The Journal of Rural and Agricultural Research Vol. 19 No. 1, 28-33 (2019)
Received January 2019; Acceptance May 2019

Soil-Site Suitability Evaluation for Cotton and Sugarcane in the Soils of North-West Gir Madhuvanti Toposequence of South Saurashtra Region of Gujarat

C. R. HAKLA, D. V. SINGH[1], GITAM SINGH[2] AND A. S. BHATI[3]
Subject Matter Specialist, Soil Science, KVK, Tonk
Corresponding author - Email: drdvs.org@gmail.com

Abstract

Six representative pedons were evaluated for their suitability of two commercial crops (sugarcane and cotton) in the soils of different land slope of north-west Gir Madhuvanti toposequence of south Saurashtra region of Gujarat. The land slopes, upper piedmont belong to Lithic Ustorthents (P_2), lower piedmont belong to Vertic Haplusterts (P_3), plain area belongs to Typic Haplusterts (P_4) and depression area belong to Sodic Haplusterts (P_5) were marginally suitable (S_3) for cotton and sugarcane. The upper coast belongs to Fluventic Calciustepts (P_6) were currently not suitable (N_1) cotton and sugarcane. The soils hill slopes belong to Lithic Ustorthents (P_1) were currently not suitable (N_1) for cotton and not permanently suitable (N_2) for sugarcane. Topography, drainage, shallow soil depth, soil pH, high $CaCO_3$, poor soil fertility (low O.C.), soil salinity and sodicity are the major limitations in most soils of north-west Gir Madhuvanti toposequence of south Saurashtra. Results showed that the suitability classes can be improved if the correctable limitations (soil fertility characteristics) are altered through soil amelioration measures.

Keywords: Soil-site suitability, Land slopes, North-West Gir Madhuvanti Toposequence, Sugarcane and Cotton

Introduction

It is clear that there is an urgent need to match land resource and land use in the most effective and logical way to continue sustainable production and to meet the needs of society, while conserving fragile ecosystems. Land resources are gradually becoming scarce as increases in population put pressure on natural resources. Population increases and urbanization have resulted in increased pressure on agricultural resources. However, this puts increased pressure on land resources, which may result in land degradation, particularly in countries with restricted water and other natural resources. Therefore, increases in crop production are urgently required to tackle poverty and land degradation problems in developing countries. Land suitability evaluation is well suited for identifying land boundaries, land use planning, specialization of crops in different regions, providing optimal cropping pattern and food policy. Land evaluation is concerned with the assessment of land performance when used for specified purposes. Cotton is one of the most important fiber and cash crop of India and plays a dominant role in the industrial and agricultural economy of the country. It provides the basic raw material (cotton fiber) to cotton textile industry. Sugarcane is an important commercial crop of the country. In addition to improving the economic condition of the farmers and agricultural labourers engaged in sugarcane farming and industries.

Materials and methods

The study area (north-west Gir Madhuvanti toposequence) was located between $21^0$13' to $21^0$25' N latitudes and $69^0$57' to $70^0$32' E longitudes encompassing parts of the Mendarda, Vanthli, and Keshod tehsils of Junagadh district and Porbandar tehsil of Porbandar district of south Saurashtra at an elevation ranged from 5 to 190 above mean sea level. IRS IA LISS II FCC imagery on 1:50,000 scale in conjunction with Survey of India topographical (SOI)

[1]Senior Scientist & Head, KVK, Tonk
[2]Subject Matter Specialist, Animal Science, KVK, Tonk
[3]Farm Manager, KVK, Tonk

Table 1: Climate and soil-site suitability criteria for Cotton (Sys *et al*., 1991 and NBBS & LUP, 1994)

Land characteristics	S_1	S_2	S_3	N_1	N_2
Climatic characteristics					
Total rainfall (mm)	700-1050	550-700	< 550	-	-
Rainfall growing season (mm)	600-950	450-600	< 450	-	-
Rainfall during critical period (soil development)	100-120	-	-	-	-
Length growing period (days)	> 135	120-135	< 120	-	-
Mean temp. growing season (^{0}C)	22-32	> 32	-	-	-
Mean max. temp grow. Season (^{0}C)	-	-	> 36	-	-
Mean min. temp grow. Season (^{0}C)	-	-	< 19	-	-
Mean R.H. in growing season	60-90	-	< 50	-	-
Length of dry spells (weeks)					-
July (beginning)	< 1	-	> 1	-	-
August (end)	< 2	-	> 2	-	-
Site characteristics					
Slope (%)	< 3	3-5	> 5	-	-
Erosion	e_1	e_2	e_3	-	-
Drainage	Well to mod.	Imperfect	Poor&excessive	-	-
Water stagnation (days AWC (mm/m)	< 2	2-3	3-5	> 5	-
Stoniness (surface)	> 150	100-150	50-100	-	-
Soil characteristics texture	< 15	15-40	> 40	-	-
Texture	sic, sicl, c, cl	scl, sicl, l, sc	sl	s, ls	-
Coarse fragments (vol. %)					
within 50 cm	< 15	15-35	>35	-	-
Below 50 cm	5-35	35-50	>50	-	-
Depth (cm)	> 75	50-75	25-50	< 25	-
$CaCO_3$ (%)	< 10	10-20	> 20	-	-
Gypsum (%)	-	-	-	-	-
Soil fertility					
CEC (cmol (p^+) kg^{-1}	> 20	< 20	-	-	-
BS (%)	> 50	35-50	<35	-	-
O.C. (%) (0-15 cm)	> 0.75	0.5-0.75	< 0.50	-	-
ECe (dSm^{-1})	< 2	2-4	4-8	>8	-
ESP	< 10	10-15	> 15	-	-
pH (1:2.5)	8.0-8.5	8.5-9.5	> 9.0	-	-

map referred above on 1:50,000 scale were used to select various land slopes of north-west Gir Madhuvanti toposequence of south Saurashtra region of Gujarat namely: hill slope (LS-1), upper piedmont (LS-2), lower piedmont (LS-3), plain area (LS-4), depression area (LS-5) and upper coast (LS-6) (Fig.-1). The mean annual rainfall is 1120 mm and the climate of the area is semi-arid characterized by extremes of temperature and low wind velocity. Horizon-wise soil samples collected from the typifying pedons were analyzed for their physical and chemical characteristics following standard procedure and soils were classified according to Key to Soil Taxonomy (Anonymous, 2003). The soil-site suitability were carried out using limitation method according to Sys et al., 1991 and NBBS & LUP, 1994 for cotton and (Sys et al., 1991 and NBBS & LUP, 1994) for sugarcane matched with generated data (Table: 1 and 2) at different limitation level: S_1- highly suitable, S_2- moderately suitable, S_3- marginally suitable, N_1- currently not suitable and N_2- not permanently suitable (Sys *et al*., 1991).

Results and discussion

The soils of different pedons of north-west Gir Madhuvanti toposequence of south Saurashtra region, the total sand, silt and clay content mean values of 22.83, 38.90 and 38.26 per cent, respectively indicating dominant of loam to clayey texture. The soil pH, organic carbon, ECe and $CaCO_3$ ranged from 6.79 to 8.28, 0.37 to 0.84 per cent, 0.63 to 11.82 dSm^{-1} and 2.75 to 31.80 per cent with the overall mean value of 7.89, 0.58 per cent, 5.00 $dSm^{-1}$and 19.93 per cent, respectively. The cation exchange capacity, BSP and ESP in the studied soils ranged from 20.60 and 43.96 cmol (P^+) kg^{-1}, 88.73 to 96.31 and 0.51 to 16.93 with

Table 2: Climate and soil-site suitability criteria for Sugarcane (Sys *et al*., 1991 and NBBS & LUP, 1994)

Land characteristics	S_1	S_2	S_3	N_1	N_2
Climatic (c)					
Mean day temp. at germination (^{0}C)	28-32	32-34	34-35	-	> 35
Mean day temp. for tillage stage (^{0}C)	27-32	32-35	> 35	-	-
Mean day temp. for veg. stage (^{0}C)	26-32	32-35	> 35	-	-
(T_{max}-T_{min}/T_{mean}) at maturation stage	> 0.45	0.45-0.4	0.4-0.3	-	< 0.3
10 days rainfall (mm)	> 60	60-50	50-30	-	< 30
Topography (t)					
Slope (%)	0-2	2-4	4-6	-	> 6
Wetness					
Drainage	Good to moderate	Imperfect	Poor	Poor but drainable	not drainable
Physical characteristics (s)					
Texture / structure	c, cl, l	sl, s, fs	s, fs	-	> 55
Coarse fragments (%)	0-15	15-35	35-55	-	> 55
Soil depth (cm)	> 80	80-50	50-25	-	< 25
$CaCO_3$ (%)	0-25	25-35	35-50	-	> 50
Gypsum (%)	0-6	6-12	12-20	-	> 20
Soil fertility characteristics (f)					
CEC cmol (p^+) kg^{-1}	> 16	< 16(-)	< 16 (+)	-	-
B.S. (%)	> 50	50-35	< 35	-	-
pH, H_2O	6.5-7.5	7.5-8.0	8.0-8.5	-	> 8.5
Organic carbon (%)	> 0.8	0.5-0.8	< 0.5	-	-
Salinity alkalinity (n)					
ECe (dSm^{-1})	0-5	5-8	8-10	10-14	> 14
ESP (%)	0-10	10-15	15-20	-	> 20

the mean value of 33.18 cmol (p+) kg^{-1}, 92.71 and 8.27. In general, the soils of of north-west Gir Madhuvanti toposequence were moderately alkaline in reaction, low in organic carbon and highly calcareous in nature. The soil at higher elevation had low in pH, EC, CEC, BSP and ESP then lower elevation (Savalia, 2005; Leelavathi *et al*., 2009; Gandhi *et al*., 2013 and Shirgire *et al.,* 2015).

Soil-site suitability for different land uses is very important for alternate and suitable land use planning. The soils under study have been rated for cotton and sugarcane. Land suitability for cotton and sugarcane crops and land quality ratings are those suggested by Sys *et al.* (1991) and NBSS & LUP (1994) for cotton and sugarcane. The sugarcane and cotton suitability evaluations of pedons P_1 to P_6 of north-west Gir Madhuvanti toposequence are presented in Table 3-6.

Pedon-1 (Karsangadh) from the Hill slope:

The soil associated with this pedon (P_1) was currently not suitable (N_1) for cotton cultivation because of major limitations topography, somewhat excessive drainage, texture and shallow soil depth. The soil was not permanently suitable (N_2) for sugarcane cultivation because of major limitations high topography, somewhat excessive drainage and shallow soil depth. Soil conservation measures like graded narrow base terrace bunds or trenches and contour bunding should be adopted (Savalia *et al*., 2009).

Pedon-2 (Malanka) from the Upper piedmont:

The soils associated with pedon (P_2) have been found to be marginally suitable (S_3) for cotton cultivation because of major limitations like topography, shallow soil depth, medium organic carbon (soil fertility). The soil was marginally suitable (S_3) for sugarcane on account of limitations like topography, shallow soil depth, high $CaCO_3$, medium organic carbon and soil pH. On adoption of corrective measures like Graded narrow base terrace bunds or trenches are recommended to increase soil

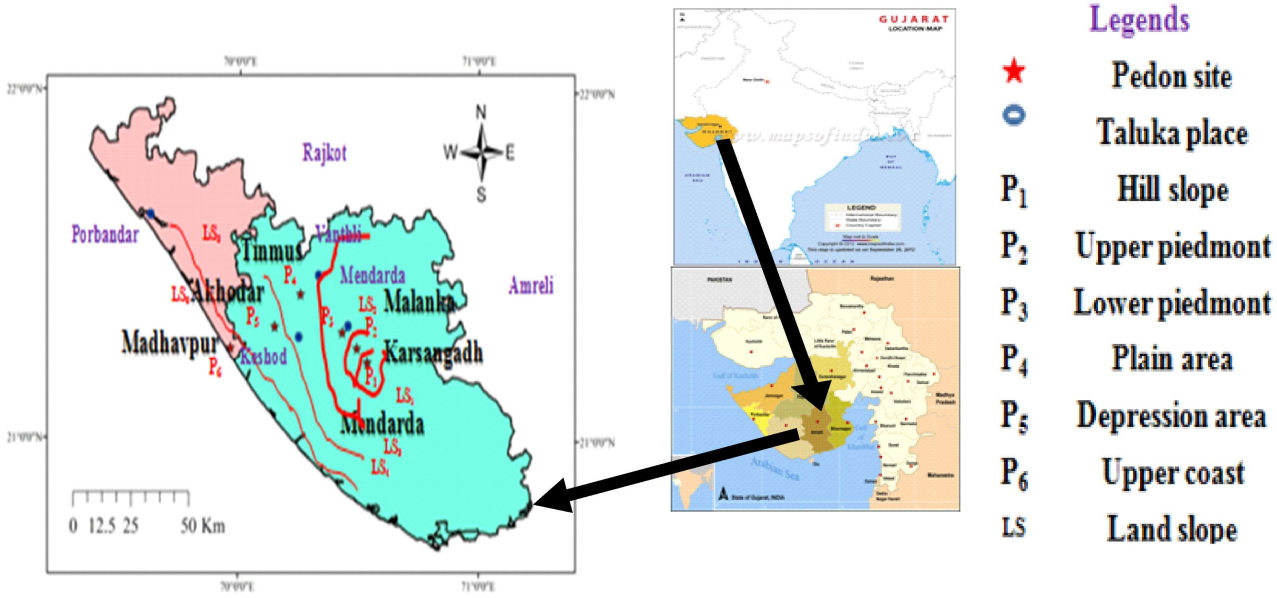

Fig. 1 Site of pedons of north-west Gir Madhuvanti toposequence in South Saurashtra

depth/rooting volume, conservation tillage, use organic manures along with balanced fertilizers and forage-based crop rotations which reduce erosion and allow soil forming factors to maintain and rehabilitate top soil. Similar results were obtained by Savalia *et al*. (2009), Patel *et al*. (2012) and Gandhi *et al*., (2013).

Pedon-3 (Mendarda) from the Lower piedmont:

The soils associated with pedon (P_3) have been found to be marginally suitable (S_3) for cotton cultivation because of major limitations like soil depth, medium organic carbon (soil fertility) and some salinity. The soil was marginaly suitable (S_3) for sugarcane cultivation on account of limitations like topography, soil depth, soil pH as well as medium organic carbon On adoption of corrective measures like use of organic manures along with balanced fertilizers, zero or minimum tillage, frequent inter culturing operation and application of weathered materials and sand in furrow are found to be effective. Similar observations were made by Savalia (2005) and Patel *et al*. (2012).

Pedon-4 (Tinmus) from the Plain area:

The soils associated with pedon (P_4) have been marginally suitable (S_3) for cotton on account of limitations like low soil fertility (low organic carbon), soil salinity as well as soil alkalinity. The soils associated with pedon (P_4) have been marginally suitable (S_3) for sugarcane on account of limitations like low soil fertility (low organic carbon), soil pH, soil salinity as well as soil alkalinity. On adoption of corrective measures of mulching, rain water leeching and use of organic manures, continuous cropping with well ranged crops, reduce, zero or minimum tillage, legumes based crop rotation, frequent interculture operation, application of sand in furrow found effective, constant monitoring of soils and entire root zone requires to be flushed for which availability of good quality water is essential. Similar observations were made by Savalia (2005), Patel *et al*. (2012) and Gandhi *et al*. (2013).

Pedon-5 (Akhodar) from the Depression area:

The soils associated with pedon (P_5) have been found marginally suitable (S_3) for cotton on account of limitations like low soil fertility (low organic carbon), soil salinity as well as soil alkalinity. The soils of this area were marginally suitable (S_3) for sugarcane on account of limitations like low soil fertility (low organic carbon), soil pH, soil salinity as well as soil alkalinity. On adoption of corrective measures like provision of surface drainage through lateral ditch (Giri *et al*, 1999), adoption of salt tolerant varieties, mulching, use of organic manures, application of sand in furrow found effective, legumes based crop rotation, constant monitoring of soils, soil and water conservation practices could be adopted

Table: 3 Soil-site suitability evaluation and land qualities for Sugarcane and cotton of the soils of north-west Gir Madhuvanti toposequence of south Saurashtra

Pedon No.	Climate Rainfall (mm)	Temp. (^{0}C)	Wetness Topography (slope %)	drainage	Physical & chemical characteristics Texture	Soil depth (cm)	$CaCO_3$ (%)	Soil fertility characteristics O.C. (%)	BSP	CEC (cmol(p$^+$)kg^{-1})	pH	Salinity/ alkalinity ECe (dSm^{-1})	ESP
P_1	1120	27.31	15-30	Somewhat excessive	l	25	2.75	0.84	88.44	20.60	6.79	0.63	0.53
P_2	1120	27.31	3-8	Well	cl	27	31.80	0.68	91.36	25.78	7.90	0.88	2.56
P_3	1120	27.31	1-3	Well	c	70	19.81	0.60	92.03	30.83	8.04	2.86	5.80
P_4	1120	27.31	0-1	Well	c	94	19.98	0.50	94.04	34.66	8.13	5.95	10.80
P_5	1120	27.31	0-1	Moderately Well	c	105	21.05	0.49	94.10	42.94	8.20	7.86	13.03
P_6	1120	27.31	0-1	Imperfect	sicl	127	25.20	0.37	96.31	43.96	8.28	11.82	16.93

c – Clay, sicl – Silty clay loam, l – Loam, cl – Clay loam

Table 4: Soil-site suitability evaluations for Cotton in the soils of north-west Gir Madhuvanti toposequence of south Saurashtra (Sys *et al*., 1991 and NBBS & LUP, 1994)

Pedon No.	Climate Rainfall (mm)	Temp. (^{0}C)	Wetness Topography (slope %)	drainage	Physical characteristics Texture	Soil depth (cm)	Soil fertility characteristics BSP	O C.	pH	CEC (cmol(p$^+$)kg^{-1})	Salinity/ alkalinity ECe (dSm^{-1})	ESP	Crop suitability class
P_1	S_1	S_1	N_1	S_2	S_2	S_3	S_1	S_1	S_1	S_1	S_1	S_1	N_1 ws
P_2	S_1	S_1	S_2	S_1	S_1	S_3	S_1	S_2	S_1	S_1	S_1	S_1	S_3 wsf
P_3	S_1	S_1	S_1	S_1	S_1	S_2	S_1	S_2	S_1	S_1	S_2	S_1	S_3 sfn
P_4	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_2	S_1	S_1	S_3	S_2	S_3 fn
P_5	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_3	S_1	S_1	S_3	S_2	S_3 fn
P_6	S_1	S_1	S_1	S_2	S_1	S_1	S_1	S_3	S_1	S_1	N_1	S_3	N_1 wfn

Table 5: Soil-site suitability evaluations for Sugarcane in the soils of north-west Gir Madhuvanti toposequence of south Saurashtra (Sys *et al*., 1991 and NBBS & LUP, 1994)

Pedon No.	Climate Rainfall (mm)	Temp. (^{0}C)	Wetness Topography (slope %)	drainage	Physical & chemical characteristics Texture	Soil depth (cm)	Soil fertility characteristics BSP	O C.	pH	CEC (cmol(p$^+$)kg^{-1})	Salinity/ alkalinity ECe (dSm^{-1})	ESP	Crop suitability class
P_1S_1	S_1	N_2	S_2	S_1	S_3	S_1	S_1	S_1	S_1	S_1	S_1	S_1	N_2 ws
P_2S_1	S_1	S_3	S_1	S_1	S_3	S_2	S_1	S_2	S_2	S_1	S_1	S_1	S_3 wsf
P_3S_1	S_1	S_2	S_1	S_1	S_2	S_1	S_1	S_2	S_3	S_1	S_1	S_1	S_3 wsf
P_4S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_2	S_3	S_1	S_2	S_2	S_3 fn
P_5S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_3	S_3	S_1	S_2	S_2	S_3 fn
P_6S_1	S_1	S_1	S_2	S_1	S_1	S_2	S_1	S_3	S_3	S_1	N_1	S_3	N_1 wsfn

these soils to make them productive. Similar observations were made by Savalia (2005), Patel *et al*. (2012) and Gandhi *et al*. (2013).

Pedon-6 (Madhavpur) from the Upper coast:

The soils associated with pedon (P_6) have been found currently not suitable (N_1) for cotton on account of limitations like drainage, poor soil fertility (low O.C.), high salinity and sodicity. The soils associated with upper coast were currently not suitable (N_1) for on account of limitations like drainage, high $CaCO_3$, poor soil fertility (low O.C. and high pH), soil salinity and sodicity. On adoption of corrective measures like provision of surface drainage through lateral ditch (Giri *et al*, 1999), adoption of salt tolerant varieties, use of organic manures along with gypsum and nitrogenous fertilizers, legumes based crop rotation and soil and water conservation practices, proper sub-surface drainage need to be ascertained, lateral ditches can serve to drain the soils of excessive salts could be adopted these soils to make them productive. For

Table 6: Limitation levels of the land characteristics and land suitability class for cotton and sugarcane

No. of Pedon	Sub group	Soil-site suitability class	
		Cotton	Sugarcane
Pedon-1 (P_1)	Hill slope (Karsangadh), MSL : 190 m, 21^{0}13' N latitudes, 70^{0}32' E longitude, Lithic Ustorthents	N_1 ws	N_2 ws
Pedon-2 (P_2)	Upper piedmont (Malanka), MSL :155 m, 21^{0}16' N latitudes, 70^{0}29' E longitude, Lithic Ustorthents	S_3 wsf	S_3 wsf
Pedon-3 (P_3)	Lower piedmont (Mendarda), MSL : 92 m, 21^{0}18' N latitudes, 70^{0}25' E longitude, Vertic Haplusterts	S_3 sfn	S_3 wsf
Pedon-4 (P_4)	Plain area (Tinmus), MSL : 27 m, 21^{0}25' N latitudes, 70^{0}15' E longitude, Typic Haplusterts	S_3 fn	S_3 fn
Pedon-5 (P_5)	Depression area (Akhodar), MSL : 13 m, 21^{0}19' N latitudes, 70^{0}08' E longitude, Sodic Haplusterts	S_3 fn	S_3 fn
Pedon-6 (P_6)	Upper coast (Madhavpur), MSL : 5 m, 21^{0}16 N latitudes, 69^{0}57' E longitude, Fluventic Calciustepts	N_1 wfn	N_1 wsfn

S_1 = Highly suitable, S_2 = Moderately suitable, S_3 = Marginally suitable, N_1 = Currently not suitable, N_2= Not permanently suitable, w = Wetness, s = Physical characteristics, f = Soil fertility characteristics, n = Salinity/Alkalinity hazard

severely degraded soils, xerophytic, halophytic trees, shrubs and grasses should be grown. Similar observations were done by Savalia (2005), Patel *et al*. (2012) and Gandhi *et al*. (2013).

References

Anonymous, (2003). Keys to Soil Taxonomy. USDA Natural Resources Conservation Service, Washington, D.C.

Gandhi, G.; Savalia, S. G. and Verma, H. P. (2013). Soil-site suitability evaluation for sesame in calcareous soils of Girnar toposequence in Southern Saurashtra region of Gujarat. Journal of Agriculture for Sustainable Development. **1**(1):7-11.

Giri, J. D.; Singh, R. S.; Shyampura, R. L. and Jain, B. L. (1999). Soil and evaluation along coastal Gujarat for alternate land use options. J. Indian Soc. Coastal Agric. Res., **17**(1&2): 76-79.

Leelavathi, G. P.; Naidu, M. V. S.; Ramavatharam, N. and Karunasagar, G. (2009). Studies on genesis, classification and evaluation of soils for sustainable land use planning in yerpedu mandal of Chittoor district. Andhra Pradesh. J. of Indian soc. of soil sci., **57**: 109-120.

NBSS and LUP, (1994). Proc. National meets on soil-site suitability criteria for different crops. Feb. 7-8, 1994 held at NBSS and LUP (ICAR), New Delhi.

Patel, H. P.; Savalia, S.G. and Chopda, M. C. (2012). Evaluation of soil constraints and Soil-site suitability for groundnut in Meghal irrigation command area of southern saurashtra region of Gujarat. An Asian J. Soil Science. **7**(1): 131-137.

Savalia, S. G. (2005). Characterization, classification and evaluation of soil and water resources across the toposequences of Southern Saurashtra. Ph.D. Thesis submitted to J.A.U., Junagadh.

Savalia, S. G.; Kachhadiya, S. P.; Solanki, M. S. and Gundalia, J. D. (2009). Assessment and management of Soil Sustainability of calcareous soils in different landforms in a transect over basaltic trap. An Asian J. Soil Science. **4**(1): 86-92.

Shirgire, S. T.; Savalia, S. G.; Misal, N. B. and Singh, N. (2015). Evaluation of soil constraints and soil-site suitability for sesame in the soils of coastal area of Jamnagar district of Gujarat. Research in Environment and Life Sciences. **8**(3): 501-506.

Sys, I. C.; Vanrasant, B. and Debavye, J. (1991). Land evaluation, Part II and III. Methods in land evaluation. Agric. Pub. General administration for development co-operation place, de, camp de mars, 5 btc, 57-1050, Brussels, Belgium.