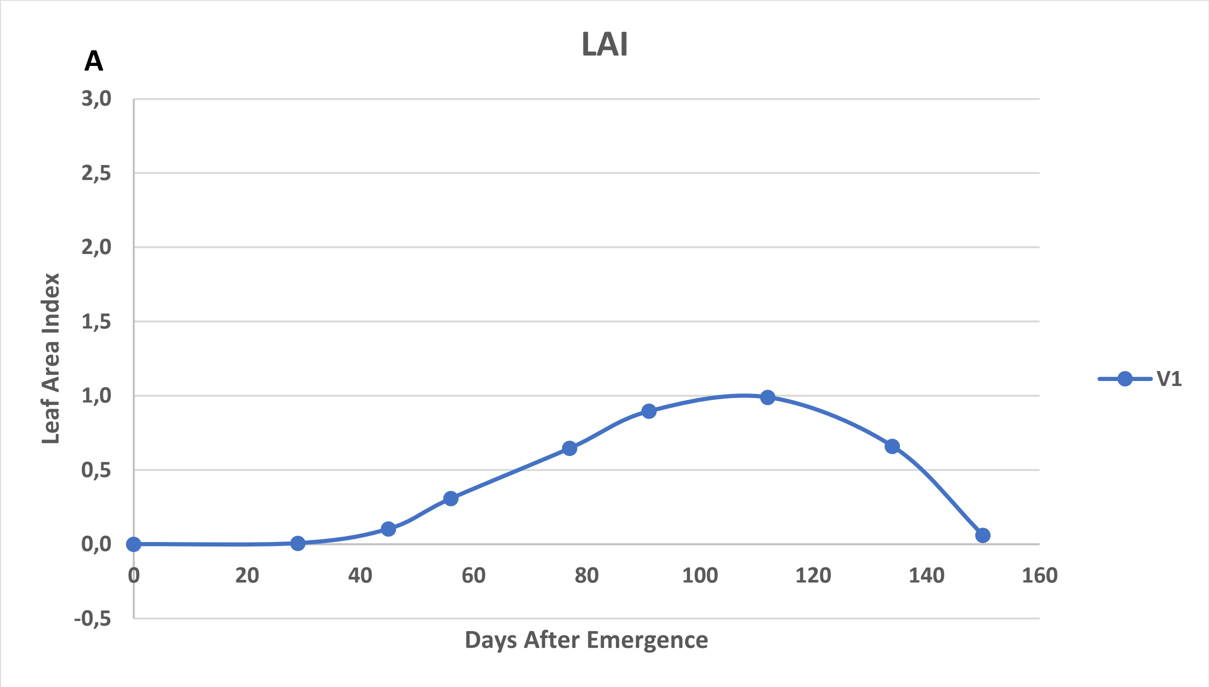
V6	1237h	323h	334i
V7	4070a	925c	923d
V8	1519f	2217c	1389c
V9	1943e	2367b	1504b
V10	1374g	2480a	2050a

Means in the same column followed by different letters are significantly different according to Duncan Multiple Range test at p=0.05

A significant variation was also observed among the tested varieties in relation to dry biomass distribution in the various plant parts (Table 11). The highest fruit dry biomass was recorded for genotype V7, whereas the lowest values were observed for genotypes V2 and V6. Moreover, the highest dry biomass of stem and leaves was determined for genotype V10, whereas the lowest values for the same parameters were recorded for genotypesV2 and V6 in the case of stems and for genotype V6 in the case of leaves.

Table 12. Leaf area index of the tested cultivars in relation to Julian days (JD) and days after emergence (DAE)

JD	DAE	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
145	0	0.0004	0.0004	0.0004	0.0004	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004
174	29	0.0075	0.0061	0.0069	0.0066	0.0064	0.0066	0.0066	0.0066	0.0063	0.0066
190	45	0.1041	0.3946	0.3500	0.4165	0.6000	0.2736	0.2242	0.4181	0.4648	0.4146
201	56	0.3082	0.7254	0.6126	0.9485	0.6259	0.3968	0.7076	1.1988	1.2001	1.1224
222	77	0.6466	0.6802	1.0291	1.3844	0.7228	0.3307	0.8138	1.3818	1.8466	2.3413
236	91	0.8959	0.4924	0.9649	1.1337	0.7778	0.2674	0.9278	1.4171	1.9370	2.7810
257	112	0.9899	0.1410	0.7265	1.0505	0.8028	0.0830	0.8752	1.3073	1.7342	2.6101
279	134	0.6602	0.1443	0.1230	0.7529	0.1654	0.0000	0.4636	1.1966	1.1667	1.7767
295	150	0.0609	0.3004	0.0398	0.4388	0.2276	0.0000	0.5226	0.2139	0.5784	0.7520



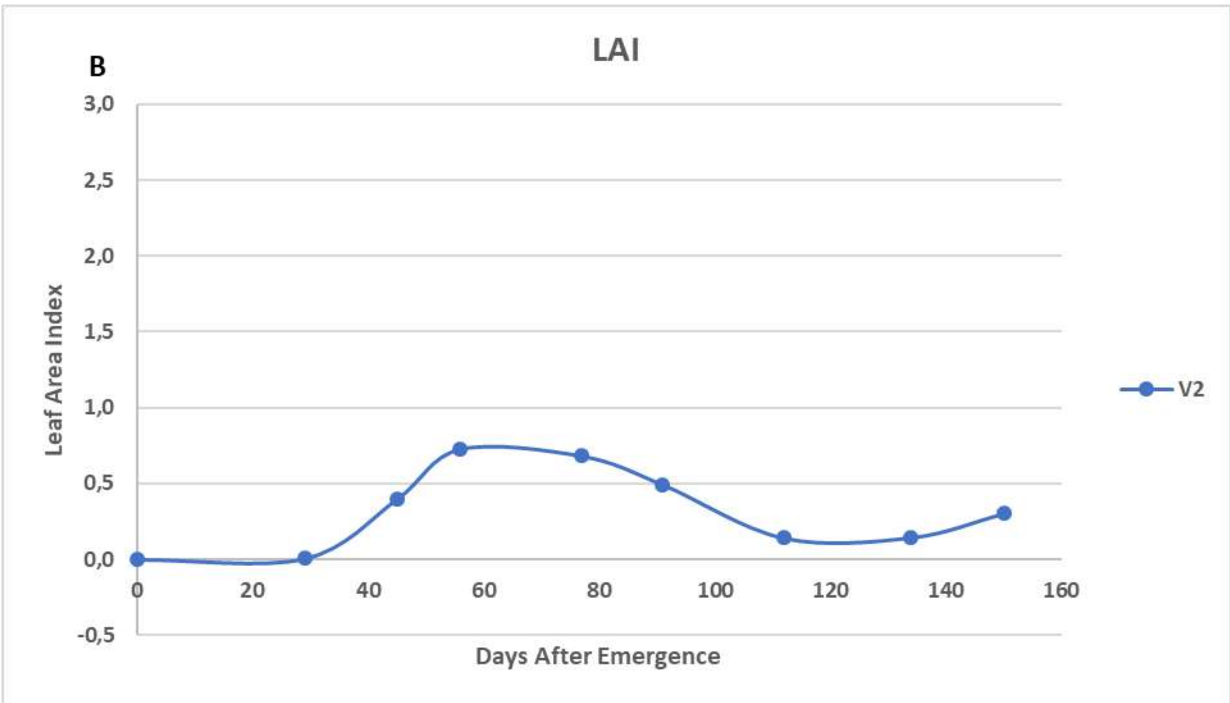


Figure 3. Graphical presentation of the LAI during the growing period.

The LAI showed a gradual increase which coincides with the inceased biomass of plants and cultivated area coverage, followed by a decrease when foliage is withered and plants enter the fruit maturation stage (Table 12). Figure 3, is an example of the trends of LAI values during the growth stage. Figure 3A is representative of cultivars that usually have one cycle of fruit production and plants are withered after fruit maturation (V1, V3, V4, V6, V8, V9 and V10), while Figure 3B is representative of cultivars where after fruit maturation a second cycle of fruit production is possible depending on the climate conditions (V2, V5 and V7).

The carbon dioxide assimilation rate of the tested pumpkin genotypes in relation to photosynthetic photon flux density was represented in Figure 4.

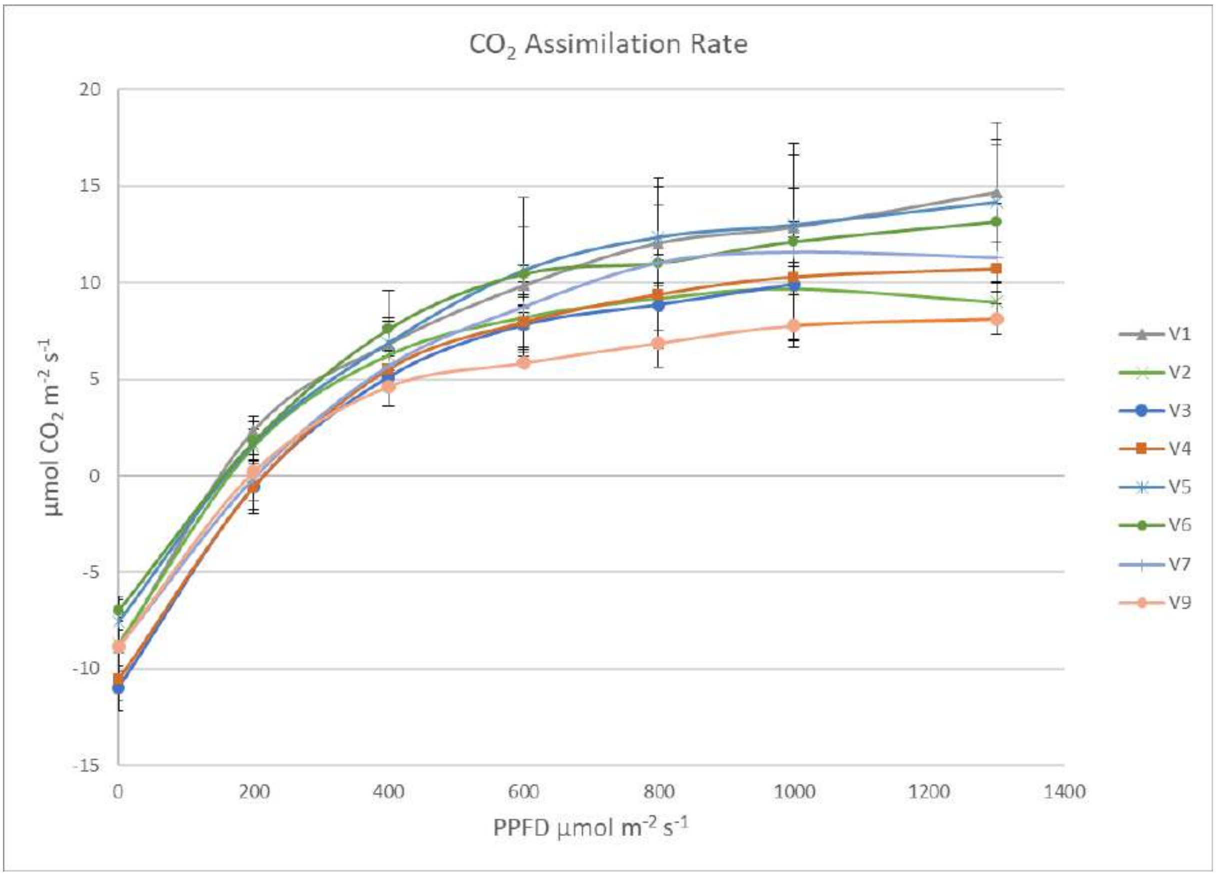


Figure 4. Carbon dioxide assimilation rate (μmol $CO_2/m^2/s$) of the tested pumpkin genotypes in relation to photosynthetic photon flux density (μmol/m^2/s.

3.2. Experiments in Tunisia

3.2.1. Conventional farming

All traits related to growth production under different fertilisation rates were differentially affected by the variety and the fertilisation rate applied. Results of plant yield showed that the highest yield was recorded to Galaoui variety with the highest fertilisation rate (+20%) (Table 13). On the other hand, the lowest squash yield plant was recorded to Karkoubi pink with the low fertilisation rate (-10%).

In the standard fertilisation rate, Galaoui and Bejaoui presented the highest and the lowest yield (4.9 and 3.76 kg per plant, respectively). However, Karkoubi pink presented the highest tickness of flesh and Bjaoui presented the lowest tickness of flesh (163.85 and 49.46 mm, respectively).

The average fertilisation rate provide the highest fruit weight for Galaoui and Batati varieties, while with the highest fertilisation rate, all squash varieties proved to have the highest fruit number.

Table 13. Yield parameters of the pumpkin landraces cultivated in Tunisia grown with conventional farming practices.

	Treatments	Yield/plant (Kg)	Fruit weight (Kg)	F. nbr./plant	Peel thickness (mm)	Flesh thickness (mm)
Karkoubi Pink	Control (-10%)	2.86 ± 0.04	5.66 ± 0.31	1.22 ± 0.07	1.51 ± 0.03	43.1 ± 3.73
	Standard fertilisation	3.98 ± 0.03	14.70 ± 0.94	1.89 ± 0.04	0.35 ± 0.05	178.45 ± 5.78
	Medium fertilisation	3.90 ± 0.05	10.76 ± 1.06	2.11 ± 0.05	0.73 ± 0.03	163.85 ± 3.11
	High fertilisation	3.14± 0.03	5.88 ± 0.39	4.33 ± 0.33	1.70 ± 0.09	46.95 ± 2.58
Galaoui	Control (-10%)	4.61± 0.03	6.74 ± 0.09	0.69 ± 0.03	0.63 ± 0.11	61.38 ± 0.58
	Standard fertilisation	4.9± 0.04	9.89 ± 0.42	1.68 ± 0.26	0.12 ± 0.05	58.73 ± 0.36
	Medium fertilisation	3.95± 0.03	13.98 ± 2.11	2.22 ± 0.18	0.35 ± 0.02	24.21± 0.30
	High fertilisation	5.20± 0.05	9.02 ± 0.68	5.22 ± 0.45	1.99 ± 0.26	14.61 ± 1.84
Bejaoui	Control (-10%)	2.99± 0.06	0.34 ± 0.04	0.55 ± 0.06	1.73 ± 0.10	49.46 ± 6.24
	Standard fertilisation	3.76± 0.06	1.8 ± 0.08	1.11 ± 0.06	0.54 ± 0.04	104.42 ± 4.80
	Medium fertilisation	3.82± 0.06	1.21 ± 0.04	3.66 ± 0.27	0.88 ± 0.06	127.46 ± 2.46
	High fertilisation	4.15± 0.05	0.38 ± 0.06	5.67 ± 0.65	3.14 ± 0.09	29.7 ± 1.65
Batati	Control (-10%)	3.99± 0.08	1.46 ± 0.06	0.55 ± 0.06	1.61 ± 0.06	48.45 ± 2.91
	Standard fertilisation	4.15± 0.06	4.04 ± 0.25	1.89 ± 0.05	1.60 ± 0.06	72.48± 2.98
	Medium fertilisation	4.50± 0.07	9.17 ± 0.60	3.44 ± 0.3	1.08 ± 0.07	43.73 ± 2.72
	High fertilisation	3.98± 0.04	0.72 ± 0.03	6.55 ± 1.27	3.12 ± 0.18	42.05 ± 4.29

3.2.2. Organic farming

The obtained data underline the significant effect of varieties on growth parameters production and qualitative parameters of squash cultivated in organic farmers (Table 14). All parameters were considerably affected by the variety, as evidenced by the mean flesh thikness of varieties under study, which ranged from 3 to 7 mm in varieties “Bejaoui green” and “Galaoui large seeds”, respectively. Moreover, the variety "Bejaoui green", was characterized by a mean Skin thikness of 6.40 mm, while Galaoui small seeds presented the lowest Skin thikness value (0.76 mm). In relation to production growth parameters, "Galaoui small seeds" presented the highest values for fruit sizeL, while the lowest respective values were noted in "Galaoui large seeds" and "Bejaoui green. Regarding the seed weight, "Bejaoui green" and "Galaoui small seeds" presented the highest and lowest values, respectively. Accordingly, significant differences were also observed for floral scar, with "Galaoui large seeds" showing the highest value for this trait, while the lowest values were recorded in "Bejaoui green" and "Galaoui small seeds", respectively.

Table 14. Morphological parameters of pumpkin fruit from Tunisian landraces grown with organic farming practices.

	Seed weight	Skin thikness (mm)	Flesh thikness (mm)	Floral Scar	Fruit size	Flesh color	Skin color
Galaoui large seeds	17.84^{b}	2.72^{b}	7^{a}	187.64^{a}	6.46^{b}	Orange	Orange Brown
Galaoui small seeds	16.32^{c}	0.76^{c}	5^{b}	144.76^{c}	9^{a}	Orange	Orange Brown
Bejaoui green	47.65^{a}	6.40^{a}	3^{c}	167.10^{b}	5.13^{c}	Green	Orange

Concluding remarks

The results from the experiments in Greece showed the great variability in pumpking agronomic performance among the studied local landraces and the commercially available genotypes. The experiments were conducted for two growing periods and in the first period we selected three genotypes based on the yield parameters and the quality of fruit as determinded in other tasks of WP1 (see Task 1.4 and deliverable D1.5) and in WP2 where the recovery of bioactive compounds from fruit by-products was evaluated. Therefore, based on these criteri we selected genotypes V1, V4 and V7 for the second year where we evaluated the effect of crop rotation on crop performance. Despite the fact that crop rotation was evaluated for one growing period, the results were very promising and highlighted the importance of using sustainable practces in pumpkin cultivation as a means to improve yield performance and also reduce the inputs in terms of fertilizers.

Similarly, the results from the experiments in Tunisia showed that plant yield, fruit weight and flesh thickness were the most variable traits in conventional farming for the tested landraces.

For conventional farming, we selected Galaoui landrace based on the yield parameters with high fertilization rate and Karkoubi pink based on the fruit weight parameters with standard fertilization rate.

For organic farming, we selected Galaoui small seeds based on the fruit size.