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Determination of properties of scion and rootstock of cashew for design of bench grafting tool

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Abstract
The information about properties of cashew scion and rootstock is scarce and needs to be known to design the bench grafting tool for grafting of cashew. The properties of scion of Vengurla - 4 variety and rootstock used for softwood grafting were determined. The determination of properties of scion grouped in different diameter classes and cashew rootstock of two extreme ages (3 months and 8 months after sowing), grouped in different diameter classes and moisture content classes for cashew grafting. The mean diameter of scion for size classes D_1, D_2 and D_3 found as 6 mm, 8 mm and 10 mm respectively. The mean diameter of 3 months old rootstock of different size classes R_1, R_2 and R_3 found as 4 mm, 6 mm and 8 mm, and for 8 months old rootstock of different size classes S_1, S_2 and S_3 found 6 mm, 8 mm and 10 mm approximately. The moisture content of scion of diameter 3 -12 mm found as 58.13% to 82.58%. The moisture content of rootstock of diameter 3-10 mm found 67.08 to 90.09%. The hardness of scion found as 16.62 to 51.83 N/mm^2. The hardness of rootstock found 2.01 to 33.24 N/mm^2. The maximum cutting strength of scion and rootstock found as 7.06 N/mm^2.

Keywords: Grafting machine, cutting strength, hardness, mechanization, cutting system, wrapping system, engineering properties, cashew grafting

1. Introduction

In the Maya worldview, all living things are connected and plants are recognized for their Indian horticulture sector contributes about 33% to the agriculture Gross Value Added (GVA) in agricultural GDP with 18% area making very significant contribution to the Indian economy. India is currently producing about 331 MT of horticulture produce during 2020-21 which has surpassed the food grain production (Anonymous, 2022) [7]. In Maharashtra average share of horticulture in Gross State Value Added (GSVA) of crop sector is 28.4 per cent. Horticulture area increased from 1.9 mha in 2019-20 to 2.11 mha in 2020-21, showing an increase of 11.4%. Maharashtra is also leading producer of grapes, mango, Sapota, pomegranate, onion and cashew nut (Anonymous, Economic survey of Maharashtra, 2022) [6]. India is the second largest producer of horticultural crops. It is strongly believed that, the consistent and rapid increase in production and availability of horticultural crops shall over period of time translate into bridging the gap between the nutritional security of the country in relation to global average (Singh *et al.*, 2022) [15].

Cashew (*Anacardium occidentale* L.) is a tree native of Eastern Brazil, which was introduced to India by the Portuguese in the 16th Century. At global scenario, though India occupied second largest area under cashew cultivation (18.76%), but contributes only 16.33% in production. The Directorate of Cashew Research and various cashew research stations in country studies indicated the superiority of softwood grafting over other vegetative propagation methods and has been recommended for commercial multiplication of quality planting material in cashew (Anonymous, Annual report of DCR, 2019) [5]. The grafting in India is done manually which has certain limitations and has much drudgery involved in it. Produce quality grafts with high capacity of graft production within time limit of grafting season is one of major problem. Only highly skilled and well experienced person is able to carry out successful grafting operation using hand grafting method. The shortage of farm labour, unavailability of skilled grafter during grafting season and the scarcity of skilled grafters and budder's make more apparent, the need of a machine for bench grafting.

The cutting force required to cut the scion and rootstock, cutting strength and hardness of scion and rootstock differs significantly due to different physical properties like size, moisture content and age of stick. These properties need determination to incorporate in the design of grafting machine. Sessiz *et al.,* (2013) [12] determined the cutting properties of the table olive branches and studied cutting behaviour to optimize the design of cutting elements in pruning machines. Sessiz *et al.,* (2015) [13] determined the cutting properties such as cutting force, cutting strength, cutting energy of different wine grape branch (cutting) as function of moisture content, diameter and variety. But the information about the properties of scion and rootstock used in grafting of cashew or other material of cashew plant is rare. The information about physical and engineering properties of cashew plant material used in cashew grafting are necessary for design of grafting machines, tools and equipments. There is necessity for mechanization of cashew grafting operation which cut the scion and rootstock in wedge ('V') shape to prepare graft union and wrap the graft union. Mechanization of operation and characterization of any process require engineering properties known. The properties of cashew scion and rootstock were determined and studied by adopting standard method.

2. Materials and Method

2.1 Preparation of rootstock sample

The healthy seedlings with brownish coloured softwood were selected to determine the engineering properties. Cashew seedlings of Vengurla 1 variety were selected for study. The rootstock with stick of length 100 mm of approximately 3 months and 8 months old each were collected from seedlings grown in nursery (Kadam, 1992) [8]. Also the samples of both age and for replications were collected. The size of collected samples of both age rootstocks were measured and grouped in three different diameter classes separately. Collected samples were stored in individual moisture proof zip lock polythene bags in refrigerator at temperature 4 - 5 °C (Sessiz *et al.,* 2013) [12] to avoid moisture exploitation. Each polythene bag with samples of various diameter and age group were tagged as shown in Fig. 2. The tests were conducted as early as possible after collecting sample from nurseries to get accurate readings.

2.2 Preparation of scion sample

Cashew trees of 12 years old of Vengurla 4 variety were selected as scion mother trees from the progeny bud wood orchard maintained at the Nursery, CoH, Dr. BSKKV, Dapoli. Unsprouted terminal, mature and healthy softwood scion budsticks with length of 100 -120 mm length were selected (Kadam, 1992) [8]. The diameter of selected scion sticks was measured and grouped in three different diameter classes. Collected samples were stored in individual moisture proof zip lock polythene bags with tags for identification in refrigerator at temperature 4-5 °C (Sessiz *et al.,* 2013) [12].

2.3 Diameter of Scion and Rootstock

Size of scion and rootstock was characterized in terms of diameter of stick, which was measured using vernier caliper. The diameter of stick was measured at three different location at the cutting side (bottom of scion stick), where the V shape cut to be taken during grafting and average diameter was noted. The measurement of diameter of sticks was followed as per procedure given by Mohsenin, 2019 [10]. The length of selected scion stick was kept 100 mm -120 mm, which showed maximum success (Kadam, 1992) [8]. Measurement of diameter of scion and rootstock is as shown in Fig. 3.1. For characterization of size, different samples of scion and rootstock each were randomly selected, with different phonology and divided into three diameter classes (Sessiz *et al.,* 2013) [12].

2.4 Moisture Content

The scion and rootstock samples for moisture content determination from sample kept in moisture proof zip lock polythene bag and coded were taken as immediately as possible after completion of other measurement. The samples for moisture determination were taken with different diameter classes and age of stick. The moisture content of scion and rootstock were determined by using standard test procedure for direct moisture content ASTM D4442-16, 2016. The stick sample was cut in 10 - 30 mm length pieces and filled in aluminium sample boxes as shown in Fig. 2. The sample boxes with stick pieces were weighed with the digital precision balance, numbered and kept in hot air oven at 103 °C for 24 hours to remove moisture. After 24 hours, sample boxes were taken out and kept in desiccator and closed with lids for cooling to room temperature without moisture absorption. Sample boxes were weighed after cooling with the digital precision balance. The moisture content of stick was

Fig 1: Scion diameter measurement with vernier caliper

Fig 2: Samples prepared for property determination

calculated as follow:

$$\text{Moisture Content, \%} = \frac{(W1 - W2)}{W1} \times 100 \quad (1)$$

Where, W_1: Initial weight of stick sample, g
W_2: Final weight of oven dried stick sample, g

2.5 Hardness

Hardness (N/mm^2) is the ability of material to resist localised plastic deformation, which was determined by a standard test, where the surface resistance to indentation is measured. A hardness test is typically performed by pressing a specifically dimensioned and loaded object (indenter) into the surface of the material. Indentation was based on standard instrumented indentation, ASTM E2546-15 and ISO 14577-1(E). Indenter tip with a known geometry was driven into material, by increasing normal load (Leroux, 2014) [19].

The Perten Instruments, TEXVOL TVT-300 XP Texture Analyser was used to determine the hardness of scion and rootstock sticks. Cylinder probe of 2 mm diameter and material of stainless steel has inserting in Insert of 10 mm diameter. Prior to test the stick samples were divided into three different approximate diameter groups from 3 mm to 12 mm for scion and 3 mm to 10 mm for rootstock (age 3 months and 8 months). The test was conducted with test speed i.e. indenting speed of 1 mm/s. The stick samples were kept in horizontal position on Heavy Duty Stand insert and loading was applied in vertical direction. The indentation was up to the depth equal to diameter of sticks. The graph of force-displacement was created with the peak point as maximum indenting force. The readings were recorded in table using computer data acquisition system. Then the hardness was calculated by,

$$\text{Hardness, H } (N/mm^2) = P_{max} / A_c \quad (2)$$

Where, P_{max} = Maximum load or maximum indenting force, N
A_c = projected contact area, mm^2

Fig 3: Samples prepared for moisture content determination

Fig 4: Cutting strength determination on Texture Analyser

2.6 Cutting Strength

Cutting strength is the maximum Cutting force which a material is capable of sustaining. Prior to experiment, the scion and rootstock stick diameter was measured with the vernier calliper, and then both the stick samples were divided into three different diameter groups, from 3 mm to 12 mm into (6, 8, 10 mm) for scion and (4, 6 and 8 mm and 6, 8 and 10 mm) for rootstock, respectively. Then sticks were tested for determination of cutting force and maximum cutting force was recorded. The Perten Instruments, TEXVOL TVT 300 XP Texture Analyser with Probe Holder Knife and Blade Set Insert was used for testing. The cutting knife was made up of steel, 1 mm thickness, and 50 mm width. During the test, the stick samples were placed on the Blade Set Insert in horizontal position (Fig. 4). The maximum cutting force readings for various experimental samples were obtained and recorded using computer data acquisition system. The diameters (mm) of sticks obtained and recorded using computer data acquisition system. The diameters (mm) of sticks were converted into cross section area of shear plane in (mm^2). The maximum cutting strength was calculated by, (Mohsenin, 2019; Sessiz *et al.*, 2013) [10, 12].

$$\text{Maximum Cutting Strength, } \sigma_s = \frac{Fmax}{A} \quad (3)$$

Where
σ_s = maximum cutting strength, N/mm^2 (MPa)
F_{max} = maximum cutting force, N
A = cross-sectional area of stick at the shear plane, mm^2

Table 1: Tex Vol Texture Analyser initial setup for experiment

Sr. No.	Operating Setup Particular	Value
1.	Test type	Compression
2.	Test mode	Single cycle
3.	Force unit	Grams
4.	Sample height	85 mm
5.	Starting distance from sample	5.0 mm
6.	Compression	20 mm
7.	Initial speed	1 mm/s
8.	Test speed	1 mm/s
9.	Retract speed	10 mm/s
10.	Trigger force	5 g
11.	Data rate	200 pps

2.7 Properties Studies

To know the effect of moisture content, diameter of scion and age of rootstock on cutting strength and hardness was evaluated by finding out strength and hardness by texture analyser. The average of three replications conducted for each experiment was taken. The experiment was carried out as per Table 2 and 3.

A. Properties studies of scion

The scion samples of diameter 4 mm - 12 mm were selected and grouped in 5 diameter classes. The 15 samples with three replications for each diameter classes were selected. The moisture content of 15 samples of each diameter class was determined as per standard procedure given in 2.4 and grouped in 5 classes for moisture content.

Table 2: Effect of parameters on engineering properties of scion stick

Sr. No.	Independent Parameter	Level	Range	Dependent Parameter
1.	Moisture content,%	5	62-72%	Cutting Strength, N/mm^2
2.	Diameter of scion, mm	5	5-11 mm	Hardness, N/mm^2

B. Properties studies of rootstock

The samples of diameter 2 mm - 10 mm were selected and grouped in 5 diameter classes for both rootstock age A1: 3 months and A2: 8 months. The 15 samples with three replications for each diameter classes were selected. The moisture content of 15 samples of each diameter class was determined as per 2.4 and grouped in 5 classes for moisture content.

Table 3: Effect of parameters on engineering properties of rootstock

Sr. No.	Independent Parameter	Level	Range	Dependent Parameter
1.	Moisture content,%	3	70 – 90%	Cutting Strength, N/mm^2
2.	Diameter of rootstock, mm	3	3 – 9 mm	
3.	Age of rootstock, months	2	A1 and A2	Hardness, N/mm^2

3. Results and Discussion

The experiments were conducted to determine properties related to grafting of cashew. The effect of properties on parameters related to mechanical grafting were also studied are presented as below.

3.1 Diameter of scion and rootstock

The diameter of scion and rootstock was measured as per standard procedure given in 2.3. The average diameter of scion for three different size classes was found approximately 6 mm, 8 mm and 10 mm. The average diameter of rootstock for three different size classes was 4 mm, 6 mm and 8 mm for 90 days old rootstock. The average diameter of rootstock for three different diameter classes was 6 mm, 8 mm and 10 mm for 240 days old rootstock.

Table 4: Diameter of scion of Vengurla - 4 variety of Cashew

	Diameter class 1, mm	Diameter class 2, mm	Diameter class 3, mm
Mean	6 mm	8 mm	10 mm
Max.	6.9 mm	8.4 mm	10.5 mm
Std. Dev.	0.81	0.25	0.72

Table 5: Diameter of 3 months (A1) old rootstock of Cashew

	Diameter class 1, mm	Diameter class 2, mm	Diameter class 3, mm
Mean	4 mm	6 mm	8 mm
Max.	4.80 mm	6.70 mm	8.50 mm
Std. Dev.	0.43	0.51	0.50

Table 6: Diameter of 8 months (A2) old rootstock of Cashew Cv. Vengurla - 1

	Diameter class 1, mm	Diameter class 2, mm	Diameter class 3, mm
Mean	6 mm	8 mm	10 mm
Max.	6.40 mm	8.50 mm	10.50 mm
Std. Dev.	0.23	0.76	0.59

3.2 Moisture Content scion and rootstock

The moisture content of scion was determined as per the procedure given in 2.4. The mean moisture content for scion diameter classes are presented in Table 7. The moisture content of scion was found from 58.13% to 82.58%. The mean moisture content for 3 months old rootstock and diameter classes are presented in Table 8. The mean moisture content for 240 months old rootstock and diameter of are presented in Table 9. The moisture content of rootstock was found from 67.08% to 90.09%.

Table 7: Moisture content of scion of three different diameter class of Cashew Cv. Vengurla - 4

	Moisture Content for 6 mm D_1,%	Moisture Content for 8 mm D_2,%	Moisture Content for D_3,%
Mean	68.84%	65.95%	63.67%
Max.	82.58%	73.54%	73.52%
Std. Dev.	5.05	3.48	3.80

Table 8: Moisture content of 3 months (A1) old rootstock of three different diameter class of Cashew Cv. Vengurla - 1

	Moisture Content for 4 mm R1,%	Moisture Content for 6 mm R2,%	Moisture Content for 8 mm R3,%
Mean	85.30%	86.15%	86.17%
Max.	87.27%	87.61%	90.09%
Std. Dev.	1.55	0.86	2.44

Table 9: Moisture content of 3 months (A1) old rootstock of three different diameter class of Cashew Cv. Vengurla - 1

	Moisture Content for 6 mm S1,%	Moisture Content for 8 mm S2,%	Moisture Content for 10 mm S3,%
Mean	77.98%	81.63%	74.44%
Max.	80.98%	84.92%	80.72%
Std. Dev.	2.13	3.04	4.50

3.3 Hardness

Hardness of the scion and rootstock were measured using Texture analysis as per standard procedure described in 2.5. The hardness of different scion and rootstock of size diameter classes were determined. The mean hardness of scion diameter classes are presented in Table 10. The hardness of scion was found to be 16.62-51.83 N/mm^2. The mean hardness of 3 months old rootstock for diameter classes are presented in Table 11. The mean hardness of rootstock of age 8 months for diameter classes are presented in Table 12. The hardness of rootstock was found 2.01-33.24

N/mm². The hardness of stick for class 2 was found lower than class 1 and 3, probably due to the vigorous swelling of large diameter with high moisture content (Softwood) of scion of class 2, offers low resistance to indentation of probe (Kadam, 1992) [8].

Table 10: Hardness of scion for three different diameter class using Texture Analyser with 2 mm diameter probe

	Hardness for D1 class 6 mm, N/mm²	Hardness for D2 class 8 mm, N/mm²	Hardness for D3 class 10 mm, N/mm²
Mean	35.65 N/mm²	38.65 N/mm²	38.14 N/mm²
Max.	40.63 N/mm²	48.27 N/mm²	40.63 N/mm²
Std. Dev.	3.66	7.03	7.29

Table 11: Hardness of 3 months old rootstock for three different diameter class using Texture Analyser with 2 mm diameter probe

	Hardness for R1 class 4 mm, N/mm²	Hardness for R2 class 6 mm, N/mm²	Hardness for R3 class 8 mm, N/mm²
Mean	13.23 N/mm²	9.71 N/mm²	10.34 N/mm²
Max.	21.88 N/mm²	11.81 N/mm²	15.36 N/mm²
Std. Dev.	5.75	2.09	5.28

Table 12: Hardness of 8 months old rootstock Cashew Vengurla-1 variety for three different diameter class using Texture Analyser with 2 mm diameter probe

	Hardness for S1 class6 mm, N/mm²	Hardness for S2 class 8 mm, N/mm²	Hardness for S3 class 10 mm, N/mm²
Mean	23.12 N/mm²	19.68 N/mm²	22.61 N/mm²
Max.	27.84 N/mm²	29.82 N/mm²	33.25 N/mm²
Std. Dev.	3.64	7.38	5.52

3.4 Cutting Strength

The cutting strength of scion and rootstock were measured using Texture Analysis as per standard procedure described in 2.6. The mean cutting strength of the scion observed for diameter classes are presented in Table 13. The mean cutting strength of the 3 months old rootstock observed for diameter classes are presented in Table 14. The mean cutting strength of the scion observed for diameter classes presented in Table 15. The maximum cutting force required to cut scion and rootstock of cashew for grafting was found to be 287.47 N. The cutting strength of scion and rootstock diameter class decreases as diameter increases, probably due to maturity of sticks has not increased much with diameter; due to this less resistance to cutting was observed as compared to lower diameter (Adams, 2016) [1].

Table 13: Cutting strength of scion of Cashew Cv. Vengurla–4 for three different diameter class using Texture Analyser

	Cutting strength for D1 class 6 mm, N/mm²	Cutting strength for D2 class 8 mm, N/mm²	Cutting strength for D3 class 10mm, N/mm²
Mean	5.49 N/mm²	4.16 N/mm²	3.60 N/mm²
Max.	7.06 N/mm²	4.96 N/mm²	4.51 N/mm²
Std. Dev.	0.87	0.39	0.55

Table 14: Cutting strength of 3 months old rootstock Cashew Cv. Vengurla-1 for three different diameter class using Texture Analyser

	Cutting strength for R1 class 4 mm, N/mm²	Cutting strength for R2 class 6 mm, N/mm²	Cutting strength for R3 class 8 mm, N/mm²
Mean	7.77 N/mm²	4.39 N/mm²	3.15 N/mm²
Max.	9.04 N/mm²	5.72 N/mm²	4.05 N/mm²
Std. Dev.	0.96	0.70	0.79

Table 15: Cutting strength of 8 months old rootstock of Cashew Cv. Vengurla-1 variety) for three different diameter class using Texture Analyser

	Cutting strength for S1 class 6 mm, N/mm²	Cutting strength for S2 class 8 mm, N/mm²	Cutting strength for S3 class 10 mm, N/mm²
Mean	5.57 N/mm²	3.83 N/mm²	3.33 N/mm²
Max.	6.54 N/mm²	4.09 N/mm²	4.24 N/mm²
Std. Dev.	0.74	0.20	0.70

3.5 Effect of moisture content, diameter of stick and age of rootstock on cutting strength and hardness

The effect of moisture content, diameter of stick and age of rootstock on cutting strength and hardness has carried out as per 2.7 (A). The experiments were conducted following scheme obtained by Design Expert Software Package Trial Version 13.0.0.

A. Effect of moisture content and diameter of scion on cutting strength and hardness

The effect of moisture content and diameter of scion on cutting strength and hardness was studied as described in Table 16. The experiment was conducted with five levels Center Composite Design (CCD). The test was carried out using five diameter class scion sticks with five moisture content range as given in Table 2. A cutting force was measured using texture analyser and cutting strength (N/mm²) was determined. Hardness (N/mm²) of scion stick was also measured. The Response Surface Methodology was used and effect of moisture content and diameter of scion on cutting strength and hardness was carried out and graphs drawn depicted at Fig. 5 and Fig. 6.

Table 16: Effect of moisture content and diameter on cutting strength and hardness of scion

Run	A:Moisture Content,%	B:Diameter of scion, mm	Cutting Strength, N/mm²	Hardness, N/mm²
1	62	11	4.45	31.30
2	67	8	2.96	40.71
3	67	12	4.68	43.75
4	67	8	5.83	36.73
5	67	8	4.96	48.27
6	67	8	2.72	34.50
7	67	4	3.79	41.53
8	60	8	6.84	40.63
9	72	5	4.48	27.59
10	74	8	4.14	40.41
11	72	11	3.77	16.61
12	62	5	4.35	36.86
13	67	8	3.87	40.08

i. Effect of moisture content and diameter on cutting strength

As shown in Fig. 5, the cutting strength of scion is inversely proportional to moisture content of scion. The cutting strength decreases with increase in moisture content of scion, which indicates that high moisture content scion were vigorous in nature than woody scion and provide less resistance to cutting. The decrease in cutting strength with increasing moisture content may be due to the behaviour of plant material. The similar results were reported by Sessiz *et al.*, 2013 [12]. The cutting strength is directly proportional to diameter of scion. The cutting strength increases with increase in diameter of scion gradually, probably due to the increase in woodiness, the resistance to cutting is increases. The similar results were also reported by Sessiz *et al.*, 2013 [12]. The maximum cutting strength found for scion with low moisture content 60% and 8 mm diameter was 6.84 N/mm^2. The minimum cutting strength was found to be 2.72 N/mm^2 for scion of diameter 8 mm at 67% moisture content.

iii. Effect of moisture content and diameter on hardness

As shown in Fig. 6, the hardness of scion is inversely proportional to moisture content of scion. The hardness increases with decrease in moisture content of scion but the maturity of scion also affects the hardness of scion. The increase in hardness indicates the woodiness or high lignin of scion at lower moisture content. The hardness of scion slightly increases with increase in diameter of scion as larger scion may be more mature or woody than smaller one and offer greater resistance to indentation. The similar characteristic behaviour of plants was observed by Adams, 2016. The large size scion is harder than the scion with small diameter. The maximum hardness found for 67% moisture content of 8 mm diameter scion as 48.27 N/mm^2. The minimum hardness was found to be 16.61 N/mm^2 for scion of diameter 11 mm at 72% moisture content.

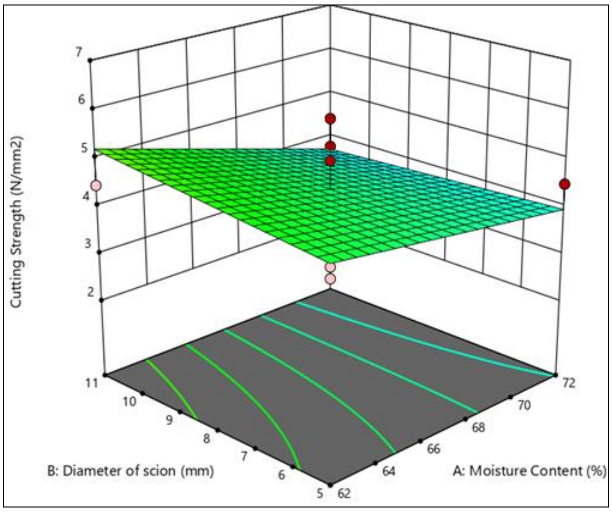

Fig 5: Effect of moisture content and diameter of scion on cutting strength of scion

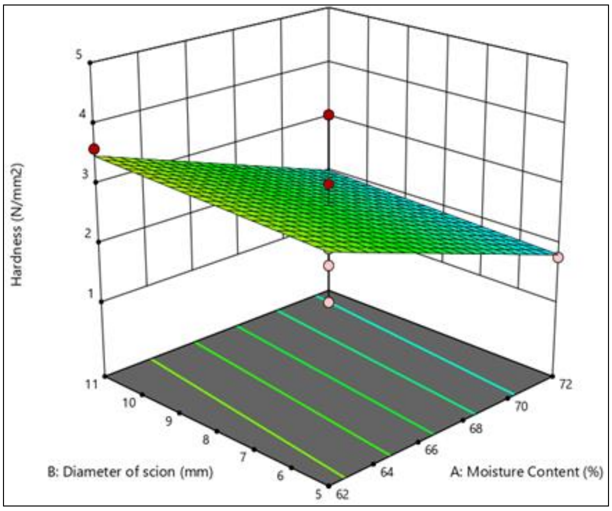

Fig 6: Effect of moisture content and diameter of scion on hardness of scion

B. Effect of moisture content, diameter of rootstock of age (A1 and A2) on cutting strength and hardness

The effect of independent parameters of rootstock on dependent engineering properties was studied as per 2.7 (B) and scheme of test given in Table 3. The experiment was conducted following test scheme obtained by Design Expert Software Trial Version 13.0.0 and present in Table 17. The experiment was conducted with five level Center Composite Design (CCD) using three independent parameter moisture content (%), Diameter of rootstock (mm) and age of rootstock (days) as categoric factor on dependent parameter, cutting strength (N/mm^2) and Hardness (N/mm^2). The age of rootstock used as A1: 3 months and A2: 8 months.

Table 17: Effect of moisture content, diameter for age A1 and A2 on cutting strength and hardness rootstock

Run	A:Moisture Content,%	B:Diameter of Rootstock, mm	C:Age of Rootstock	Cutting Strength, N/mm^2	Hardness, N/mm^2
1	70	3	A1	5.11	26.55
2	90	3	A1	3.34	22.40
3	70	9	A1	4.05	18.02
4	90	9	A1	3.13	20.40
5	66	6	A1	2.68	33.24
6	94	6	A1	2.93	18.89
7	80	2	A1	1.90	26.44
8	80	10	A1	4.03	17.34
9	80	6	A1	3.45	26.18
10	80	6	A1	3.68	27.76
11	80	6	A1	3.92	29.82
12	80	6	A1	4.01	5.99
13	80	6	A1	3.98	17.14
14	70	3	A2	4.24	15.27
15	90	3	A2	3.89	8.74
16	70	9	A2	3.11	2.01

17	90	9	A2	2.49	11.39
18	66	6	A2	4.13	14.17
19	94	6	A2	3.64	10.16
20	80	2	A2	2.60	13.14
21	80	10	A2	4.99	8.65
22	80	6	A2	4.09	11.68
23	80	6	A2	4.03	11.81
24	80	6	A2	3.99	9.97
25	80	6	A2	3.74	8.10
26	80	6	A2	4.18	14.48

i. Effect of moisture content, diameter for age A1 and A2 on cutting strength of rootstock

The effect of moisture content, diameter on cutting strength of rootstock of age A1 and A2 were shown in Fig. 7 and Fig. 8 respectively. The cutting strength for rootstock of age A1, increases with decrease in moisture content, and the cutting strength is inversely proportional to moisture content. The cutting strength is directly proportional to diameter of rootstock A1. The cutting strength increases with increase in size of diameter of rootstock gradually, due to increase in resistance to cutting because of increase in woodiness. Cutting strength is directly proportional to diameter of rootstock of age A2. As moisture content increases, cutting strength decreases probably due to vigour rootstock, the resistance to cutting was decreases. The same trends in result were reported by Sessiz, 2015. The highest cutting strength of rootstock A2 was found to be 4.99 N/mm^2 for the rootstock of diameter 10 mm at 80% moisture content. Whereas the highest cutting strength of rootstock A1 was found to be 5.11 N/mm^2 for 3 mm diameter rootstock at 70% moisture content. This indicates that moisture content of rootstock has more significant effect on cutting strength than diameter.

ii. Effect of moisture content, diameter for age A1 and A2 on hardness of rootstock

The effect of moisture content, diameter of age A1 and A2 on hardness of rootstock were shown in Fig. 9 and Fig. 10. The hardness of rootstock A1 increases with decrease in moisture content, which indicates the hardness, was inversely proportional to moisture content. The woodiness of stick increases with decrease in moisture content due to this the resistance to indentation of probe in rootstock increases. The hardness was also inversely proportional to diameter of rootstock A1.The hardness increases with decrease in size may be due to decrease in the woodiness of stick, the rootstock was compressed initially by probe and then probe intended because of insufficient strength of small diameter rootstock. The similar effects of woodiness and moisture content of stick was also reported by Adams, 2016. The hardness of rootstock A2 increases with increase in diameter of rootstock A2 and also increases with increase in moisture content of rootstock. The maximum hardness of rootstock A1 was found to be 33.24 N/mm^2 for 6 mm diameter at 67% moisture content. The minimum hardness of rootstock was found to be 5.99 N/mm^2 for 6 mm diameter at 80% moisture content. The maximum hardness of rootstock A2 was found to be 15.27 N/mm^2 for 3 mm diameter at 70% moisture content. The minimum hardness of rootstock A2 was found to be 2.01 N/mm^2 for 9 mm diameter at 70% moisture content.

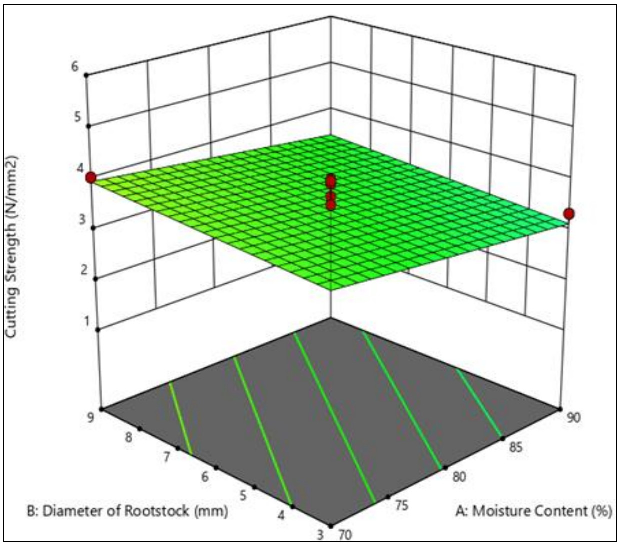

Fig 7: Effect of moisture content and diameter on cutting strength for A1

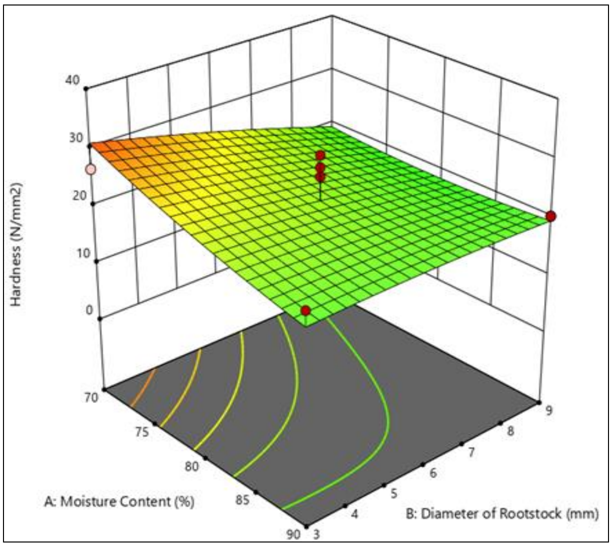

Fig 8: Effect of moisture content and diameter on hardness for A1

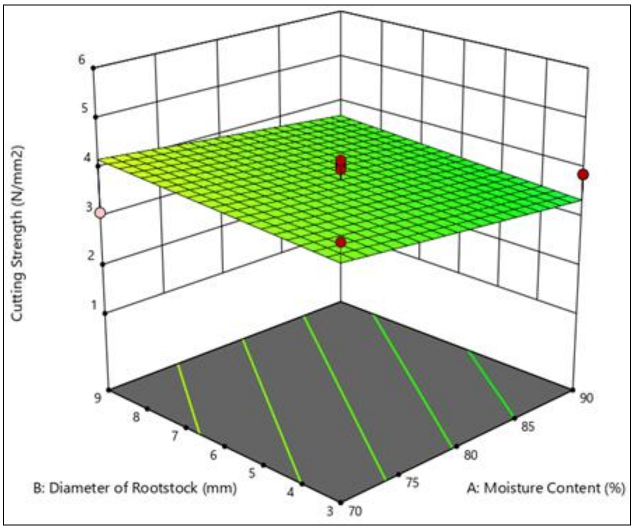

Fig 9: Effect of moisture content and diameter on cutting strength for A2

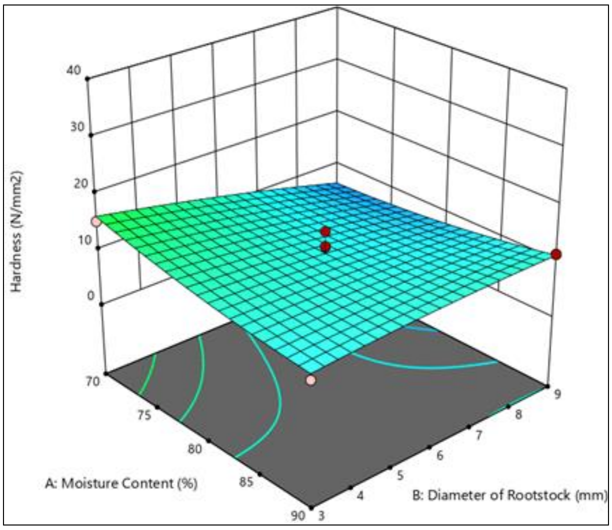

Fig 10: Effect of moisture content and diameter on hardness for A2

5. Conclusion

Based on study of properties of scion and rootstock and its effect on cutting process of scion and rootstock of cashew graft, following conclusions are drawn from the study,

1. The cutting properties of scion and rootstock vary with moisture content, size and age of rootstock.
2. The maximum cutting strength for Cashew Cv. Vengurla - 4 scion found as 7.06 N/mm^2. Cutting strength increases with increase in diameter and decrease in moisture content of scion.
3. The maximum hardness for Cashew Cv. Vengurla - 4 scion was found as 48.27 N/mm^2. The hardness increases with increase in diameter and decrease in moisture content of scion.
4. The maximum cutting force required to cut Cashew Cv. Vengurla - 4 scion and rootstock for grafting was found 287.47 N.

6. Reference

1. Adams SW. The effects of rootstock, scion, grafting method and plant growth regulators on flexural strength and hydraulic resistance of apple. Unpublished M.Sc. Thesis, submitted to Utah State University, Logan, Utah; c2016.
2. Anonymous. ASTM E2546-15. Standard Practice for Instrumented Indentation Testing. American Society for Tesing and Materials; c2015. p. 77-85.
3. Anonymous. ISO 14577-1(E). Standardized Nono-indentation Test for Hardness. The International Standard organization (ISO) Journal; c2015. p. 1-9.
4. Anonymous. ASTM D4442-16. Standard Test Methods for Direct Moisture Content Measurement of wood-based Materials. American Society for Tesing and Materials; c2016.
5. Anonymous. Annual report of DCR; c2019.
6. Anonymous. Directorate of Economics and Statistics. Planning Department, Government of Maharashtra, Mumbai. Economic survey of Maharashtra; c2021-22.
7. Anonymous. 2022. (https://hortnet.gov.in/NHMhome_new.aspx). National Horticulture Mission, hortnet.
8. Kadam SG. Studies on in situ softwood grafting in cashew nut. Unpublished M.Sc. Thesis, submitted to Konkan Krishi Vidyapeeth, Dapoli; c1992.
9. Leroux P. Hardness evaluation of biological tissue using nano-indentation. Technical Report; c2014.
10. Mohsenin NN. Physical properties of plant and animal materials. A Textbook. Published by Routledge Taylor and Fransis, New York; c2019.
11. Nayak MG. Propagation and Nursery Management in Cashew. ICAR, Directorate of Cashew Research, Puttur, E-book. 24-1; c2015.
12. Sessiz A, Elicin AK, Esgici R, Ozdemir G, Nozdrovicky L. Cutting properties of olive sucker. Acta technologica agriculturae. 2013;3:82-86.
13. Sessiz A, Esgici R, Ozdemir G, Eliçin AK, Pekitkan FG. Cutting properties of different grape varieties. Agriculture & Forestry. 2015;61(1):211-216.
14. Sessiz A, Ozdemir G, Esgici R. Some physical, mechanical and ripening properties of the Bogazkere Grape and theirs relationships. Journal of Agricultural Machinery Science. 2017;13(1):11-19.
15. Singh AK, Murthy BNS, Rao ES. Achievements in Horticulture in Independent India. Indian Agriculture after Independence, ICAR; c2022. p. 114-133.