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SUNIL PURI

Department of Forestry
Haryana Agricultural University
Hisar, India

P.K. KHOSLA

Director of Extension Education
University of Horticulture and Forestry
Solan, India

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Seedling Production of *Prosopis juliflora* in Northeastern Brazil

Paulo Cesar Fernandes Lima

Embrapa-Cpatsa, Caixa Postal 23, 56300 - Petrolina, PE, Brazil

ABSTRACT

This paper reports on the techniques of seedling production of *Prosopis juliflora* used in the semiarid region of Northeastern Brazil. After the harvest of pods, the seed is extracted manually. Seeds of *P. juliflora* will not germinate well unless their dormancy is overcome by immersion in hot water for three to five minutes. By this process the average germination obtained is above 80 per cent. For seedling production, the plastic bag is the most common container used in the region. Research on propagation by cuttings is being developed in the region. The best results were obtained with the use of a greenhouse at a temperature of 30 to 35°C and relative humidity of 70 to 80 per cent. Care and management of seedlings in nursery are reported, with incidence of insects and diseases, fertilizer requirements, irrigation, root pruning, and shading.

INTRODUCTION

The genus *Prosopis* is generally used in afforestation programmes in the semiarid regions of the world. *Prosopis juliflora* (SW) DC is the species used for planting in reforestation programmes by the Brazilian government and among the small farmers in Northeastern Brazil. This species is valuable in recuperation of degraded areas, production of firewood and charcoal for energy, and production of pods for animal nutrition. The wood productivity, was estimated by Lima (1986b), is 15 m^3/ha, five years after planting. The average pod yield is around 75 kg/year per tree in plantations above 15 years old (Lima, 1987).

In this region, the most common process used for seedling production is by seed. Research institutions and universities are studying techniques to obtain seedlings of *Prosopis* by cutting. The Centro de Pesquisa Agropecuária do Trópico Semi-Árido (CPATSA) has done some studies, and the seedlings obtained by cutting are being used in genetic programmes.

This paper reports on the techniques of seedling production of *P. juliflora* in the semiarid region of Northeastern Brazil.

PLANT PRODUCTION BY SEED

The high quality of seeds is very important for successful seedling production and afforestation programmes. But in this region there is no programme of seed collection of *Prosopis juliflora*. The seeds are collected without taking into consideration the genetic characteristics of the mother trees, although some people collect pods by the phenotypic appearance of trees, only choosing plants without thorns and collecting elongated pods. The harvest consists of manual collection of pods from the ground.

Seed Extraction

The seed extraction from the pods in the region is done manually. Gomes (1961) described the most common technique used by farmers in Northeastern Brazil, in which they immerse the fruit in water at room temperature for approximately 12 hours and then, with a knife, cut the pod in the narrow part in the longitudinal direction. Another process is cutting the sun-dried pods of *P. juliflora* with scissors in the narrow part in the longitudinal direction. When the blade becomes sticky because of the sugar in the pods, the scissors must be washed to facilitate the operation.

The extraction of seeds with chemical products is an expensive and dangerous technique for people who live in the farm. Souza *et al.* (1983), with the objective of finding a method for the extraction of seeds of *P. juliflora* in large amounts, at low cost, without damage to germination potential, showed that it is possible to obtain good seeds for planting through the use of a fodder machine. The technique consists of allowing the pods to dry in the sun and crushing them in a fodder machine with low rotation, using a large sieve. Then, the seeds are collected by hand from the meal. For planting, these seeds do not need scarification, the germination being around 70 per cent.

Data from different methods of seed extraction tested by Souza *et al.* (1983) are shown in Table 9.1. Hand-mill and forage machine extraction methods from sun-dried pods had least requirement of human labour and total cost, and the smallest amount of undamaged seeds. The manual processing showed an intermediary labour requirement and total cost, but the greatest amount of undamaged seeds.

The number of seeds per kilogram of *P. juliflora* is approximately 28,400 (Carvalho, 1976). For storage, it is necessary to destroy any insects or fungi in the seeds. Moraes *et al.* (1981) identified Bruchidae, classified as *Mimosestes minosae* (F), harming seeds of *P. juliflora*. Before storage the seeds must be fumigated.

Sowing

The important requirement in sowing during nursery operation is to obtain the maximum number of seedlings for planting from the available seed. In the semiarid zones, it is necessary to know the correct time to sow the species in order to obtain the seedling in the rainy season. In most parts of the semiarid zone of Northeastern Brazil, the rainy season occurs from February to April. For planting, seeds of *P. juliflora* should be sown at least three months before the rainy period.

Table 9.1. Seed weight (damaged and undamaged) in 250 g of pods and costs with different extraction methods (Souza *et al.*, 1983)

Extraction method	Seed weight (g) 250 g of pods*		Costs (Cr $/kg of seeds)*		
	Undamaged	Damaged	Material	Human labour	Total
Manual	20.83[a]	0.53[a]	—	9,096.02	9,096.02[b]
Immersion at 100°C water/4 min	19.40[a]	0.77[a]	—	21,525.77	21,525.77[de]
Immersion at 100°C water/6 min	17.40[a]	0.33[a]	—	24,222.41	24,222.41[c]
Immersion at 100°C water/8 min	19.27[a]	0.50[a]	—	18,761.29	18,761.29[cd]
Scarification with sulphuric acid 2N	19.30[a]	0.43[a]	4,932.64	13,423.32	18,355.96[cd]
Scarification with sulphuric acid 5N	19.50[a]	0.40[a]	12,205.12	13,285.64	25,490.76[e]
Scarification with sulphuric acid 10N	19.50[a]	0.40[a]	24,410.25	14,475.38	38,885.63[f]
Scarification with chloridric acid 1N	19.73[a]	0.57[a]	3,641.27	11,464.77	15,106.04[c]
Hand-mill	14.60[bc]	0.67[a]	—	3,840.41	3,840.41[a]
Forage machine (sun-dried pods)	10.77[c]	2.90[b]	233.98	3,769.73	4,003.71[a]
Forage machine (oven-dried pods)	5.93[d]	3.37[b]	424.96	8,477.23	8,902.19[b]

* Means followed by the same letter do not differ statistically by Tukey test ($P > 0.05$)

Depth of sowing depends on the size of the seed. In the Brazilian semiarid region, *P. juliflora* is usually sown at 1 cm depth. After sowing, the seeds are covered with sand. Test seeds for germination are sown in each container and at about two weeks after germination, the seedlings are thinned, leaving only one per container. The extra vigorous seedlings may be transplanted to another pot in which seeds did not germinate.

Seeds of *P. juliflora* will not germinate well unless their dormancy is overcome by special pre-treatment. The most common technique used among the farmers to scarify *P. juliflora* seeds is to immerse them in hot water for three to five minutes. By this process the average germination obtained is above 80 per cent.

Containers

Several types of containers (biodegradable and non-biodegradable pots) are used for seedling production. The plastic bag is the most common container used in the region for *P. juliflora* and other species on a large scale. However, some farmers use non-conventional pots like cans and mini-baskets for seedling production on small scale.

Silva and Lima (1985) studied the quality of *P. juliflora* seedlings produced in different kinds of containers. Inoculated seeds were sown in plastic bag (18 cm height and 8 cm diameter), veneer tube (18 cm height and 8 cm diameter, bottomless), styroblock system (2 cm diameter and 12 cm length with hole of 7.6 mm for drainage), paper tube (18 cm height and 5 cm diameter, bottomless), and wood-pulp container (5 cm height and 6 cm diameter). The results obtained 60 days after sowing in the nursery are shown in Tables 9.2 and 9.3.

Table 9.2. Growth, root collar diameter, and survival of *Prosopis juliflora* plants 2 months old in nursery and 12 months old in field (Silva and Lima, 1985)

Container	In nursery (2 months)			In field (12 months)		
	Height (cm)	Root collar diameter (mm)	Survival %	Height (cm)	Root collar diameter (mm)	Survival %
Wood-pulp	20.9^{c*}	1.7^{a}	100	1.38	2.68^{ab}	100^{a}
Plastic bag	21.8^{a}	1.7^{a}	100	1.58	3.23^{ab}	100^{a}
Veneer tube	16.7^{ab}	1.3^{b}	100	1.73	3.50^{a}	90^{ab}
Styroblock	8.0^{b}	1.2^{b}	100	1.32	2.11^{b}	80^{b}
Paper	12.7^{b}	1.3^{b}	100	1.56	2.21^{b}	90^{ab}

* Means followed by the same letter do not differ statistically

There was no significant difference for seedling survival among the treatments in nursery. But there was significant difference in the field, 12 months after planting (Tables 9.2 and 9.3). The ratio between dry weight of root and dry weight of upper part of the plant was influenced by the kind of container. This balance shows the quality of seedlings and their probability of survival and establishment in the field. The plastic bag provided the best height for upper part of plant and length of roots. The smallest height of upper part of plant and length of root were obtained in

Tabe 9.3. Root length of *P. juliflora* plants 2 months old in nursery and 12 months old in field (Silva and Lima, 1985)

Container	In nursery (2 months)		In field (12 months)	
	Root length (cm)	Root dry weight / Above-ground weight	Root length (m)	Canopy diameter (m)
Wood-pulp	23	0.25	1.2	2.06^{a*}
Plastic bag	30	0.37	1.3	2.32^{a}
Veneer tube	24	0.33	1.3	2.55^{a}
Styroblock	13	0.66	1.3	1.57^{b}
Paper	26	0.32	1.4	2.30^{a}

* Means followed by the same letter do not differ statistically

the styroblock system. By this process the roots grow until the drainage hole, and then their growth is interrupted by contact with the air.

The great advantage of seedling production by styroblock system is the small cost of transport and planting. A worker should be able to plant an average of more than 1,300 seedlings per day and styroblock can be reused. For *P. juliflora* seedling production it is necessary to test a large styroblock, i.e., 5 cm diameter and 25 cm length with 7.6 mm hole for drainage.

PROPAGATION BY CUTTINGS

Research is being done by CPATSA in order to obtain seedlings of the genus *Prosopis* through cutting, since 1982. Studies are being undertaken to find the effect of treatments with auxin, size of cuttings, position of branches on tree, season of collection of cuttings, influence of temperature and relative humidity on rooting, and other aspects of propagation.

The cuttings are taken from branches up to one year old. Cuttings are collected and stored in boxes with water, but must be planted as soon as possible. The best results of rooting were obtained with the use of a greenhouse at a temperature of 30 to 35°C and relative humidity of 70 to 80 per cent.

Lima (1986a) compared the rooting of *P. juliflora* cuttings obtained from 18-month-old plants vegetatively propagated and cultivated in a pot in a greenhouse with *P. chilensis*, *P. pallida*, and *P. alba* cuttings from 12-month-old plants. All cuttings for each species contained two nodes with leaves. Rooting percentages were evaluated 150 days after planting and the results showed *P. juliflora* with a rooting rate of 20 per cent, *P. chilensis* and *P. pallida* 54 per cent and *P. alba* 44 per cent.

Rooting percentages obtained with *P. juliflora* were very low compared to results obtained by Souza and Nascimento (1984) and Nascimento *et al.* (1985) using *P. juliflora* older than 10 years, around 70 per cent.

Use of Hormones

The use of indoleacetic acid (IAA), indolebutyric acid (IBA), a

combination of the two, and a combination of the two with other hormones has been tested with *Prosopis*. Souza and Nascimento (1984) tested the influence of different concentrations of IBA on rooting of *P. juliflora* cuttings. They used different dosages of hormones in cuttings of 15 cm length and 4.39 mm diameter with all leaves removed and in cuttings with 50 and 100 per cent of leaves. The results obtained by them suggest the use of 2,000 ppm of IBA on cuttings with all leaves in nodes (Table 9.4).

Table 9.4. Effect of IBA and percentage of leaves removed on the rooting of *P. juliflora* cuttings (Souza and Nascimento, 1984)

IBA concentration (ppm)	Leaves removed (%)		
	100	50	0
0	25	18	47
1000	18	45	58
2000	3	33	67
3000	12	40	45
4000	20	40	45
5000	5	13	28
6000	8	25	27

Length of Cutting

The size of cuttings was studied by Souza and Nascimento (1984). They obtained 70 per cent of rooting with cuttings of 10 cm length and 2.37 and 3.30 mm diameter, and with cuttings of 15 cm length and 4.39 mm diameter (Table 9.5). The cuttings of *P. juliflora* were planted with one third of their length in the soil.

Table 9.5. Rooting percentage of *P. juliflora* cuttings based on their length and diameter (Souza and Nascimento, 1984)

Length of cuttings (cm)	Diameter of cuttings (mm)			
	2.37	3.30	4.39	6.91
10	70	70	50	30
15	53	60	70	20
20	57	60	33	10

The number of buds influences the length and percentage of rooting of cuttings. Nascimento *et al.* (1985) developed an experiment in a greenhouse in which the cuttings were planted leaving different combinations of numbers of buds above and under the soil. After 60 days of planting, the best rooting and new leaf sprouting percentages were obtained from the treatment in which two buds were left in the soil and three buds above soil. The best rooting (95%) was observed when there was one bud in the soil and two buds above soil but there was no significant difference in

relation to five other treatments with 60, 75, 80 and 85 per cent rooting. The results of this experiment are given in Table 9.6.

Table 9.6. Percentage of rooting, callus, above-ground parts and root emergence and dry weight of root (g) from *P. juliflora* cuttings with different bud numbers (Nascimento *et al.*, 1985)

Treatments*	Rooting %	Above-ground parts and root emergence	Callus %	Root dry weight
1	0^{c**}	0^{c}	0^{c}	0^{c}
2	45^{b}	10^{bc}	95^{ab}	0.432^{abc}
3	75^{ab}	30^{abc}	100^{a}	0.322^{bc}
4	95^{a}	20^{abc}	100^{a}	0.360^{bc}
5	35^{bc}	10^{bc}	45^{b}	0.332^{bc}
6	60^{ab}	15^{abc}	100^{a}	0.560^{ab}
7	75^{ab}	40^{ab}	100^{a}	0.426^{bc}
8	45^{b}	10^{bc}	65^{ab}	0.097^{bc}
9	80^{ab}	60^{a}	100^{a}	0.977^{a}
10	85^{ab}	45^{ab}	90^{ab}	0.572^{ab}

*T1: 1 bud in the soil and no bud above soil
T2: no bud in the soil and 1 bud above soil
T3: 1 bud in the soil and 1 bud above soil
T4: 1 bud in the soil and 2 buds above soil
T5: 2 buds in the soil and 1 bud above soil
T6: 1 bud in the soil and 3 buds above soil
T7: 2 buds in the soil and 2 buds above soil
T8: 3 buds in the soil and 1 bud above soil
T9: 2 buds in the soil and 3 buds above soil
T10: 3 buds in the soil and 2 buds above soil

** Means followed by the same letter do not differ statistically by Tukey test ($P > 0.05$)

CARE AND MANAGEMENT OF SEEDLING IN NURSERY

After transplanting of seedlings from greenhouse to nursery, the new plants need some care to grow regularly and without damage. Irrigation, artificial shading, and pruning are techniques studied on *P. juliflora* in the region in which the stock is heterogeneous. However, the most important management techniques of *P. juliflora* seedling production observed among farmers and nurserymen in the region are irrigation and animal and insect control.

Insects and Diseases

In this region no disease or insect pest in nursery with *P. juliflora* seedlings is reported. To prevent domestic animals such as sheep and goats from grazing or browsing the seedlings, the nursery is protected with fences. Another concern is to keep the soil and the nursery area free of termites and ants.

Santos and Silva (1983) tested seedlings of some forest trees from this region for susceptibility to *Meloidogyne javanica*. Among the species studied, *P. juliflora* was classified as a susceptible host. Until 115 days after inoculation there was no damage from nematode attack on seedling survival.

Fertilizer Requirements

Rapid growth of seedlings is possible with the use of fertilizers. However, there are few studies about the use of fertilizer in the seedling production phase of *P. juliflora*. Haag *et al.* (1986) studied the macronutrient deficiencies, dry matter production, and levels of the macronutrients in leaves of *P. juliflora* seedlings, in a substrate of sand and vermiculite (1:1). They concluded that visible symptoms were unclear, and the lack of fertilizers affected the growth of plants (dry matter) in the following order: N > K > P > Mg > Ca > S. The levels of nutrients in the new and old leaves, stem, and branches of seedlings either subjected to denutrition or grown in the presence of all elements are shown in Table 9.7.

Table 9.7. Macronutrient concentrations (%) in *P. juliflora* seedlings (Haag *et al.*, 1986)

Treatments	Elements	New leaves %	Old leaves %	Stem + branches %
With all elements: (macro and micro nutrients)	N	2.59	1.90	0.80
	P	0.23	0.14	0.13
	K	1.93	2.04	1.17
	Ca	0.64	0.96	0.12
	Mg	0.49	0.63	0.09
	S	0.20	0.21	0.20
With no elements	N	1.80	1.80	0.50
	P	0.14	0.14	0.06
	K	0.97	0.46	0.66
	Ca	0.45	0.64	0.15
	Mg	0.22	0.24	0.05
	S	0.09	0.09	0.08

For *P. juliflora* seedling production, it is necessary to inoculate the seeds with specific *Rhizobium* strains before sowing, to favour symbiotic association of bacteria with the roots of the new plants. Moreira *et al.* (1982) selected several *Rhizobium* strains for seedling production of *P. juliflora*. They compared the dry-matter of nodules and nitrogenase activity in plants that received *Rhizobium* with others that received N and with a check (without *Rhizobium* and N). The results are shown in Table 9.8.

Although all of these practices help in the establishment and development of the seedlings, they are not used by the farmers in the region. It is common to use the mixture of soil and animal manure in the proportion 2:1, as substrate in seedling production.

Irrigation

During germination and seedling stages, it is usual to water the plant a minimum of three times a day in the region. At the time of planting *P. juliflora* seedlings in the field, the number of irrigations are decreased to allow the plants to adapt to the new environmental conditions.

Root Pruning

Generally, the seedlings remain in the nursery for 45 to 60 days, from

Table 9.8. Effect of inoculation of different *Rhizobium* strains on nodulation, symbiosis and growth of *P. juliflora* (Moreira *et al.*, 1982)

Treatments	Above-ground dry weight (g)	Nodule dry weight (g)	Nodule number	Nitrogenase activity (μmoles C_2H_4/h)
BR 4001	1.06 ^{abc*}	0.06 ^{abc}	61 ^{cd}	3.02 ^{bc}
BR 4002	1.15 ^{ab}	0.06 ^{abc}	73 ^{cd}	4.26 ^{a}
BR 4003	1.02 ^{abcd}	0.08 ^{ab}	98 ^{cd}	2.41 ^{bc}
BR 4004	0.42 ^{gh}	0.04 ^{bcd}	61 ^{cd}	0 ^{d}
BR 4005	0.66 ^{efgh}	0.04 ^{bcd}	109 ^{bc}	0.14 ^{d}
BR 4006	0.78 ^{cdef}	0.10 ^{a}	113 ^{abc}	3.58 ^{ab}
BR 4007	0.18 ^{ab}	0.05 ^{bc}	48 ^{cd}	2.16 ^{bc}
BR 4008	0.89 ^{bcde}	0.03 ^{cd}	0 ^{e}	3.36 ^{ab}
BR 4009	0.59 ^{efgh}	0 ^{d}	0 ^{e}	0 ^{d}
BR 4010	0.71 ^{defg}	0.08 ^{ab}	205 ^{a}	2.00 ^{c}
Check (Without *Rhizobium* or N)	0.37 ^{h}	0 ^{d}	1 ^{e}	0.12 ^{d}
With only N	1.34 ^{a}	0 ^{d}	1 ^{e}	0 ^{d}
C.V. (%)	23	56	32	40

* Means followed by the same letter do not differ statistically by Tukey test (P > 0.05)

sowing to planting out in the field. *P. juliflora* produces a long tap-root immediately after germination. In India, Gupta and Balara (1972), studying germination, growth, and seedling biomass in nursery of *P. juliflora*, found 52.3 cm root length for 10-week-old seedlings. A disadvantage of some containers is that if the seedlings are kept in them too long, the root system may be deformed by spiralling. So, it is necessary to prune the roots before planting.

P. juliflora has a good ability to regrow root and upper part after pruning and cutting. Vasconcelos and Vasconcelos (1987) studied the possibility of decreasing the cost of *P. juliflora* planting in semiarid zone of Brazil, using different ways of seedling production. One of the methods was seedling pruned 10 cm below and above the collar. They found a high survival and growth of the plants in the field, and no significant difference between this system and traditional planting from a seedling produced in a plastic bag.

Shading

In the nursery, some practices are recommended to favour the development of a seedling without harming its quality. The artificial shading in *P. juliflora* seedling production is not used in Northeastern Brazil. Freires and Drumond (1987) found that percentage of germination in *P. juliflora* increases with the increment of shading levels. There was no significant difference for seedling height and leaf area among the three levels studied (25, 50, and 75%), except at 25 per cent level, which was significantly inferior to all the other shading levels. The measurements for collar diameter, length and dry weight of roots, dry weight of upper part of plant, and root to upper part of plants ratio were highly significant without shading, decreasing as the shading levels increased (Table 9.9).

Table 9.9. Germination, survival, growth, root collar diameter, and root length of *P. juliflora* seedlings, at 44 days (Freires and Drumond, 1987)

Shading level (%)	Germination (%)	Survival (%)	Height (cm)	Root collar diameter (CM)	Root length (cm)
0	59 [b]	66 [a]	25.96 [a]	0.26 [a]	27.86 [a]
25	65 [ab]	70 [a]	22.31 [a]	0.22 [a]	25.76 [ab]
50	71 [a]	76 [a]	22.54 [a]	0.20 [bc]	23.91 [bc]
75	74 [a]	80 [a]	22.17 [a]	0.18 [c]	22.19 [c]

* Means followed by the same letter do not differ statistically by Tukey test ($P > 0.05$).

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