RESULTS AND DISCUSSION

IV – RESULTS AND DISCUSSION

4.1. Pathogenicity studies :-

Rootstocks reaction against Fusarium oxysporum, singly or combined with M. incognita.

Results in Table (1) indicate that the investigated cucurbitaceous rootstocks significantly differed in their reactions to fusarium wilt disease. Percentages of wilt infection and disease severity ranged between 2.5% and 1.50% in the highly resistant root stock (Figleaf gourd) to 82.50% and 53.40% in the highly susceptible rootstock (watermelon). According to results in Table (1), the tested root stocks showing significant differences in their reactions could be catogerized into five groups as follows;

1- Highly resistant rootstocks:

Citrullus colocynthis (citron) and Cucurbita ficifolia (figleaf gourd).

2- Resistant rootstocks :

Cucurbita pepo var Askandarani and Lageneria siceraria (Bottle gourd).

3- Moderately susceptible root stocks :

Cucurbita moschata and Cucurbita maxima var. turban.

4- Susceptible root stocks :

Cucumis melo var Flexuosus and Momardica balsaminia.

5- Highly susceptible root socks :

Luffa cylindrica, Cucumis melo var. Agyptiacus and Citrullus lanatus.

Results in Table (1) also demonstrate that – providing soil with M. incognita before infestation with F. oxysporum showed considerable increase in wilt infection concerning the tested rootstocks. However,

Table (1) : Percentage of Fusarium wilt disease of eleven cucurbitaecous cultivars in soil infested singly with wilt pathogen (F. oxysporum) or combined with M. incognita under greenhouse conditions.

Cucubitaceaus crops	Treatments	% of infections	Disease severity	Losses
Balsam apple Momardica balsaminia	Fusarium oxysporum F. Oxy. + M. incognita Check	62.50 67.50 0.00	40.30 42.70 0.00	25.19 28.82 0.00
Bottle gourd Lagenaria siceraria	Fusarium oxysporum F. Oxy. + M. incognita Check	10.00 20.00 0.00	6.40 13.50 0.00	0.64 2.70 0.00
Citron Citrullus colocynthis	Fusarium oxysporum F. Oxy. + M. incognita Check	7.50 12.50 0.00	4.70 9.40 0.00	0.35 1.18 0.00
Figleaf gourd Cucubita ficifolia	Fusarium oxysporum F. Oxy. + M. incognita Check	2.50 5.00 0.00	1.50 2.10 0.00	0.04 0.11 0.00
Lofa Luffa cylindrica	Fusarium oxysporum F. Oxy. + M. incognita Check	67.50 72.50 0.00	42.50 46.80 0.00	28.69 33.93 0.00
Muskmelon Cucumis melo var. Agyptia cus	Fusarium oxysporum F. Oxy. + M. incognita Check	75.00 80.00 0.00	50.70 51.50 0.00	38.03 41.20 0.00
Pumpkin Cucurbita moschata	Fusarium oxysporum F. Oxy. + M. incognita Check	30.00 42.50 0.00	20.20 26.40 0.00	6.06 11.22 0.00
Snake cucumber Cucumis melo var flexuosus	Fusarium oxysporum F. Oxy. + M. incognita Check	45.00 57.50 0.00	31.20 36.10 0.00	14.04 20.76 0.00
Squash Cucurbita pepo var. Askandarani	Fusarium oxysporum F. Oxy. + M. incognita Check	25.00 32.30 0.00	10.80 20.20 0.00	4.20 6.59 0.00
Turban Cucurbita maxima var. turban.	Fusarium oxysporum F. Oxy. + M. incognita Check	37.50 45.00 0.00	22.60 30.20 0.00	8.48 13.59 0.00
Watermelon Citrullus lanatus	Fusarium oxysporum F. Oxy. + M. incognita Check	82.50 87.50 0.00	53.40 56.80 0.00	44.06 59.70 0.00

L.S.D. at 5% FOR : Cucurbitacesus crops : Cultivars (C) = 5.03 1.20
Treatments (T) = 2.62. 0.63 C X T = 8.70 2.08

significant synergism was realized with Bottle gourd, Pumpkin and Snake cucumber as percentages of infection increased from (10,30 and 45%) to (20.00 , 42.50 and 57.50%), respectively. Moreover, percentages of their disease severity which also increased from (6.40, 20.20 and 31.20%) to (13.50, 26.40 and 36.10%), respectively, evidently supported the previous synergistic effect of the mixed inocula on disease incidence.

Susceptibility of the tested eleven cucurbitaceous rootstocks to fusarium wilt and nematode pathogens realized that Cucurbita ficifolia, Citrullus colocynthis and lagenaria Siceraria were the most tolerant hosts to infection.

On the contrary, Citrullus lanatus and Cucumis melo var. Agyptiacus were the least resistant hosts resulting in 44.06 and 38.03% losses respectively. Variation in disease reaction of different cucurbitaceous hosts to the investigated isolates of F. oxysporum could be ascribed to the physiobio chemical processes of the infected plants. Besides it might be attributed to differences in their genetic structures which affect root exudates and chemical compounds of their seeds.

Obtained results are in confirmity with ***Bird*** (1969), ***Otiefe*** et al (1970), ***Yoneyama*** (1976), ***Mijuskovic*** and ***Vucinic*** (1977), ***Klose*** (1980), ***Balaz*** (1982), ***Stephenc*** et al (1987), ***He-Zl*** and ***Fu-XY*** (1988), ***Nomura*** (1992 and 1993), ***Weng*** et al (1993) and ***Sharma*** et al (1995).

Nematode – Fusarium disease complex was confirmed by infesting soil with combined inocula of M. incognita and F. oxysporum. Significant synergistic increases in percentage of infection, disease severity and losses in healthy survivals of Bottle gourd, Pumpkin and Snake cucumber since the increase in these estimations reached (10.00, 7.10 and 2.06%), (12.50, 6.20 and 5.16%) and (12.50, 4.90 and 6.72%), respectively. The aforementioned results emphasized that root- knot nematode favoured the infection with Fusarium wilt disease of cucurbits. Increases in disease criteria could be attributed to M. incognita which is considered herein as a predisposing agent for incidence and developments of Fusarium wilt symptoms. These results completely agreed with those reported by several investigators on the relationship between root-knot nematode and Fusarium wilt diseases regarding certain cucurbitaceous plants.

Obtained results were in confirmity with those of ***Summer*** and **Johanson** (1972), ***Donald*** et al (1973), ***Johanson*** and ***Harmon*** (1974), ***Caperton*** et al (1978), ***Costache*** et al (1978), ***Honick*** (1984), ***Choo*** et al (1990); ***Jebari*** (1994) and ***Sharma*** et al (1995).

4.2. Anatomical examinations :-

Primary structures of scion.

The structural part of scion which inserted in stocks is hypocotyl, the anatomical structures of scion at grafting time revealed primary structure of hypocotyl which consisted of uniseriate epidermis and ground tissues (cortex & pith) and six open bicolletral bundles embeded in ground tissues.

Grafting process resulted in cutting and ruptured the epiderimis tissues around the scion but, there could not succeed to remove all the epidermis tissues around the scion, these produced a separate region of epidermis which remained in contact with cortex and alternated with paranchymatous cortical cells.

The structure of bicolletral bundles revealed external primary phloem, vascular cambium, primary xylem and internal phloem (Fig. 1 A & B). It is worthy to snow that family cucurbitaceae recognized with the presence of bicolletral bundles (***Esau*** (1960)).

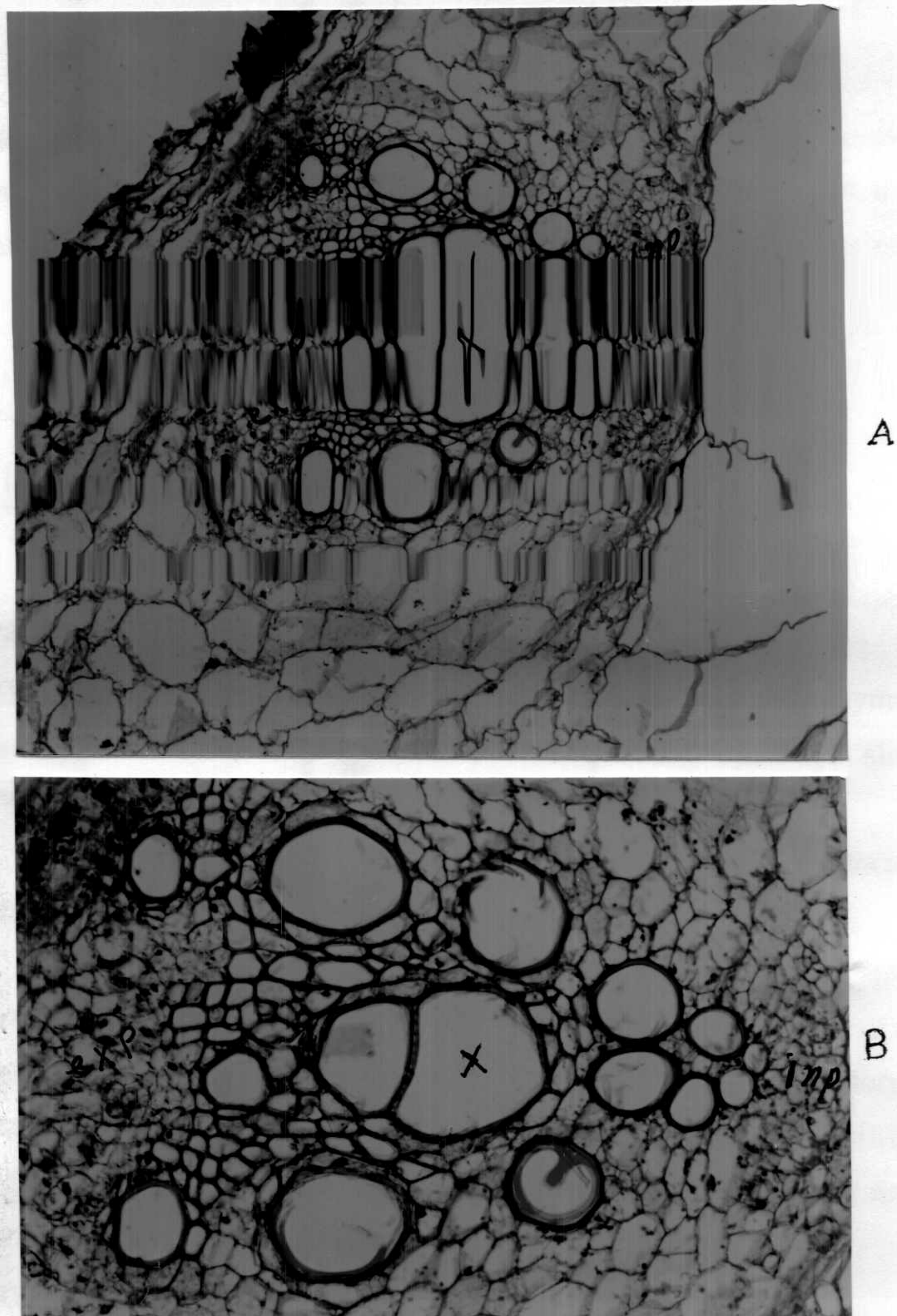


Fig. 1 Cross – section showing primary bicollaterl bundles of scion, 15 days after grafting.

A : 200 X B : 400 X

inp : internal pholem X : Zylem exp : external phloem

The sections illustrated in the (Figs. 5 & 6) show clearly that the differentation of callus to vascular elements started weather the callus in both stock and scion connected together or not (***Mounir*** (1965)). On the other side, the ability to give more callus than cortical parenchyma of scion.

The connection of callus tissues of scion and stock succeded in at least 2 or 3 regions, but not at whole regions (Figs. 3 A. B. C. D and 7).

The highest number of connected regions between each scion and stock of the different used rootstocks could be arranged as follows figleaf gourd, pumpkin, bottle gourd and squash. Similar results were found by ***Tiedemann*** (1989) who reported that phloem development in the graft union resulted in different numbers of connecting sieve tubes in individual graft, but the average number of scion tube connection in cucumis/cucurbita was much lower than in cucumis/cucumis.

Secondary growth of scion and rootstocks :

During secondary growth, the vascular cambium started to divide and give secondary phloem outwardly and secondary xylem inwardly (Fig. 8). Secondary growth in the bicolletral vascular bundles of scion usually happens in all plants which contains this bundles, (***Esau*** (1960)). In some cases, the region between two bundles (rays) showed some activities of intervascular cambium which is developed to some new xylem vessels and phloem elements, this occurred separately between the same bicolletral bundles (Figs. 3 & 8).

The vascular bundles of stock revealed that secondary growth i.e., accessory cambium between inner phloem and primary xylem this accessory cambium divided and gave secondary phloem outwardly and secondary xylem inwardly i.e., secondary xylem faced the primary xylem of the bundles (Figs. 9 &10). Similar results were found in grafting watermelon /cucurbita rootstocks (***Mounir,*** 1965), where the results showed an increase in thickness of grafting union. The rapid formation of the secondary vascular tissues in the bundles and in the neighbouring vascular bundles were considered as one of the major steps in setting forward successful grafting.

<u>Anatomical features of grafting failure</u> :-

1- <u>Technique procedures</u> :-

Grafting technique plays an important role to set forward the success or failure of grafting. Therefore, mechanical technique was performed by robots in Japan.

Obtained results show that remaining parts of epidermis of scion prevent the connection between scion and stocks. Consequently, grafting may be completely failed (Fig. 11). Moreover, the ruptured cells resulted from grafting process in stock make a barrier between scion and stock. The cell wall of these cells became thicker and showed subrin like substance (Figs. 5 A. B. & 6). This substance was also formed as a result of the incompatibilty between scion and stock (Figs. 1,2,3). Similar results were obtained by ***Prataviera*** <u>et</u> <u>al</u> (1983) who stated that Juglone is an inhibitor of callus formation of graft walnut tree and it resulted in graft failure.

During grafting process selective stock diameter with suitable diameter was considered as a major step to give successful grafting. This finding was indicated also by ***Oda*** <u>et</u> <u>al</u> (1993 ; 1994) who found that minimizing the difference in the diameter of the hypocotyl and rotation angle between the scion and stocks enhanced the survival rate.

In contrast, unsuitable diameter (thick and thin) of both stock and scion led to a gap between them (Figs. 5, 6, 12). In this case, callus tissues which are produced from stock and scion could not be able to fill these gaps. Consequently, the connection between stock and scion was failed in the gap region.

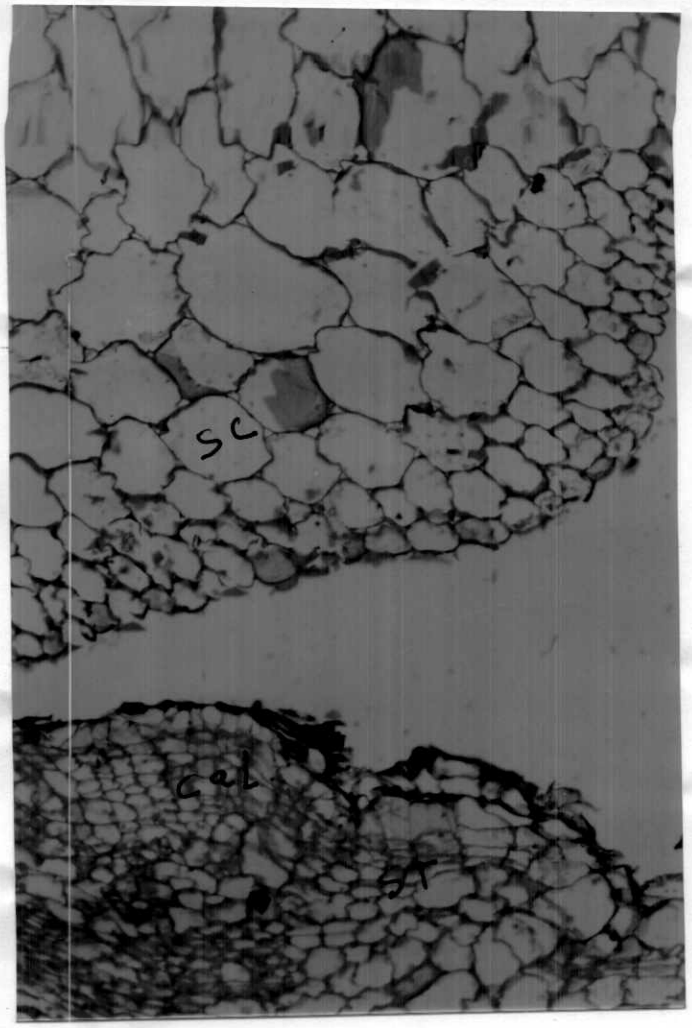


Fig. 11 Epidermis of scion prevent callus building and connection with rootstock (Pumpkin) (30 days after grafting)

200 X Cal : Callus

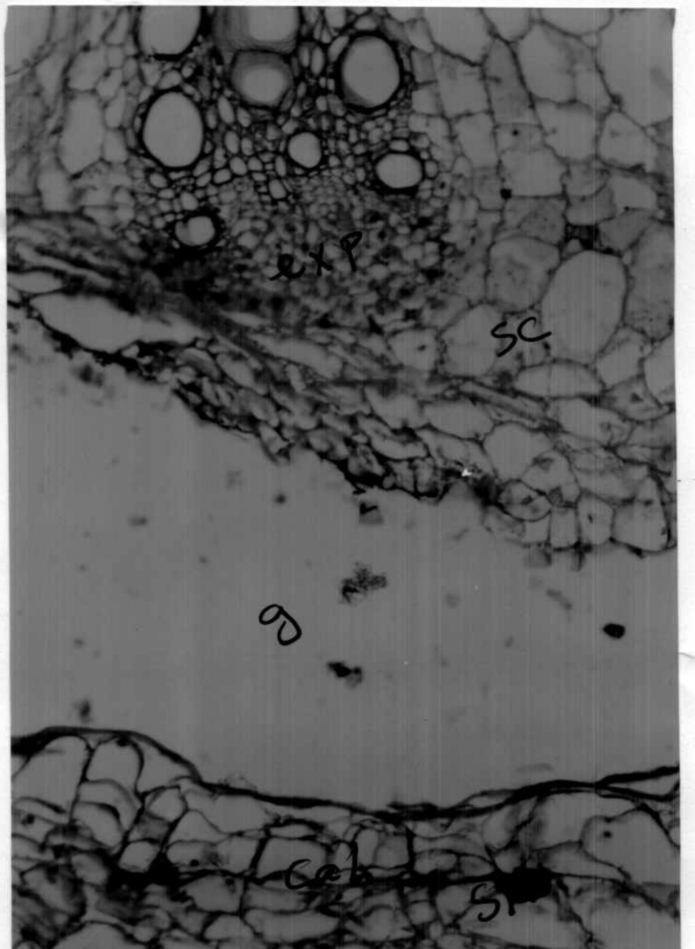


Fig. **12** Callus building in both scion and rootstock (Pumpkin) (15 days after grafting)

exp : external phloem

Cal : Callus

Adventitious lateral root formation in the scion :-

Successful grafting depends on the root system of stock. However in case of failure, adventitious root system was developed from the scion and this favoured survival of plants. The adventitious roots began from the cells adjacent to vascular bundles near to phloem parenchyma (Figs. 2; 6; 13). An early stage of roots formation was observed as a mass of meristematic cells formed close to a vascular bundles i.e., from the parenchymatous cells. By continuous division and cellular multiplication, the adventitious roots made its way penetrating the cortical cells of scion, ***Mounir*** (1965), such roots were able to force their way through the tissues of the stock. In some cases, lateral root developed down wardly throughout the stock tissues until it reached to soil. Similar results were found by ***Moiseave*** (1958) and ***Mouneir*** (1965).

These results were obtained at all root stocks specially in scion grafted on squash and bottle gourd. Once the grafting was completely succeeded, the development of laterl roots were blocked before the lateral roots become morphologically visible.

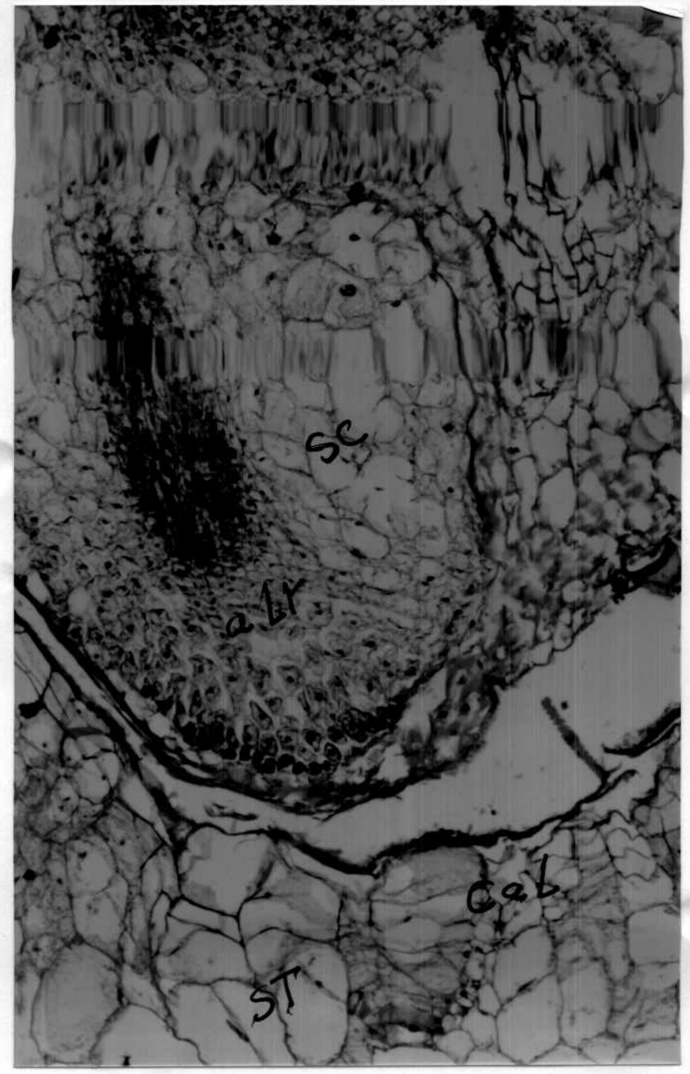


Fig. 13 Adventitious lateral root in front of rootstock (15 days after grafting) Bottle gourd.

alr : adventitious lateral root

Cal : Callus St : rootstock Sc: scion

(400 X)

4.3. Effect of different rootstocks on the successful grafting :-

Cucumber plants were grafted on different stocks of cucurbita species i.e. figleaf gourd (C. ficifolia), bottle gourd (Lagenaria siceraria), pumpkin (C. moschata), squash (C. pepo) A new growth on the scion was observed after junction between scion and stocks. This observation could be considered as a reliable index to the phenomenon of compatability between the scion and stocks. Results in Table (2) show that there was high degree of compatablility between cucumber and the stocks of figleaf gourd and pumpkin. Obtained results are going in the same trend at all seasons of this work. Such results may be attributed to the rapid vascular connection between the vascular bundles of both scion and stocks. Anatomical studies show that failure of grafting may be due to the physiological repulse between cucumber as a scion and squash or bottle gourd as a rootstock. This was caused by the formation of the impermeable layer of suberin which, in turn obstructed the connection between tissues. Moreover, the different development between the stocks and scion during growth period was due to this observation. These results were in agreements with those of ***lee***, (1989) on cucumber who reported that grafted cucumber plants onto figleaf gourd rootstocsk performed better than the plants grafted onto bottle gourd. These results were also in agreement with those obtained by ***Choi*** et al. (1980) on watermelon. Moreover, ***Park*** and ***Chung***, (1989) working on cucumis melo found that cucumis melo as a scion grafted onto 16 cultivars of squash, the percentage of healthly plants for some rootstocks ranged from 96.7 to 100%.

Table (2) Precentage of successeful grafting as affected by grafting cucumber on different cucurbutaceous rootstocks .

Characteristic	Successful grafting %			
	Autumn		Spring	
Seasons / Scion / stocks	96 - 97	97 – 98	96 - 97	97 – 98
C /-	-	-	-	-
C / S	86.0	82.1	78.1	76.4
C / P	92.2	85.3	84.3	80.8
C / B	88.0	83.0	80.5	78.0
C / F	93.0	89.2	84.3	86.0
L.S.D.at 0.05	6.4	5.7	4.8	7.4

C: Cucumber S : Squash P: Pumpkin B : Bottle gourd F: figleaf gourd

4.4. <u>The effect of different rootstocks on vegetative growth characteristics</u>:-

a) Plant length, number of leaves and leaf area :-

Data in Table (3) show that all rootstocks increased the length of cucumber scion at autumn and spring plantations. Moreover, figleaf gourd and bottle gourd had the most promotive effect on plant length in autumn growing season. Meanwhile, the figleaf gourd and pumpkin rootstocks had the most increasing effect on plant length in spring plantation. On the other hand, ungrafted cucumber plants were the shortest in this respect.

Concerning the effect of grafting cucumber on the used four rootstocks on the number of leaves per plant, the same data in Table (3) indicate that grafting had no significant effect on increasing the number of leaves in the autumn and spring plantings except in the spring planting of the second season where a significant increment in number of leaves was noticed.

Regarding, the effect of grafting on the leaf area, it was found that there was a significant increment in leaf area of passandra F_1 hybrid cucumber plants that grafted onto figleaf gourd or bottle gourd rootstocks compared with the other used rootstocks or the control. This was true only in the autumn plantation of the second season. However, insignificant effect to the grafting process was detected in the spring plantations. The figleaf gourd pumpkin as rootstock showed the highest leaf area per plant of passandra F_1 hybrid in spring plantation although such increment did not reach the level of significancy.

b) Fresh and dry weight of stems, leaves and total foliage :-

The data reported in Table (4) show that there were significant differences among the different used rootstocks, where figleaf gourd and bottle gourd had the highest effect on fresh and dry weights of foliage i.e, Table (3) Vegetative growth characteristics as affected by grafting cucumber on different cucurbitaceous rootstocks.

Season	Autumn 96 - 97			Autumn 97 / 98		
Characteristic / Scion/stocks	Plant length (cm)	No. of leaves/ plant	Leaf area (cm^2)	Plant length (cm)	No. of leaves/ plant	Leaf area (cm^2)
C	211.3	35.8	201.9	149.5	32.8	210.9
C/S	215.0	38.0	247.5	226.0	38.0	280.6
C/P	214.5	37.8	225.6	203.5	36.3	225.6
C/B	278.5	39.0	258.9	265.5	39.8	283.9
C/F	326.3	46.3	285.8	291.0	41.3	285.7
L.S.D. at 0.05	15.9	N.S.	N.S.	52.1	N.S.	2.1
Season	Spring 96 / 97			Spring 97 / 98		
C	207.3	37.8	355.5	258.7	41.2	305.2
C/S	211.7	38.7	363.3	265.0	45.2	347.9
C/P	235.5	40.8	389.5	280.8	47.7	366.3
C/B	219.0	40.0	382.7	270.0	45.7	365.5
C/F	242.0	41.0	404.9	282.7	50.0	367.5
L.S.D. at 0.05	24.4	N.S	N.S	13.9	3.3	N.S

C: Cucumber S : Squash P: Pumpkin B : Bottle gourd F: figleaf gourd each of the fresh and dry weights both of stem and leaves of plant foliage of cucumber However, squash and pumpkin had less values in autumn plantations. Meanwhile, cucumber grown onto figleaf gourd or onto pumpkin showed the highest vegetative growth characteristics in spring planting. Such results may be attributed to absorption ability of nutrient elements by the root sytem of stocks and in turn, vigorous vegetative growth. Consequently, it may be concluded that grafting cucumber onto different used rootstocks showed the highest promotive effect on vegetative growth parameters. Obtained results are in confirmity with those of ***shimada*** and ***Moriya*** (1977), ***Shimada*** and ***Nakamura*** (1977) who found that cucumber grafted onto pumpkin in the first trial and on bottle gourd in the second one showed greater plant height comparing with untreated plants. ***Arisawa*** et al (1980) and ***Choi*** et al (1980) on watermelon and ***Weng*** et al (1993) on cucumber reported that grafted plant showed larger leaf area and greater plant height. The increment in leaf area was 44 – 70% compared with the control. Furthermore, ***Matsuda*** and ***Honda*** (1981) on melon, ***Nijs*** (1981) and ***Zijlstra*** et al. (1993) on cucumber reported that rootstocks significnatly promoted vegetative growth of the scion and tended to be more vigorous compared with the control. On the other hand, ***Kim*** and ***lee*** (1989) found that grafting inhibited the excessive growth of rootstocks, on scion hypocotyls. Respecting the effect of grafting on plant dry mater content, ***Shimada*** and ***Moriya*** (1977) on cucumber and ***Jebari*** (1994) on melon indicated that the grafted plants had larger dry matter production compared with the ungrafted plants.

Table (4) Fresh and dry weights (stem, leaves and foliage) as affected by grafting cucumber on different cucurbitaceous rootstocks.

Season	Autumn 96 - 97						Autumn 97 / 98					
Characteristic	Stem		Leaves		Foliage		Stem		Leaves		Foliage	
Scion/stocks	F.W. g/plant	D.W. g/plant	F.W. g/plant	D.W. g/plant	F.W. g/plant	D.W. g/plant	F.W. g/plant	D.W. g/plant	F.W. g/plant	D.W. g/plant	F.W. g/plant	D.W. g/plant
C	88.4	9.9	189.2	27.8	277.6	37.7	95.3	9.3	201.6	29.6	296.9	28.9
C/S	96.1	10.6	205.9	32.1	302.0	42.7	100.6	11.1	227.7	38.4	328.3	49.5
C/P	94.3	10.1	212.6	35.9	306.9	46.0	99.3	11.1	254.2	43.1	353.5	54.2
C/B	98.0	10.8	266.4	45.2	364.4	56.0	106.4	12.1	291.6	45.4	398.0	57.5
C/F	109.5	12.6	352.1	64.8	461.6	77.4	112.5	12.9	305.0	56.1	417.5	69.0
L.S.D.at 0.05	5.2	2.0	13.7	1.7	10.1	2.0	N.S.	1.4	1.9	1.1	6.6	2.4
Season	Spring 96/97						Spring 97/98					
C	98.6	10.2	218.1	32.1	316.7	42.3	109.4	11.3	239.5	35.1	348.9	46.4
C/S	102.3	11.8	220.7	34.4	323.0	46.2	111.6	12.5	298.6	45.9	410.2	58.4
C/P	115.6	12.8	272.5	46.4	388.1	59.2	125.7	13.8	350.0	50.5	457.5	64.3
C/B	113.3	12.7	260.2	43.9	373.5	56.6	120.5	13.4	301.9	50.4	422.4	63.8
C/F	129.3	14.7	365.7	54.6	494.0	69.3	130.0	14.9	353.3	59.5	483.3	74.4
L.S.D.at 0.05	5.4	0.7	11.6	3.7	1.8	1.9	8.1	0.9	36.9	5.4	15.4	2.6

C: Cucumber S : Squash P: Pumpkin B : Bottle gourd F: figleaf gourd

4.5. <u>Effect of different rootstocks on the chemical compostion of cucumber plant foliage</u>:-

4.5.1. Photosynthetic Pigments in plant leaves :-

Concerning the effect of different rootstocks on photosynthetic pigments of cucumber scion, data in Table (5) clearly show that the grafting on different rootstocks significantly increased the plant photosythetic pigments. Such data indicate also that figleaf gourd followed by pumpkin resulted in the significantly highest values of chlorophyll a, total chlorophyll and carotenoids of cucumber scion in both autumn seasons. With regard to the effect of different rootstocks on chlorophyll b plant leaves content, the same data in Table (5) show that figleaf gourd had an improving effect showing the highest values in this respect followed by bottle gourd, pumpkin, squash and control, respectively.

These results were obtained at both autumn seasons. With regard to the spring plantations, the effect of different rootstocks on the content of chlorophyll a, b and total chlorophyll as well as total carotenoids, it is evident that all rootstocks had higher values of the chlorophyll pigments as compared with the control. It is also clear that figleaf gourd resulted in the highest values in cucumber scion than those of the other rootstocks followed by pumpkin, bottle gourd and squash. Obtained results are going in the same trend at both spring seasons of this work. Such results may be attributed to the essential role of nitrogen and magnesium elements in the formation and constancy of such pigments in plant tissues. The stimulative effect of different rootstocks on photosynthetic pigments in cucumber plant foliage was previously mentioned by ***Weng*** <u>et</u> <u>al</u> (1993) working on cucumber, who indicated that the grafting increased chlorophyll content by 3.6 – 11.6% in cucumber grafting on cucurbita species. Moreover, it had been reported by

Ma Hong et al (1997) working on cucumber that cuttage grafting increased leaf photosynthesis rate in cucumber scion grafted on cucurbita ficifalia.

4.5.2. Effect of different rootstocks on total phenols and indoles of cucumber plant leaves : -

Concerning the effect of different kinds of rootstocks on total phenols and indoles of cucumber leaves contents, data in Table (5) clearly show that at both autumn seasons, figleaf gourd had the highest value between all rootstocks followed by bottle gourd, pumpkin and squash, in addition to the control respectively. With regard to the effect of different rootstocks on total phenols and indoles leaves content of cucumber scion at both spring seasons, data in Table (5) show the same trend of both autumn seasons, where figleaf gourd had the highest values followed by bottle gourd, pumpkin and squash respectively. While, the control had the least values compared with all used rootstocks.

Obtained results are in confirmity with ***Musacchl*** (1996) who found that phenols (coumarins, catechins and flovanones) are the main substances involved in successful grafting (compatibility between scion and stocks) . Also, he indicated that the failure of grafting (incompatibility) is due to breaking down these compounds by B-glucosidase into 2 molecules of glucose, 1 of benzoic aldehyde and 1 of hydrocyanic acid. The later is toxic to cells.

Table (5) Chlorophyll, carotenoids, total phenols and indoles as affected by grafting cucumber on different cucurbitaceous rootstocks.

Season	Autumn 96 - 97						Autumn 97 / 98					
Characteristic / Scion/stocks	Chlorophyll and carotenoids mg/ 100g F.W.				Total Phenols mg/g D.W.	Total Indoles mg/g D.W.	Chlorophyll and carotenoids mg/ 100g F.W.				Total Phenols mg/g D.W.	Total Indoles mg/g D.W.
	a	b	a + b	carotenoids			a	b	a + b	carotenoids		
C	105.0	66.2	171.2	84.1	80.2	0.091	103.8	64.2	168.0	82.6	85.0	0.94
C/S	123.6	75.1	198.7	92.0	103.3	0.102	117.0	72.0	189.0	97.4	104.3	0.110
C/P	143.2	79.6	222.8	115.6	118.0	0.115	130.1	76.8	206.9	117.2	125.5	0.116
C/B	133.0	82.0	215.0	112.4	166.7	0.120	128.2	77.0	205.2	113.1	171.0	0.126
C/F	150.7	89.3	240.0	127.3	209.8	0.128	146.0	87.3	233.3	123.5	230.1	0.140
L.S.D.at 0.05	1.2	1.6	3.9	1.2	2.5	0.005	2.3	1.9	3.1	1.6	2.5	0.004
Season	Spring 96/97						Spring 97/98					
C	132.4	63.3	195.7	94.6	135.0	0.130	125.6	61.3	186.9	91.9	163.2	0.132
C/S	158.2	69.3	227.5	110.0	172.1	0.146	153.1	70.7	223.8	105.0	104.6	0.150
C/P	177.6	86.5	264.1	133.2	163.5	0.155	175.3	84.0	259.3	129.4	184.0	0.158
C/B	168.0	78.0	246.0	125.0	190.3	0.173	164.0	75.9	239.9	123.3	197.0	0.178
C/F	193.2	95.1	288.3	143.1	213.6	0.182	182.2	93.9	276.1	138.2	225.6	0.189
L.S.D.at 0.05	1.5	1.6	2.5	1.6	2.2	0.007	1.9	1.6	2.2	1.8	2.8	0.160

C: Cucumber S : Squash P: Pumpkin B : Bottle gourd F: figleaf gourd

4.5.3. Effect of different rootstocks on macro –elements constituents of cucumber foliage: -

The effect of different rootstocks on N, P, K, Ca and Mg content of cucumber plant foliage is shown by the data presented in Table (6). It is obvious from such data that using figleaf gourd as rootstock significantly increased the values of such constituents of macro elements in cucumber plant foliage followed by using bottle gourd at the first autumn plantation but at second autumn plantation, figleaf gourd was followed by pumpkin while the squash as rootstocks came in the last rank at both autumn plantations between different rootstocks. Genarally, all rootstocks significantly increased the plant content of N, P, K, Ca and Mg than control (cucumber without grafting). With respect to the effect of different rootstocks on N, P, K, Ca and Mg content of cucumber plant foliage constituents at both spring plantations, data in Table (6) show that cucumber grafted on figleaf gourd had the highest increasing effect on such plant foliage constituents followed by pumpkin, bottle gourd and squash respectively. Generally, all rootstocks gave higher values compared with the control. In this respect, ***Shimada*** and ***Moriya*** (1977) working on cucumber mentioned that K and Ca concentrations in the scion plant were higher in case of cucumber grafted onto pumpkin than that grafted on cucumber. In addition, ***Shimada*** and ***Nakamura*** (1977) working on watermelon reported that Ca content was increased in the top of watermelon grafted onto pumpkin compared with those of watermelon grafted on watermelon. Moreover, ***Arisawa*** et al (1980) working on watermelon found that watermelon plants grafted on gourd rootstocks absorbed large amounts of N and K but watermelon grafted on pumpkin absorbed large amounts of P, Ca and Mg. Similar findings were reported by ***yamasaki*** et al (1994) working on watermelon where they mentioned that the absorption rates of N, P, K, Ca and Mg were increased by watermelon grafted on bottle gourd.

Table (6) : Macro-elements constituents of cucumber plant foliage as affected by grafting cucumber on different cucurbitaceous rootstocks.

Season	Autumn 96 - 97 Plant foliage mg/D.W.					Autumn 97 / 98 Plant foliage mg/D.W.				
Characteristic / Scion/stocks	N	P	K	Ca	Mg	N	P	K	Ca	Mg
C	1670	245	1052	324	64	1717	257	1098	358	64
C/S	2048	294	1280	418	83	2392	342	1538	491	82
C/P	2480	363	1610	469	96	2980	434	1905	559	109
C/B	2758	420	1816	420	93	2868	414	1854	506	89
C/F	4192	685	2808	804	165	3838	635	2478	718	153
L.S.D.at 0.05	29	7	10	12	4	11	6	6	5	5
Season	Spring 96/97					Spring 97/98				
C	1907	296	1203	371	76	2100	319	1340	445	88
C/S	2268	337	1482	457	88	2907	437	1874	578	144
C/P	3285	479	2113	604	127	3596	526	2279	661	136
C/B	2825	430	1885	566	99	3265	454	2168	644	105
C/F	3922	609	2522	720	152	4243	677	2694	774	167
L.S.D.at 0.05	6	9	42	15	12	10	8	9	14	7

C: Cucumber S : Squash P: Pumpkin B : Bottle gourd F: figleaf gourd

On the other hand, ***Schonhard*** (1973) working on cucumber reported that graft chlorosis of cucumber was associated with reduced Ca and Mg translocation from the squash rootstocks. Moreover, ***shimada*** and ***Moriya*** (1977) working on cucumber indicated that the phosphrus concentration was less in plants grafted onto pumpkin. In addition, ***Shimada*** and ***Nakamura*** (1977) working on watermelon reported that magnesuim and nitrogen content decreased in the scion of watermelon grafted onto bottle gourd as compared with watermelon grafted on wateremlon . In this respect, ***Ikeda*** et al (1986) working on cucumber indicated that Mg deficiency sysmptoms was less severe in plants grafted on Cucurbita ficifolia and not apparent in plants grafted on their own roots. Moreover, ***Yamasaki*** et al (1994) working on watermelon indicated that the absorbed minerals of N, P, K, Ca and Mg of watermelon grafted on bottle gourd was less than those grafted on squash.

4.5.4 Protein analysis: -

Water soluble as well as water nonsoluble leaf protein fractions from cucumber Passandra F_1 hybrid grafted on figleaf gourd (Cucurbita ficifolia); bottle gourd (Lagenaria siceraria); pumpkin (Cucurbita moschata) and squash (Cucurbita pepo) in addition to ungrafted plants were separated by SDS-PAGE. Banding patterns of the four scion for both fractions were compared with ungrafted plant leaves (control).

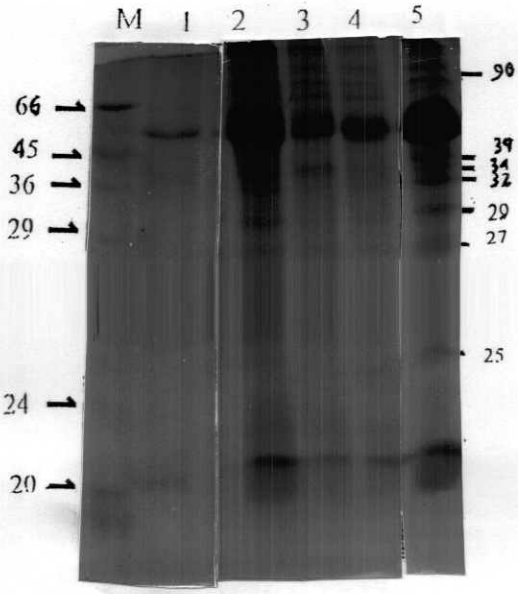
The overall results regarding both protein fractions in scion leaves for the used rootstocks indicated the presence of some polymorphic bands, which can be used in distinguishing the different rootstocks used in the present finding.

The comparison for the water – soluble protein indicated the presence of seven novel protein bands, i.e., 90, 39, 34, 32, 29, 27 and 25 kDa that were absent in ungrafted plant leaves {control (1)}. Five bands (90.34.32.29 and 27 kDa) were induced when using bottle gourd (2) as a rootstock, while pumpkin (3) showed two novel protein bands i.e., 90 and 34 kDa, whereas, squash (4) showed three novel bands. i.e., 90.34 and 32 kDa, and figleaf gourd (5) showed seven protein bands i.e., 90, 39, 34, 32, 29, 27 and 25 kDa that were absent in ungrafted plant leaves (1).

Occurrence of these novel bands can be explained due to the possible migration of the different protein fraction from stocks to the scion through the graft union area. The presence of some of these bands is probably due to the interaction between different proteins which originally found in the scion plus those came from the stocks.

The results of the water-nonsoluble protein indicated the presence of five novel bands i.e., 92, 78, 66, 33 and 28 kDa, which were absent in the banding of the control. These five bands corresponded in size to the scion indicating the migration of the protein fraction via the union area of the

a. Water soluble protein



b. Water nonsoluble protein

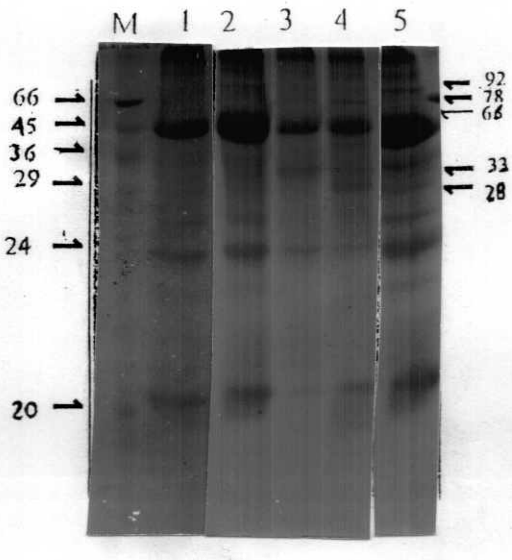


Figure 14. SDS-PAGE of leaf water soluble (a) and water nonsoluble (b) proteins extracted from passandra F_1 hybrid grafted on bottle gourd (2), pumpkin (3), squash (4) and figleaf gourd (5) as root stocks, besides the control (1). M refers to the protein standard (66.0, 45.0, 36.0, 29.0, 24.0 and 20.0 kDa).

grafting. Two novel proteins (29 and 78 kDa) were induced in case of using bottle guard (2) as a rootstock, while pumpkin (3) showed three novel bands i.e., 92, 78 and 33 kDa, whereas squash (4) showed also three bands i.e., 92, 78 and 66 kDa, but figleaf gourd (5) showed five novel bands i.e., 92, 78,66, 33 and 28 kDa.

In general, it can be concluded that the occurrence of additional novel protein bands after grafting is reported with regard to the possibility of some kind of migration across the graft union via the connecting area (***Tiedemann*** and ***Carstens – Behrens***, 1994).

4.5.6. Effect of different rootstocks on flowering and fruit setting percentage :-

1- Number of days to first flower :-

Concerning the effect of different rootstocks on the number of days required for the appearenc of the first flower; the number of flowers per plant and the percentage of fruit setting, data in Table (7) clearly show that there were significant differences between different rootstocks on the days required for appearence of the first flower. It is also evident that cucumber grafted onto figleaf gourd, bottle gourd or pumpkin needed between 34-35.5 days whereas cucumber onto squash or control needed 37-37.2 days to produce the first flower. Obtained results are going in the same trend at two autumn plantations, whereas the appearence of first flower in spring plantation delayed 2-6 days over the autumn plantation. It is noticed at this study also that used different stocks decreased the number of days to produce the first flower at the range of 3-7 days than those needed in the control treatment. The differernce in obtained results between the used stocks at autumn and spring plantation may be due to the difference in temperature inside the plastic house as shown from Table in page 15. These ressults are in agreement with Those of ***Nienhuis*** et al (1979)[a] working on Cucumis

Table (7) Number of (days to first flower; flowers/ plant); fruit set percentage as affected by grafting cucumber on different cucurbitaceous rootstocks.

Season	Autumn 96 - 97			Autumn 97 / 98		
Characteristic / Scion/stocks	No. of days to first flower	No. of flowers/ plant	Fruit set (%)	No. of days to first flower	No. of flowers/ plant	Fruit set (%)
C	37.2	47.3	34.9	36.5	46.3	32.4
C/S	37.0	52.5	33.1	36.0	51.3	32.4
C/P	35.5	58.5	36.1	34.6	59.7	34.0
C/B	35.0	54.0	30.6	34.0	56.9	28.6
C/F	34.0	54.4	39.5	33.7	57.4	36.6
L.S.D.at 0.05	1.2	4.4	1.9	1.1	3.2	2.2
Season	Spring 96 / 97			Spring 97 / 98		
C	42.0	51.5	32.0	41.4	54.8	29.0
C/S	36.2	54.3	32.1	37.0	57.6	30.2
C/P	38.3	59.4	32.6	39.5	61.9	30.5
C/B	39.0	58.0	30.0	40.5	61.8	26.3
C/F	35.5	66.5	32.8	36.0	68.3	32.4
L.S.D.at 0.05	1.2	3.3	0.7	0.9	3.6	2.0

C: Cucumber S : Squash P: Pumpkin B : Bottle gourd F: figleaf gourd

hardwickii, and reported that flowering was initiated at about 65 days after planting in the control and at 45 days when grafting was made. Moreover, ***Jebari*** (1994) on muskmelon found that the grafted plants flowered seven days earlier compared with ungrafted melons. In addition, ***Yamasaki*** et al., (1994) on watermelon mentioned that the node order of the first pistillate flower was lowered by grafting on bottle gourd than plants grafted on squash.

2- The effect of grafting on number of flowers per plant :-

Data in Table (7) showed a significant difference between the rootstocks concerning the effect of grafting on number of flowers per plant. Using figleaf gourd and pumpkin as rootstocks led to increment in the number of flowers per plant compared with the other used rootstocks and the control. Obtained results were of the same trend at both autumn and spring plantations. Generally, cucumber scion onto all rootstocks gave number of flowers per plant more than ungrafted plants. These results were in confirmity with those found by ***Nienhuis*** et al. (1979)[b] working on Cucumis hardwikii, who reported that the grafting increased number of total flowers and that of the pistillate flowers per plant in Cucumis hardwikii scion.

The effect of grafting on fruit setting percentage :-

Data presented in Table (7) show that there were significant differences between different used rootstocks regarding fruit setting percentage. It is evident from such data that cucumber plants grafted on figleaf gourd or on pumpkin rootstocks had higher fruit setting % than those grafted on squash, bottle gourd or control at both autumn and spring plantations. In this regard, the same results were obtained by ***Arisawa*** et. al. (1980) working on watermelon who indicated that watermelon plants grafted on figleaf gourd rootstock had a higher fruit set percent than control.

4.5.7. <u>Effect of different rootstocks on yield and its components</u> :-

Data presented in Table (8) show that all the four used rootstocks gradually and significantly increased yield and its components i.e., fruit weight as well as fruit number, early yield and total yield per plant and total yield per m^2 as kg/m^2. compared with control (ungrafted cucumber)

Concerning the effect of rootstock on number of fruits per plant, data in Table (8) show that plants grafted on figleaf gourd and pumpkin respectively had higher values at both autumn and spring seasons while those grafted on squash and bottle gourd respectively had less values.

With respect to the effect of different used rootstocks on fruit weight, data in Table (8) show that bottle gourd as a rootstock resulted in the highest value followed by figleaf gourd and pumpkin respectively, whereas squash had the lowest value, The same trend was obtained at the different growing seasons of this work.

Regarding the effect of different rootstocks on the yield i.e., early yield, yield per plant and yield per m^2, data in Table (8) show that figleaf gourd followed by pumpkin had the highest values while bottle gourd and squash came in the third and fourth ranks respectively. It is obvious from the same data that obtained results are going in the same trend in both growing autumn and spring seasons.

In conclusion, data in Table (8) show that the number of fruits per plant was the main characteristic which affected yield for all different rootstocks. Therefore, the improving effect of different rootstocks in this respect is mainly attributed to the number of flowers per plant and fruit set percentage which, in turn, resulted in high yield. Obtained results are in agreement with those reported by ***Nijs*** (1981), ***Uffelen*** (1983), T***sambanankis*** (1984), ***Janowski*** and ***Skapski*** (1985), ***Lee*** (1989) and ***Weng*** (1993) who found that cucumber grafted onto <u>cucurbita</u> <u>ficifolia</u> gave higher total fruit yield about 15.1 - 46.7% and higher early yield by up to 200%.

Table (8) : Early and total yield and its components of cucumber as affected by grafting on different cucubitaceous rootstocks.

Season	Autumn 96 - 97					Autumn 97 / 98				
Characteristic / Scion/stocks	No. of fruits/ plant	Average Fruit weight (g.)	Early yield / plant (g)	Yield/ Plant (kg)	Yield (kg /m^2)	No. of fruits/ plant	Average Fruit weight (g.)	Early yield / plant (g)	Yield/ Plant (kg)	Yield (kg /m^2)
C	16.5	105.4	559.4	1.739	3.826	15.0	109.3	596.1	1.639	3.607
C/S	17.4	103.0	597.3	1.792	3.943	16.6	111.0	623.6	1.843	4.054
C/P	21.1	111.1	717.3	2.344	5.157	20.3	114.5	855.3	2.324	5.114
C/B	16.5	122.3	672.8	2.017	4.439	16.3	132.4	702.0	2.158	4.748
C/F	21.5	112.0	849.0	2.408	5.297	21.4	118.4	994.7	2.534	5.574
L.S.D.at 0.05	0.19	1.3	52.4	0.130	0.220	1.2	0.8	42.7	0.156	0.340
Season	**Spring 96/97**					**Spring 97/98**				
C	16.5	105.2	610.4	1.735	3.817	15.9	120.5	662.4	1.916	4.215
C/S	17.4	121..0	670.9	2.115	4.655	17.4	122.3	688.5	2.128	4.682
C/P	19.3	124.2	886.7	2.397	5.274	18.9	122.5	886.3	2.315	5.094
C/B	17.4	136.5	764.8	2.375	5.225	16.3	138.2	732.4	2.253	4.956
C/F	21.8	131.4	913.2	2.864	6.302	22.1	130.6	983.6	2.886	6.349
L.S.D.at 0.05	1.7	1.6	17.6	0.201	0.892	0.7	2.3	39.3	0.331	0.383

C: Cucumber S : Squash P: Pumpkin B : Bottle gourd F: figleaf gourd

Similar findings were also reported by ***Simonov*** (1974) and ***Yamasaki*** et al (1994) working on watermelon, who indicated that using rootstocks out-yielded the control by 85% and produced 74% of its total yield early Moreover, they observed that watermelon grafted onto squash tolerant of heavy crop than those of watermelon grafted on bottle gourd and non grafted one. In addition, ***Buitelaar*** (1987) and ***Jebari*** (1994) working on melon indicated that early and total yields were higher with grafting compared with ungrafted melon (control) where the grafted plant yielded 2.5 times more than the ungrafted ones. Moreover, ***Granges*** and ***leger*** (1996) working on tomato reported that grafted plants had accumulative yield which was 50% higher at the beginning and 30% higher at the end of harvest than ungrafted plants.

On the other hand, contra results were reported by ***Uffelen*** and ***Bulthuis*** (1982) working on cucumber, who found that average yields of ungrafted plants were higher at all assessment dates. Concerning the effect of grafting on fruit weight and number of fruits per plant, ***Uffelen*** (1985) working on cucumber grafted on Cucurbita ficifolia reported that average fruit weight were higher than control. In addition, ***Buitelaar*** (1987) working on melon found that fruit weight and number of fruits/m^2 were higher with Napoleon rootstocks. Meanwhile, ***Zijlstra*** et al (1993) working on cucumber reported that code E rootstock induced a significantly higher fruit yield (7-9 fruits/ plant) than the standard rootstocks corona (5-8 fruits/ plant) and code D induced the highest fruit yield (25.2 fruits/ plant) . It is concluded that the existing genotypic variation together with grafting process can be used to improve fruit production in cucumber.

4.5.8. Effect of grafting on physical and chemical fruit characteristics

a- Physical fruit characteristics:

1- Effect of grafting on panel test :-

Data concerned with panel test presented in Table (9) show the colour, shape, taste, smell and touch of the fruits taken from the plants of passandra F_1 hybrid grafted on the different studied cucurbitaceous stocks. Such data show clearly that bottle gourd as rootstock came in the first rank followed by figleaf gourd and then pumpkin which came in the third rank in this respect. However, control and squash treatments came at the last rank of fruit quality.

Table (9) Some physical characteristics of fruits (Panel test) as affected by grafting on different cucurbitaceous rootsocks:-

Character / Scion/stocks	Colour	Shape	Taste	Smell	Touch
Control	Fair	Good	Good	Fair	Very good
C / Squash	Fair	Very good	Fair	Fair	Good
C / Pumpkin	Very good	Good	Excellent	Fair	Good
C/Bottle gourd	Excellent	Good	Excellent	Very good	Excellent
C / Ficifolia	Very good	Fair	Good	Very good	Excellent

C : Cucumber. Control : Cucumber without grafting .

2- Effect of different rootstocks on fruit length and diameter of cucumber scion:-

Data presented in Table (10) show the length and diameter of cucumber fruits as affected by grafting cucumber on the used different rootstocks. The fruit length and diameter were significantly increased compared with the control. This was true during autumn plantations, while variations were not significant in the spring seasons except fruit length in the first spring season which was significantly affected.

In this respect, the bottle gourd rootstock surpassed the other used rootstocks. Obtained results are in agreement with those reported by ***Matsuda*** and ***Honda*** (1981), on melon and ***Tsambanakis*** (1984) on cucumber who reported that fruit length of scion was positively affected by grafting.

b- Chemical fruit characteristics:

1 - The Effect of different rootstocks on total carbohydrates of cucumber fruits.

Data presented in Table (10) show the effect of grafting cucumber passandra F_1 hybrid on to different rootstocks during autumn and spring plantations on cucumber carbohydrates fruit content. From such data, it is evident that cucumber grafted on figleaf gourd showed the highest values compared with the other used rootstocks. Such increment was statistically significant compared with some other used rootstocks and control. Meanwhile, no significant difference between figleaf gourd and pumpkin was detected. This was true during both autumn and spring seasons. In spring plantations, it is worthy to mention herein, that cucumber grafted on figleaf gourd showed the highest significant values compared with all used rootstocks in addition to the control treatment. Such results may be attributed to increasing rate of photosynthesis process and formation and constancy of such carbohydrates in the plant tissues. The obtained results are supported by those found by ***Balaz*** (1982) working on watermelon, who reported that the grafted plants onto Lagenaria vulgarise (siceraria) rootstocks produced fruits with higher sugar content than ungrafted ones. In addition, ***Buitelaar*** (1987) working on melon mentioned that grafting melon on Napoleon rootstocks (melon) enhanced the sugar content in the melon fruits of the grafted plants compared with the ungrafted ones.

Table (10) Physical and chemical characteristics of cucumber fruits as affected by grafting on different cucurbitaceous rootstocks.

Season	Autumn 96 - 97				Autumn 97 / 98			
Characteristic / Scion/stocks	Fruit length (cm)	Fruits diameter (cm)	Total carbohydrates (mg/100g)	T.S.S. (%)	Fruit length (cm)	Fruits diameter (cm)	Total carbohydrates (mg/100g)	T.S.S. (%)
C	12.8	3.2	1873	3.70	15.1	3.3	1801	3.92
C/S	15.1	3.6	1602	3.56	16.6	3.5	1702	3.75
C/P	15.1	3.7	2575	4.25	16.3	3.6	2601	4.30
C/B	16.2	3.7	2314	3.75	17.7	3.6	2207	3.95
C/F	15.8	3.9	2597	3.87	17.2	3.6	2602	4.05
L.S.D.at 0.05	2.1	0.4	2	0.39	1.9	0.2	3	0.52
Season	Spring 96/97				Spring 97/98			
C	15.5	3.0	2112	3.90	15.4	3.2	2120	3.85
C/S	16.6	3.3	1977	3.48	16.6	3.3	2061	3.58
C/P	16.7	3.3	2742	4.10	16.8	3.4	2746	4.22
C/B	17.5	3.4	2631	3.95	17.5	3.3	2741	3.93
C/F	16.8	3.4	2825	4.00	16.8	3.3	2804	4.08
L.S.D.at 0.05	0.4	N.S	2	0.51	N.S	N.S	1	0.39

C: Cucumber S : Squash P: Pumpkin B : Bottle gourd F: figleaf gourd

2- The Effect of grafting on total soluble solids (T.S.S) percentage in cucumber fruits:-

Data presented in Table (10) also show that there were significant differences between different rootstocks in the effect of grafting on the percentage of total soluble solids in cucumber fruits. In this regard, using pumpkin and figleaf gourd as rootstocks led to increments in the total soluble solids in fruit scion compared with the other used rootstocks and the control. Obtained results are of the same trend at both autumn and spring plantations. These results are in confirmity with those found by ***Park*** and ***chung*** (1989) on Cucumis melo. However, contra results were reported by ***Lee*** (1989)working on cucumber and oriental melo.