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Seed development and maturation in sesame (*Sesamum indicum* L.) AS influenced by growing seasons

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Abstract
An investigation has been planned to study the influence of growing season on the pattern of seed development and maturation in sesamum. Seed crops of sesame cv. Nirmala were grown during summer- 2015, *kharif* -2015 and *rabi* 2015-16 at the Central Research station OUAT, Bhubaneswar, adopting recommended package of practices. Observation on various capsule and seed characteristics were recorded at weekly intervals from the day of anthesis (DAA) up to 42 days. Capsule length and dry weight of seeds showed a steady increase upto 35 days. Capsule width (0.693 cm) and thickness (0.826 cm) increased up to 21 days and then decreased slowly up to maturity. The physiological maturity of seeds reached between 35-42 days. Although, seed germinability attained on the 14 DAA, the maximum germination (85%) and vigour reached around physiological maturity stage. The seed weight, an important determinant of seed yield and quality was the highest (0.16g) in *kharif* followed by that in summer (0.11g) and the least (0.06g) in *rabi* season. Considering both seed yield and quality parameters, *kharif* and summer season appears to be ideal time for quality seed production in sesame.

Keywords: sesame, seed development, seed quality, seasonal influence

Introduction
High quality seed is essential for better field establishment and productivity of crops. Pre-harvest environmental conditions and degree of seed maturity are important factors that determine the quality of seed and their longevity in storage [1, 2]. Therefore, it is essential to determine the ideal planting time and stage of harvest of seed crops for obtaining seeds of high longevity. Although, attainment of physiological maturity of seed is under genetic control, it is influenced by environmental factors [3, 4]. Seed maturation refers to the morphological, physiological and functional changes that occur from the time of fertilization until the mature seeds are ready for harvest [5]. Tracing the sequence of seed development and fixing the time for maturity have more practical utility in getting higher quantity of quality seeds. Sesame, being an important oil seed crop of the country, is grown in all the three growing season. Due to its nutritional and medicinal values, the crop is now gaining importance among the farmers, for which the demand of quality seed is increased. There is need to increase quality seed yield of the crops, to meet the growing demand of farmers. The present investigation has been planned to study the influence of growing season on the pattern of seed development and maturity in sesame and to find out the ideal planting time to successfully take up seed production programme of this crop

Materials and Methods
The seed crops of sesame cv. Nirmala were grown at the Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar, Orissa during summer-2015, *kharif*-2015 and *rabi*-2015-16, adopting recommended package of practices [6, 7]. Sufficient number of plants of uniform growth was marked. The mature flower buds that would open on the subsequent day were tagged coinciding with 50% flowering stage of the crop. The capsules that developed on the tagged flowers were collected at weekly intervals commencing from the 7th DAA and a total of six samples were taken. At each sampling, sufficient numbers of capsules were collected to record observations, viz. length, width, thickness and weight of fresh capsules, fresh and dry weight of seed, seed moisture content, germination percentage, seedling length and dry weight. Standard procedures were followed for determination of seed moisture and germination percentage of seeds [8] and length and dry weight of seedlings [9].

Results and Discussion
Among the capsule characteristics, the capsule length increased at a relatively faster rate (16%) up to 14 DAA and reached the maximum value (2.05 cm) on 35 days and then decreased slightly up to maturity. The capsule width and thickness increased up to 21 DAA reached their maximum values and then decreased slowly up to maturity. The weight of fresh capsules showed a rapid initial increase (77%) up to 14 days followed by a slow increase (11%) up to 21 days and then gradually decreased up to maturity due to loss of moisture. The pattern of development of these traits in different seasons (Table 1-3) indicated that the capsules were relatively larger in size and heavier in *kharif* season closely followed by summer and the values were the least in *rabi*

season. The restricted capsule growth during *rabi* season may be due to low temperature prevailing during this season.

Like capsule weight, the weight of fresh seeds showed a rapid initial increase up to 14 days and reached the maximum value (0.17 g) followed by gradual decrease up to maturity (Table-4) due to slow rate of desiccation. On the other hand, the dry seed weight showed a rapid initial increase up to 14 days, then gradual increase up to 35 days, reached the maximum value (0.111g) and then slightly decreased. This indicated that the physiological maturity in this variety of sesame, as measured by attainment of maximum dry weight, have attained between 35 and 42 DAA. The developmental pattern of those seed traits showed similar trend in all the three seasons (Table 1-3).

However, the seeds produced in *kharif* season were comparatively heavier (0.16g) in comparison to that of summer (0.11g) and *rabi* season (0.06g). The low temperature during this season might have restricted translocation of photosynthates into the developing seeds that resulted in poor seed development. A similar study in mustard by Chamling [10] indicated the attainment of maximum fresh weight and dry weight of seed at 21 and 35 DAA, respectively.

The seed moisture content which was 54 percent on the 7th day was rapidly increased up to 80 percent on the 14th day and then gradually declined to 16.7 percent at maturity due to continuous accumulation of photosynthates in the seed associated with gradual loss of seed

moisture (Table - 4). The change of seed moisture content showed similar trend in all the three seasons (Table 1-3).

The germination of seeds was attained around two weeks after anthesis, reached 31 percent on the 14 DAA followed by rapid increase to 62 percent within one week and then slowly increased and reached the maximum value (85%) at maturity (Table-4). There was positive association between dry matter accumulation and improvement in germination percentage of seeds. Although the final germination percentage of maturity stage of seed was same in all the seasons, the rate of improvement was rapid in *kharif* in comparison to summer and *rabi* season (Table 1-3). In similar study, Rajsekaran *et al*., [11] reported that although gerination of seeds attained after 15 DAA, the maximum germination (94%) was observed at 35 DAA.

The seedling length and dry weight which are the measures of seed vigour showed similar trend of improvement like germination. These traits showed a rapid initial increase up to 21 days followed by relatively slow rate of improvement up to 42 days (Table-4). The improvement in seed germination and vigour were associated with dry matter accumulation in the developing seeds [12].

The results of the study suggested that the physiological maturity of sesame seeds attained between 35 to 42 days after anthesis where the dry matter, germination and vigour were at their maximum value. Further, the seed moisture content at this stage is 16.87 to 16.77 percent which is safe for harvest of the seed crop. Considering the boldness of capsule, seed and seed quality, the *kharif* and summer seasons appears to be the most favourable time for quality seed production in sesame.

Table 1: Changes in the developmental and quality traits of capsules and seeds in Sesamum cv. Nirmala at different growth stages, grown in summer season.

Name of traits	DAYS AFTER ANTHESIS							
	7	**14**	**21**	**28**	**35**	**42**	**CD (0.05)**	**CV (%)**
1. Fresh capsule weight(g)	0.36	0.48	0.52	0.46	0.44	0.40	0.024	2.976
		(33.33)	(8.33)	(-11.53)	(-4.34)	(-9.09)		
2. Fresh capsule length(cm)	1.69	1.88	1.93	1.95	2.05	2.04	0.130	3.845
		(11.24)	(2.65)	(1.03)	(5.12)	(-0.48)		
3. Fresh capsule width(cm)	0.48	0.54	0.77	0.72	0.70	0.70	0.035	3.068
		(12.50)	(42.59)	(-6.49)	(-2.77)	(0)		
4. Fresh capsule thickness (cm)	0.65	0.71	0.86	0.85	0.84	0.84	0.021	1.76
		(9.23)	(21.12)	(-1.16)	(-1.17)	(0)		
5. Fresh seed weight(g)	0.03	0.16	0.14	0.13	0.13	0.12	0.018	8.925
		(433.33)	(-12.50)	(-7.14)	(0)	(-7.69)		
6. Dry seed weight (g)	0.02	0.03	0.05	0.08	0.11	0.10	0.007	6.706
		(50)	(66.66)	(60)	(37.50)	(-9.09)		
7. Seed moisture Content (%)	33.33	83.01	65.81	35.83	18.59	16.60	5.262	6.331
		(149.05)	(-20.72)	(-45.55)	(-48.11)	(-10.70)		
8. Seed germination	0	37.33	57.00	69.00	82.67	85.0	5.180	5.918
			(52.69)	(21.05)	(19.81)	(2.81)		
9. Seedling length (cm)	0	3.87	4.62	4.86	5.03	5.02	0.346	5.287
			(19.37)	(5.19)	(3.49)	(-0.19)		
10. Seedling dry weight (mg)	0	1.10	1.97	2.03	3.07	3.06	0.446	15.322
			(79.09)	(3.04)	(51.23)	(-0.32)		

*Figures in Parentheses indicate percentage change over the previous stage

Table 2: Changes in the developmental and quality traits of capsules and seeds in Sesamum cv. Nirmala at different growth stages, grown in *kharif* season.

Name of Traits	Days After Anthesis							
	7	**14**	**21**	**28**	**35**	**42**	**CD (0.05)**	**CV (%)**
1. Fresh capsule weight(g)	0.40	0.59	0.63	0.56	0.55	0.50	0.010	1.446
		(47.50)	(6.77)	(-11.11)	(-1.78)	(-9.09)		
2. Fresh capsule length(cm)	2.03	2.21	2.27	2.29	2.38	2.36	0.085	2.134
		(8.86)	(2.71)	(0.88)	(3.93)	(-0.84)		
3. Fresh capsule width(cm)	0.55	0.59	0.67	0.65	0.64	0.63	0.018	1.678
		(7.27)	(13.55)	(-2.98)	(-1.53)	(-1.56)		
4. Fresh capsule thickness (cm)	0.71	0.77	0.80	0.78	0.76	0.76	0.019	1.384
		(8.45)	(3.89)	(-2.50)	(-2.56)	(0)		
5. Fresh seed weight(g)	0.05	0.21	0.18	0.17	0.17	0.16	0.012	4.329
		(320)	(-14.28)	(-5.55)	(0)	(-5.88)		
6. Dry seed weight (g)	0.02	0.06	0.07	0.12	0.16	0.15	0.014	9.049
		(200)	(16.66)	(71.42)	(33.33)	(-6.25)		
7. Seed moisture Content (%)	67.22	72.33	59.94	29.78	18.00	16.0	9.453	11.292
		(7.60)	(-17.12)	(-50.31)	(-39.55)	(-11.11)		
8. Seed germination (%)	0	34.67	74.33	82.33	84.67	85.0	8.628	8.786
			(114.39)	(10.76)	(2.84)	(0.38)		
9. Seedling length (cm)	0	4.67	5.68	6.13	6.28	6.30	0.550	6.783
			(21.62)	(7.92)	(2.44)	(0.31)		
10. Seedling dry weight (mg)	0	1.27	2.17	2.67	3.27	3.26	0.623	18.679
			(70.86)	(23.04)	(22.47)	(-0.30)		

*Figures in Parentheses indicate percentage change over the previous stage

Table 3: Changes in the developmental and quality traits of capsules and seeds in Sesamum cv. Nirmala at different growth stages, grown in *rabi* season.

Name of Traits	Days After Anthesis							
	7	**14**	**21**	**28**	**35**	**42**	**CD (0.05)**	**CV (%)**
1. Fresh capsule weight(g)	0.13	0.36	0.44	0.43	0.43	0.40	0.013	2.002
		(176.92)	(22.22)	(-2.27)	(0)	(-6.97)		
2. Fresh capsule length(cm)	1.17	1.58	1.67	1.74	1.74	1.70	0.110	3.930
		(35.04)	(5.69)	(4.19)	(0)	(-2.29)		
3. Fresh capsule width(cm)	0.43	0.60	0.64	0.62	0.62	0.60	0.020	1.935
		(39.53)	(6.66)	(-3.12)	(0)	(-3.22)		
4. Fresh capsule thickness (cm)	0.54	0.74	0.82	0.79	0.78	0.76	0.018	1.405
		(37.03)	(10.81)	(-3.65)	(-1.26)	(-2.56)		
5. Fresh seed weight(g)	0.04	0.14	0.10	0.08	0.07	0.06	0.019	12.689
		(250)	(-28.57)	(-20.00)	(-12.50)	(-14.28)		
6. Dry seed weight (g)	0.01	0.02	0.04	0.05	0.06	0.05	0.012	18.515
		(100)	(100)	(25)	(20)	(-16.66)		
7. Seed moisture content (%)	61.67	85.81	57.88	36.11	19.04	17.72	13.920	15.019
		(39.14)	(-32.54)	(-37.61)	(-47.27)	(-6.93)		
8. Seed germination (%)	0	22	49.33	54.00	76.00	85.0	3.889	5.428
			(124.22)	(9.46)	(40.74)	(11.84)		
9. Seedling length (cm)	0	3.99	4.13	4.78	5.29	5.30	0.547	8.441
			(3.50)	(15.73)	(10.66)	(0.18)		
10. Seedling dry weight (mg)	0	1.17	1.20	2.07	2.50	2.50	0.388	15.745
			(2.56)	(72.50)	(20.77)	(0)		

*Figures in parentheses indicate percentage change over the previous stage

Table 4: Changes in the developmental and quality traits of capsules and seeds in Sesamum cv. Nirmala at different growth stages (mean of three seasons).

SL. NO.	Traits	Days After Anthesis					
		7	**14**	**21**	**28**	**35**	**42**
1	Fresh capsule weight(g)	0.269	0.476	0.530	0.480	0.470	0.431
			(76.9)	(11.34)	(-9.43)	(-2.08)	(-8.21)
2	Fresh capsule length(cm)	1.63	1.89	1.95	1.99	2.05	2.032
			(15.95)	(3.17)	(2.05)	(3.01)	(-0.97)
3	Fresh capsule width(cm)	0.486	0.576	0.693	0.663	0.653	0.643
			(18.51)	(20.31)	(-4.32)	(-1.50)	(-1.53)

4	Fresh capsule thickness (cm)	0.633	0.740	0.826	0.806	0.793	0.784
			(16.90)	(11.62)	(-2.42)	(-1.61)	(-1.13)
5	Fresh seed weight(g)	0.040	0.17	0.14	0.126	0.123	0.115
			(325)	(-17.64)	(-10.0)	(-2.38)	(-6.50)
6	Dry seed weight (g)	0.016	0.036	0.053	0.083	0.111	0.106
			(125)	(32.07)	(56.0)	(33.7)	(-4.50)
7	Seed moisture content (%)	54.03	80.36	61.21	33.90	16.87	16.77
			(48.15)	(-23.75)	(-44.26)	(-50.0)	(-0.59)
8	Seed germination (%)	0	31.33	60.22	68.44	81.11	85.0
				(92.21)	(13.64)	(18.51)	(4.93)
9	Seedling length (cm)	0	4.17	4.81	5.25	5.53	5.54
				(15.34)	(9.14)	(5.33)	(0.18)
10	Seedling dry weight (mg)	0	1.18	1.78	2.25	2.94	2.94
				(50.84)	(26.40)	(30.66)	(0)

*Figures in Parentheses indicate percentage change over the previous stage

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