



ASSESSMENT OF FRUIT MORPHOLOGY IN *WITHANIA COAGULANS* (STOCKS) DUNAL OF SOLANACEAE

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Abstract

The main aim of the present study is to describe taxonomical important macro-morphological characters of fruit (berry) including seeds. The experiment conducted at Department of Botany, University of Rajasthan, Jaipur from August, 2018 to November, 2019. The fruit has variations in shape, size and colour. There are three types of berries on the basis of fruit weight *i.e.* large, medium and small with the weight of 361-535 mg, 191-360 mg and 110-190 mg respectively. Variation in the number of seeds, sclerotic granules and fruiting pulp were observed. The amount of fruit pulp varies in different berries. The maximum number of seeds, sclerotic granules and fruit pulp were observed in large berries followed by medium and small. As per observation fruit can be classified into three categories *i.e.* large, medium and small. Large berries are most suitable in among berries for agriculture (farmers), seed research and pharmaceutical industries.

Key words: Fruit, Seed, vernier callipers and sclerotic granules.

Introduction

The family Solanaceae is known as nightshade family and characterized by alternate leaves without stipules, solitary inflorescence, bilobed stigma, swollen placenta, oblique septum, carpel present at the angle of 45°, berry or capsule fruit as key characters. The family occupies a wide range of terrestrial habitats from desert to rainforest (Knapp *et al.*, 2004). It has a worldwide distribution except for Antarctica. There are approximately 90 genera and 2000 species. About 59 genera are native to South America while 28 are endemic (Willis, 1973). In India, the family represents 24 genera and 108 species, out of these 10 genera and 34 species are native to India, while 14 genera and 74 species are exotic (Deb, 1979). According to Shetty and Singh, (1987) the family represents naturally occurring 7 genera with 23 species while 6 genera with 15 species are cultivated in Rajasthan.

Solanaceous fruits are berries that are globose and having a smooth surface. Seeds are miniature of the plants. Solanaceous seeds are small and embedded into fruit pulp. Seed viability and germination play an important role in the plant's life. The study of the comparative morphology of the seeds has been largely ignored in the field of taxonomy and classification. Limited information is available on the structure of the seeds of Solanaceae

(Maheswari, 1944; Johri and Tiagi, 1952).

The plant *Withania coagulans* is native to the Indian subcontinent. The plant is a highly medicinal herb, commonly known as “Indian cheese maker” or vegetable rennet due to its milk coagulating property (Atal and Sethi, 1963). *W. coagulans* specimens are selected in Rajasthan from Ajmer: Lohargal, Sharma; Jaisalmer, Bhandari; Jodhpur, Bhandari. This plant becomes rare in these days (Shetty and Singh, 1987). The plant is used to cure various ailments and has anti-oxidant, anti-analgesic and anti-tumour activities.

Seed morphology is an important tool for seed identification by various ornamentation of seed surface. Seed morphology has been shown to provide useful characters for the analysis of taxonomic relationships in a wide variety of plant families *i.e.* Campanulaceae (Shelter, 1986). Microscopic and morphological characters were helpful in distinguishing the genus and species.

The plant is critically endangered due to unrestricted collection from natural stands, destruction of natural habitat and low propagation rate in nature (Karnick, 1978; Vakeeswaran and Krishnasamy, 2003).

Material and Methods

The fruits of the plant were collected from the local

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market in Jaipur and Jodhpur cities of the Rajasthan (India). The specimen of the plant deposited in the herbarium of Botanical Survey of India (BSI), Jodhpur and RUBL, Jaipur. The healthy berries and seeds were used for photographs. The extensive observation of fruits including seeds of the plant was done from August, 2018 to November, 2019. Seeds have been isolated manually from the pulp by using tap water and dried at room temperature on filter papers by air. Selection of berries for the experiment has been made to find uniformity and seeds were isolated from the berries and stored in dry glass containers. The colour and shape of the berries and seeds were determined by eye observation under the light microscope. Fully dried seeds were selected for photographic analysis. The size was measured by vernier callipers. The dimensions were taken at the point of maximum length/width/thickness in five replicates of randomly selected seeds. Weight of the berries and seeds were taken by electronic weighing balance. Pulp weight of the berries is calculated by the sum of the weight of seeds and weight of sclerotic granules and minus it with the weight of berries without seed coat. Fruit coat weight of the berries calculated by using the following formula-

Fruit coat weight = berries weight with fruit coat – berries weight without fruit coat.

Results

The mature berries enclosed by a leathery calyx (Fig. 1B). The berries are globose in shape, yellowish to dark brownish in colour with the glabrous surface (Fig. 1C). The size of the berries is 5.0 to 13.0 mm in length and 6.0 to 13.0 mm in width. Weight basis three categories *i.e.* small berries having 110-190 mg weight, medium berries having 191-360 mg weight and large berries having 361-535 mg weight have been observed (Fig. 1, Image B).

Fruit coat weight very in all three berries. Fruit coat

weight was obtained 16-39 mg, 31-52 mg and 25-66 mg in small, medium and large berries respectively. Observation of fruit coat shows that heaviest fruit was reported in large berries and lightest was in small berries (Tables 1, 2 & 3).

The seeds are embedded in fruiting pulp with a sharp fruity smell. The majority of seeds are ear shaped while few are ob-ovate in shape (Fig. 2A & B). Size of the seeds is 2.2 to 3.7 mm in length, 1.8 to 2.7 mm in width and 0.9 to 1.3 mm in thickness.

The total number of seeds calculated in small berries 10-60 number in ten samples. Among all, approximately 39 seeds have been found in average per fruit. Medium berries contain 37-76 seeds and among all approximately 54 seeds have been found in average per fruit and large-sized berries have 48-93 seeds. Among all, approximately 69 seeds have been found in average per fruit (Tables 1, 2 & 3).

Total seed biomass reveals a range in average weight in each berry *i.e.* 74.8 to 216.4 mg. Biomass of large-sized berries increased three times as compared to small (74.4 to 216.4 mg) (Tables 1, 2 & 3).

Sclerotic granules show size from 1.0 to 5.5 mm in length, 1.0 to 3.8 mm in width and 0.7 to 3.8 mm in thickness (Fig. 1, Image F). The number of sclerotic granules is present in small berries are 2-8 in number in ten samples, 3-7 in medium berries and 4-11 number observed in large berries. To find the average number of sclerotic granules there are 5.0 and 6.0 granules were observed. In small and medium there are 5.0 granules while in large this number is 6.0. Weight of sclerotic granules are varying in different sized berries *i.e.* 03-28 mg in small berries, Medium berries have 05-39 mg and large berries contains 11-55 mg. The average weight of sclerotic granules in large berries (6.21 mg) and medium berries (4.28 mg) are thrice and twice than small berries

Table 1: Large berries.

Sr. no.	Weight (in mg of/in each berry)						Number (in each berry)			
	BWFC	BWOFC	Fruit coat	Total seeds	Pulp	TSG	Total seeds	DBCS	YCS	SG
1.	364	316	48	193	92	31	56	00	56	06
2.	407	359	48	236	51	72	62	04	58	07
3.	535	475	60	343	94	38	93	93	00	06
4.	373	307	66	169	99	39	56	00	56	05
5.	420	376	44	208	113	55	75	16	59	11
6.	384	341	43	194	106	41	48	40	08	05
7.	415	377	38	208	153	16	81	00	81	04
8.	402	343	59	218	82	43	71	71	00	05
9.	390	365	25	202	130	33	69	08	61	06
10.	404	379	25	193	175	11	80	00	80	06

Abbreviations - BWOFC- Berries Without Fruit Coat; BWFC- Berries With Fruiting Coat; TSG- Total Sclerotic Granules; DBCS- Dark Brown Coloured Seeds; YCS- Yellowish Coloured Seeds; SG- Sclerotic Granules; MG- Milligrams.

Table 2: Medium berries.

Sr. no.	Weight (in mg of/in each berry)						Number (in each berry)			
	BWFC	BWOFC	Fruit coat	Total seeds	Pulp	TSG	Total seeds	DBCS	YCS	SG
1.	358	319	39	182	115	22	59	00	59	06
2.	358	323	35	201	96	26	76	00	76	06
3.	197	166	31	99	62	05	42	00	42	05
4.	307	271	36	144	108	19	57	00	57	04
5.	349	297	52	133	142	22	63	23	40	05
6.	282	241	41	103	120	18	41	27	14	06
7.	347	303	44	183	96	24	74	17	57	04
8.	272	241	31	112	117	12	37	37	00	03
9.	262	224	38	112	85	27	46	37	09	07
10.	307	268	39	143	86	39	50	50	00	04

Abbreviations - BWOFC- Berries Without Fruit Coat; BWFC- Berries With Fruiting Coat; TSG- Total Sclerotic Granules; DBCS- Dark Brown Coloured Seeds; YCS- Yellowish Coloured Seeds; SG- Sclerotic Granules; MG- Milligrams.

**Fig. 1:** A. Plant habit; B. Fruit size with leathery calyx; C. Fruit categories.

(2.34 mg) respectively (Tables 1, 2 & 3).

Berries are different in pulp quantity. The pulp in small berries are 21-93 mg in ten samples, medium berries pulp weight is 85-175 mg and 130-305 mg pulp is reported in large berries. Medium berries (119.5 mg) contain two times more pulp than small berries (63.1 mg) while large berries (102.7 mg) contains a lesser amount of pulp than medium berries and more than small berries (Tables 1, 2 & 3).

Morphological observation of the variation of the seed in colour and the total number obtained yellowish and dark brown coloured seeds (Fig. 2A & B). In small berries, there are 13% dark-brownish and 87% yellowish coloured seeds observed. Medium berries contain 35% dark-brownish and 65% yellowish coloured seeds, while 34% and 66% dark-brownish and yellowish coloured seeds respectively observed in large berries.

Discussion

The plant *Withania coagulans* (Stocks) Dunal is a desertic plant. Leaves of the plant are leathery and whitish coloured (Fig. 1A). The berries of the plant are inflated in the leathery greyish calyx (Fig. 1B). These are globose and yellowish to dark-brownish in colour (Fig. 1C). The berries contain seeds, pulp and sclerotic bodies. The sclerotic granules are greatly varying in shape and size (Fig. 2C).

Table 3: Small berries.

Sr. no.	Weight (in mg of/in each berry)						Number (in each berry)			
	BWFC	BWOFC	Fruit coat	Total seeds	Pulp	TSG	Total seeds	DBCS	YCS	SG
1.	131	104	27	91	03	16	61	20	41	04
2.	133	103	30	44	53	06	26	00	26	04
3.	142	124	18	82	29	13	45	08	37	06
4.	161	132	29	96	33	03	58	00	58	04
5.	183	151	32	93	48	10	38	00	38	06
6.	110	71	39	29	39	03	14	14	00	02
7.	119	97	22	49	20	28	10	10	00	05
8.	124	107	17	65	26	16	27	00	27	08
9.	174	154	20	94	55	05	52	00	52	03
10.	162	146	16	105	24	17	60	00	60	08

Abbreviations - BWOFC- Berries Without Fruit Coat; BWFC- Berries With Fruiting Coat; TSG- Total Sclerotic Granules; DBCS- Dark Brown Coloured Seeds; YCS- Yellowish Coloured Seeds; SG- Sclerotic Granules; MG- Milligrams.

Three types of berries were observed in the plant *i.e.* small, medium and large berries that are 110-190 mg, 191-360 and 361-535 mg in weight respectively (Fig. 1C & Table 1, 2 & 3). The berries show variations in the number of seeds and sclerotic granules.

Large berries weight was found highest and that was 361-535 mg. Fruit coat weight of the large berries was found 25-66 mg and that was highest among fruits. The weight of the total seeds was recorded in large berries *i.e.* 169-343 mg. Fruiting pulp in these fruits was weighted highest (130-305 mg). The highest weight of the sclerotic granules was observed in large berries (11-72 mg). The total number of seeds and sclerotic granules were counted highest in large berries *i.e.* 48-93 and 4-11 respectively (Table 1).

Medium-sized berries contain the moderate weight of berries, seed biomass and sclerotic granules and fruit pulp weight *i.e.* 197-358 mg, 99-201 mg and 5-39 mg 62-142 mg respectively. The number of seeds and sclerotic granules was found moderate (Table 2).

Small berries were lightest berries. Weight of these berries, fruiting coat weight and seed biomass weight were observed lesser than large and medium berries *i.e.* 110-183 mg, 16-39 mg and 29-105 mg respectively. The number of seeds and sclerotic granules was found

minimum 10-61 and 02-08 respectively (Table 3).

Small berries have the minimum number of seeds and range from 10-61 seeds (39.1 seeds per berry) and large berries have a maximum number of berries ranges from 48-93 seeds (69.1 seeds per berry).

Weight of seeds varies in berries and a maximum weight of seeds are observed in large berries ranges from 361-535 mg (216.4 mg per berry) while the minimum weight of seeds observed in small berries and ranges from 110-190 mg (74.8 mg per berry).

Solanaceous plants also have sclerotic granules in fruit pulp. Sclerotic granules in the plant *Withania coagulans* (Stocks) Dunal also varies in shape, size and number. The minimum number and minimum average weight of the sclerotic granules observed in small berries (5 per berry, 2.34 mg per berry) while the maximum number and maximum average weight of these granules are observed in large berries (6.1 per berry, 6.21 mg per berry).

The maximum amount of average fruit pulp is reported in large berries (109.5 mg in per berry) while the minimum is present in small berries (63.1 mg per berry).

The Taxonomic important characters of fruits and seed characters of the plant were studied by using 30

different berries and seeds. Seed characters for taxonomic importance of *Solanum* have been carried out by Lester, (1991) and Junlakitjawat *et al.*, (2010) while Khafagy *et al.*, (2018) used 20 fruit and seed characters to study family Solanaceae.

Most of the seeds of the plant were ear shaped while few were ob-ovate. Mahdy *et al.*, 2019 investigated ob-

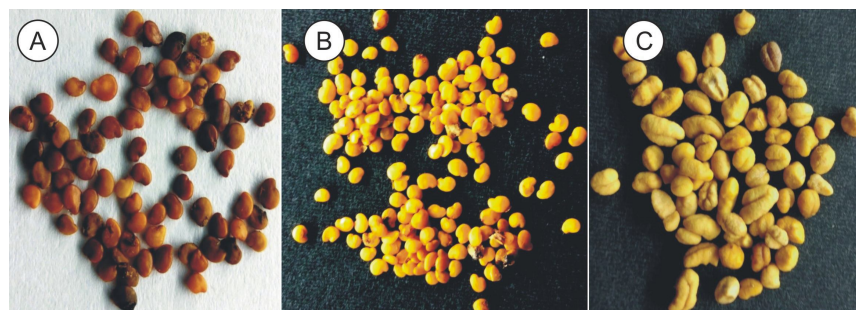


Fig. 2: A. Dark brownish seeds; B. Yellowish seeds; C. Sclerotic granules.

ovate and reniform seed shape in various *Solanum* species. The ob-ovate shape was observed in *S. nigrum*, *S. villosum* and *S. virginianum* and reniform was in *S. diphyllum*, *S. forskalii*, *S. melongena* and *S. macrocarpon*.

Seed surface was observed smooth. Mahdy *et al.*, 2019 observed a hairy and smooth seed surface in Solanaceae. *S. lycopersicum*, *S. seafortianum* and *S. villosum* have hairy seed surface while *S. abutiloides*, *S. nigrum*, *S. umbellatum* and *S. sinaicum* have smooth seeds surface

On the colour basis, two variant of seeds were observed *i.e.* yellowish coloured seeds and dark-brownish coloured seeds (Fig. 1D & 1E). Mahdy *et al.*, 2019 observed colour of seeds of various species of Solanaceae. They observed variation in colour from pale yellowish-reddish brown *i.e.* *S. laciniatum*, *S. forskalii* and *S. sinaicum* are reddish-brown, dark brown and dark brown respectively.

The size of the seeds was measured 2.2 to 3.7 mm in length, 1.8 to 2.7 mm in width and 0.9 to 1.3 mm in thickness. Gunn, 1972 observe externally the seeds of the Solanaceae and placed in two categories moderate size and minute sized seeds. Seeds larger than 1.5 mm are classified as moderate size and those smaller as a minute (Gunn and Gaffney, 1974).

Mahdy *et al.*, 2019 observed dimension in seeds of various *Solanum* species *i.e.* *Solanum lycopersicum* have 2.14-3.96 mm in length 2.65-3.91 mm in width, *S. diphyllum* have 2.42-3.46 mm length and 2.65-3.91 mm in width, *S. abutiloides* 1.03-1.41 in length and 0.93-1.35 mm in width and *S. macrocarpoa* have 2.5-3.0 mm in length and 2.5-3.0 mm in width. Dimension range of the seeds of the plant *W. coagulans* was observed 2.2 to 3.7 mm in length, 1.8 to 2.7 mm in width and 0.9 to 1.3 mm in thickness.

Conclusion

The berries of the plant are enclosed in leathery fruiting calyx. The berries have sweat unique smell. Large berries are much useful for farmers and pharmaceutical industries because it contains the maximum weight of seeds, the maximum number of seeds and maximum fruiting pulp.

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