Seed Res., Vol. 41(1): 97-101 June 2013

Short Communication

Studies on seed development and maturation in *Andrographis paniculata*

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Medicinal plants are the local heritage with global importance and continue to be an important therapeutic aid to alleviating ailments of human kind. World is endowed with a rich wealth of medicinal plants. Herbs have always been the principal form of medicine in India and presently they are becoming popular throughout the developed world. The demand for medicinal plants has increased globally due to the resurgence of interest in and acceptance of herbal medicine. Most of the demand is being met through collection of large quantities of medicinal plants and plant parts from wild populations. Thus, there is an urgent need to develop and implement regeneration/conservation strategies of over exploited medicinal plant species. The common means of regeneration and propagation of medicinal plants include seed, clonal and micro-propagation based methods. However, it is a challenging task there is lack of adequate information about their seed biology. Much effort has not been made to search elite specimen and their propagation. There is a need to adopt scientific approach for the propagation of medicinal plants and collect relevant information regarding agrotechnology, genuine planting material, economics of field cultivation etc. Keeping these in view, an experiment was conducted to trace the seed development and maturation stage for the harvest of quality seed in Kalmegh [*Andrographis paniculata (Burm f.)* wall.] belonging to the family Acanthaceae is one of the 32 prioritized medicinal plants by National Medicinal Plants Board (NMPB). This is used mainly for treating fever, liver diseases, diabetes, snake bite, common cold and bronchitis and a variety of ailments.

Bulk seed crop of Kalmegh was raised at Horticultural College and Research Institute, TNAU, Coimbatore. About 1000 flowers were tagged soon after opening and anthesis. The pods developed from the tagged flowers were collected at 5 days interval up to 30 days after anthesis (DAA) and designated as S_1, S_2, S_3, S_4, S_5 and S_6 and their pod and seed characters were observed. The pod characters *viz.*, pod length, pod width, pod area and pod perimeter were recorded by subjecting to image analysis technique using Delta-T (© Delta-instrument device-Cambridge, UK) Image analysis system by running custom written software 'WinDIAS' [1], with three replications of twenty five pods each.

The fresh and dry weight of randomly selected pods was recorded and the mean weight of 10 pods was expressed in g pods^{1}. The pod and seed moisture content was recorded [2]. The fresh and dry weight of randomly selected 100 seeds was recorded in 3 replicates and the mean values were expressed in g/100 seeds. The following seed physiological characters were recorded *viz.*, germination percentage [2], root and shoot lengths, dry matter production and vigour index [3]. The biochemical characters *viz.*, electrical conductivity (EC) [4], Total dissolved solids (TDS), and Alpha – amylase activity [5] were also recorded at different stages of seed development.

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Received: Revised: November 2012 Accepted: November 2012

The pod length (1.655 cm), pod width (0.463 cm), pod area (0.444 sq. cm) and pod perimeter (5.892 cm) increased rapidly up to 25 DAA. The maximum fresh weight (0.526 g) and dry weight (0.3599 g) accumulation of pods was recorded at 30 DAA. The pod moisture content of 20.8 percent was attained at 30 DAA from 86.0 percent at 5 DAA (Table 1). The pod length, pod width, pod area and perimeter increased rapidly up to 25 DAA, which declined thereafter. The rapid pod growth at initial stages might be due to more uptake of water with lesser intake of carbon and nitrogen as the development of seed continues till the maturity of pod [6]. The results revealed that the seed development continued beyond the development of pod. Similar results were reported in *Abelmoschus moschatus* [7].

The pod fresh and dry weights increased upon maturation and attained maximum at 25 DAA, which declined thereafter. Similar results were reported in *Solanum nigrum* [8]. The reduction in dry weight of pod might be due to the nutrients and volatile substances in a semi fluid state which might escape along with the water when fresh weight was converted into dry weight through elimination of moisture during the process of dessication [9]. The reduction in dry weight of pod might be due to oxidation and volatilization of chemical entities [10].

The fresh weight of seed was used for differentiating seed development and maturation [3] and fresh weight of seed is an important factor that determines the quality of seed [10]. It was observed that the fresh weight of the seed after reaching maximum (0.250g) on 25th day after anthesis started decreasing (Table 2). This could be attributed to the steady accumulation of dry matter during seed maturation phase, which are similar to results reported in *Solanum nigrum* [8].

Physiological maturity is normally depicted at the stage at which the seeds attain maximum dry weight in developing seeds. It can be employed as a criterion to assess seed maturity [11-12]. In the present study, it was observed that the dry weight of seeds increased with increase in the maturity stages and reached the maximum (0.180g) at 30 DAA, which indicated that large amount of food reserves accumulated in the seed till 30 DAA (Table 2). These results are in line with the those reorted in ashwagandha [13] and ocimum [14].

The seed moisture content declined from 57.2 percent at 5 DAA reaching a lung of 16.3 percent at 30 DAA. Loss of moisture during ripening and maturation of pod and seed is a common phenomenon and has been observed in many crops [15]. The present

Table 1. Changes in length, width, area, perimeter, fresh weight, dry weight, moisture content and colour of pod during seed development and maturation in kalmegh

Days after anthesis	Pod lenght (cm)	Pod width (cm)	Pod area (sq.cm)	Pod perimeter (cm)	Pod fresh weight (g pod^{-1})	Pod dry wt. (g pod^{-1})	Pod moisture content (%)	Pod colour
5 (S_1)	0.678	0.225	0.124	2.311	0.107	0.0149	86.0	Light green
10 (S_2)	1.242	0.403	0.296	4.855	0.279	0.0594	78.7	Light green
15 (S_3)	1.532	0.427	0.346	5.178	0.346	0.1330	61.56	Green
20 (S_4)	1.553	0.441	0.396	5.267	0.452	0.2112	53.31	Green
25 (S_5)	1.655	0.463	0.444	5.892	0.526	0.3599	31.6	Yellowish green
30 (S_6)	1.646	0.452	0.433	5.775	0.364	0.2889	20.8	Light brown
Mean	1.3844	0.4017	0.3398	4.8795	0.3460	0.1779	55.32	
CD (p=0.05)	0.0867	0.0249	0.0217	0.3048	0.0226	0.0130	3.643	

Table 2. Changes in fresh weight, dry weight, moisture content and colour of seed during seed development and maturation in kalmegh

Days after anthesis (DAA)	Seed fresh weight (g /100 seeds)	Seed dry weight (g/100 seeds)	Seed moisture content (%)	Seed colour
5 (S_1)	0	0	0	-
10 (S_2)	0	0	0	-
15 (S_3)	0.159	0.068	57.2	Light green
20 (S_4)	0.283	0.156	44.8	Yellowish brown
25 (S_5)	0.250	0.172	31.2	Light brown
30 (S_6)	0.215	0.180	16.3	Brown
Mean	0.1513	0.096	24.91	
CD (p=0.05)	0.0113	0.0075	1.999	

results are in corrobortion with ashwagandha [13], *Abelmoschus moschatus* [7] and periwinkle and senna [16].

Among the physiological manifestations of the seed, germination plays a significant role. The developing seed attained the germination potential at 20 DAA (24%), and increased gradually, attaining a maximum at 30 DAA (48%). The increasing trend in germination percentage during the development stages might be attributed to the maximum dry matter content in seeds (Table 3). Similar increase in germination was evident from the reports in ashwagandha [13], in *Solanum nigrum* [8], in periwinkle and senna [16] and in *Phyllanthus amarus* [17].

The relative length of root and shoot of the seedlings would predict their subsequent growth and performance. In the present study, the maximum root length (3.76 cm) and shoot length (3.84 cm) of the seedlings were observed at 30 DAA. The reason might be the maximum dry matter accumulation of the seed in the above stages of seed development and maturation. This is in conformity with the findings in *ocimum* [14] and in *Abelmoschus moschatus* [7].

The dry matter production of seedlings could be taken as a manifestation of the physiological efficiency dependent of seed vigour [18]. In this study, the seedlings attained higher dry matter production on 30 DAA (11.2 mg) (Table 3).

Vigour is the inherent ability of seed to survive, germinate and produce a seedling capable of performance under wider range of conditions [18]. The computed vigour index values were maximum (363) at 30 DAA coinciding with the higher germination and dry matter production. Since the vigour index was the product of these two parameters, it was highest at 30 DAA and in conformity with findings in ashwagandha [13], in *Solanum nigrum* [8] and in periwinkle and senna [16].

The electrical conductivity and total dissolved solids of the seed leachates were initially low, which increased towards maturity to reach maximum at 25 DAA, without any further change till 30 DAA. At initial stage, the seed size and the biochemical components were minimum, which increased during maturation. During the full maturation stage, seed coat become thick walled [19] which might have reduced the solutes to leach out. The maximum - amylase activity of the seeds was observed on 30 DAA, which may be due to the maximum accumulation of protein in the seed [20].

The pod colour was initially light green and turned into yellowish green colour at 25 DAA

Table 3. Changes in germination, root length, shoot length, dry matter production, vigour index, electrical conductivity (EC), total dissolved solids (TDS) and alpha amylase activity during seed development and maturation in kalmegh

Days after anthesis (DAA)	Germination (%)	Root length (cm)	Shoot length (cm)	Dry matter production (mg seedlings^{-10})	Vigour index	Seed EC (dSm^{-1})	Seed TDS (ppm)	Alpha amylase activity (mm)
5 (S_1)	0 (0.5848)	0	0	0	0	0	0	0
10 (S_2)	0 (0.5848)	0	0	0	0	0	0	0
15 (S_3)	0 (0.5848)	0	0	0	0	0.008	14.56	3.4
20 (S_4)	24 (29.33)	3.25	3.62	10.2	165	0.011	22.34	4.2
25 (S_5)	32 (34.44)	3.74	3.81	10.8	243	0.026	35.87	7.3
30 (S_6)	48 (43.85)	3.76	3.84	11.2	363	0.026	34.27	7.9
Mean	17.3 (18.23)	1.79	1.87	5.36	128	0.0117	17.83	3.80
CD (p=0.05)	0.925	0.154	0.161	0.460	11.562	0.001	1.394	0.298

(Figures in parentheses are arc-sine values)

and then to light brown colour. The seed colour was initially light green and engaged to brown colour at 30 DAA. This might be due to chlorophyll degradation on physiological maturation and accumulation of principal chemical compounds. Similar results were observed in periwinkle and senna [16].

It was inferred that the physiological maturity of kalmegh seeds was attained at 30 DAA. It was associated with changes in colour of pods as well seeds with higher germination and vigour. It was important to note that splitting of pods and seed shattering occurred beyond 30 DAA due to environmental factors and over maturity.

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