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Interactive effects of scion-rootstocks combinations on quality parameters of bottle gourd (*Lagenaria siceraria*)

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Abstract
A study was carried out to determine the interactive effect of scion-rootstock combination on biochemical and quality parameters of bottle gourd fruits. The experiment were conducted on two bottle gourd scion (Haruna and Gaurav) that were grafted onto five different cucurbitaceous rootstock *viz*., Watermelon, Pumpkin OP, Pumpkin F1, Bottle gourd and Muskmelon. The data on important fruit quality parameters *viz*., total chlorophyll content, protein content, iron content, total soluble solids, ascorbic acid, reducing and non-reducing sugars in bottle gourd fruit were analyzed and recorded to compare grafted plants with non-grafted controls. The grafting method adopted in this study was slant grafting. The possibility of applying grafting to improve quality of fruit has been sincerely investigated and presented here. The experiment was laid out in Factorial Randomized Block Design with additional treatment computed as control *versus* others. The result revealed that highest chlorophyll content, protein content, ascorbic acid, iron content and total soluble solids content was observed in Haruna grafted onto pumpkin OP also it found to be at par with Haruna grafted onto watermelon. Apart from protein and TSS content with an average of 1.27 and 3.0 °Brix respectively, other quality parameters were significantly affected by grafting.

Keywords: Slant grafting, chlorophyll, reducing sugar, biochemical

Introduction
Bottle gourd (*Lagenaria sicereria*) is widely grown cucurbit of the world (Hidayatullah *et al*.) [3] for its tender fruits and tender leaves. It is one of the important vegetable crop belonging to the family cucurbitaceae with a chromosome no. of 2n=22. It might be the only cucurbit that was known to man in both the new and old world from very early prehistoric times. It is considered as one of the lowest-calorie vegetables carrying just 14 calories per 100g also high in nutritive value. The grafting is commercially adopted and widely used in cucurbitaceous and solanaceous crops. Research on cucurbit grafting began in 1920s with the use of *Lagenaria sicereria* as a successful rootstock for watermelon. Changes appear in grafted cucurbit fruit quality causing contradictory reports in the literature. Moreover, Imazu (1949) [2] reported that *Cucurbita moschata* rootstock causes inferior texture and flavor in grafted 'Honey Dew' fruits. Grafting reportedly caused a small reduction, approximately 1 ºBrix, in total sugar content of both watermelon and melons (Xu *et al*., 2005; Qi *et al*., 2006) [4]. Fortunately under the best circumstances, when specific combination of scion-rootstock is used, grafting has enhanced fruit quality (Total soluble solids, carotenoid and ascorbic acid content) Xu *et al*., 2005 [4]; Alan *et al*., 2007 [1]. Screening for best scion-rootstock combination had resulted in high quality fruits, and is beginning to decrease the number of negative quality issues for grafted cucurbit crops.

Grafting has become a technique with a high potential to improve the efficiency of modern and intelligent vegetable cultivation. Fruit quality and appearance of vegetables may be influenced by grafting as well as grafting methods. Based on FAO and WHO, the quality standard of fresh vegetable mostly considered external quality attributes (size, shape, colour and freshness) whereas internal quality attributes (texture, flavor and biochemical parameters) are not considered previously. Consumer interest in the quality of vegetable products has increased in recent years especially for the beneficial effect of vegetable on human health. Therefore, adequate rootstock-scion combination could help to improve fruit quality, enhanced nutrient and water uptake, improved plant growth, yield increase, rootstock effect on fruit quality.

Materials and Methods
Site of the Experiment
The proposed experiment was conducted and carried out in the experimental farm of Centre of Excellence on Protected cultivation and Precision Farming, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during the year 2019-20 and 2020-21. Raipur, which is situated at 244 to 409 meters above sea level and comes under tropical region where, in summer the maximum temperature reaches to 45 °C, and recently temperature has been recorded in the city as high as 44.3 °C and minimum of 12.5 °C. The soil of the experimental field is clay-loam, which is locally known as "Dorsa" in this region.

Experimental details
The experiment used as a Factorial Randomized Block Design with additional treatment computed as control versus others having three replication. The experimental materials consisted of six wild and cultivated cucurbitaceous species which were used as rootstocks and two scions which is a private sector hybrid *viz.,* Haruna from VNR seed company and Gaurav from Bioseed company, CG. The commercial and local cultivated cucurbitaceous species *viz*., water melon (*Citrullus lanatus*), pumpkin (*Cucurbita moschata)*, bottle gourd (*Lagenaria siceraria*), and musk melon (*Cucumis melo*) were collected from different parts of Chhattisgarh, India.

Method of grafting and culture condition
This approach was preferred when rootstocks and scion were having same hypocotyl thickness at the time of grafting (Sakata *et al.,* 2007). In slant grafting, one cotyledonary leaf of rootstock was removed and scion seedlings of same thickness were cut below the cotyledonary leaves at 10 to 14 days after sowing. True leaves from scion seedlings were removed to avoid over weight. A wound was made by removing outer skin (3-3.5 cm length) of both the stems of scion and rootstock without damaging the vascular bundles. The wounded surfaces of both rootstock and scion (the same size on each) were bound tightly together with grafting clips, where the two wounded areas were brought to in contact. After grafting, the plants were kept under mist chamber for one week at more than 90 per cent relative humidity, 25-30 ºC temperature and darkness. Initially, for two days, in mist chamber the plants were kept under dark for fast healing of graft union. After acclimatization, the plants were transferred to shade net house for five to six days. The clips were removed after assurance of graft union in slant grafting. After successful graft combination and two non-grafted plants were planted in the main field for its performance for quality, growth observations, and also for other important horticultural traits were taken. Fifteen days old seedlings (scions) and grafts (25 days after grafting) were planted at a spacing of 2 x 1.5 m2. Totally ten plants were maintained in each replication of treatments.

Fruit harvest and analytical method
Harvesting of bottle gourd fruit for quality analysis was performed by collecting tender fruits, weekly during two months. For each plant, a sample made up of at least two to three tender fruits per vine was taken for analysis for the fruit quality parameters. The number and weight of the fruit collected per plant were recorded for all harvested fruits, in order to determine fruit yield. The data for total chlorophyll content, protein content, iron content, total soluble solids, and ascorbic acid in bottle gourd fruit were analyzed and recorded to compare grafted plants with non-grafted controls.

Results
The result pertaining effect of total chlorophyll content of bottle gourd in different graft combination and non-grafted plants are presented in Table. 1. There were significant differences in total chlorophyll content among the different graft combination. Among the five rootstock, highest chlorophyll content was recorded (5.2 mg and 5.2 mg) in Bottle gourd (*Lagenaria siceraria*) whereas with respect to the non-grafted plants or scion, Haruna scion recorded highest chlorophyll content of (4.9 mg and 5.0 mg). Among the ten graft combination, highest chlorophyll content was recorded as (5.2 mg and 5.2 mg) in Haruna grafted onto pumpkin OP and it was found to be at par with Haruna grafted onto bottle gourd (5.0 mg and 5.1 mg), whereas Lowest chlorophyll content of (4.6 mg and 4.5 mg) was recorded in GT3 *i.e* Gaurav scion grafted onto muskmelon rootstock.

Protein content in fruits is estimated by using Micro-Kjeld Hal method using KEL PLUS machine. Protein content of different graft combination and non-grafted plants were found to be non-significant and was presented in Table 1. Among five rootstock, highest protein content was recorded (1.25 gm) in T4 bottle gourd (*Lagenaria siceraria*). With respect to the non-grafted plants or scion, both Haruna and Gaurav contain same amount of protein content of (1.24 gm) and among the ten graft combination, highest protein content was recorded as (1.25) in Haruna grafted onto water melon and it was found to be at par with Haruna grafted onto pumpkin (1.25), whereas Lowest protein content of (1.24) was recorded in Gaurav scion grafted onto pumpkin rootstock.

Iron is an important mineral for both plants as well as human being. The result pertaining iron content of fruit of different graft combination and non-grafted plants are presented in Table.2. Highest iron content was recorded (0.25 and 0.26) in bottle gourd (*Lagenaria siceraria*) rootstock whereas in case of non-grafted plants or scion, Haruna scion recorded highest iron content of (0.24 and 0.25) in fruit. Among the ten graft combination, highest iron content was recorded as (0.26) in Haruna grafted onto water melon and it was found to be on par with Haruna grafted onto pumpkin (0.25 and 0.25) whereas, lowest iron content of (0.22 and 0.22) was recorded in Gaurav scion grafted onto pumpkin OP rootstock.

Bottle gourd showing higher percentage of soluble solids are more prefer in processing industries for making desired processed product. High TSS affects the flavor and quality of bottle gourd fruit. The result pertaining total soluble solids in different graft combination and non-grafted plants are presented in Table.2. Among the five rootstock, highest TSS content (3.18 °Brix and 3.17 °Brix) was recorded in pumpkin (*Cucurbita moschata*) rootstock whereas With respect to the non-grafted plants or scion, Haruna scion recorded highest TSS content of (3.0 °Brix and 3.1 °Brix) whereas, Gaurav recorded (2.9 °Brix and 2.9 °Brix) lowest TSS content. Among the ten graft combination, highest total soluble solids (TSS) content was recorded as (3.3 º Brix and 3.2 º Brix) in Haruna grafted onto pumpkin and it was found to be on par with Haruna grafted onto bottle gourd (3.2 º Brix and 3.0 º Brix), whereas lowest TSS content of (2.93 º Brix and 2.87 º Brix) was recorded in Gaurav scion grafted onto pumpkin OP rootstock

Ascorbic acid is also known as vitamin C, is an essential vitamin that must be consumed in the diet. It has a direct impact on flavor of the fruit. Ascorbic acid was observed as an important factor to be considered for optimizing the process parameters and is found to be significant among grafted and non-grafted plants. Among the five rootstock, highest ascorbic acid content was recorded (10.25 mg and 9.8 mg) in T1 watermelon (*Citrullus lanatus*) rootstock whereas non-grafted plants or scion, Haruna scion recorded highest ascorbic acid content of (9.43 mg and 9.45 mg) whereas, Gaurav recorded (8.8 mg and 8.8 mg) lowest ascorbic acid content. Among the ten graft combination, highest ascorbic acid content was recorded as (11.5 mg and 12.0 mg) in Haruna grafted onto water melon and it was found to be at par with Haruna grafted onto bottle gourd (10.5 mg and 9.9 mg), whereas lowest ascorbic acid content of (9.0 and 7.6) was recorded in Gaurav scion grafted onto pumpkin OP rootstock.

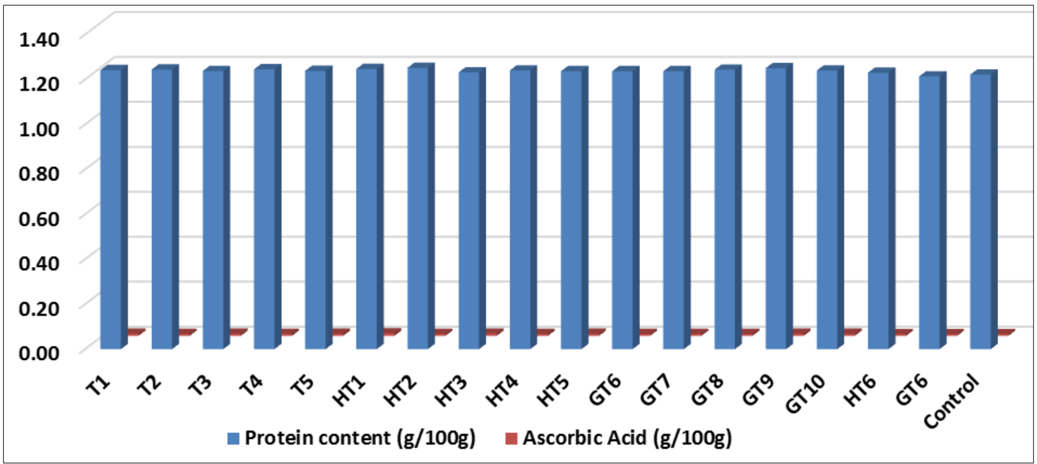
Table 1: Effect of grafting on total chlorophyll content and protein content of fruit

	Total Chlorophyll content (mg/ml)			Protein content (g/100g)		
Treatments	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
Rootstock						
T1	4.88	4.87	4.88	1.25	1.23	1.24
T2	4.92	4.93	4.93	1.24	1.25	1.24
T3	4.87	4.87	4.87	1.24	1.24	1.24
T4	5.00	5.05	5.03	1.25	1.25	1.25
T5	4.82	4.85	4.83	1.24	1.24	1.24
S.Em	0.07	0.07	0.07	0.01	0.01	0.01
CD at (LSD)	0.20	0.20	0.20	NS	NS	NS
Scion						
H	4.96	5.02	4.99	1.24	1.24	1.24
G	4.74	4.74	4.74	1.24	1.24	1.24
S.Em	0.04	0.04	0.04	0.005	0.004	0.00
CD	0.12	0.11	0.11	NS	NS	NS
Cont. vs Others						
Control	4.62	4.72	4.67	1.22	1.22	1.22
Others	4.88	4.90	4.89	1.24	1.24	1.24
S.Em	0.05	0.05	0.05	0.01	0.01	0.01
CD	0.16	0.15	0.16	NS	NS	NS
Interaction						
HT1	5.07	5.03	5.05	1.27	1.23	1.25
HT2	5.20	5.27	5.23	1.24	1.27	1.25
HT3	4.73	4.73	4.73	1.23	1.24	1.23
HT4	5.07	5.17	5.12	1.24	1.24	1.24
HT5	5.00	5.13	5.07	1.24	1.24	1.24
GT1	4.70	4.70	4.70	1.24	1.24	1.24
GT2	4.63	4.60	4.62	1.24	1.24	1.24
GT3	5.00	5.00	5.00	1.24	1.24	1.24
GT4	4.93	4.93	4.93	1.25	1.25	1.25
GT5	4.63	4.57	4.60	1.24	1.24	1.24
HT6	4.67	4.77	4.72	1.23	1.23	1.23
GT6	4.57	4.67	4.62	1.21	1.21	1.21
S.Em	0.10	0.09	0.10	0.01	0.01	0.01
CD	0.28	0.28	0.28	NS	NS	NS

Table 2: Effect of grafting on Iron content, Total Soluble Solids (TSS) and Ascorbic acid content on fruits

	Iron Content		TSS (ºBrix)				Ascorbic acid (mg/100g)		
Treatments	**2021**	**2022**	**2021**	**2022**	**Pooled**	**Pooled**	**2021**	**2022**	**Pooled**
Rootstock									
T1	0.24	0.25	2.99	3.08	3.03	0.24	10.25	9.85	10.05
T2	0.24	0.24	3.18	3.17	3.18	0.24	8.37	8.87	8.62
T3	0.24	0.24	2.95	2.98	2.97	0.24	9.57	9.37	9.47
T4	0.25	0.26	3.18	3.08	3.13	0.25	9.12	9.10	9.11
T5	0.24	0.24	2.95	2.99	2.97	0.24	9.75	9.65	9.70
S.Em	0.01	0.01	0.07	0.07	0.07	0.01	0.23	0.14	0.18
CD at (LSD)	NS	0.02	NS	0.21	NS	0.02	0.66	0.42	0.54
Scion									
H	0.24	0.25	3.09	3.11	3.10	0.24	9.43	9.45	9.44
G	0.23	0.23	2.98	2.99	2.99	0.23	8.89	8.83	8.86
S.Em	0.005	0.004	0.042	0.041	0.04	0.00	0.130	0.082	0.11
CD	NS	0.01	NS	NS	NS	0.01	0.38	0.24	0.31
Cont. vs Others									
Control	0.21	0.22	2.96	3.01	2.99	0.21	7.93	8.00	7.97
Others	0.24	0.24	3.05	3.06	3.05	0.24	9.34	9.30	9.32

S.Em	0.01	0.01	0.06	0.06	0.06	0.01	0.18	0.11	0.15
CD	NS	0.02	NS	NS	NS	0.02	0.52	0.33	0.43
Interaction									
HT1	0.26	0.27	3.08	3.15	3.12	0.27	11.50	12.07	11.78
HT2	0.23	0.23	3.30	3.27	3.28	0.23	8.63	8.70	8.67
HT3	0.25	0.25	2.97	3.10	3.03	0.25	10.53	9.97	10.25
HT4	0.24	0.27	3.27	3.07	3.17	0.25	8.40	8.37	8.38
HT5	0.23	0.23	2.90	2.97	2.93	0.23	9.47	9.53	9.50
GT1	0.22	0.22	2.90	3.00	2.95	0.22	9.00	7.63	8.32
GT2	0.25	0.24	3.07	3.07	3.07	0.25	8.10	9.03	8.57
GT3	0.22	0.22	2.93	2.87	2.90	0.22	8.60	8.77	8.68
GT4	0.25	0.25	3.10	3.10	3.10	0.25	9.83	9.83	9.83
GT5	0.24	0.24	3.00	3.00	3.00	0.24	10.03	9.77	9.90
HT6	0.22	0.22	3.05	3.12	3.08	0.22	8.07	8.07	8.07
GT6	0.20	0.21	2.88	2.91	2.89	0.21	7.80	7.93	7.87
S.Em	0.01	0.01	0.10	0.10	0.10	0.01	0.32	0.20	0.26
CD	NS	0.03	NS	NS	NS	0.03	0.94	0.59	0.76



Graph 1: Representing protein content and ascorbic acid content in fruits

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