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Research Article

Numerical Taxonomy of the Apple and Pear Cultivars cultivated in north of Iraq

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Abstract

The current research included numerical taxonomy of cultivars of apple (Pyrus malus L.), namely: ('EarlyGold', 'GrannySmith', 'RoyalCala', Red Delicious' و'Golden Delicious','Honey Crisp', 'Mcintosh', 'Cox'), and cultivars of pear (Pyrus communis L.): ('Coneference', 'Decana', 'Bonica', 'Alkhatuni', 'Alothmani' and 'William') of the family (Rosaceae) cultivated in northern Iraq, using morphological, anatomical and spectroscopic and pollen grains Characteristics. These characteristics were processed mathematically and with one weight for all the characteristics; the result showed that clear extent of similarity between the cultivars of the two species, apple and pear, ranged between (20-75%); the highest level was (75%) between the two cultivars 'Alothmani' and 'Alkhatuni' of P. communis L. species, and the lowest similarity was between the two cultivars 'Honey. Crisp' of P. malus L., and 'Alkhatuni' for P. communis L. with a similarity of (20 %). It was clear from the dendrograms that the studied cultivars of the two species met at a similarity percentage of (44 %), and this is evidence of the correlation between these cultivars one to another for the two studied species of the genus Pyrus. L.

Keywords

Numerical taxonomy, Apple (Pyrus malus L.), Pear (Pyrus communis L.), Cultivars

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Introduction

The scientific and technical advancement achieved in all fields, including computers, helped on the development of the so-called numerical taxonomy, and this is what Davis & Heywood, (1973) and Satece, (1980) referred to, which means the numerical evaluation of the total similarity between the groups with the help of computers and to clarify the degree of correlation and convergence between the operational taxonomic units (OUTS), and then arranging them in the form of clusters depending on the similarity (Sneath & Sokal, 1987).

Numerical taxonomy has been referred to as Adansonia Taxonomy, Computer Taxonomy, or Numerical phenotypic analyses.

Anderson (1949) was the first to use these methods, and Sneath (1957) supported the application of his hypotheses and the use of computers in taxonomy that actively contributed to the emergence of numerical taxonomy. Numerical taxonomy was also used by many researchers to find the degree of similarity and to determine the degree of relation shipe between taxa.

Goodfellow *et al*., (1976) asserted that the selected characteristics must contain a high degree of genetic stability and not be subjected to laboratory changes, and as a result of the absence of a term given to the organisms (genera, species, subspecies, cultivar) for which the taxon is intended to be classified by computers, Sakin and Jones (1980) suggested that using the term "Operational Taxonomic Unit (OTUS)" or the actual unit of classification. Computers have been widely used in the development of quantitative denominations for classification (Heywood, 1974).

The *Rosaceae* family is one of the widespread families in large parts of the world, especially in the northern half of the planet, and its plants grow in the form of herbs, shrubs or trees; according to Aydin and Donmez (2017), it includes about (100) genus and (3000) species. It is the third largest economically important families, especially in temperate regions (Dirlewanger *et al*., 2002), due to the abundance of the fruits it produces such as apple (*Pyrus mauls* L.), pear (*P. communis* L.), *Prunus pursica*, *Prunus domistica*, *P.armeniaca*, *Cydonia* sp. and *Fragaria* spp., as well as ornamental plants such as *Rosa* spp., *Crataegus* spp. and *Potentilla*; in Iraq they comprise (19) genera and (50) wild species, of which (39) species are economically cultivated Al-Katib (2000) and among the common genera in this family are the genus *Pyrus* L., *Prunus* L. and *Rosa* L. The genus *Pyrus* includes both apple (*P. malus* L.) and pear (*P. communis*) which are among the types of fruits of important nutritional and economic value in this family because of their content of nutrients, organic and mineral materials and vitamins necessary for the growth of the body, including carbohydrates, sugars, amino and organic acids, as well as magnesium, sodium and potassium and some rare elements such as copper and manganese (Al-Hadhari, 2000; Abdul-Razzaq, 2013).

Numerical taxonomy methods have been used in many taxonomic studies such as the study of Omran (1988); Al-Mashhadani (1992); Al-Sawah (1992), and Al-Maa'thidy (2003) when he used numerical classification in isolating the taxonomic ranks of the genus *Prunus* L. (*Rosaceae*) and in determining the relationship between them.

In addition to the study of Al-Maa'thidy *et al*., (2007); it classified the species and cultivars of the genus *Crataegus* L. (Rosaceae) which grows in Iraq by numerical taxonomy using morphological characteristics, pollen grains and chromosomes number.

Al-Samurai (2014) also used numerical taxonomy to isolate the species of the genus *Lathyrus* L. (Papilinoaceae) in the northern and central regions of Iraq using morphological, anatomical, chemical and molecular characteristics.

Al- Jowari *et al*., (2018) classified six species of the *Pinus* L. which belongs taxonomically to the *Pinaceae* family which grows in northern Iraq using morphological and chemical characteristics.

The present study aims to numerically classify cultivars the apple (*P. malus* L.) and pear (*P. communis* L.) using the morphological characteristics of vegetative and reproductive organs, pollen grains, some anatomical and spectral characteristics.

Materials And Methods

Computational methods were used in the present study to find the relationships, links and differences between the taxonomic orders of the cultivars species *P. malus* L. and *P. communis* L. collected from different locations in northern Iraq.

Cultivars of these two species were used (Operation Taxonomic Units - OTUS), which were based on the morphological, anatomical, and chemical aspects and pollen grains in order to find the degree of similarity between the two cultivars species, (12) characteristics were selected to prepare the

polygonal diagrams, as shown in Table (1); (40) characteristics (36 qualitative and 4 quantitative characteritic) were selected for numerical taxonomy to compare (14) taxonomic units numerically as reported by Sneath (1957) and Sneath and Sokal (1987) shown in Table (3). After that, and according to the similarities and differences of species according to table (5), the studied characteristics were transformed into numerical data, placed in a numerical matrix and were analyzed statistically through the computer using the program (SPSS 20), and among the approaches of numerical taxonomy, (clusters analysis) was chosen; the taxonomic units of high similarity were arranged in cluster shape, and the process was used successively on the lower proportions until it included all the taxonomic orders, thus it was possible to distinguish the taxonomic ranks of the genus with high degrees of similarity or kinship, and these clusters were arranged by a tree - diagram or what is called the Dendrogram which is shown in Figure (2).

Results & Discussion

(12) main characteristics of taxonomic importance at the level of the studied cultivars of the two species were chosen to draw polygonals by relying on the qualitative rather than the quantitative traits in order to avoid the wide variation of the characteritics, especially at the level of individuals of the same species and to find the effect of clear environmental conditions on the quantitative morphological characteristics. Table (1) and figure (1) indicate the differences in the shapes of cultivars. The cultivar 'EarlyGold' of *P. malus* L. was unique in its diagram's form due to its difference in some morphological characteristics. As for the cultivars 'GranySmith', 'RoyalCala' and 'Mcintosh' of *P. malus* L., they were similar in their external appearance and this similarity was supported by the diagrams, but they differed in the shape of the buds and the shape of the seed. The cultivars 'Red Delicious' and 'Golden Delicious' of the species *P.malus* L. and 'William' of *P.communis* L. were very similar in their external appearance and their diagrams, except that they differed in the surface configuration of the seed coat and the type of veining, which confirms their belonging to the same genus; *Pyrus* L., while the two cultivars 'Honey Crisp' and Cox' of *P.malus* L. showed similarity in their external appearance and their two diagrams, but they differed in the shape of the calyx, the seed and the shape of the stalk. The cultivar 'Conference' of the species *P. communis* L., showed convergence in its diagram with the cultivar 'Bonica' in all of the selected characteristics, and this confirms that they share the same species, *P. communis* L., whereas the cultivar 'Decana' of the species *P. communis* L. was unique in its diagram, which confirms its difference in morphological characteristics. The two cultivars; 'Alkhatuni' and 'Alothmani' of the species *P. communis* L., showed great similarity in their external appearances, but they differed in the habit of the stem, the shape of the bud and the seed, which supports their joining of one species *P. commuins* L.

Table (1)
selected characteristics to draw polygonals for the cultivars of apples (*Pyrus* L.) and pears (*P. communis* L.) genera species

No. symbol	Character	Character state	No. of states
A		Erect	1
	Stem habit	Semi-erect	2
		Spreading	3
B		Acut triangle	1
		Conical	2
	Bud shape	Round-ovate	3
		Lanceolate-oblong lanceolate	4
C		Ovate	1
	Leaf shape	Broadly ovate	2
		Obovate	3

		Lanceolate	4
		Deltoid-obtus	5
D		Dentate	1
	Leaf margin	Serrate	2
		Serrulate	3
		Undulate	4
E		Glabrous	1
	Hairs on style	Pilose	2
		Tomentose	3
F		Spheroid	1
		Oblong spheroid	2
	Fruit shape	Oblate spheroid	3
		Pyriform	4
		Pyriform-globose	5
G		Small	1
	Fruit size	Medium	2
		Big	3
H		Pyriform	1
	Seed shape	Ovoid	2
		Narrowly ovid	3
		Spherical-subspherical	4
I		Striate	1
		Striate papillae	2
	The surface configuration of the seed coat	Pitted	3
		Reticulate irregular	4
		Reticulate papillae	5
		Alveolate	6
J		Triangular	1
	Pollen grain shape	Spherical triangular	2
		Tetrangular	3
K		Circular or subcircular	1
	Petiole shape	Horseshoe	2
		Globose-ovoid	3
		Cordate	4
L		Crescent	1
	Vascular bundle shape in midrib of leaf	Reniform	2
		Subcircule	3
		Elliptic	4

Table (2):
Selected characteristics matrix for drawing polygonals of cultivars of apple (*P. malus* L.) and pear (*P. communis* L.)

No.	Species	Cultivars	Characters A	B	C	D	E	F	G	H	I	J	K	L
1	*Pyrs malus* L.	'Early Gold'	2	1	1	1	3	2	1	1	1	1	2	2
2		'Granny Smith'	2	1	4	2	3	3	3	3	2	2	1	1
3		'Royal Cala'	1	4	4	2	3	3	3	2	1	2	3	1
4		'Red Dilicious'	3	3	1	2	3	1	2	2	4	1	1	2
5		'Golden Dilicious'	2	1	1	2	3	3	1	2	6	1	2	2
6		'Honycrisp'	3	3	4	2	3	1	3	1	1	1	3	2
7		'Mcintosh'	3	3	3	2	3	3	2	1	1	1	1	2
8		'Cox'	2	1	1	2	3	1	3	3	1	1	4	1
9		'Coneference'	2	2	2	3	2	4	2	1	3	1	1	4
10		'Decana'	1	2	2	3	3	5	1	4	3	2	4	4
11	*Pyrus communis* L.	'Bonica'	1	2	1	3	1	4	1	2	3	1	1	3
12		'Alkhatuni'	2	2	5	4	2	4	1	3	3	1	1	4
13		'Alothmani'	1	4	5	4	2	4	1	1	3	3	3	4
14		'William'	2	4	1	3	2	2	3	1	5	2	2	4

Figure (1): Polygonal diagrams to compare some cultivars of apple (*P.malus* L.) and pear (*P.communis* L.)

Through Table (5), we find that the extent of similarity between the cultivars of the two studied species ranged between (20-75%) and the highest level of similarity is (75%) between the two cultivars 'ALothmani' and 'Alkhatuni' of the species *P. communis* L. They are considered to be the closest similar cultivars in most of the morphological and anatomical characteristics and in pollen grains, but they differed in the habit of the stems and the shape of the bud, as it is Lanceolate in the first cultivar

and conical in the second, and the shape of the seed and the shape of the stalk, and from table (5) it is clear that the two cultivars; 'Golden Delicious' and Early Gold' of *P.malus* L. meet at a level of 70% similarity in most of the morphological, anatomical and spectral characteristics, yet they showed difference in the surface configration of the seed coat; it was alveolate in the first one and striate in the second cultivar. They also differed in the shape of the seed; it was ovoid in the first cultivar and pyriform in the second.

At the level of similarity of 70%, 'Cox' cultivar met with 'Royal Cala' cultivar of *P. malus* L., as they had similarity in a number of characteristics such as the shape of the margin, apex, of the leaf blade, the indumentum of it, the surface configuration of the seed coat, the vascular bundle shape of the midrib of the leaf and the absorbance value of the chlorophyll extract.

The two cultivars, 'Honey Crisp' and 'Red Delicious' of *P.malus* L., showed similarity between them at a level of 70%, as the first cultivar is similar to the second in the shape of the buds, the margin and the apex of the leaf blade, the color of the corolla, the indumentum of the style, the shape of the calyx, the shape of the fruit, and the shape of the pollens in the polar view, and the shape of the lower epidermal cells morphology, the type of venation, the shape of vascular bundle of the midrib, and the absorbance value of the chlorophyll extract. The two cultivars 'Bonica' and 'Decana' of *P. communis* L. meet at a level of 70% of similarity; these two types were similar in most of the morphological characteristics, but they differed in the color of the bark, the shape of the fruit and its color, and the shape of the seed. As for the anatomical characteristics, they provide a similarity relationship between the two previous cultivars; they were similar in the type of venation and the type of trichomes, while the two cultivars ' Cox' and 'Early Gold' of *P.malus* L. showed similarity at the level of 67.5%, as these two cultivars were similar in most of the morphological, anatomical and spectral characteristics, but they differed in the color of the bark and the margin of the leaf blade was serrate in the first cultivar and dentate in the second, as well as the seed shape and the cross-section shape of the leaf stalk.

At a level of similarity (67%) the two cultivars 'Royal Cala' and 'Granny Smith' of *P.malus* L. met, as they were similar in a number of characteristics such as the color of the bark, the shape of the blade and the margin of the leaf in addition to its indumentum, the color of the anthers, the shape of the fruiting stalk, the shape of the fruit and the shape of the pollen in the polar and equatorial views, lower epidermal cell shape, type of venation, petiole shape, vascular arch shape of the petiole, vascular bundle shape of leaf midrib, and absorbance value of leaf extract. The two cultivars 'Mcintosh' and 'Golden Delicious' of *P.malus* L., showed similarity at a level of (60%); they were close in the shape of the margin of the leaf blade, the indumentum of it, the shape of the calix, the color of the corolla, the color of the anthers, the indumentum of the style, the shape of the fruiting stalk, the shape of the fruit and the shape of the pollen grains in the polar view, the venation and the vascular bundle shape of the midrib.

At a level of 60% similarity, the two cultivars 'Cox' and 'Golden Delicious' of the species *P.malus* L. met; the two cultivars share some morphological and anatomic characteristics where they showed similarity in the habit of the stems, the shape of the buds, the shape of the leaf blade, its margin, apex and base in addition to its indumentum, the color of the corolla, the color of the anthers, the indumentum of the style, the shape of the fruiting stalk, the shape of the vascular arch in the leaf stalk and the absorbance value of the chlorophyll extract. The two cultivars 'Red Delicious' and 'Early Gold' of *P.malus* L., which are anatomically and spectrally similar, showed similarity at (52%) level, as these two cultivars were similar in the absorbance value of the leaf chlorophyll extract, the vascular bundle shape of the midrib of the leaf and the shape of the vascular arch of the cross-section of the leaf stalk, the polar and equatorial views, the shape of the fruiting stalk, the shape of the leaf blade and the color of the bark, while these two cultivars showed differences in the rest of their morphological and anatomical characteristics, which are the habit of the stems, the shape of the buds, the margin of the leaf blade, its base and apex, the shape of the calyx, the indumentum of the fruiting stalk, the shape of the fruit, the shape of the seed, the surface configuration of it, and the shape of the leaf stalk. As for 'Al-othmani' cultivar of *P. communis* L., it showed similarity at the level of 30% with 'Royal Cala' of *P. malus* L., as these two cultivars were similar in habit of stems, bark color, bud shape, base and apex of leaf blade, fruiting stalk, petiole and vascular arch shape of the petiole. The cultivar 'Alkhatuni' of *P. communis* L., and 'Honey Crisp' of *P. malus* L., showed a level of (20%) of similarity despite their differences in general appearance, but similar in form of fruiting stalk, pollen shape in polar view and absorbance value of chlorophyll extract.

Table (3):
Symbols of selected characteristics in numerical taxonomy of cultivars of apple (*P.malus* L.), and pear (*P.communis* L.)

No.	Character	Character state	No. of States
1.	Stem habit	Erect	1
		Semi-erect	2
		Spreading	3
2.	Bark color	Brown	1
		Reddish brown	2
		Brown-gray	3
		Grayish	4
3.	Bud shape	Acut triangle	1
		Conical	2
		Round-ovate	3
		Lanceolate-oblong lanceolate	4
4.	Leaf shape	Ovate	1
		Broadly ovate	2
		Obovate	3
		Lanceolate	4
		Deltoid-obtus	5
5.	Leaf margin	Dentate	1
		Serrate	2
		Serrulate	3
		Undulate	4
6.	Leaf base	Rounded	1
		Oblique	2
		Cuneate	3
7.	Leaf apex	Found	1
		Absent	2
8.	Hairs of leaf	Globrous	1
		Pilose	2
		Tomentose	3
9.	Stipules	Found	1
		Absent	2
10.	Color of pedicels	Grimson	1
		Green	2
11.	Hairs of pedicels	Glabrous	1
		Vilous	2
		Tomentose	3
12.	Hairs of hypanthium	Glabrous	1
		Tomentose	2
13.	Shape of sepals	Triangular	1
		Tap-like	2
14.	Hairs of sepals	Glabrous	1
		Tomentose	2
15.	Color of petals	Pink	1
		Read	2
		White	3
16.	Number of stamens	Less than 20	1
		20 or more	2
17.	Color of anther	Yellow-yellow pale	1
		Purple	2
18.	Hairs of style	Glabrous	1
		Pilose	2
		Tomentose	3
19.	Length of fruiting stalk	Short (9.7-22.7)	1
		Long (22.7-40. 4)	2
20.	Shape of fruit stalk	Cylindrical	1
		Funnel	2

21.	Hairs of fruiting stalk	Glabrous	1
		Pilose	2
22.	Shape of fruit	Spheroid	1
		Oblong spheroid	2
		Oblate spheroid	3
		Pyriform-globos	4
23.	Color of fruit	Yellow or yellowish red	1
		Green or yellowish green	2
		Red or light red	3
24.	Size of fruit	Small	1
		Medium	2
		Large	3
25.	Shape of seed	Pyriform	1
		Ovoid	2
		Narrowly ovoid	3
		Spherical-subspherical	4
26.	Color of seed	Yellow	1
		Light brown	2
		Brown	3
		Brown blackish	4
27.	The surface configuration of the seed coat	Striate	1
		Striate papillae	2
		Pitted	3
		Reticulate irregular	4
		Reticulate papillae	5
		Alveolate	5
28.	Flowering period	Early flowering	1
		Late flowering	2
29.	Shape of pollen grain in polar view	Triangular	1
		Spherical triangular	2
		Tetrangular	3
30.	Shape of pollen grain in equatorial view	Spherical – sub spherical	1
		Ovate-ovate prolate	2
31.	Shape of epidermal cells	Straight-curved	1
		Undulate	2
		Strongly undulate	3
32.	Venation type	Brochidodrostronly	1
		Semicraspedodromous	2
33.	Petiole shape	Circular of subcircular	1
		Horseshoe	2
		Globose-ovoid	3
		Cordate	4
34.	Vascular bundle shape	Crescent or deep crescent	1
		Reniform	2
35.	Number of vascular bundle	One bundle	1
		Two bundle	2
		Three bundle	3
36.	Number of cortex layer on petiole	Less than 4	1
		4 or more	2
37.	Number of palisad layer	Two rows	1
		Three rows	2
		Four rows	3
38.	Vascular bundle shape in midrib of leaf	Crescent	1
		Reniform	3
		Sub circule	3
		elliptic	4
39.	Number of hairs on epidermis	8.27-19.30 mm^2	1
		19.30-33.98 mm^2	2
40.	The absorbance value of the chlorophyll extract	1.178-2.176	1
		2.176-3.830	2

Table (4),
A Matrix Illustrating Selected Characteristics In Numerical Taxonomy Of Cultivars Of Apple (*P. Malus* L.), And Pear (*P. Communis* L.)

No.	Species	Cultivars	Characters																																										
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1		'Early Gold'	2	3	1	1	1	1	2	2	1	1	2	2	2	2	1	1	1	3	2	1	1	2	1	1	1	1	1	2	1	1	1	1	2	1	3	2	2	2	2	1
2		'Granny Smith'	2	4	1	4	2	1	1	2	1	1	3	2	1	2	1	1	1	3	2	1	2	3	2	3	3	2	2	2	2	1	3	1	1	1	3	2	3	1	1	2
3		'Royal Cala'	1	4	4	4	2	1	2	2	1	1	3	2	2	2	2	1	1	3	1	1	2	3	3	3	2	4	1	2	2	1	3	1	3	1	3	2	1	1	2	2
4	*Pyrus malus* L.	'Red Dilicious'	3	3	3	1	2	2	1	2	1	1	3	2	1	2	2	1	1	3	2	1	2	1	3	2	2	2	4	2	1	1	2	1	1	1	2	2	2	2	2	2
5		'Golden Dilicious'	2	2	1	1	2	1	2	2	1	1	3	2	1	2	1	1	1	3	2	1	1	3	1	1	2	3	6	2	1	1	3	1	2	1	3	1	2	2	1	2
6		'Honycrisp'	3	1	3	4	2	3	1	3	1	1	3	2	1	2	2	2	1	3	2	1	2	1	3	3	1	1	1	2	1	2	2	1	3	2	2	2	2	2	2	2
7		'Mcintosh'	3	3	3	3	2	2	1	2	1	1	3	2	1	2	1	1	1	3	1	1	2	3	2	2	1	1	1	2	1	2	3	1	1	1	3	1	1	2	1	2
8		'Cox'	2	4	1	1	2	1	2	2	1	1	3	2	2	2	1	1	1	3	1	1	2	1	3	3	3	1	1	2	1	2	1	1	4	1	3	2	2	1	2	2
9		'Coneference'	2	4	2	2	3	1	1	1	2	2	3	2	1	2	3	1	2	2	2	2	1	4	1	2	1	2	3	2	1	1	3	2	1	2	1	1	1	4	1	1
10		'Decana'	1	3	2	2	3	1	2	1	2	2	2	2	1	2	3	2	2	3	2	1	1	5	3	1	4	2	3	2	2	1	1	2	4	1	1	2	2	4	2	2
11	*Pyrus communis* L.	'Bonica'	1	4	2	1	3	1	2	1	2	2	2	2	1	2	3	2	2	1	2	1	1	4	3	1	2	2	3	2	1	1	2	2	1	2	1	2	1	3	2	2
12		'Alkhatuni'	2	4	2	5	4	1	2	1	2	2	2	2	1	2	3	1	2	2	2	1	1	4	1	1	3	1	3	1	1	2	1	2	1	1	3	1	2	4	1	1
13		'Alothmani'	1	4	4	5	4	1	2	1	2	2	1	1	1	2	3	1	2	2	2	1	1	4	1	1	1	3	3	1	3	2	2	2	3	1	3	1	2	4	1	2
14		'William'	2	4	4	1	3	1	1	1	2	2	1	1	1	1	3	1	2	2	2	2	2	2	2	3	1	2	5	1	2	1	2	2	2	2	3	1	2	4	1	2

Table (5):
A Matrix Of Similarities And Differences Percentages Of Cultivars Of Apple (*P.Malus* L.), And Pear (*P.Communis* L.)

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1	**1**													
2	**0.500**	**1**												
3	**0.500**	**0.675**	**1**											
4	**0.525**	**0.550**	**0.550**	**1**										
5	**0.700**	**0.625**	**0.550**	**0.575**	**1**									
6	**0.450**	**0.450**	**0.500**	**0.700**	**0.425**	**1**								
7	**0.500**	**0.650**	**0.550**	**0.650**	**0.600**	**0.575**	**1**							
8	**0.675**	**0.650**	**0.700**	**0.575**	**0.600**	**0.575**	**0.575**	**1**						
9	**0.325**	**0.400**	**0.250**	**0.325**	**0.500**	**0.250**	**0.375**	**0.225**	**1**					
10	**0.450**	**0.350**	**0.350**	**0.400**	**0.375**	**0.325**	**0.225**	**0.375**	**0.475**	**1**				
11	**0.375**	**0.500**	**0.350**	**0.425**	**0.375**	**0.350**	**0.225**	**0.325**	**0.625**	**0.700**	**1**			
12	**0.450**	**0.325**	**0.225**	**0.250**	**0.450**	**0.200**	**0.325**	**0.375**	**0.625**	**0.550**	**0.550**	**1**		
13	**0.325**	**0.400**	**0.300**	**0.225**	**0.400**	**0.250**	**0.275**	**0.275**	**0.500**	**0.500**	**0500**	**0.750**	**1**	
14	**0.275**	**0.450**	**0.250**	**0.275**	**0.325**	**0.250**	**0.250**	**0.250**	**0.575**	**0.375**	**0.425**	**0.475**	**0.625**	**1**
15	**0.465**	**0.540**	**0.442**	**0.463**	**0.500**	**0.408**	**0.444**	**0.475**	**0.419**	**0.419**	**0440**	**0.427**	**0.410**	**0.369**

When we look at the diagram illustrated in figure (2), we note that cultivars of the two species meet at ratio of similarity equals 44%, and this is evidence to the correlation of these cultivars with each other in many characteristics, and the dendogram of the two species' cultivars shows that they are divided into three main groups:

First: The first main group included two sub- groups

a- The first subgroup included the cultivars 'Coneference', 'Decana', 'Alkhatuni', 'Honey Crisp', 'Alothmani', 'Royalcala', Bonica', and 'Mcintosh'; and this group was divided into: the first cluster between the two cultivars 'Coneference' and Decana', with a similarity rate of (47.5%), and the results showed that the two cultivars 'HoenyCrisp' and 'Alothmani' shared the formation of the second cluster, with a percentage of similarity equals (25%). The results also showed that the cultivar 'Royalcala' was closer to the cultivar 'Mcintosh', so it was related to a similarity percentage which reached 55%. Then the three clusters were combined into one cluster when the cultivars 'Conference' and 'Mcintosh' shared (37.5%) of the characteristics analyzed by this process.

b- The second subgroup included the cultivars 'Early Gold', 'Red Delicious', 'Cox', and 'Golden Delicious '. This group was divided into the first cluster between the two cultivars 'Early Gold' and 'Red Delicious', with a similarity of (52.5%). The two cultivars 'Early Gold' and 'Cox' shared the formation of the second cluster with a percentage of similarity equals (67.5%). Then the two clusters were combined into one cluster when the cultivars 'Early Gold' and 'Golden Delicious ' shared (70%) of the characteristics analyzed by this process.

2- The second main group represented by the cultivar 'William'

3- The third main group consisted of the cultivar 'Ganny Smith' alone and it was the remotest from the cultivar 'Conference' where they differed in many morphological and anatomical characteristics and the similarity between them was 40%.

The polygonal diagrams (Fig. 1), and the dendogram (Fig. 2), showed much convergence between the morphological similar cultivars in the dendogram; the reason for this may be the type of characteristics used in the two cases and the number of those characteristics, noting that this study is conducted for the first time on the cultivars of the two species *P. malus* L. and *P. communisl* L. of the genus *Pyrus* L. in Iraq. These results are in agreement with those of Dye, 1981; Vries and Raamsdonk; 1994; Al-Zubaidi, 1998; Andres *et al*., 1999; Al-Dusky, 2001; Liber *et al*., 2002; Maa'thidy, 2003; Al-Maa'thidy *et al*., 2007; Obeid, 2008; Al-Samarrai, 2014 and Al-Jowary *et al*., 2018.

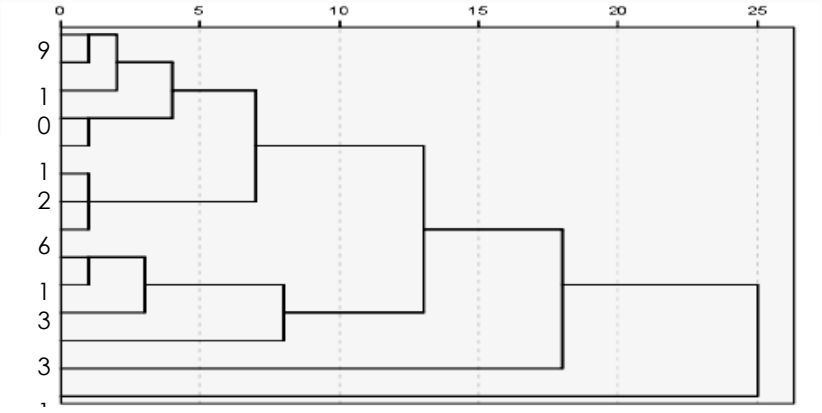

Figure (2): A dendogram illustrating similarities and differences between cultivars of apple (*P. malus* L.) and pear (*P.* communis L.) according to their order in table (5)

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