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PATTERNS OF SEED DEVELOPMENT IN PEA (*Pisum sativum* L.)

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ABSTRACT

The experiment was conducted to evaluate the performance of the developmental pattern of the seed considering the morphological, physiological and biochemical changes. The pea seeds (*Pisum sativum* L.) cv. AP-3 was collected from every 3 replications under RBD fashion in University (BCKV) farms considering consecutive two years (2018-19 and 2019-20). A sufficient number of flowers was tagged on a specific day beginning from the 10th day after anthesis (DAA) to the 45th DAA allowing for 5 days interval. The collected seeds were examined for seed developmental programmes considering seed length, width, fresh and dry seed weight, chlorophyll content, and alpha-amylase activity of the seed. Seed length and width were increased up to 35th DAA. Enrichment of seed dry weight was noted up to 35th DAA though the seed dry weight was increased up to the last stage of maturity. The chlorophyll content and alpha-amylase activity were highest in 20th DAA and 30th DAA, respectively and declined afterwards. In concern of physiological maturity, the second last stage (40th DAA) may be the suitable stage for maturity because maximum dry matter accumulated in the seed at this stage (40th DAA). Hence, this stage may be suitable for seed maturity. From the study, it can be inferred that, the perfect harvesting time of pea pod [*P. sativum* (L.) cv. AP-3] was 40th days after anthesis.

(Key words: Development, pea seed, physiological maturity, seed morphology, *Pisum sativum*)

INTRODUCTION

Field pea (*Pisum sativum* L.) is one of the world's essential and ancient cultivated vegetables. It is *rabi* season pulse vegetables widely cultivated for their green pods worldwide (Kumar *et al.,* 2014; Kindie *et al.,* 2019). The crop is a major source of protein (21% - 25%) with high levels of amino acids, lysine and tryptophan that have high nutritional value (Bhat *et al.,* 2013; Gregory and Hans, 2021, Sunday and Asabar, 2018). It contains a great amount of carbohydrates, a little quantity of fibre and contains 86% to 87% total digestible nutrients creating the crop also an outstanding livestock feed. India is the second largest producer of peas after China. Higher production with enriched nutritional values of peas can be achieved by various agricultural management practices to accomplish the peas demand of the world (Kumar *et al.,* 2022; Lal *et al.,* 2022).

The initial stages of seed expansion are categorised by the advanced accumulation of mass, through cell division, elongation, nutrient accumulation, and water uptake (Atif *et al.,* 2013). It is a very difficult task, to control the quantity and quality of seed simultaneously seeing different food reserves within the seed (Jones *et al.,* 2010; Aghamirzaie *et al.,* 2013). The developmental process is usually alienated into three stages i.e. embryogenesis, expansion, and maturation according to adjustments in seed weight (Ochatt, 2015; Mandal *et al.,* 2017). In the first stage of seed development or embryogenesis, the embryo is differentiated into various types like globular, heart and torpedo that can be terminated at the cotyledon stage, alike somatic embryos (Verdier *et al.,* 2013). Numerous studies have shown that the time for optimum harvest maturity depends on the accumulation of maximum dry matter in seed or physiological maturity for obtaining good quality seed (Mandal *et al.,* 2017). Moreover, the environment plays a vital role in the maturation process in addition to the time taken for a particular crop harvest that adjusts the ûnal seed quality (Weerasekara *et al.,* 2021). The physiological maturity stage for pod and seed may be modified by the diverse nature of the environment, genotypic attitude as well as soil conditions (Li *et al.,* 2017; Raveneau *et al.,* 2011). Generally, good quality is characterized by storability, percentage of germination, seedling vigour, stable appearance in uniformity and establishment of seedlings, improved tolerance to environmental hazards and more constant maturity of the crop (Mandal *et al.,* 2017; Filho, 2015).

In the present situation, the seed development and maturation study are appropriate and important as the seed collection may be perfect to escape ageing and to obtain the optimum quality that kept the standard viability, vigour and ultimate field performance. The physiological maturity along with the specific pattern of seed development considering morphological, physiological and biochemical

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seed traits may be helpful for succeeding in the seed production of pea.

MATERIALS AND METHODS

The observations were continued on various seed traits like length and width of seed, fresh and dry seed weight, seed chlorophyll content, alpha-amylase activity at 24 hrs. of seed imbibition considering the crop Pea (*Pisum sativum* L.) cv. AP 3. The seeds were collected during seed growth at specific intervals from replicated field plots under AB block Seed Farm, Kalyani, BCKV (Agriculture University), West Bengal considering two consecutive years (2018-19 and 2019-20). A sufficient number of flowers was tagged on a particular day of anthesis under a specific plot to observe the phenology during seed growth. Developing seeds were collected at eight various phases beginning from the 10th day after anthesis (DAA) to the 45th DAA allowing for 5 days interval. D_1, D_2, D_3, D_4, D_5, D_6, D_7 and D_8 refers 10th DAA, 15th DAA, 20th DAA, 25th DAA, 30th DAA, 35th DAA, 40th DAA and 45th DAA respectively. Observations were recorded on 50 seeds of each replication. Chlorophyll was estimated by following the protocol of Arnon (1949) and alpha-amylase activity at 24 hrs. of imbibition (Cui *et al.,* 2002). Seed length, seed width, fresh weight, dry weight, moisture content, chlorophyll content and alpha amylase contents were measured after 10th DAA to 45th DAA at an interval of 5 days following protocols of the International Seed Testing Association (Anonymous, 1976). Statistical analysis was done considering the factorial analysis of 2 factors under CRD fashion (Krzywinski and Altman, 2014).

RESULTS AND DISCUSSION

The observations on seed development progressed in significant differentiation with some exceptions at the end. During seed growth, the seed length showed progression (Table 1) up to D_6 (35th DAA) followed by a small decline at the last two stages of maturity (40th DAA and 45th DAA). Similarly, the width of the seed followed a similar pattern considering the value of subsequent years where significant enhancement was sustained up to D_5 (30th DAA) followed by a significant lessening in seed growth. The fresh and dry weight of pea seeds showed valuable indications regarding seed maturity. The increasing trend was observed up to D_6 (35th DAA) for fresh weight, while the inclination on dry weight was followed up to maturity. The dry matter accumulation evidently indicated its advanced deposition particularly at the last two stages i.e. D_7 (40th DAA) and D_8 (45th DAA) though a non-significant observation was followed in between them. During seed development and maturation, the differentiation in dry matter accumulation was recorded over the years of experimentations indicating its varying response towards differential climatic conditions over the years. An increasing tendency in development was recorded up to stage D_7 (40th DAA) for both the years. Among various phases as treatment, D_6 (35th DAA) exposed the highest effect in fresh weight of seed development with a significant manner that was abruptly declined, it might be due to reduction of seed moisture. A decreasing propensity was followed in seed moisture content favourable for boosting seed maturation. A reduction was determined in every step up to D_8 (45th DAA) though the rate was advanced in later stages with the highest at the ending i.e. D_7 (40th DAA) to D_8 (45th DAA). The dry matter in the seed was slowly added with the progression of seed maturation as the elimination of moisture was supportive to endure the suitable maturation. However, relative humidity may influence seed maturity. The chlorophyll content of the seed was measured carefully as its quantity was dropped after D_5 (30th DAA) to the end. The enzyme alpha-amylase may have a role in seed germination through the utilisation of seed deposition. In the seed developmental stages, it showed differential action of alpha-amylase where significant variation was observed between advanced stages of seed maturity. The alpha-amylase activity was increased with the progression of seed development after D_5 (30th DAA). It was dropped rapidity at the last stages. The important variation was noted in mean values of development phases in continuation of its marked superiority up to D_5 (30th DAA) or D_6 (35th DAA) though all parameters were not truly followed. A sharp decreased was observed in the last stage i.e. D_8 (45th DAA) for both the years. There was a significant variation between Y_1 (1st year i.e. 2018-19) and Y_2 (2nd year i.e. 2019-20) for all characters except in seed length and width (Table 2).

The association among various morphological and biochemical parameters of pea seeds was observed through correlation (Table 3). The morphological characters such as seed length (-0.599), seed width (-0.621), fresh weight of seed (-0.512), dry weight (-0.880) with the moisture content of seed showed a negative correlation but a significant positive association was observed with alpha-amylase (0.508) and chlorophyll content (0.514) indicating moisture favours their actions. Seed length showed a positive correlation with seed width (0.960), fresh weight (0.936) and dry weight of seed (0.808) but the correlation with chlorophyll content was not-significant.

Table 1. Study on various qualitative parameters of seed during seed developmental stages

Characters	D_1(10th DAA)	D_2(15th DAA)	D_3(20th DAA)	D_4(25th DAA)	D_5(30th DAA)	D_6(35th DAA)	D_7(40th DAA)	D_8(45th DAA)	SEm (±)	LSD 0.01
Seed Length (mm)	4.420	5.610	9.110	9.890	10.470	11.140	11.060	10.640	0.012	0.351
Seed Width (mm)	2.585	3.358	5.415	7.527	9.168	9.778	9.112	8.722	0.197	0.571
Fresh weight of seed (g)	0.019	0.256	1.606	3.015	3.702	4.597	3.994	2.848	0.041	0.120
Dry weight of seed (g)	0.003	0.038	0.304	0.701	1.017	1.726	2.087	2.115	0.013	0.038
Moisture content	86.47	85.48	81.08	76.08	72.38	62.45	47.72	16.48	0.510	1.480
Chlorophyll content (mg g-1)	0.40	0.56	0.97	0.71	0.62	0.54	0.43	0.37	0.014	0.04
á- amylase (µg g-1 m-1)	99.5	135.7	181	210.8	257	196.3	131.7	63.0	37.37	12.91

Table 2. Study on various qualitative parameters of different seed growth stages (average throughout the development) considering two years and its interaction effects

Year	Seed Length (mm)	Seed Width (mm)	Fresh weight of seed (mg)	Dry weight of seed (mg)	Moisture content	Chlorophyll content (mg g-1)	á- amylase (µg g-1 m-1)
Y_1 (2018-19)	9.104	6.917	2.495	0.962	67.4	0.588	149.0
Y_2 (2019-20)	8.979	7.000	2.514	1.035	64.7	0.562	169.8
SEm (±)	0.061	0.099	0.021	0.007	0.26	0.007	6.46
LSD 0.01	—	—	—	0.019	0.74	0.020	18.69
Y×D							
SEm (±)	0.171	0.279	0.059	0.019	0.975	0.020	18.26
LSD 0.01	—	—	0.17	0.054	2.842	0.057	—

Table 3. Correlation of different seed parameters through seed development

	Seed Length (mm)	Seed Width (mm)	Fresh weight of seed (mg)	Moisture content	Chlorophyll content (mg g-1)	á- amylase (µg g-1m-1)
Seed Width (mm)	0.960**					
Fresh weight of seed (mg)	0.936**	0.967**				
Moisture content	-0.599**	-0.621**	-0.512**			
Chlorophyll content (mg g-1)	0.108NS	-0.095NS	-0.058NS	0.514**		
á- amylase (µg g-1m-1)	0.325*	0.321*	0.387**	0.395**	0.508**	
Dry weight of seed (mg)	0.808**	0.855**	0.815**	-0.880**	-0.446**	-0.113NS

R^2 value= 0.310; * Significant at P > 0.05, ** P > 0.001, NS- Not significant

Seed width showed a positive correlation with fresh weight of seed (0.967) and dry weight of seed (0.855). The observation was supportive through the action of alpha-amylase which indicated a strong positive correlation with fresh weight (0.387), and chlorophyll content (0.508).

In seed formation, various parameters are crucial for the progress of seed in different aspects *viz,* morphological, physiological, biochemical etc. considering the physiological seed maturation. These can be studied through various modifications that were inter-connected in some morphological and physiological characteristics, precisely seed length, width, moisture content, and accrued dry mass content (Filho, 2015). In seed expansion, the content of water plays a vital role and was primarily involved in the way of cell division and enlargement (Bareke, 2018). In seed growth, the number and size of cells can also be regulated by cell division and enlargement (Dante *et al.,* 2014). Therefore, the seeds are confined to a major part of fresh mass at the initiation of growth, due to the huge amount of water inside the cells that will promote formation of various reserves such as carbohydrates, proteins, lipids and minerals (Carvalho *et al.,* 2016). In addition, water plays a vital role in photosynthesis for the development of photosynthates that will be the portion of seed cells or will be deposited as a reserve. In the existing study, the results indicated that the seeds were matured for physiological maturity after D_6 (35th DAA) as the higher values were non-significant or declining at later stages in most cases. The enzyme exhibited rising measure up to D_5 (30th DAA), and then downward drive till to the seed maturity, as its role may be related to the release of the deposited biomolecules for cell activity during cell division and expansion of seed. Alpha-amylase plays a vital role in the hydrolysis of starch during seed germination and maintenance of water potential, by providing soluble sugars during seed development (Murtaza and Asghar, 2012). The enzyme alpha-amylase is most commonly recognized with the early outbreak of starch granules (He *et al.,* 2019). After entering its peak at D_5 (30th DAA), the activity was reduced up to the seed maturity as the food reserve was in a stable position. The correlation studies on alpha-amylase indicated a strong positive association with all characters except dry weight as the reduced activity of the enzyme stabilises the reserves and quality of the seed. This study on various seed characters may be the indicator of various precise studies on a particular set of characters.

From the above study it is stated that, the development and maturation of seed through the signal of physiological, morphological and biochemical characters probable physiological maturation of pea seed was at 40th DAA considering dependable character seed dry weight with different configuration variable parameters essential to growing good quality seed. Hence, the optimum dry matter depositing stage at D_7 (40th DAA) can be ideal to confirm physiological maturity in contrast to extreme rate moisture reduction with signalling on total chlorophyll content in a declining trend.

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