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Suitability evaluation for pigeon pea in southern transition zone of Karnataka Plateau, India

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ABSTRACT

Soil - crop suitability studies provide information on choice of crops to be grown on best suited soil unit for maximizing crop production per unit of land, labour and inputs. Soil-site suitability evaluation for identifying potential areas of pigeon pea (*Cajanus cajan*) was conducted at 1:8000 scale in Basavanagiri of Mysore district, Karnataka. Detailed soil survey of study area was carried out using cadastral map and four soil series mapped with 23 soil-mapping units. The results showed that 22 per cent of total area covering four mapping units of Bg 3 soil series is highly suitable for growing pigeon pea. Whereas, sixteen units covering 122 ha is moderately suitable and two mapping units of Bg1soil series are found not suitable for pigeon pea cultivation. Soil depth, topography, effective rooting depth and gravelliness found to be major limitations for pigeon pea production in the study area.

Key words: Mapping units, Pigeonpea, Soil site evaluation.

INTRODUCTION

Pigeon pea [*Cajanus cajan* (L.) Mill sp.] is a second most important grain legume crop next to chickpea, occupies a prominent place in Indian dry land agriculture by covering an area of around 3.9 m ha with productivity of about 729 kg ha^{-1} (MOA, 2016). It is an integral component of various agro ecological systems of the country mainly inter cropped with cereals, pulses, cotton, oilseeds and millets. It is mainly consumed as dry split dal throughout the country as its seeds are rich in dietary protein (20-22%), carbohydrates and high levels of vitamin A and C. Being a legume crop, pigeon pea is reported to be efficient in soil enrichment through extraction of iron-bound phosphorous from typical Alfisols (Ae *et al*., 1990), besides greater N fixation rates compared to several other legumes (Chikowo *et al.,* 2004).

In Karnataka, pigeon pea is a major pulse crop grown in an area of 0.73 m ha with production of 0.47 m tones (MOA, 2016). However, the productivity (651 kg ha^{-1}) is much lower than national average 729 kg ha^{-1} due to several abiotic and biotic constraints. Since it is mainly grown as a rainfed crop, the climatic variability in terms of rainfall and its association with the characteristics of soils such as soil depth, texture, structure, drainage, acidity, salinity, stoniness etc., will influence the crop productivity to a greater extent. Production potential of any crop largely affected by soil-site parameters as conditioned by climate, topography, fertility and management levels (Sehgal, 1991). Systemic study of soil as natural resource provides information on nature and type of soil, their constraints, potentials, capabilities and their suitability for various uses (Sehgal, 1996). Thus, it is crucial to evaluate soil-site suitability of crops to identify potential for particular area for enhancing the productivity of crop and to increase use efficiency of resources. Land suitability evaluation for legumes like chickpea (Meena *et al*., 2012), pigeonpea (Shivaramu, 2012; Hegde *et al,* 2017) and groundnut (Savalia and Gundalia, 2009 and 2010) have been reported. Shivaramu (2012) and Hegde *et al.* (2017) evaluated Kuthanagere watershed of Bangalore rural district and Mormanchi watershed of Gulburga district, Northern Karnataka, respectively and identified suitable areas for pigeon pea. However, such information on soils of Southern transition zone of Karnataka plateau is very scanty, where sizable area is under pigeon pea cultivation (4817 ha). Hence, the present investigation was carried out in H. D. Kote taluk of Mysore district, a major tribal habitats of the state, where pigeon pea is commonly grown in an area of 1280 ha (Mysore- DAG, 2015-16) as sole crop, boarder crop and intercrop with cotton .

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MATERIALS AND METHODS

Location and agro climate

Basavanagiri is located in H.D. Kote taluk of Mysore district, Karnataka (Fig 1). The study site lies between 12° 10′ 65″

to 12° 11′ 36″ N latitude and 76° 26′ 83″ to 76° 27′ 29″ E longitude. Ago climatically, it belongs to Southern transition zone of Central Karnataka plateau, hot, moist semi-arid eco sub region (Velayutham *et al*., 1999). The mean annual precipitation of the area is 885 mm with 55 rainy days. The length of growing period varied from 150 to 180 days.

Soil survey and mapping

Before conducting detailed soil survey of study area, preliminary traversing was carried out by using 1: 8000 cadastral map and drawn topo-sequences to locate profile points in a transect. The slope varied from 3 to 8 per cent. Eighteen soil profiles were opened up to the parent material at selected locations along the transect and morphological characteristics were studied as outlined by Soil Survey Staff (1999). Horizonwise soil samples were collected for laboratory analysis. Processed samples were analysed for various physicochemical properties by following standard procedures (Jackson, 1973). Tentatively four soil series namely Basavanagiri1 (Bg1), Basavanagiri2 (Bg2), Basavanagiri3 (Bg3) and Basavanagiri4 (Bg4) were identified using major differentiating soil characteristics such as soil depth, texture, colour, gravel, nature of sub stratum and horizon sequence (Table 1) were mapped into 23 soil mapping units as phases of soil series (Fig 2). The soils are classified according to Key to Soil Taxonomy (Soil Survey Staff, 1999).

The suitability of soils for growing pigeon pea was evaluated by matching the site characteristics of the studied mapping units with the soil-site suitability requirements (Naidu *et al.,* 2006). The mapping units were grouped as S1 (highly suitable), S2 (moderately suitable having moderate limitations), S3 (marginally suitable having severe limitations) and N (not suitable, lands which has qualities that appears to preclude its sustained use).

RESULTS AND DISCUSSION

Soil maps

The twenty three soil mapping units defined as phases of soil series were mapped on 1:8000 scale to derive soil map of the study area (Fig 2). The map shows that Bg1series with three, Bg2 with ten, Bg3 with eight and Bg4 series with two mapping units covering 10, 31, 33 and 6 percent of total area respectively, were identified with variations in texture, slope, erosion, gravelliness and stoniness. Most of soils were moderately deep to deep having well drained to moderately drained conditions. There were four textural and three slope classes found in the study area (Table 2). The sandy clay loam texture occur dominantly covering 60.7% of total area. The very gently sloping and gently sloping lands have 44 and 32 per cent of total area respectively. Gentle slopes are good for crop production, provided appropriate soil and water conservation measures need to be taken up before cultivation of crops (Naidu *et al*., 2006).

Characterization of soils

The physicochemical characteristics (weighted mean) of the typifying pedons are depicted in Table 3. The pH of the soils in study area ranged from 6.36-8.12. neutral to slightly alkaline in reaction (pH). In general the red soils (P1, P2 and P3), were neutral in nature and black soil pedon (P4) was slightly alkaline in reaction. Relatively high pH value in black soil pedon attributed to nature and the accumulation of the bases in the solum. Similar observation was made by Dasog and Patil (2011). The organic carbon content of soils ranged from 4.95 to 10.28 g kg^{-1} with a mean of 7.31 ±4.02 g kg^{-1}.

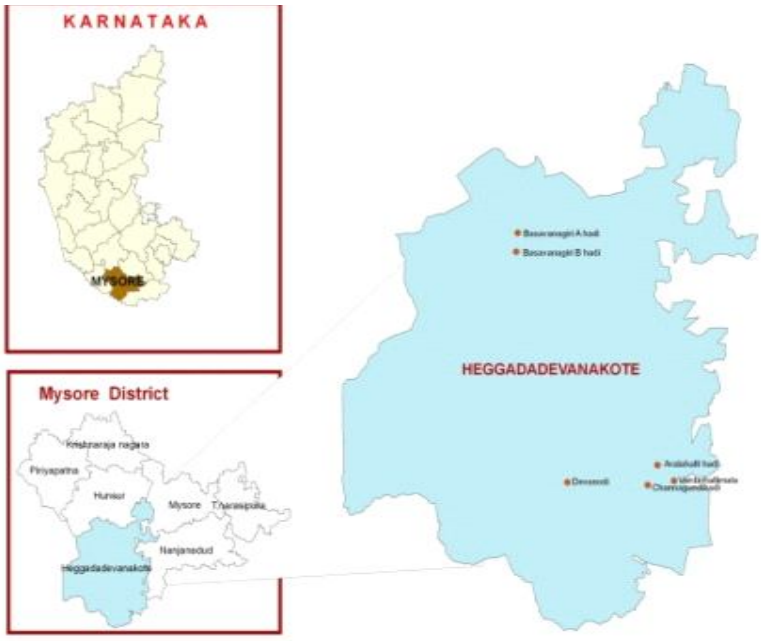

Fig 1: Location map of study area.

Table 1: Morphological features of identified soil series in the study area.

Soil series	Horizon	Depth (cm)	Boundary	Colour		Texture	Structure	Consistency	Gravel volume (%)	Roots	Pores
				Dry	Moist						
Basavanagiri 1 Pedon 1: Loamy-skeletal, Lithic Rhodustalfs											
	A	0-17	as	7.5YR 3/4	7.5YR 3/4	scl	2 msbk	l,vfr, so,po	nil	fc	fc
	Bt1	17-45	cs		2.5 YR 3/6	scl	1msbk	sh, fr, ss,sp	60	ff	cf
Basavanagiri 2 Pedon 2: Fine, Typic Haplustalfs											
	A	0-14	as	5 YR 4/3	5 YR 3/3	scl	2 msbk	sh fr ms mp	nil	ff	fc
	Bt1	14-42	cs		5 YR 3/3	scl	2 msbk	fr ms mp	5-10	ff	cf
	Bt2	42-87	cs		5 YR 3/4	c	2 msbk	fr ms mp	5-10	ff	cf
Basavanagiri 3 Pedon 3: Fine, Rhodic Paleustalfs											
	Ap	0-12	cs	5 YR 4/4	5 YR 3/4	scl	2 msbk	sh fr ss sp	nil	ffm	cf
	Bt1	12-36	gs		5 YR 3/3	c	2 msbk	fr ms mp	nil	ff	cf
	Bt2	36-70	gs		2.5 YR 3/4	c	2 msbk	fr ms mp	nil	ff	mf
	Bt3	70-106	gs		2.5 YR 3/4	c	2 msbk	fr ms mp	nil	ff	mf
	Bt4	106-150	gs		2.5 YR 3/4	c	2 msbk	fr ms mp	nil	ff	mf
Basavanagiri 4 Pedon 4: Fine, Vertic Haplustepts											
	Ap	0-19	cs	10 YR 3/4	10 YR 3/3	c	2 m-c sbk	vh vfi vs vp	nil	cf	cf
	Bw1	19-38	cs		10 YR 3/2	c	3 m-c sbk	vh vfi vs vp	nil	cf	cf
	Bw2	38-72	cs		10 YR 3/1	c	3 m-c sbk	vh vfi vs vp	nil	cf	cf
	Bw3	72-102	cs		10 YR 3/2	c	3 m-c sbk	vh vfi vs vp	nil	cf	cf

*Boundary: c- clear, s- smooth, a-abrupt, g-gradual, Texture: s-sand, c- clay, l- loam, , Structure: m- medium, c –coarse, 2- moderate,3-strong, sbk- subangular blocky, Consistence:l-loose, vfr-very friable, so-non sticky, po –non plastic,sh-slightly hard, ss-slightly sticky, fr- friable, ms-moderately sticky, mp-moderately plastic, vh-very hard, vp-very plastic vs-very sticky -, Roots: f-few, c-common, ff-fine few, m-medium.

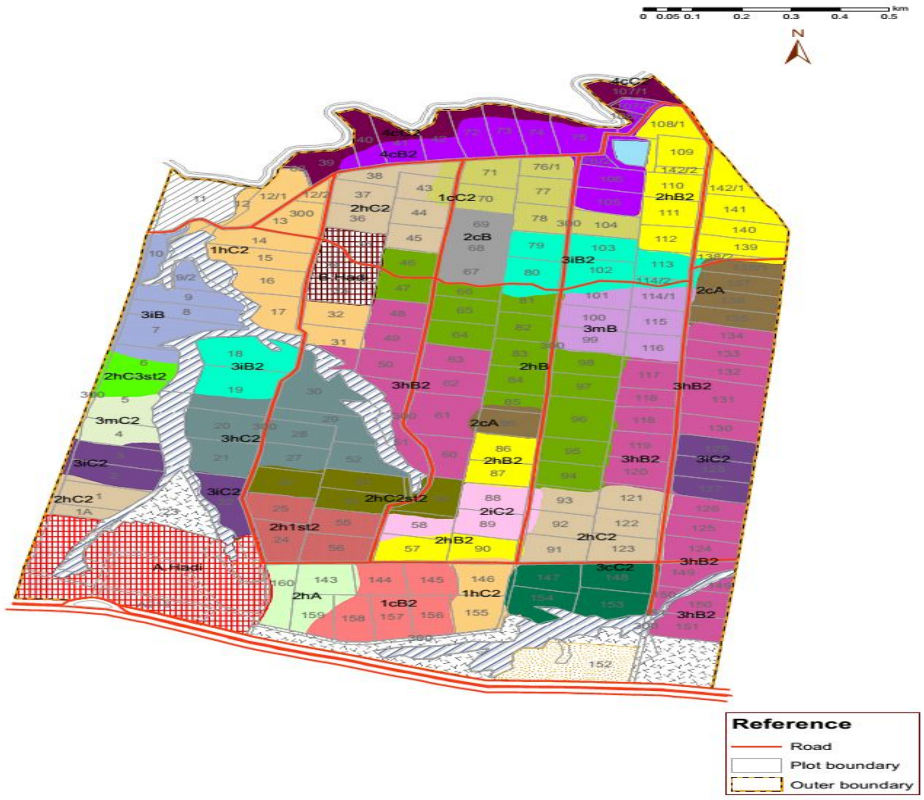

Fig 2: Soil map of Basavanagiri.

Table 2: Extent of spread and soil site characteristics of mapping units.

Soil series	Mapping units	Area		Depth	Texture	Slope	Erosion	Drainage	Gravelliness	Stoniness
		(ha)	(%)	(cm)		%			(%)	(%)
Basavanagiri1	Bg 1cB2	6.50	2.25	25-50	sl	1-3	moderate	Well drained	nil	nil
	Bg 1cC2	7.60	2.29	25-50	sl	3-5	moderate	Well drained	nil	nil
	Bg 1hC2	14.6	5.76	25-50	scl	3-5	moderate	Well drained	nil	nil
Basavanagiri 2	Bg 2cA	5.80	2.29	75-100	sl	0-1	slight	Well drained	nil	nil
	Bg 2cB	3.50	1.36	75-100	sl	1-3	slight	Well drained	nil	nil
	Bg 2hA	5.40	2.13	75-100	scl	0-1	slight	Well drained	nil	nil
	Bg 2hB	3.70	1.44	75-100	scl	1-3	slight	Well drained	nil	nil
	Bg 2hBg1st2	17.60	6.95	75-100	scl	1-3	slight	Well drained	15-35	0.1-3
	Bg 2hB2	16.40	6.46	75-100	scl	1-3	moderate	Well drained	nil	nil
	Bg 2hC2	15.60	6.14	75-100	scl	3-5	moderate	Well drained	nil	nil
	Bg 2hC2st2	5.50	2.16	75-100	scl	3-5	moderate	Well drained	nil	0.1-3
	Bg 2hC3st2	2.00	0.80	75-100	scl	3-5	severe	Well drained	nil	0.1-3
	Bg 2iC2	4.10	1.61	75-100	scl	3-5	moderate	Well drained	nil	nil
Basavanagiri 3	Bg 3cC2	5.80	2.27	>150	sl	3-5	moderate	Well drained	nil	nil
	Bg 3hB2	32.20	12.68	>150	scl	1-3	moderate	Well drained	nil	nil
	Bg 3hC2	11.40	4.50	>150	scl	3-5	moderate	Well drained	nil	nil
	Bg 3iB	6.40	2.51	>150	scl	1-3	slight	Well drained	nil	nil
	Bg 3iB2	11.00	4.32	>150	scl	1-3	moderate	Well drained	nil	nil
	Bg 3iC2	8.10	3.21	>150	scl	3-5	moderate	Well drained	nil	nil
	Bg 3mB	6.30	2.49	>150	c	1-3	slight	Well drained	nil	nil
	Bg 3mC2	2.60	1.01	>150	c	3-5	moderate	Well drained	nil	nil
Basavanagiri 4	Bg 4cB2	9.40	3.70	100-150	ls	1-3	moderate	Moderately well drained	nil	nil
	Bg 4cC2	4.80	1.88	100-150	ls	3-5	moderate	Moderately well drained	nil	nil

Table 3: Physical and chemical characteristics (Weighted mean) of soil series.

Soil series/ soil taxanomy	Bg1- Loamy-skeletal, Lithic Rhodustalfs	Bg2- Fine, Typic Haplustalfs	Bg3- Fine, Rhodic Paleustalfs	Bg4- Fine, Vertic Haplustepts
Soil depth (cm)	45	87	151	102
Particle size distribution				
Sand (%)	66.47	47.76	50.57	42.98
Silt (%)	5.96	18.70	7.15	9.05
Clay (%)	27.57	33.54	42.28	47.59
pH (1.25)	6.78	7.17	6.36	8.12
EC (dSm^{-1})	0.03	0.06	0.04	0.16
OC (g/kg)	10.28	8.43	5.54	4.95
CEC (cmol/kg)	16.62	27.94	15.30	29.56
BS (%)	99	98	99.00	97.00

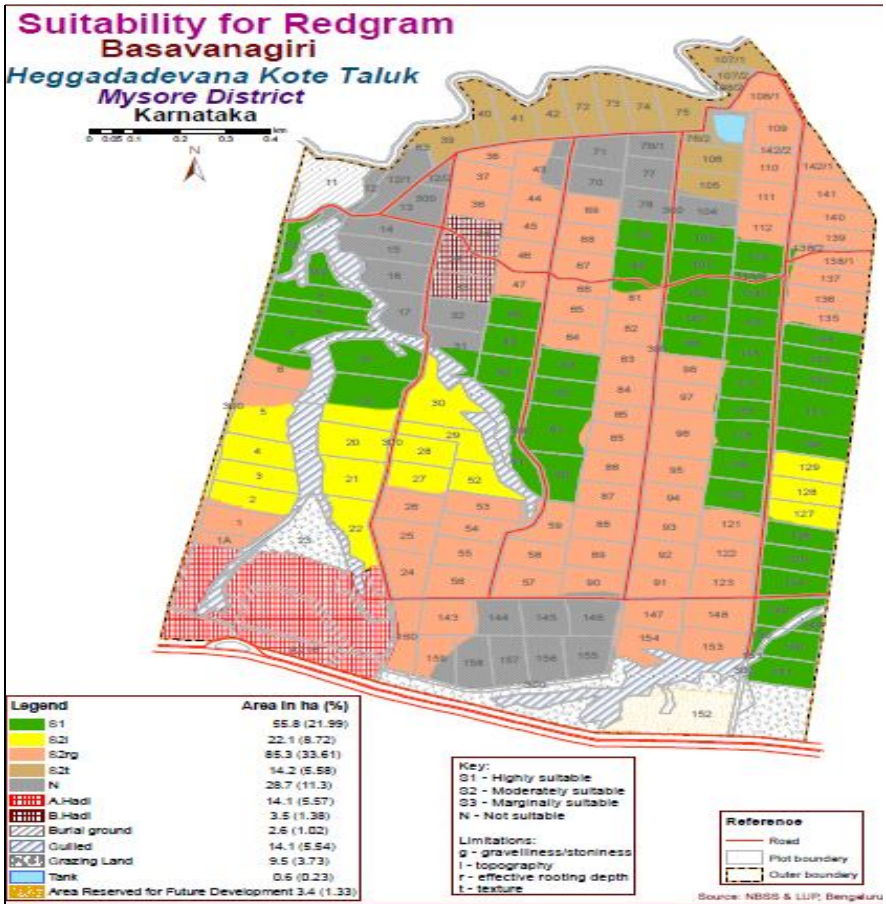

Fig 3: Soil suitability map for pigeon pea in Basavanagiri.

It was found that around 93 per cent of soils have medium to high status of organic carbon, which promotes good structural condition and stability for crops (Pam Hazelton and Brain Murphy, 2016). Cation Exchange Capacity (CEC) of the pedons varied from 15.3 cmol (p+) kg^{-1} in P3 to 29.56 cmol (p+) kg^{-1} in P4. There was a high degree of correlation between clay and CEC in both red and black soil. CEC of the soils in all the pedons followed the trend of clay distribution in soil (Thangyasamy *et al*., 2005). Relatively low CEC (P1 and P3) is attributed to high sand content of the soils (Table 3). The per cent base saturation varied from 97 to 99. The higher base saturation might be due to higher Ca^{+} occupying exchange sites on the colloidal complex. Similar results were also quoted by Sireesha and Naidu (2013).

Suitability evaluation

Bg3 soil series with Bg3hB2, Bg3iB, Bg3iB2 and Bg3mB mapping units constituting 22% total area were highly suitable for cultivation of pigeon pea (Fig 3). As Bg3 soils

Table 4: Soil site suitability and management strategies for pigeon pea.

Suitability class	Mapping units	Limitations	Management strategies
S1	Bg 3hB2	No limitations	Suitable HYV and soil test based integrated nutrient management
	Bg 3iB		
	Bg 3iB2		
	Bg 3mB		
S2l	Bg 3hC2	Topography	Contour trench cum bunding, opening of dead furrows perpendicular to slope for in-situ water conservation
	Bg 3iC2		
	Bg 3mC2		
	Bg 4cB2		
	Bg 4cC2		
S2rg	Bg 2cA	Effective rooting depth, gravelliness/ stoniness	Short duration varieties, opening of dead furrows perpendicular to slope for in-situ water conservation, protective irrigation (if possible from farm pond), mulching with grass or stone, if terminal drought harvest pods for vegetable purpose
	Bg 2cB		
	Bg 2hA		
	Bg 2hB		
	Bg 2hBg1st2		
	Bg 2hB2		
	Bg 2hC2		
	Bg 2hC2st2		
	Bg 2hC3st2		
	Bg 2iC2		
	Bg 3cC2		
N	Bg 1cB2	Depth and slope	Grow alternative crops like minor millets and sesame/green gram
	Bg 1cC2		
	Bg 1hC2		

are very deep occur on gently sloping lands coupled with sandy clay loam surface horizon and clay texture in the subsurface horizons. This helped in better infiltration and moisture holding capacity of soil in sub-soil layers favoured in enhanced water and nutrient uptake by the crop. Pigeon pea being a long duration crop with deep rooting pattern requires longer LGP for higher productivity. Shivaramu (2012) reported that productivity of pigeon pea significantly influenced by soil site parameters such as soil depth, coarse fragments and slope. However, sixteen mapping units of Bg2, Bg3 and Bg4 series constituting larger area of 122 ha are moderately suitable with moderate limitations of topography, effective rooting depth and gravelliness (Fig 3) (Naidu *et al.,* 2006). In these areas, construction of contour trench cum bunds and opening of dead furrows perpendicular to slope for in-situ moisture conservation and growing of suitable varieties will help in improving the productivity of pigeon pea (Table 4). The mapping units of Bg1 series were found not suitable for pigeon pea with severe limitations of soil depth (Chadar *et al.,* 2018). Since, Bg1 series are shallow (25-50 cm) soils growing of alternative crops like minor millets and sesame or green gram would be ideal.

CONCLUSION

The soil site suitability evaluation Basavanagiri soils showed that around 70 per cent of total study area has potential for pigeon pea cultivation. Excluding Bg1 series all other identified soil series are suitable for pigeon pea cultivation. However, four soil mapping units of Bg3 series is highly suitable and sixteen mapping units of Bg2, Bg3 and Bg4 soil series are moderately suitable with limitations of topography, effective rooting depth and gravelliness.

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