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# Soil Suitability for Rice in Different Agroclimatic Zones of Punjab

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**Abstract :** *Dominant soils of terraces, piedmont, filled up channels and floodplains in the ustic and aridic zones of Punjab were studied for suitability evaluation for rice. The soils varied in morphological, physicochemical, mineralogical characteristics and degree of profile development. The productivity was evaluated using parametric/limitation approaches and found to be high in moderately well drained, medium/fine textured soils showing the development of cambic/argillic horizon. The validity of the land coefficients was further supported by linear regression relating to the yield of rice obtained under recommended package of practices. The significant correlation between yield and land coefficient values suggests the reliability of soil parameters for evaluating soil suitability for rice.*
(**Key words** : *Soil suitability evaluation, land coefficients, productivity indices, soil variability).*

The productivity ratings of soils based on soil-site characteristics is found significant in crop production under defined management systems. (Storie 1933, 1976 & Riquier *et al.* 1970; FAO 1976). However, the information on this aspect specific to rice grown in Punjab and covering major acreage (2 ha) is lacking. In the recent years, rice is being grown on light and medium textured soils without assessing their suitability. It therefore necessary to evaluate the soil in a given agroclimatic zone for production of rice under defined management system.

## MATERIAL AND METHODS

Dominant soils of terraces, floodplains, channels (filled up) and interdunal areas in ustic and aridic zones of Punjab were selected for soil-site suitability evaluation for rice. Seventeen soil profiles varying in texture, drainage, carbonates, salts and profile development were exposed to 1.5 to 2.0 m depth and studied for their morphology and physico-chemical characteristics according to standard procedures (Soil Survey Staff 1951).

The fields of ongoing simple fer-

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tilizer trials on rice (IR-108) were selected. All these experiments received recommended management practices. The crop yield at the recommended management level was used for evaluating the productivity of soils (Table 1) by using parametric approach (Riquier *et al.* 1970), and limitation approaches (FAO 1976 and Sys 1981). The variables like drainage, texture, lime content, exchange capacity, organic carbon, salinity and sodium saturation were the parameters used to evaluate soil productivity.

The suitability criteria by slightly modifying the ratings given by Sys (1981), and Sehgal (1986) for organic carbon and calcium carbonate is given in Table 1. The selected parameters for suitability evaluation for each soil is given in Table 2. The productivity indices or land coefficients based on the indices for individual soil characteristics and degree of limitations have been calculated (Table 3).

## RESULTS AND DISCUSSION

Data indicated that the productivity indices in general, are high in fine texture soils. The range of physico-chemical characteristics of soils (Table 2) indicated that the Dhoda, Ghorewaha, Gondpur and Sarkowal soils from ustic (semi-arid and less hot) zone have sandy loam to silt loam texture at surface layer and finer texture (silty clay loam) in the subsurface horizons. The Kanjli, Nabha, Sarkowal and Gulpur soils have sandy loam surface texture and sandy clay loam/clay loam subsurface texture. Kanjli, Nabha, and Gondpur soils are moderately well drained whereas the Dhoda, Sarkowal and Rawalpindi soils have imperfect and Gorewaha soil has poor drainage. All these soils except Gulpur series have structural (cambic) horizon and qualify for the great group Ustochrepts. Gulpur soils show the development of argillic horizon and qualify for the Haplustalfs great group.

Kanjli, Nabha and Gondpur soils have the limitations of low organic carbon and lighter surface textures giving the land coefficients of 65 and rice yields of 62.7, 59.3 and 67.8 $qha^{-1}$, respectively. Comparatively low yield in case of Nabha soils is probably due to slight limitation of CEC.

The Gulpur soils have slight limitation of drainage and moderate limitation of surface texture while

TABLE 1. Soil-site parameters and their limitation scores for suitability of rice.

| Land characteristics | Range in degree of limitation | | | | |
|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 |
| **Topograhy (t)** | | | | | |
| Slope (%) | 0-1 (100) | 1-2 (90) | | | |
| **Characteristics of wetness limitation** | | | | | |
| Drainage | Imper-fect (100) | Mod. well (90) | Well (80) | Excessive (45-60) | |
| Flooding | No (100) | Slight (90) | Slight (70) | Mod. (50) | Sev. (50) |
| **Characteristics with regard to physical soil conditions** | | | | | |
| Texture | Sicl,Cl Sil + (100) | C(m),Sc Sic,Sil (90) | L,SCl, Si,Sl + (80) | Sl,lS (50) | lS (25) |
| **Stoniness** | | | | | |
| Surface | No (100) | 15 (90) | 35 (80) | 55 (60) | - |
| Subsoil | No (100) | 35 (90) | 55 (80) | 55 (60) | - |
| Depth (cm) to 1 m permeable layer | 70 (100) | 50 (90) | 20 (65) | 20 (55) | - |
| **Characteristics with regard to fertility** | | | | | |
| CEC (me/100 g) | 16 (100) | 16-12 (90) | 12-8 (80) | 8-4 (70) | - |
| Org. carbon (%) (0-15 cm) | 0.6 (100) | 0.6-0.4 (90) | 0.4-0.2 (85) | 0.2 (85) | - |
| **Salinity and alkalinity in saturation extract** | | | | | |
| EC(dS/m) | 2 (100) | 2-4 (90) | 4-6 (85) | 6 | - |
| Na saturation (ESP) | 20 (100) | 20-30 (90) | 30-40 (80) | 40 (70) | - |

Source: Sys, C. 1981; Mod. = moderate; Sev. = Severe; C = Clay loam, Sil = Silt; Sicl = Silty clay loam; Sil = Silt loam; C = Clay; SC = Sandy clay; LS = Loamy sand.

TABLE 2. Range of characteristics of some rice-growing soils of Punjab

| Soil series | Drainage | Texture Sur-face | Sub-surface | Lime (%) | CEC (50-100cm depth) | OC (%) Surface | ECe(dS/m) Sub-surface | Dev. | Profile |
|---|---|---|---|---|---|---|---|---|---|
| Dhoda | Imper-fect | SiL (24) | SICL (27-40)* | Nil | 12-14 | 0.44 | 1.9 | 0.9-1.5 | Bw |
| Ghorewaha | Poor | SiL (22) | SICL (31-37) | Nil | 16-22 | 0.50 | 0.9 | 0.8-1.3 | Bwg |
| Ghondpur | Mod.well | L (15) | SICL (17-38) | Nil | 12-25 | 0.50 | 1.2 | 0.6-0.8 | Bw |
| Gulpur | Mod.well | SL (16) | SCL-CL (17-32) | Nil | 14-18 | 0.70 | 1.8 | 1.4-1.6 | Bt |
| Gurdaspur | Mod. well | SL (12) | L (15-20) | Nil | 10-13 | 0.60 | 0.5 | 0.2-0.6 | Bt |
| Jalalpur | Well | SL (11) | SL (13-17) | Nil | 8.5 | 0.20 | 0.8 | 0.5-1.8 | Ac |
| Kanjli | Mod.well | SL (12) | SCL-CL (20-31) | 0.8 | 14-20 | 0.53 | 1.3 | 1.0-1.2 | Bw |
| Kapurthala | Poor | SiL (15) | L (20-22) | 3.5 | 12-14 | 0.52 | 2.9 | 2.8 | Bwg |
| Machaki-Kalan | Well | SL (16) | SiL (18-23) | 0.4 | 10.15 | 0.24 | 3.5 | 3.2-5.3 | Bw |
| Nabha | Mod.well | SL (18) | LCL (24-31) | Nil | 15-19 | 0.52 | 1.2 | 0.9-1.3 | Bw |
| Nanaksar | Mod.well | SL (13) | SiL (14-18) | 8.2 | 8.5 | 0.27 | 6.4 | 1.6-3.9 | Bwk |
| Narika | Mod.well | SL (14) | L-SCL (20-27) | 7.2 | 9-12 | 0.17 | 2.4 | 2.8-4.6 | Bw |
| Rawal Pindi | Imperfect | CL (30) | CL (28-37) | 3.5 | 13-15 | 0.45 | 1.6 | 0.7-2.3 | Bw |
| Samana | Well | SL | SL (14-18) | Nil | 8.9 | 0.26 | 0.7 | 0.70 | Bw |
| Sarkowal | Imperfect | SiL (22) | SICL (29-22) | Nil | 14-15 | 0.74 | 0.8 | 0.4-0.7 | Bw |
| Sultanpur | Well | L (19) | SL (12-24) | 2.4 | 6.4 | 0.35 | 1.4 | 0.8 | Ac |
| Tulewal | Well | SL ('3) | SCL (19-24) | Nil | 12.5 | 0.25 | 0.9 | 0.5-0.7 | Bw |

*Figures in parentheses indicate clay per cent; ESP is < 20 and the soils are saturated with bases.

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

| Soil series | Drainage | Texture | | Lime | Fertility | | Salinity | ESP | Land coefficient | Yield ($qha^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Surface | Subsoil | | CEC (B hor) | OC(%) (Ap) | | | | |
| Dhoda | 0 (100) | 1 (90) | 0 (100) | 0 (90) | 1 (90) | 1 (90) | 0 (100) | 0 (100) | 73 | 76.0 |
| Dhota | 2 (80) | 0 (100) | 0 (100) | 0 (100) | 0 (90) | 1 (90) | 0 (100) | 0 (100) | 72 | 76.0 |
| Ghondpur | 1 (90) | 2 (80) | 0 (100) | 0 (100) | 0 (100) | 1 (90) | 0 (100) | 0 (100) | 65 | 67.8 |
| Gulpur | 1 (100) | 2 (90) | 0 (100) | 0 (90) | 1 (90) | 1 (90) | 0 (100) | 0 (100) | 72 | 60.0 |
| Gurdaspur | 1 (90) | 2 (80) | 2 (80) | 0 (100) | 1 (90) | 0 (100) | 0 (100) | 0 (100) | 52 | 60.0 |
| Jalalpur | 2 (80) | 2 (80) | 2 (80) | 0 (100) | 2 (80) | 2 (85) | 0 (100) | 0 (100) | 35 | 51.0 |
| Kanjli | 1 (90) | 2 (80) | 0 (100) | 0 (100) | 0 (100) | 1 (90) | 0 (100) | 0 (100) | 65 | 62.7 |
| Kapurthala | 2 (80) | 1 (90) | 2 (80) | 1 (90) | 1 (90) | 1 (90) | 0 (100) | 0 (100) | 65 | 62.7 |
| Machaki-Kalan | 2 (80) | 2 (80) | 2 (100) | 0 (80) | 1 (100) | 2 (90) | 1 (85) | 0 (90) | 35 | 43.2 |
| Nabha | 1 (90) | 2 (80) | 0 (90) | 0 (80) | 1 (80) | 1 (80) | 0 (85) | 0 (90) | 65 | 59.3 |
| Nanaksar | 1 (90) | 2 (80) | 1 (90) | 2 (80) | 2 (80) | 2 (80) | 1 (85) | 0 (90) | 32 | 46.0 |
| Narika | 1 (90) | 2 (80) | 1 (90) | 2 (80) | 2 (80) | 2 (85) | 0 (100) | 3 (70) | 25 | 26.4 |
| Rawal Pindi | 0 (100) | 0 (100) | 0 (100) | 1 (90) | 1 (90) | 1 (90) | 0 (100) | 3 (90) | 65 | 63.0 |
| Samana | 2 (80) | 2 (80) | 2 (80) | 0 (100) | 2 (80) | 2 (85) | 0 (100) | 0 (100) | 35 | 51.0 |
| Sarkowal | 1 (90) | 0 (90) | 1 (90) | 0 (100) | 1 (90) | 0 (100) | 0 (100) | 0 (100) | 73 | 75.0 |
| Sultanpur | 1 (90) | 1 (90) | 2 (80) | 0 (100) | 2 (80) | 2 (85) | 0 (100) | 0 (100) | 44 | 60.0 |
| Tulewal | 2 (80) | 2 (80) | 1 (90) | 0 (100) | 1 (90) | 2 (85) | 0 (100) | 0 (100) | 44 | 56.7 |

Ghorewaha soils have the moderate limitation of drainage (moderately well drained) and slight limitation of organic carbon (surface horizon). The other fine texture soils like Sarkowal and Dhoda series have three slight limitations of soil texture (surface or subsurface), drainage (only Dhoda series) and inherent fertility. The productivity indices of these soils are as high as 72 or 73. The high productivity indices in these soils are very much in line with the high rice yields (73.5 to 76.0 $qha^{-1}$). These are traditionally rice soils having compact plough pan between 15 to 30 cm (Sur *et al.* 1981).

The Sultanpur soils (Torrifluvents) from the arid zone and Gurdaspur soils (Haplustalfs) from the semi-arid and sub-moist zone have moderate productivity for rice. Sultanpur soils have loam texture upto 34 cm depth and sandy loam below, whereas Gurdaspur soils have loam texture throughout the profile. Thus these soils having two moderate limitations and two slight limitations with productivity indices of 50 and 52 respectively, and rice yield of 60 q $ha^{-1}$.

Nanaksar and Machaki Kalan soils having 4 moderate and 2 or 3 slight limitations have productivity indices of 32 and 35 and rice yields of 46 and 43.2 $qha^{-1}$, respectively. Both these soils have four moderate limitations, *viz.*, drainage, texture (both surface and subsoil); and organic carbon in case of Machaki Kalan, and texture (surface), lime, inherent fertility (CEC and organic carbon) in case of Nanaksar. Low yield in case of Machaki Kalan soils may be due to additional slight limitation of salinity (EC 3-5 $dSm^{-1}$) as the water table fluctuates between 0.8 and 1.5 m depth in this soil. Low land coefficient (32) in case of Nanaksar soils (yield 46 $qha^{-1}$) is mainly due to moderate limitation of lime when compared with Machaki Kalan (35) where there is no limitation of lime. Since waterlogging is not a limiting factor for rice, meaningful correlation between actual rice yield and productivity ratings using parametric approach of Riquier (1970) was reported by Dent (1974) in Thailand. Samana and Jalalpur soils having five moderate limitations have productivity indices of 35 and yield of 51 $qha^{-1}$. Both these soils are not traditionally rice soils. Tulewal soils from semi-arid (less hot) zone have the moderate limitations of drainage, texture (surface) and organic carbon and slight limitations of texture (subsur-

face) and CEC with a land coefficient of 44 and yield 56.7 q $ha^{-1}$; whereas Kapurthala soils from the same zone has land coefficient 42 and yield 57.8 q $ha^{-1}$ owing to moderate limitations of drainage, texture (subsurface) and slight limitations of CEC, organic carbon, texture (surface).

Narike soils has the lowest calculated and actual productivity due to strong limitations of nitrogen (as indicated by low organic carbon content in surface horizon), and sodium saturation alongwith two moderate limitation of CEC and texture (surface) and lime and two slight limitations of drainage and texture (subsurface). This soil has the productivity index as low as 25 and yield of rice 26.4 q $ha^{-1}$. Salinity and alkalinity are the primary obstacles for sustained rice cultivation in these soils (Sawhney & Sharma, 1988).

It may be concluded that imperfectly drainage, deep, fine textured, moderately calcareous ( 6% CaCO3) soils having no salinity (EC 2 dS/m) and alkalinity (ESP ) are best suited for rice. For irrigated rice, nearly level landscapes free from flood hazard are the most suitable sites. The validity of the land coefficients (LC) is supported by the linear regression relating to yield of rice (Yp) obtained under recommended package of practices.

$$Yp = 21.72 + 0.712\,LC\,(r = 0.91^{**})$$

Highly significant positive correlation at 1 per cent probability level between rice yields and land coefficients suggests that the soil parameters used for calculating land coefficients are responsible for variation in crop productivity.

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