Soil-Site Suitability for Wheat in Different Agro-Climatic Regions of Punjab

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***Abstract** : Productivity indices for 16 soils developed under different agro-climatic regions, were calculated by giving the ratings for different limiting soil characteristics. It is seen that for wheat, the well drained, medium textured soils with cambic diagnostic horizons (Vijalpur and Tulewal) are highly productive. It is found that the increasing degree of limitations decreases the productivity. Saline Nanaksar, saline and calcareous Machaki Kalan, poorly drained Kapurthala, and stratified Jalalpur soils have low productivity. Kanjli, Gondpur, Sarkowal, Gulpur, Gurdaspur, Samana soils have moderate productivity. The validity of the land coefficients (LC) ratings was supported by the linear regression coefficient relating yields of wheat obtained under recommended practices. It suggests the reliability of soil parameters, such as drainage, texture, lime content, fertility status and salinity for soil site suitability evaluation for wheat.*

Soil survey provides an information on the soil types and their distribution. However, administrators and land users are interested in its suitability for alternative land uses rather than the map with hard legend. The soil suitability for crop production is based on soil properties affecting root ramification, and supply of moisture and nutrients (Bartelli, 1978) and other factors like topography, and climate. It is, therefore, imperative to evaluate soil and site properties in relation to crop production. Punjab the state of larger wheat producing area, has little information on this aspect. In view of this the present investigation was undertaken.

MATERIAL AND METHODS

Sixteen soil profiles from the fields under simple fertilizer trials representing soils on terraces, piedmont, filled up channels and flood plains in the Ustic and Aridic moisture regime zones of Punjab (Fig. 1) were studied for morphological and physico-chemical characteristics. Productivity of soils was

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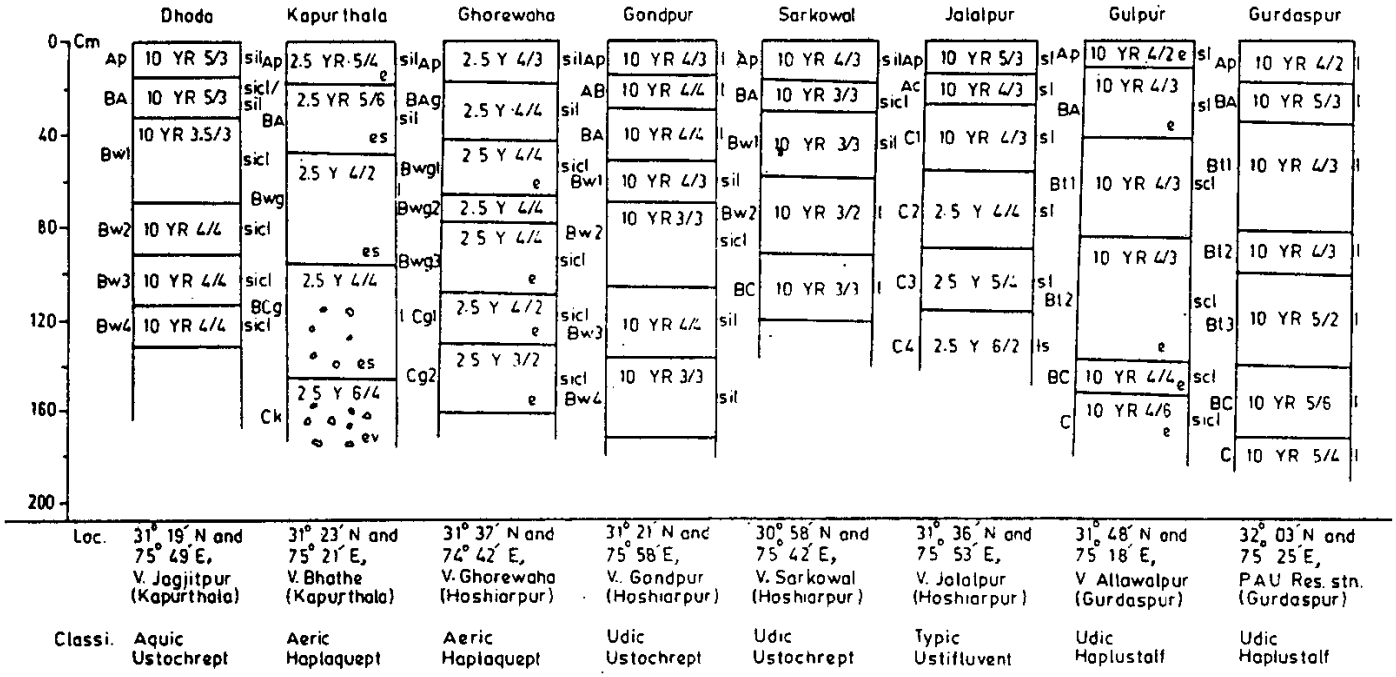

Figure 1. Morphology and taxonomy of soils

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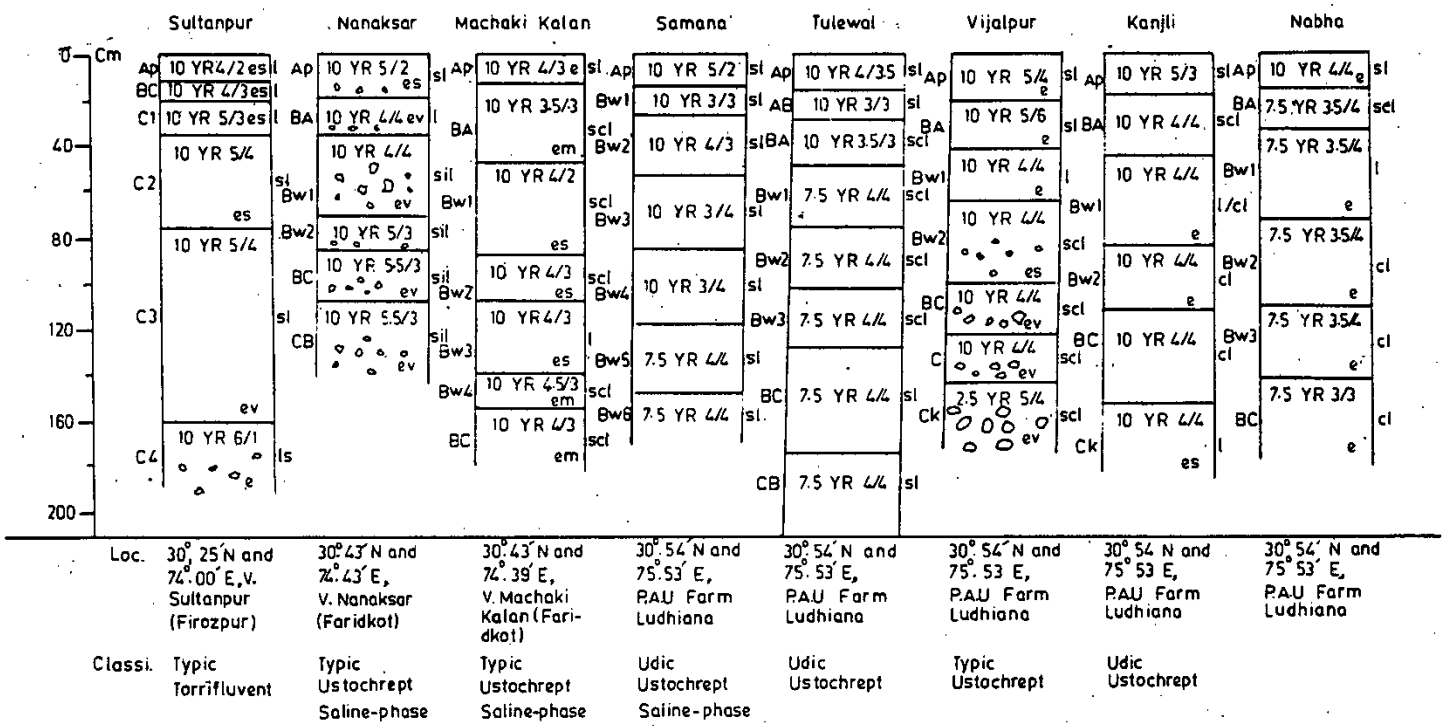

Figure 1. Morphology and taxonomy of soils

evaluated using the parametric (Riquier *et al.* 1970) and limitation approaches (FAO, 1976; Sys, 1981). The variables like drainage, texture/structure, nature of clay/exchange capacity, organic matter, calcium carbonate, sodium saturation and soluble salts were used to evaluate the productivity of soils for wheat. For the purpose, the data on wheat yields obtained through the adoption of recommended management level and with farmers' practices were collected from the research stations (Ludhiana and Gurdaspur) of Punjab Agril. University, Ludhiana.

Rating for the soil and site paramters for wheat was computed as suggested by Riquier *et al.* (1970), Sys. (1981, 1986) and Sehgal (1986) and expressed in terms of degree of limitation from 0 to 4 (Table 1). Each parameter was assigned a suitable rating. The productivity index or land coefficient was worked out and correlated with yields to find out the reliability of these ratings.

RESULTS AND DISCUSSION

The soils vary in respect of drainage, texture, profile development (diagnostic horizons), fertility status, lime and salt content (Table 2, Fig. 1) and also in productivity ratings for wheat (Table 3).

The productivity index is high in soils of Vijalpur, Kanjli and Tulewal series (69 to 77), which are well drained and medium textured (sl to scl) except for Kanjli soils (clay loam texture in the sub-soil). They are developed in semi-arid and sub-moist zone (Ustic moisture regime), and show the development of cambic (structural) horizon. The clay content (12-14 % in the surface horizons) increases with depth (20-25 % in the B-horizon). These medium textured, well aerated soils favour unrestricted development of roots, and hence high productivity. The yield of wheat in these soils at the recommended level of management varies between 43.1 and 51.2 ha.

Gondpur, Nabha, Sarkowal, Dhoda and Ghorewaha soils with productivity index between 51 and 66, have medium texture (sl/l/sil) in surface horizons and relatively heavy texture (cl/l/sicl) in subsurface horizons. They qualify for fine loamy family. The y have blocky structure in the subsoil and the B-horizon meets the requirements of cambic diagnostic horizon. Ghorewaha, Dhoda and Sarkowal soils also show characteristic wetness suggesting restricted drainage, caused by fluctuating water table. Nabha and Gondpur soils are non-calcareous, moderately well drained, and free from characteristic wetness, (Udic Ustochrepts). They produced wheat yield of about 40 q ha^{-1} with productivity index of 66. The imperfectly drained Dhoda soils and poorly drained ghorewaha soils (artificially drained) have low productivity. index of 52 and 51 with corresponding yields of 34.0 and 33.7 a ha^{-1}.

Kapurthala soils are poorly drained and show the wetness below the plough

TABLE 1. Evaluation of soil and site characteristics for wheat production in Punjab

Land characteristics	Range in the degree of limitation				
	0	1	2	3	4
Topography					
Slope (%)	0-2	2-8	8-16	16-30	30+
Wetness Limitations					
Drainage					
1. Med. & fine text-	Well	Moderate	Imeprfect	Poor (50)	Excessive
-ure soils	(100)	(90)	(80) (*dr 85)	(dr. 70)	(20)
2. Coarse textured	Imperfect	Moderate	Well		
soils	(100)	(90)	(70)		
Physical Soil Conditions	Sil,Scl	Sl+Cl	Sl-,Sc	ls,Sic	Sic, C
Texture	(100)	(90)	(80)	5(45)	(40)
Stoniness (%)	5	5-15	15-40	40-80	+80
	(100)	(90)	(80)	(60)	(25)
Depth (cm)	+120	80-120	50-80	20-50	-20
	(100)	(90)	(75)	(55)	(30)
Fertility (+)	Bw	A-C	Bt	Bn	--
Profile development	(100)	(90)	(80)		
Fertility requirements:					
Organic carbon (%)	0.6	0.6-0.4	0.4-0.2	0.2	--
(0-15) cm	(100)	(90)	(80)	(70)	--
CEC (meq/100 g)	16	16-12	12-8	8-4	--
(B-horizon)	(100)	(90)	(80)	(70)	--
Salinity & Alkalinity					
EC (mmhos/cm) in Sat.	0-2	2-4	4-6	6	
Extract	(100)	(90)	(85)	(80)	
Na-saturation (ESP)	20	20-30	30-40	40	
	(100)	(90)	(85)	(80)	
Base saturation	All the soils are saturated with bases, not evaluated				

* dr = Artificially drained

TABLE 2. Characteristics of the studied pedons

Soil Series	Drainage	Texture (0-20 cm)	Texture (20-100 cm)	Lime (%)	Fertility CEC(meq 1) (50-100 cm)	OC (%) (0-20 cm)	Salinity (Ece) mmhos/cm) (0-20 cm)	Salinity (Ece) mmhos/cm) (20-100 cm)	Profile Dev.
Sultanpur	Well	l(19.3)	Sl(16.1)		2.4	6.5	0.35	1.4	0.9	Ac
Nanaksar	Mod.well	Sl(13.6)	Sil(15.8)		8.2	8.3	0.27	6.4	2.8	Bwk
Machaki Kalan	Well	Sl(16.0)	Sl(18.0)		0.4	12.8	0.24	3.5	3.6	Bw
Samana	Well	Sl(14.2)	Sl(20.5)		0.0	9.3	0.26	0.7	0.0	Bw
Tulewal	Well	Sl(13.0)	Scl(21.5)		0.0	12.5	0.25	0.9	0.6	Bw
Vijalpur	Well	Sl(14.0)	Scl(22.0)		0.8	11.7	0.40	1.4	1.2	Bw
Kanjli	Mod.well	Sl(12.3)	Scl(25.5)		0.8	16.0	0.53	1.3	1.1	Bw
Nabha	Mod.well	Sl(17.6)	l-cl(27.5)		0.0	16.6	0.52	1.2	1.1	Bw
Dhoda	Imperfect	Sil(24.2)	Sicl(33.5)		0.0	13.4	0.44	1.90	1.2	Bw
Kapurthala	Poor	Sil(14.8)	l(21.0)		3.5	12.2	0.52	2.9	2.8	Bwg
Ghorewaha	Poor	Sil(21.8)	Sicl(34.0)		0.0	20.4	0.50	0.9	1.3	Bwg
Gondpur	Mod.well	l(14.8)	Sicl(27.5)		0.0	20.5	0.50	1.2	0.7	Bw
Sarkowal	Imperfect	Sil(21.8)	Sicl(25.5)		0.0	14.5	0.74	0.8	0.6	Bw
Jalalpur	Well	Sl(11.4)	Sl(20.0)		0.0	8.4	0.20	0.8	0.6	Ac
Gulpur	Mod.well	Sl(16.3)	Scl-cl(24.5)		0.0	16.0	0.70	1.8	1.5	Bt
Gurdaspur	Mod.well	l(12.4)	l(17.5)		0.0	11.5	0.60	0.5	0.5	Bt

Figures in parethesis indicate clay per cent; ESP is 20 and the soils are saturated withbases; Clay, lime, CEC and ECe (weighted average).

layer. The major limitations are poor drainage and low Cation Exchange Capacity. They have productive index of 46 and yields production of 38 q ha^{-1}. Considerable reduction in wheat yield has been reported by De la Rosa et al. (1981) due to fluctuating water table and the characteristics associated with wetness.

Gulpur and Gurdaspur soils of stable terraces are developed under annual rainfall of 800 mm and MAT of 23.2° C. They have clay enriched B (argillic) horizon. Thin patchy to continuous clay coatings are present in the pores and ped faces. Gurdaspur soils are medium textured (clay, 12 % in surface and 15-20 % in B horizon). On the other hand, the Gulpur soils have finer texture in the subsurface horizons (scl/cl with 17-32 % clay). Both these soils qualify for fine loamy family of Udic Haplustalfs with a productivity index of 58. The yield of wheat in these soils is comparatively less (33 q ha^{-1}), as they are traditional paddy soils with compact plough pan between 15 to 3 cm (Sur *et al.* 1981).

Low yields in fine textures soils (Dhoda, Kanjli, Nabha, Sarkowal, Gondpur series) and in soils showing the development of clay enriched B (argillic) horizons (Gulpur and Gurdaspur series) may be due to restricted aeration

TABLE 3. Evaluation of soil types for wheat according to soil-site characteristics

Soil Series	Drainage	Physical characteristics		Fertility Limitations			Salinity (EC mmhosin sat. Extr.)	Land coeffi-cient	Yield (qha^{-1})
		Texture	Lime	CEC(meq/1) (B hor.)	OC(%) (Ap)	Profile Dev.			
Sultanpur	0(100)	0(100)	2(90)	2(80)	2(85)	1(90)	0(100)	55	44.0
Nanaksar	1(90)	0(100)	0(100)	2(80)	2(85)	2(80)	2(80)	49	38.0
Machaki Kalan	0(100)	0(100)	2(90)	2(85)	0(100)	0(100)	2(80)	51	36.5
Samana	0(100)	1(90)	2(90)	2(80)	2(85)	0(100)	0(100)	55	38.0
Tulewal	0(100)	0(100)	2(90)	1(90)	2(85)	0(100)	0(100)	69	50.9
Vijalpur	0(100)	0(100)	1(95)	1(90)	1(90)	0(100)	0(100)	77	51.2
Kanjli	1(90)	1(90)	1(95)	1(100)	1(90)	0(100)	0(100)	69	43.1
Nabha	1(90)	1(90)	2(90)	0(100)	1(90)	0(100)	0(100)	66	39.8
Dhoda	2(80)	1(90)	2(90)	1(90)	1(90)	0(100)	0(100)	52	34.0
Kapurthala	3(70)	0(100)	1(95)	1(95)	1(90)	1(90)	0(100)	46	33.7
Ghorewaha	3(70)	1(90)	2(90)	0(100)	1(90)	0(100)	0(100)	51	33.7
Gondpur	0(100)	1(90)	2(90)	2(80)	2(85)	0(100)	0(100)	55	38.0
Sarkowal	2(80)	1(90)	2(90)	1(90)	0(100)	0(100)	0(100)	58	38.8
Jalapur	0(100)	2(80)	2(90)	2(80)	2(85)	0(90)	0(100)	44	31.0
Gulpur	1(90)	1(90)	2(90)	0(100)	0(100)	2(80)	0(100)	58	33.0
Gurdaspur	1(90)	0(100)	2(90)	1(90)	0(100)	2(80)	0(100)	58	33.0

affecting the root growth. Minimum pore size for root entry is reported to be 0.1 to 0.4 mm diameter (Weir-sum, 1957). On the fine textured soils the pores are finer due to destruction of structure and dispersion of clay during puddling (Ghildyal, 1978; Moorman and Breeman, 1978).

Samana and Jalalpur soils developed in Ustic moisture regime zone are coarse loamy, non-calcareous, well drained, free from salinity hazard and low in organic carbon. Samana soils showing the development of structural B-horizon (Udic Ustochrept) have productivity index of 51, whereas Jalalpur soils are young and stratified (Typic Ustifluvents) with productivity index of 44. The wheat yields from Samana and Jalalpur soils are 38 and 31 q_t ha^{-1} respectively (Table 3).

Sultanpur soils from the old flood plain in the arid zone are stratified and low in lime and organic carbon content. They are loamy in the upper 34 cm and sandy loam below, and are not affected by flooding and waterlogging. Their productivity index is 55 with yield capacity of 40 q_t ha^{-1} (Table 3).

Machaki Kalan and Nanaksar soils also show the development of weak subangular blocky structure in the B-horizon suggesting the formation of altered B (cambic) horizon. The texture of the surface horizons is sandy loam and that of B-horizon, silt loam/sandy clay loam. The clay content is low in the surface horizons (13-16 %) which

increased to a level of 18 per cent in the subsoil horizons in the Nanaksar profile and 23 per cent in Machaki Kalan profile. They are classified as Typic Ustochrepts. Nanaksar soils qualify for coarse loamy and the Machaki Kalan soils, for fine loamy textural family. The electrical conductivity of saturation extract (ECe) of the surface horizons is 6.4 and 3.5 mmhos/cm, respectively. The water table in these soils fluctuates between 1.0 and 1.5 metre which is responsible for the accumulation of salts in the soil profile. The Nanaksar soils are highly calcareous ($CaCO_3$ 3-15 %) in the upper 50 cm, whereas Machaki Kalan soils are almost normal ($CaCO_3$ 0.4 %) (Table 2).

The productivity indices of Nanaksar and Machaki Kalan soils are 49 and 51 with the yield capacity of 38 and 36.5 q/ha, respectively. These relatively low indices are due to the limitation of salinity and low inherent fertility.

It may be concluded that medium textured, well drained soils of Vijipur, Tulewal, Kanjli, Nabha and gondpur soil-series having structural B horizon, and l and coefficient between 66 and 77 are best suited for wheat. Increase in degree of limitation decrease the productivity. Saline Nanaksar, poorly drained Kapurthala, and Young and stratified Jalalpur soils have low productivity. The remaining soils have moderate productivity for wheat. The validity of the land coefficients (LC) is supported by the linear regression equation, YW = 8.0 + 0.526 LC (r = 0.83), relating yields obtained under recommended package of practices. Thus, the land coefficients/ratings appear to be a reliable parameter for soil-site suitability.

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