Full Research Article

Assessment of Suitability of Fallow Lands for Major Medicinal Plants in Tamil Nadu

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Abstract

The present study was carried out to assess the extent of permanent fallow lands and identify the suitability of fallow lands for cultivation of major medicinal plants viz., Aswagandha (*Withania somnifera* Dunal), Senna (*Cassia angustifolia* M. Vahl) and Tulsi (*Ocimum sanctum* Linn) in Nanguneri Block of Tamil Nadu during 2013–14. Indian Remote sensing satellite Resourcesat-2 LISS IV data was used to map the extent and distribution of permanent fallow lands of study area and the detailed soil survey work was carried out to identify the problems and potentials of land resources. The biophysical survey revealed that 41.3% of total geographical area (TGA) in Nanguneri block is identified as permanent fallow lands. Climate and soil resources of fallow lands were evaluated for the medicinal plants suitability for cultivation using the parametric methodology. The results showed that out of 5 identified soils, two soils (N_4 and N_5) are highly suitable for cultivation of all the three medicinal plants. Depth, soil texture and soil pH are identified as a major constraints in other soils. The area analysis revealed that 53.4% of fallow lands in Nanguneri block are highly suitable for Aswagandha and 72.2% of fallow lands as highly suitable for Senna and Tulsi cultivation. These results can be transferred to the local stakeholders for converting unproductive fallow lands into productive hub for medicinal plants.

1. Introduction

Indian sub-continent is blessed with most diverse soil and climatic conditions, which are suitable for the growth of many medicinal plant species. Medicinal and aromatic plants and their products to the tune of ₹ 200 crores are produced annually in the country and also India exports large quantities of medicinal and aromatic plants and derivatives to various countries (Rajendran et al., 2008). There is a considerable scope for India to contribute towards the increasing worldwide demand for medicinal plant products (GOI, 2000). Since the major prime lands of country are occupied with cereals and cash crops, medicinal plants are allocated to marginal and degraded lands which resulted to low productivity. Identification and allocation of suitable land for medicinal plants cultivation is a challenging task for stakeholders (Pirbalouti, 2009, Pirbalouti et al., 2011; Nimasow et al., 2016).

On the other hand, large extent of productive lands are left as fallow for more than year due to uneconomical returns from agriculture, inadequate supply of water, severe soil constraints,

silting of canals and rivers, soil and water pollution and socio-economic conditions of farmers (Sharma et al., 2011; Natarajan et al., 2010; Ramasamy et al., 2005). The Govt of India statistics showed that permanent fallow lands in India are increased from 8.8 mha in 1970–71 to 10.3 mha in 2010–11 (DES, 2013). Permanent fallow lands in Tamil Nadu state has increased drastically from 0.61 mha in 1960's to 1.1 mha in 1990's and to 1.54 mha in 2009–2010 which is 11.4% of the total geographical area of the state (Season and Crop report of Tamil Nadu, 2011).

The untapped potential of the fallow lands if harnessed and allotted to high value crops such as medicinal plans it would enhance production and provide greater benefits to the poor and marginal farmers of the region. In this context, the present paper aims to bring out suitability of permanent fallow lands for cultivation of major medicinal plants. Three medicinal plants Aswagandha (*Withania somnifera* Dunal), Senna (*Cassia angustifolia* M. Vahl) and Tulsi (*Ocimum sanctum* Linn) were selected and evaluated for suitability for fallow lands of Nanguneri block. Aswagandha roots and its leaf and seed are

used in ayurvedic and unani medicines. Roots are prescribed in medicines for hiccup, several female disorders, bronchitis, rheumatism, dropsy, stomach and lung inflammation and skin diseases (Shah et al., 2010; Khanna et al., 2006; Kulkarni and Dhir, 2008). Aswagandha is late *kharif* crop and grows well under dry climate. It grows well in well drained sandy loams or light red soils, having pH of 7.5 to 8.0 and requires 600 to 750 mm rainfall for successful cultivation of Aswagandha (Jat et al., 2015; Ramamurthy and Singh, 2015; Naidu et al., 2006). The soil site suitability criteria ratings for Aswagandha are given in Table 1.

Senna botanically known as *Cassia angustifolia* M. Vahl leaves and the pods are the economical parts, containing sennosides which have laxative properties. It was considered as a "cleansing" herb because of its cathartic effect (Kayina and Reddy; 2012, Ramamurthy and Singh, 2015). It is mainly used as a purgative. Soil site suitability criteria ratings for Senna are given in Table 2. Tulsi or *Ocimum sanctum* Linn, the most sacred herbs in Ayurveda and considered good for the lungs and strengthens the adrenals (Cohen, 2014). Tulsi grows well in rich loamy soil with sufficient precipitation (Ramamurthy

and Singh, 2015) and its suitability criteria ratings are listed in Table 3. In the present investigation an attempt has been made to characterize the fallow lands of Nanguneri block and identify the best soils for cultivation of medicinal plants.

2. Materials and Methods

2.1. Location of study

Nanguneri block: It is located in Thirunelveli district with a total geographical area of 50,259 ha and lies between 77°51'42'' and 77°35'55'' East longitudes and 8°21'42''and 8°37›10›› North latitudes (Figure1). The elevation of the block ranged from 35–100 m above msl. The mean maximum temperature is 35.3 °C and minimum temperature is 22.7 °C. The mean annual rainfall is 660.5 mm (Table 4). The LGP of Nanguneri block is 13 weeks which starts from September last week to end of December.

2.2. Delineation of Fallow lands and characterisation

Three seasons Resources at-2 Linear Imaging Self-Scanner (LISS IV) imagery of 2011–2013 was used for identification of fallow lands. Fallow lands were delineated by visual

Table 1: Soil-site suitability criteria for Aswagandha

Land use requirement Soil-site characteristics		Unit	Rating			
			Highly suitable S₁	Moderately suitable S₂	Marginally suitable S₃	Not suitable N
Climatic regime	Mean temperature in growing season	°C	28−32	33−36 25−27	36−40 10−24	<10 >40
	Total rainfall	mm	600−750	500−600	400−500	<350
Land quality						
Moisture availability	Length of growing period	Days	>150	120−150	90−120	<90
Oxygen availability to roots	Soil drainage	Class	Well drained	Moderate	Imperfect	Poor
Nutrient availability	Texture	Class	sl, l, cl, sil, scl	sicl, sic, sc, c (m k⁻¹)	C (ss)	ls, s
	pH	1:2.5	6−8	5.0−5.9 8.1−8.5	<5 >8.5	
	CEC	C mol (P+) kg⁻¹	>15	10−15	<10	
	CaCO₃ in root zone	%	Non-calcareous	Slightly calcareous	Strong calcareous	
Rooting conditions	Effective soil depth	cm	>75	50−75	25−50	<25
	Coarse fragments	Vol %	<15	15−35	>35	
Soil toxicity	Salinity (EC saturation extract)	dSm⁻¹	Non-saline	Slight	Strongly	
	Sodicity (ESP)	%	Non-sodic	Slight	Strongly	
Erosion hazard	Slope	%	<3	3-8	8-15	>15

Table 2: Soil-site suitability criteria for Senna

Land use requirement Soil-site characteristics		Unit	Rating			
			Highly suitable S₁	Moderately suitable S₂	Marginally suitable S₃	Not suitable N
Climatic regime	Mean temperature in growing season	°C	26−32	24−25 32−36	15−23 36−42	<15 >42
	Total rainfall	mm	600−750	500−600	400-500	<350
Land quality						
Moisture availability	Length of growing period	Days	>150	120−150	90−120	<90
Oxygen availability to roots	Soil drainage	Class	Well drained	Moderate	Imperfect	Poor
Nutrient availability	Texture	Class	sl, l, cl, scl, sil	sc, sicl, sic	C (m k⁻¹)	ls, c (ss), s
	pH	1:2.5	6.5−7.5	7.6−8.5 5.0−6.4	<5 >8.5	
	CEC	C mol (P+) kg⁻¹	>15	10−15	<10	
	CaCO₃ in root zone	%	>8.5	Slightly calcareous	Strong calcareous	
Rooting conditions	Effective soil depth	cm	>75	50−75	25−50	<25
	Stonnines	%				
	Coarse fragments	Vol %	<15	1−35	>35	
Soil toxicity	Salinity (EC saturation extract)	dSm⁻¹	Non-saline	Slight	Strongly	
	Sodicity (ESP)	%	Non-sodic	Slight	Strongly	
Erosion hazard	Slope	%	1−5	5−10	10-15	>15

interpretation. Forest survey of India maps (FSI, 2011), Topo sheets and soil map of Tamil Nadu (Natarajan et al., 1997) were used as reference information. Two year data sets were used to eliminate current fallows from permanent fallows. Ground truthing and detailed soil survey work was carried out during November–December, 2013.

2.3. Field investigations and laboratory characterization

The satellite imageries were visually interpreted based on textural and tonal variations and different land form units were delineated. Pre field landform map was verified in the field during 2013–14. Soil profiles were opened based on slope and landform characteristics and the soil and site characteristics were recorded for all profile sites as per the standard guidelines (Soil Survey Staff, 1993). Based on the soil-site characteristics, the profiles were grouped into different soil types and their area was delineated. Soil samples from representative profiles were collected and air dried and processed for laboratory analysis. Organic carbon was estimated by Walkley and Black (1934) method. The soil reaction (1:2.5 soil water suspensions), electrical conductivity and caution exchange capacity were determined by standard procedures (Jackson, 1973). Available Nitrogen (Subbiah and Asija, 1956), available Phosphorous by Olsen method (Olsen et al., 1954), available potassium by Neutral Normal Ammonium acetate method and micronutrients by DTPA method (Lindsay and Norvell, 1978) estimated to assess the status of fertility in the fallow lands. Soil attribute data collected from field and laboratory results were entered in ArcGIS platform for soil site suitability evaluation.

2.4. Land suitability analysis

The soil site suitability for medicinal plants has been evaluated as per the FAO frame work on land evaluation (FAO, 1983) modified by Naidu et al. (2006). The specific requirements of each medicinal plant compared with the characteristics of land and based on the extent of matching, the suitability of the area for the crop is arrived (Sys et al., 1991). Soil characteristics like depth, texture, gravelliness, pH and calcareousness, land features like slope, erosion and drainage and climatic factors such as amount of rainfall and its distribution and length of growing period was used to assess the suitability of land for different crops (Dharumarajan and Singh, 2014).

Table 3: Soil-site suitability criteria for Tulsi

Land use requirement			Rating			
Soil-site characteristics		Unit	Highly suitable S_1	Moderately suitable S_2	Marginally suitable S_3	Not suitable N
Climatic regime	Mean temperature in growing season	°C	26−30	24−25 31−34	15−23 35−36	<15 >36
	Total rainfall	mm	600−1000	500−600 1000−1500	400−500 1500−2000	<350 >2000
Land quality						
Moisture availability	Length of growing period	Days	>150	120−150	90−120	<90
Oxygen availability to roots	Soil drainage	Class	Well drained	Moderate	Imperfect	Poor
Nutrient availability	Texture	Class	sl, l, cl, scl, sil	sc, sicl, sic, s	C (m k^{-1})	ls, c(ss)
	pH	1:2.5	6.5−7.5	7.6−8.5 5.0−6.4	<5 >8.5	
	CEC	C mol (P+) kg^{-1}	>15	10−15	<10	
	CaCO$_3$ in root zone	%	Non-calcareous	Slightly calcareous	Strong calcareous	
Rooting conditions	Effective soil depth	cm	>75	50−75	25−50	<25
	Stonnines	%				
	Coarse fragments	Vol %	<15	15−35	>35	
Soil toxicity	Salinity (EC saturation extract)	dSm^{-1}	Non-saline	Slight	Strongly	
	Sodicity (ESP)	%	Non-sodic	Slight	Strongly	
Erosion hazard	Slope	%	1−5	5−10	10−15	>15

3. Results and Discussion

3.1. Fallow lands delineation and characterisation

The high resolution remote sensing data (Resoursat-2 IRS LISS IV) was visually interpreted and fallow lands were delineated and verified in the field. The results showed that 41.3% (20,770 ha) of total geographical area are identified as permanent fallow lands in Nanguneri block. Low water availability, severe soil erosion, silting of canals and poor soil fertility, labour scarcity, inadequate capital and low profitability in agriculture are the major biophysical and socio-economical causes (Natarajan et al., 2010; Ramasamy et al., 2005) for increasing fallow lands in Nanguneri block.

Three distinct landform units were identified in the fallow land of Nanguneri block viz., nearly level summits and upland, gently sloping lands and concave slope lowland. Soil profile study was carried out across the landforms and the profiles were grouped into major soils based on differentiating characteristics (Natarajan and Sarkar, 2010). The major differentiating

characteristics are depth, colour, gravels and texture. Five soils (soil N_1 to Soil N_5) were identified based on differentiating characteristics in the fallow lands of Nanguneri block. Soil morphological and physio-chemical properties of identified soils are presented in Table 5. The major soils in gently sloping uplands and summits are very shallow (<25 cm) red gravelly sandy clay soils (N_1), moderately shallow (50–75 cm) red gravelly clayey soils (N_2), moderately shallow (50–75 cm) black gravelly clayey soils (N_3) and moderately deep (75 –100 cm) gravelly sandy clay soils (N_4) whereas deep (100–150 cm) non gravelly sandy clay soils (N_5) observed in concave slope lowlands. N_4 soils occupying largest area (7933 ha) followed by N_3 (3932 ha) and N_2 soils (3887 ha). N_1 soils occupying lowest area (1814 ha) and deep non gravelly sandy clay soils (N_5) occupies 15.7 % of total fallow lands.

Biophysical survey revealed that Soil N_1, N_2 and N_3 are having depth less than 75 cm which limits suitability for majority of deep rooted crops. Except soil N_5, all the soils in Nanguneri block have moderate to severe problem of gravelliness. Soil N_1
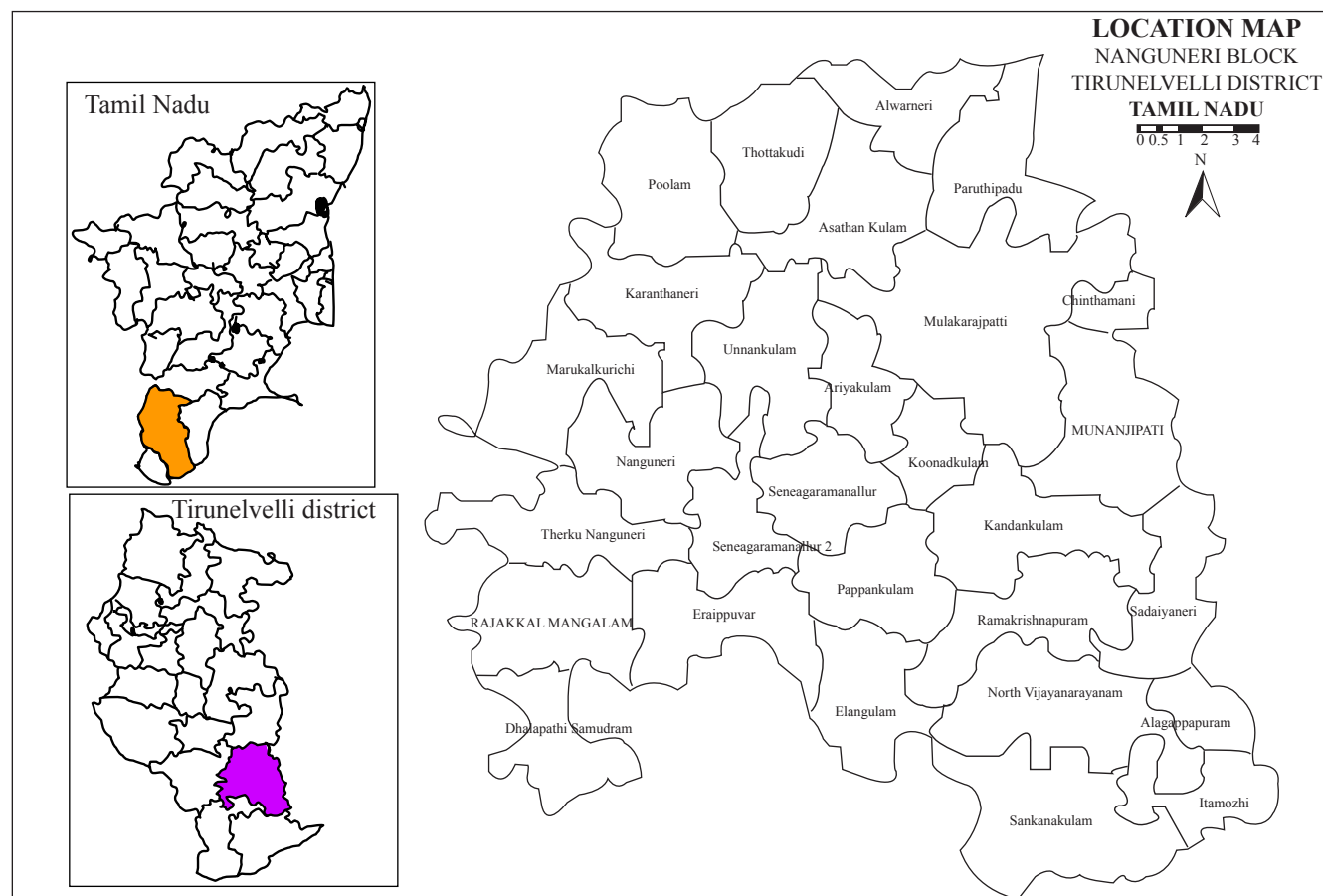
Figure 1: Location map of Nanguneri block

Table 4: Rainfall, temperature and potential Evapo-transpiration of Nanguneri block

Months		Nanguneri block			
		Mean temperature		PET	Rain-fall
		max.	min.		
January	winter	32.0	18.7	112.2	19.6
February		34.3	19.8	137.5	26.2
March		36.5	22.0	167.0	28.2
April	summer	37.7	23.5	171.4	44.5
May		38.3	24.8	183.5	28.8
June		37.2	25.7	173.0	18.1
July	*SW monsoon	37.1	24.6	171.8	16.7
August		37.1	24.4	176.4	14.4
September		36.5	23.7	169.7	31.6
October	#NE monsoon	34.1	23.1	167.0	164.4
November		31.6	22.4	138.1	180.3
December		31.0	20.4	112.2	96.5
Mean annual		35.30	22.70	1879.8	669.4

*SW: South West; #NE: North East

and Soil N_2 are affected by very severe to severe erosion and soil N_3 and N_4 are undergoing moderate erosion. The severe sheet erosion in the uplands and summits is major cause for shallow soil depth (Natarajan et al., 2010). Soil N_4 and Soil N_5 are alkaline in reaction (pH>8) whereas other soils are slightly acidic in reaction (pH 6.07–6.46). The organic carbon content varies from 0.19 % to 0.95 % in the surface and 0.1 % to 0.62 % in the sub-surface. Soil N_3 recorded lowest organic carbon content (0.19 %) and soil N_5 recorded higher organic carbon content (0.95 %). Cation exchange capacity varied from 13.9 to 15.9 c mol (p+) kg^{-1} in the surface and 8.1 to10.5 c mol (p+) kg^{-1} in the sub-surface. Available nitrogen content is very low (99.7 to 265 kg ha^{-1}). Available Phosphorous and potassium content ranged from 6.4–28.5 and 103.7–559 kg ha^{-1} respectively.

3.2. Land Suitability evaluation

The study area is under water scarce, land use system should emphasize on cultivation of low water requirement and high value medicinal plants (Kiran et al., 2009; Pirbalouti et al., 2011; Nimasow et al., 2016). The soil morphological and physiochemical parameters obtained from field as well as laboratory along with climate were evaluated for suitability of Aswagandha, Senna and Tulsi. Climatic parameters such as

Table 5: Major soil and site characteristics of fallow lands in Nanguneri block

Soil		N_1	N_2	N_3	N_4	N_5
Site characteristics						
Slope (%)		1−3	1−3	0−1	0−1	0−1
Drainage		Well	Mod. Well	Well	Well	Mod. Well
Flooding		F0	F0	F0	F0	F0
Erosion		Very severe	severe	moderate	moderate	slight
Soil characteristics						
Texture		scl	gc	gsc	sc	sc
Depth (cm)		25	52	70	90	130
Gravels (%)		50	40	40	25	-
Effervescence with acid		e0	e0	e0	e0	e0
Physiochemical characteristics						
pH	surface	6.46	6.38	6.07	8.18	8.68
	subsurface	6.6	6.48	5.9	8.14	8.62
EC dSm^{-1}	surface	0.11	0.14	0.06	0.10	0.15
	subsurface	0.05	0.15	0.03	0.27	0.16
OC (%)	surface	0.47	0.59	0.19	0.67	0.95
	subsurface	0.35	0.62	0.35	0.1	0.23
CEC	surface	14.8	15.4	13.9	15.7	15.9
C mol (p$^+$) kg^{-1}	subsurface	9.6	10.5	8.1	9.4	10
Available N (kg ha^{-1})		232	265	132.9	99.7	132.9
Available P (kg ha^{-1})		7.3	28.5	14.6	6.4	17.93
Available K (kg ha^{-1})		353	175.8	103.7	147	559
DTPA Fe (mg kg^{-1})		7.02	4	3.28	14.62	10.52
DTPA Mn (mg kg^{-1})		6.16	9.98	4.9	8.98	6.92
DTPA Cu (mg kg^{-1})		1.04	2.66	4.3	2.04	3.86
DTPA Zn (mg kg^{-1})		0.18	0.1	0.16	0.2	0.14

Mod. Well: Moderately well drained; F0: No flooding; scl: Sandy clay loam; gc: Gravelly clay; gsc-Gravelly sandy clay; sc: sandy clay; e0: Nil effervescence with dil Hcl

rainfall, temperature and length of growing period are highly suitable for all the medicinal plants. The major limiting factor in the study area is depth and texture. Though cation exchange capacity and organic carbon is limiting factor in the soils, these can overcome by applying site specific recommendations. The non parametric approach revealed the Soils N_4 and N_5 are highly suitable for cultivation of Aswagandha whereas N_2 and N_3 are moderately suitable with the limitations of texture and pH. Soil N_3 is marginally suitable for Senna due to limitations of texture and drainage whereas as N_2, N_4 and N_5 soils are highly suitable for cultivation. Soil N_2, N_4 and N_5 are highly suitable for cultivation of Tulsi. Soil N_1 is not suitable for all the three medicinal plants due to shallow depth. The area analysis revealed that 11051 ha (53.4%) of fallow lands in Nanguneri block is highly suitable for Aswagandha cultivation and 14913 (72.2%) ha is highly suitable for Senna and Tulsi whereas 1819 ha (8.7%) of fallow lands is not suitable for all the three medicinal plants.

4. Conclusion

The primary objective of this study is to predict the inherent suitability of fallow lands for supporting different medicinal plants for a long period of time. Fallow lands resources were characterized to evaluate the suitability of soils for three medicinal plants Aswagandha, Senna and Tulsi. The results showed that 53.4% of fallow lands in Nanguneri block is highly suitable for Aswagandha 72.2% of fallow lands is highly suitable for Senna and Tulsi cultivation. This study helps to convert the unproductive lands into productive hub for medicinal plants.

Table 6: Agro ecological and pedological related limitation and suitability for the cultivation of medicinal plants in Nanguneri fallow lands

Soil	N-1			N-2			N-3			N-4			N-5		
	A	S	T	A	S	T	A	S	T	A	S	T	A	S	T
Climatic characteristics															
Total annual rainfall (mm)	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1
Mean annual temperature (°C)	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1
Site characteristics															
Slope (%)	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1
Drainage	S_1	S_1	S_1	S_1	S_1	S_1	S_2	S_2	S_2	S_1	S_1	S_1	S_1	S_1	S_1
Flooding	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1
Soil characteristics															
Texture	S_1	S_1	S_1	S_1	S_1	S_1	S_2	S_3	S_3	S_1	S_1	S_1	S_1	S_1	S_1
Depth (cm)	N	N	N	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1
Soil fertility															
EC (dSm^{-1})	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1
pH (1:2.5)	S_2	S_1	S_1	S_2	S_1	S_1	S_2	S_2	S_2	S_2	S_1	S_1	S_2	S_2	S_1
CaCO$_3$ in root zone	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1
Suitability class for dominant soil	N	N	N	S_2	S_1	S_1	S_2	S_3	S_3	S_1	S_1	S_1	S_1	S_1	S_1

S_1: Highly suitable; S_2: Moderately suitable; S_3: Marginally suitable; N: Non suitable; A: Aswagandha; S: Senna; T: Tulsi

5. Acknowledgement

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