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Effect of Seed Pre-Treatment and Time of Sowing on Germination and Biomass of *Cassia angustifolia* Vahl. in Arid Regions

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Abstract: Studies have been conducted to develop seed germination and suitable agri-silvi practices for *Cassia angustifolia* in arid areas under rainfed and irrigated conditions. Seeds were found dormant due to physical reasons and gave poor germination without any pre-treatment. The germination can be enhanced (>80%) by mechanical scarification, hot water and acid pre-treatments. Green seeds in the lot showed slightly poor germination as compared to yellow seeds. Seeds of tested seedlots without treatment gave 22% to 41% germination and average mean germination time was from 4.1 to 5.1 days. However, pre-treatments enhanced the germination percentage and reduced the mean germination time in almost all the lots. Various experiments were initiated with different spacing (30 x 30 cm, 30 x 45 cm and 45 x 45 cm), date of sowing (July, August and September) and irrigation trials. In another experiment various agroforestry tree species namely *Acacia nilotica, Prosopis cineraria, Azadirachta indica* and *Eucalyptus camaldulensis* have been selected for experimental trial with a single frequency of irrigation (after 1st plucking) in 3 replication and RBD design.

Key words: *Cassia angustifolia*, seed germination, agri-trials, arid region, pre-treatments.

Senna (*Cassia angustifolia* Vahl.) is an important leguminous (Caesalpiniaceae) species native to Sudan, South Arabia, North Africa, Somalia, Ethopia, Egypt and other neighboring countries is one of the selected plant species. The plant is found growing in wild state in certain coastal parts of Gujarat especially in the Bhuj region of India. The plant can be cultivated all over the sub-tropical areas of India. Senna is a fast growing and spreading Indian shrub of which seeds, pods and leaves are extensively used for pharmaceutical applications (Tripathi, 1999; Kinjo *et al*., 1994; Arya, 2003;). The seeds have been found to be an alternative source of commercial gums (Chaube and Kapoor, 2011). Senna is one of the most commonly used laxative drugs in the Eastern and Western countries for the treatment of constipation (Pareek, 1983). Commercially available consists of the dried leaflets of Alexandria senna (*Cassia acutifolia* Delile) or Tinnevelly senna (*Cassia angustifolia* Vahl.). The phytoconstituents principally responsible for its characteristic action is two anthraquinone glycosides namely; sennoside A and sennoside B. Sennoside A and B together are responsible for upto 40-60% activity of crude senna (Kinjo *et al*., 1994). The sennosoides had been extracted from senna leaves, stems, pods, buds and flowers (Agarwal and Bajpai, 2010). Sennosoid contents in senna varied with time of sowing, collection and storage conditions (Upadhyay *et al*., 2011). Leaves are used as purgative drug in eastern and western countries. Senna also contains small quantities of other anthraquinones such as sennosides C and D, rhein 8-glucoside, rhein 8-diglucoside, aloe-emodin, 8-glucoside, anthrone diglucoside and rhein. Senna also contains naphthalene glycosides, flavonoid, phytosterols, salicylic acid, mucilage, resin and calcium oxalate (Babash *et al*., 1985; Arshi *et al*., 2006; Upadhyay *et al*., 2011).

Senna is cultivated in coastal districts of Tirunelvelli, Ramanthapuram and Madurai in Tamil Nadu. Although successful cultivation has been demonstrated in many parts of western India, its commercial cultivation has recently come up in Kutch, Gujarat and Jodhpur, Jaisalmer and Barmer districts of Rajasthan (Arya, 2003). It can grow over sand- after rainy season and can be maintained as a perennial crop for 2-3 years. Agricultural developments in hot arid region is challenging task and certain other land-uses to enhance income of rural farmers is essential for their livelihood support. Cultivation of senna due to good growth even under non-irrigated conditions

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may be boon for economic development in arid region. Despite of its extensive use in medicine, its cultivation practices has not been worked out properly (Pareek, 1983; Singh *et al*., 1997; Arya, 2003). Present communication deals with cultivation practices for this commercially important species in arid region.

Material and Methods

Seeds of *Cassia angustifolia* were procured from locally grown variety (Sonna) from Jodhpur (Seedlot A) and Bikaner (Seedlot B) and Thirunelveli senna (Lot C) from Institute of Forest Genetics and Tree Breeding, Coimbatore. The seeds from Coimbatore contain 10-15% shrivelled dark brown seeds, while local lots contain no such seeds. Moisture content of seed samples were calculated as per standard ISTA (1993) rules.

$$Moisture\ (\%) = \frac{Fresh\ weight - Dry\ weight}{Fresh\ weight} \times 100$$

Seeds were pretreated and germinated over quartz sand in seed germinator at 30±2°C and 90±2% relative humidity and incubated for 21 days. Germination was represented as:

$$Germination\ (\%) = \frac{Total\ germination}{No.\ of\ seeds\ \ sown} \times 100$$

The time taken to complete germination under various treatments was determined as mean germination time (MGT) in days as per the method of Rawat and Thapliyal (2003).

$$MGT = \frac{\Sigma\ (daily\ germination * days)}{number\ of\ seed\ sown}$$

For developing suitable agri-silvi practices for *Cassia angustifolia* in arid areas under rainfed and irrigated conditions, experimental field trials were initiated with different spacing (30 x 30 cm, 30 x 45 cm and 45 x 45 cm), date of sowing (July, August and September), combinations of irrigation, fertilizer application in three replications and in RBD design. In another experiment various agroforestry tree species namely *Acacia nilotica, Prosopis cineraria, Azadirachta indica* and *Eucalyptus camaldulensis* have been selected for experimental trial with a single frequency of irrigation (after 1st plucking) in 3 replication and RBD design. The experimental design for agri-trial was as:

Main treatment: Irrigation

I_0: No irrigation; I_1**:** Two irrigation 30 and 75 days after sowing (Ist plucking); I_2**:** One irrigation (75 days after sowing).

Sub-main treatment: Fertilizer dose (farmyard manure and urea)

0 = N_0, Control; 1 = N_1, 25 kg ha^{-1}; 2 = N_2, 50 kg ha^{-1}; 3 = N_3, 75 kg ha^{-1}; 4 = N_4, 5,000 kg FYM ha^{-1}; 5 = N_5, 10,000 kg FYM ha^{-1}

All the collected data were analyzed using MS-Excel (version-7). The P values <0.05 were taken as significant and CD was derived for interpretation of results. Coefficient of variation (CV) was calculated as: CV= SD*100/Mean for seed weight replication results.

Results and Discussions

Seeds collected from all three sources (Jodhpur, Bikaner and Coimbatore) were inter-compared with respect to various seed traits. The moisture content of the seed varied from 5.58 to 6.8% (Mean 6.1±0.48%) in all the three seedlots. Number of seeds per kilogram was from 39000 to 42000 with 31.6% to 63.7% of green seeds. The number of green seeds were maximum in lot B and minimum in lot A. 100 seed weight of either green or yellow seeds of lot A was higher than lot B. Lot B showed

Table 1. Source variation of 100 seed weight (gm) of three seedlots of Cassia angustifolia

Parameters	Seed lot A : Jodhpur		Seed lot B : Bikaner		Seed lot C : Coimbatore	
	Green seed	Yellow seed	Green seed	Yellow seed	Green seed	Yellow seed
Mean	2.27	2.45	1.70	2.05	2.38	2.65
SD	0.12	0.05	0.07	0.03	0.11	0.07
Range	0.35	0.15	0.73	0.09	0.35	0.26
Minimum	2.10	2.38	1.16	2.01	2.16	2.53
Maximum	2.45	2.54	1.89	2.10	2.51	2.80
CV	3.96	2.04	4.11	1.46	4.62	2.64

CD at 5% = 0.09 Green; 0.31 Yellow; Moisture content varies from 5.58 to 6.8% Mean 6.10± 0.48%.

Table 2. Effect of various pre-sowing treatments on per cent germination and mean germination time of Cassia angustifolia seeds. Values in parenthesis are arc sine transformed.

Pre-treatments	Mean per cent germination	Mean germination time (in Days)
Control (Lot A)	26.20 (30.80)	4.90
Control (Lot C)	40.70 (39.66)	4.11
Control (Yellow seeds)	25.00 (30.01)	4.98
Control (Green seeds)	21.00 (27.29)	5.31
Mechanical scarification (MS)	92.50 (74.14)	2.06
Hot water (80°C)	82.00 (64.92)	2.09
1N H_2SO_4 (1 min)	96.00 (78.50)	1.50
1N H_2SO_4 (5 min)	87.50 (69.93)	1.82
1N H_2SO_4 (10 min)	85.20 (67.40)	2.24
1N H_2SO_4 (15 min)	81.00 (64.19)	2.34
CD at 5%	11.19	1.25

minimum seed weight. Green seeds of Lot A showed higher weight even than the yellow seeds of Lot B (Table 1). Seeds received from Coimbtore showed highest seed weight of both type of seeds. Seedlots differed with each other significantly with respect to green or yellow composition as well place of collection. Analysis of coefficient variation indicated clearly that yellow seeds irrespective of collection source, are more homogeneous (CV <4.0) then green seeds having higher values.

Initial germination studies were performed on all the three seedlots (Table 2). The seeds were found dormant due to physical reasons and gave poor germination without any pre-treatment. Seed germination is over within 5 days and seeds required pre-treatments. Several pre-treatments were imposed and germination trend were studied. The germination can be

Table 3. Effect of seed source on plant height (above-ground height), fresh and dry weight of Cassia angustifolia (values are means of five individuals randomly collected plants from the desired plots)

Parameters	Lot A	Lot B	Lot C
Plant height (cm)	21.20	13.10	15.50
Fresh weight (g)	4.60	3.14	3.50
Dry weight (g)	1.50	1.10	1.17
CD	5%		
Height	3.50		
Fresh weight	1.20		
Dry weight	0.18		

enhanced (>80%) by mechanical scarification, hot water and acid pre-treatments. Maximum germination was observed with seeds treated with NH_2SO_4 followed by mechanical scarification. Green seeds showed slightly poor germination as compared to yellow seeds. Seeds of tested seedlots without treatment gave 22% to 40.70% germination and average mean germination time was from 4.10 to 5.10 days. Seeds received from Coimbatore showed better germination percentage under control (40.70%) than seeds collected from Jodhpur (26.20%) and Bikaner (22.00%). For further treatments, seeds of Coimbatore were taken. Pre-treatments enhanced the germination percentage from 40.70% to 96.0% with 1N H_2SO_4 (96.0%). Hot water pre-treatment also gave good results (82.0%) germination with 2.09 MGT. Mean germination time decreased in almost all the treatments. Seeds without pretreatment have longer mean germination time subsequently enhanced significantly from 5.31 in green control seeds to 1.50 in seeds treated with NH_2SO_4. Results were significant for all the pre-treatments for seed germination and mean germination time.

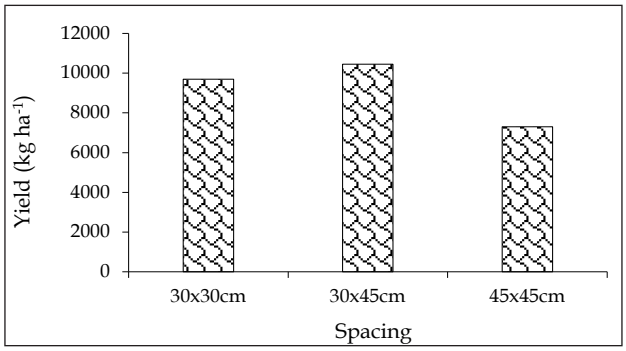

Fig. 1. Effect of density on harvested biomass of Cassia angustifolia after 75 days of sowing.

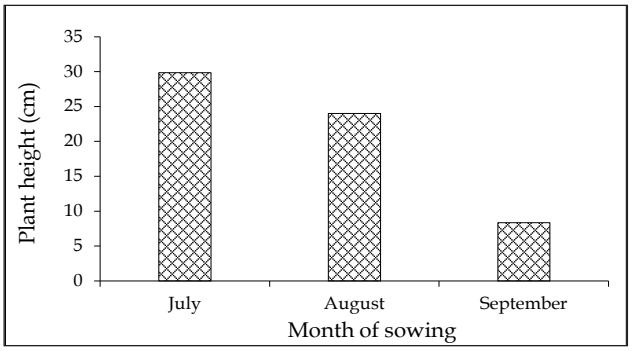

Fig. 2. Effect of time of sowing on plant height (above-ground height) of Cassia angustifolia after 60 days of sowing.

For comparison of seedlots, field trial was initiated with different seedlots. Seeds were sown in July and height was measured after 30 days of sowing. Senna attained maximum height in lot A (21.2 cm) followed by lot C (15.5 cm). Lot B showed minimum (13.1 cm) height. Same trend was evident for fresh and dry weights of respected seedlots (Table 3). Results of plant height, fresh and dry weight were significantly higher in seedlot A than seedlot B and C. Seedlot B and C showed insignificant effect and they are at par with each other.

Germplasm variability is one of the important aspects of nature. A growing stock is bound to have variations and it is key for improvement in any system. Seed weight and size are moderate characteristics of plant species and are dependent on variety of factors (Baker, 1972; Cavers and Steel, 1984). A close relationship between seed size/weight and seed quality has been documented earlier also and our data are in accordance with them (Ponnammal *et al*., 1993; Wightman *et al*., 2001).

Figure 1 showed the effect of density (spacing) on the performance of *Cassia angustifolia*. Seeds of seedlot A were sown at three spacing of 30 cm x 30 cm, 30 cm x 45 cm and 45 cm x 45 cm in July and harvested after 75 days. One irrigation was provided after 30 days of sowing. Fresh harvested biomass was higher (10,452 kg ha^{-1}) at 30 x 45 cm spacing and the spacing of 45 x 45 cm gave minimum produce (7,297 kg ha^{-1}). Thus it is recommended that farmers should grow this crop at the above-mentioned spacing.

Time of sowing is also a very important factor for senna. The crop should be sown immediately after rain. The field should thoroughly and deeply ploughed after the first shower and left open for a while to kill soil pests. Experiment was initiated to find out the best period for sowing. Three time intervals (15^{th} July, 15^{th} August and 15^{th} September) were selected. Above ground plant height of *Cassia angustifolia* after 60 days of sowing was measured from three periods and were compared (Fig. 2). It was observed that seeds sown in July period gave best height (29.83 cm) in comparison to August (24 cm) and September (8.36 cm) sowing.

Senna is a tropical crop and requires full sunshine for its optimum growth. Heavy rains and cloudy weather is harmful to the crop. Plants while interacting with the crop for nutrients also interfere for sunlight. As for propagation of this crop to the farmers, one should know its fullest requirement and interactive behavior with the adult tree neighbors. As the tested trees are always associated with the farmlands, an experiment was initiated to observe the interactive effect of *Acacia nilotica*, *Prosopis cineraria*, Eucalyptus camaldulensis and *Azadirachta indica* on the performance of senna under irrigated and rainfed conditions (Fig. 3). All the tree species were growing in the AFRI experimental area at 5 x 5 m spacing and were of 8-10 years of age. The plant height of *Cassia angustifolia* was measured after 30 days of sowing. It was found that plant height was always higher in irrigated conditions. Maximum growth

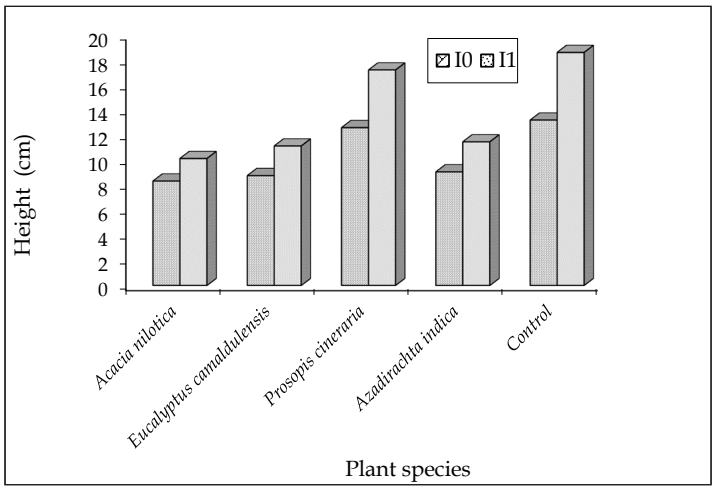

Fig. 3. Interactive effect of various plants species on growth (above-ground height) of Cassia angustifolia after 30 days of sowing in the field under irrigated (I1, at 15 days after sowing) and non-irrigated (I0) conditions.

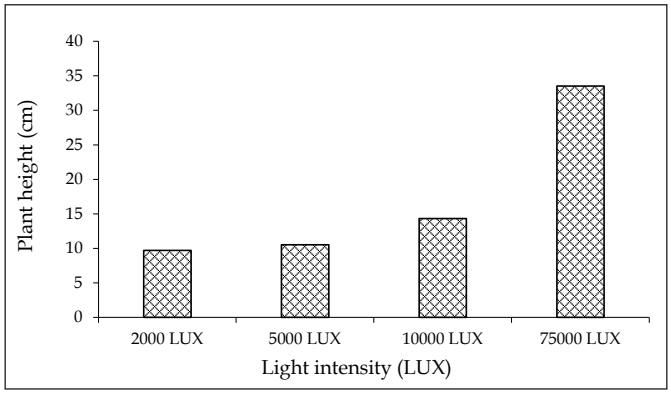

Fig. 4. Effect of light intensity on the growth (height) of senna after 60 days of sowing under irrigated conditions.

was observed under *Prosopis cineraria* with or without irrigation in comparison with other tree species. However, growth was always higher under control.

To test the performance of senna under light and shade conditions, experiment was initiated under irrigated and non-irrigated conditions. It is clear from the Fig. 4 that full Sunlight (75,000 Lux) light intensity is optimal for its fullest growth under Jodhpur conditions. Light intensity of 2000 Lux gave minimum height of 9.7 cm. whereas, 5000 Lux gave only 10.5 cm plant height.

Effect of irrigation and nitrogen fertilizer and farmyard manure was also studied and it was found that Senna responded to both irrigation and fertilizer treatments (Table 4). Irrigation provided after 30 days of sowing was beneficial to the crop and biomass production was significantly enhanced from 6222 kg ha^{-1} to 11840 kg ha^{-1}. Addition of nitrogen (urea) and 5-10 tons of FYM ha^{-1} increased biomass production significantly. The biomass produced after first plucking was reduced in successive harvest and the irrigation provide after first plucking was beneficial to the crop.

The time of harvest is also important and it was found that Senna should be harvested after 60-75 days of sowing. The main harvest of Senna is leaves. After 75 days of sowing leaves are of 56-62% of the total above ground biomass of the plant. If harvesting is delayed, the leaf biomass was reduced by 10-15%, which was converted into flower biomass. The weight of dry leaves was 25-29.8% of the fresh weight.

The performance of *C. angustifolia* with other agricultural crops has been performed previously by Sastry *et al*., 2001. Arya (2003) studied the production potential and economic viability under silvi-herbal trials in Rajasthan. Cultivation trial was established with *Acacia nilotica*, *Ailanthus excelsa* and *Dalbergia sissoo*. The results were compared among tree species and data were non-significant for choice of species targeted. However, there was no control and data were compared with the cultivation experiments performed by Lal and Prajapati, 1999. A field experiment conducted by Pandit *et al*., 2011 to assess the performance of senna (*Cassia angustifolia*) in cotton, pigeonpea and castor at different row proportions. The treatment consists of cotton, pigeonpea, castor

Table 4. Effect of irrigation, nitrogen and farmyard manure on annual biomass production of Cassia angustifolia. The values are means of three replications and fresh biomass production was shown in kg ha^{-1} per year

Treatments	N_0	N_1	N_2	N_3	N_4	N_5	Mean
I_0	6222	10148	9578	9274	8037	8926	8697.5
I_1	6540	10565	9890	9592	8469	9443	9083
I_2	7400	11840	10125	9955	9014	10008	9657
Mean	6720.66	10851	9864.3	9607	8506.66	9459	
CD	5%						
FYM	274.89						
Irrigation	274.89						
Interaction	549.78						

and senna in sole stand as well as intercropping system with two row proportions and pigeonpea + pearl millet (1:2) intercropping system as a check. Intercropping significantly reduced the leaf and pod yield of senna as compared to the sole crop of senna. Our results are at par with them. In our results though the performance was lowered in all the treatments with the introduction of tree species, *Prosopis cineraria* performed at par with control.

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