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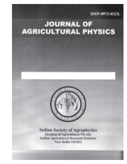

Research Article

Evaluation of Tillage Rating Index of Soils of Uttar Pradesh and Uttaranchal for Appropriate Recommendations

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ABSTRACT

Owing to the complexity of diversified soil, crop and climatic conditions, reliable cost effective tillage recommendations have not been routinely available as in case of fertilizer recommendations. Thus, evaluation of tillage requirement for diversified soil and specifying the soil suitability for tillage treatments are essential for better crop production. A tillage guide is therefore, required for systematic adoption of tillage for different crops under specific soil and agro-climatic conditions. In view of the above, studies on tillage rating were carried out for representative soil profiles in Uttar Pradesh and Uttaranchal states, growing *kharif* and *rabi* crops. Results revealed that the hilly soil of Almora and Bundelkhand soil of Lalitpur have low accumulative tillage rating index (ATRI) values (28 to 33 and 36 to 38, respectively). This could be attributed to high erosivity and erodibility, and low tolerance to soil loss. For such soils, minimum or no seasonal tillage along with corrective soil and moisture conservation measures are suggested. Comparatively higher ATRI values of alluvial soil of Sitapur, Bhabar soil of Nainital and Vindhyan soils of Sonbadra districts (ATRI 39 to 42, 39 to 43 and 40 to 46, respectively) suggest chiseling once in 3 years and secondary tillage for seed bed preparation / or furrow irrigated raised bed planting system for *kharif* and *rabi* crops.

Key words: Tillage rating index, Soils of Uttar Pradesh and Uttaranchal, Tillage recommendations

Introduction

Tillage, defined as the mechanical manipulation of soil aimed at improving soil conditions, is a basic requisite for optimizing the soil physical properties for crop growth. Properly used, tillage can be an important tool to alleviate soil physical constraints and in achieving potential productivity (Bandyopadhyay *et al.*, 2009). Improperly used, tillage can set in motion wide range of degrading processes *e.g.,* deterioration of soil structure, accelerated erosion and disruption in water, carbon and nutrient cycles.

Adopting appropriate tillage management practices keeping into consideration of both the soil and crops will be useful in developing effective management guidelines leading to improved and sustainable crop production. The accumulated tillage rating index (ATRI) estimated from Lal's Model (1985) varied from 37-41 for lateritic sandy loam soil under both rice-wheat and rice-mustard cropping system (Anonymous, 1996a). In alluvial soils of Delhi, Punjab and Haryana States having low organic matter and

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restricted (compact) sub-surface layer and surface crusting, the soil management practices should include ploughing once in 2-3 years, contour, ridge and furrow bed planting (Aggarwal *et al.,* 1997; Gajri *et al.*, 1997). The present investigation was undertaken with the objective to evaluate the tillage rating index and to match appropriate tillage recommendations for representative soils of Uttar Pradesh (U.P.) and Uttaranchal.

Materials and Methods

Soil data

Data on physical and chemical properties of major soil groups of U.P. and Uttaranchal were collected from annual reports of All India Coordinated Research Project on 'Tillage requirements of major Indian soils for different cropping systems', reports of U.P. State Soil Survey, National Bureau of Soil Survey and Land use Planning, Nagpur and research articles of various authors served as sources of data. A tillage rating index based on system approach was developed by Lal (1985) from 14 climate, soil and crop parameters. This system approach has been utilized for identifying suitable tillage for alluvial soil of Sitapur (U.P.), hill soil of Almora (Uttarakhand), Bhabar soil of Nainital (Uttarakhand), Vindhyan soil of Sonbadra (U.P.) and Bundelkhand soils of Lalitpur (U.P.) Data of representative soil profiles of these soils were used to compute accumulative tillage rating indices (ATRI).

Parameters used for computation of tillage rating

Parameters used for computation of tillage rating index (Lal, 1985) are: annual cumulative erosivity (MJ-mm ha^{-1} h^{-1} yr^{-1}), soil erodibility (Mg-ha-h ha^{-1} MJ^{-1} mm^{-1}), soil loss tolerance (Mg ha^{-1} yr^{-1}), slope (%), available water holding capacity (cm), bare soil temperature (maximum) at 5 cm depth (^{0}C), probability of rainless period ≥10 days, soil permeability (μm s^{-1}), change in bulk density (%), relative compaction (%), ground cover (%), soil pH, clay content (%) and CEC [cmol(p^{+})kg^{-1}].

Modifications in the rating system proposed by Lal (1985)

The tillage rating index (Lal, 1985) fails to accommodate the relative importance of some parameters *viz.,* soil temperature, permeability and pH in estimating most appropriate rating index in Indian condition. An attempt was therefore, made to improve the tillage rating index (Aggarwal *et al.,* 1997).

Tillage rating indices (TRI) for soil and climatic parameters

The rating index for different soil and climatic parameters were obtained from the values as reported by Lal (1985) and its modified form. Accumulative tillage rating index (ATRI) was obtained by numerical addition of tillage rating values of all 14 soil and climatic parameters. Finally, the accumulative tillage rating index and the corresponding appropriate tillage system were obtained from the classification described by Lal (1985) and its modified form (Table 1).

Tillage rating indices of different soils belonging the U.P. and Uttaranchal under different cropping systems were computed using Lal (1985) and its modified form.

Results and Discussion

Tillage rating of alluvial soils, Sitapur

Alluvial soil of Sitapur under sub-humid climate with nearly level to gently sloping lands (1.7% slope) and has low cumulative erosivity (3459 MJ-mm ha^{-1} h^{-1} yr^{-1}). The soil loss tolerance was high (>10%) (Table 2). Soils are fine silty, non calcareous and slightly alkaline in nature and suffers from slight to moderate erosion. However, the comparatively low available water capacity, clay content and CEC and higher soil permeability could be major limitations. An accumulative tillage rating index (ATRI) of 41 was obtained for *kharif* crops as per Lal (1985). For cultivation of *rabi* crops, an ATRI of 39 was obtained. However, the ATRI values were the same (42) for *kharif* and *rabi* crops as per modified system. The ATRI obtained following Lal (1985) suggest

Table 1. Accumulative tillage rating index and appropriate tillage systems as suggested by Lal (1985) and its modified form

Accumulative tillage rating	Appropriate tillage system
(i) Lal (1985)	
<30	No tillage farming with periodic following
30-45	Chiseling in the row zone
35-40	Minimum tillage or permanent ridge and furrow system
40-45	Ploughing at the end of the rainy season
>45	Both primary and secondary tillage
(ii) Modified form	
<30	No tillage
30-40	(a)For loamy sand soils: Surface compaction(b)For other than loamy sand soils: Conservation or minimum tillage / construction of ridge and furrow
40-45	Chiseling once in 3 years and secondary tillage only for seedbed preparation/furrow irrigated bed planting system under limited irrigation
>45	Both primary and secondary tillage for soils other than Vertisol and raised bed sunken bed for Vertisol

minimum tillage or ridge-and-furrow system; but furrow-irrigated-raised-bed-planting system in modified ATRI. Velayutham *et al.* (1999) also reported similar findings for alluvial soil. The results of ATRI demonstrate that under rice-wheat cropping system in the Indo-Gangetic plains, growing rice with minimum tillage and wheat under raised bed planting system hold great promise.

Tillage rating of Bhabar soils, Nainital and Vindhyan soils, Sonbadra

Intermediate soil loss tolerance and annual cumulative erosivity were obtained in Bhabar soils (Table 2). These soils are slightly acidic in nature. The cation exchange capacity and clay content of these soils were 20 [mmol (p^+) kg^{-1}] and 29.7%, respectively. The changes in bulk density and compaction were comparatively less. The ATRI of 42 (*kharif* crops) originated in both the methods, while for *rabi* crops the rating values of 43 and 39 were obtained through Lal's rating and its modified form, respectively.

Vindhyan soils has 4.9% slope but with high soil loss tolerance. The annual cumulative erosivity and erodibility of the soils were intermediate. The ATRI values were 42 and 46 for *kharif* and *rabi* crops, respectively as per Lal's method. However, the same were 40 and 44 as per modified tillage rating model.

Comparable ATRI values were obtained for Bhabar soils of Nainital district (39-43) and Vindhyan soil of Sonbadra district (40-46). In both the soils, the cumulative erosivity was of similar magnitude. Comparatively higher soil erodibility and soil slope contributed to lower rating values in Bhabar soils; however these were compensated by comparatively higher clay content and CEC of these soils than in Vindhyan soils. The ATRI values suggest chiseling once in 3 years and secondary tillage for seed bed preparation or raised bed planting system, particularly under limited irrigation water supply.

Tillage rating for Bundelkhand soils, Lalitpur

The soils occur on gently sloping undulating plains with irregular blocks of granites and sand stones. The soils have fairly deep cracks developed from basalt lying over granite. Soils are nearly neutral in reaction, and have higher annual cumulative erosivity, higher erodibility and less soil tolerance (Table 2). The conditions accentuated with unfavourable hydrothermal regimes such as relatively low available water holding capacity, higher maximum soil temperatures during both *kharif* and *rabi*, change

Table 2. Tillage rating for soils of Uttar Pradesh and Uttaranchal

Parameters	Alluvial (Sitapur)			Bhabar (Nainital)			Vindhyan (Sonbadra)			Bundelkhand (Lalitpur)			Hill (Almora)		
	Magni-tude	Rating		Magni-tude	Rating		Magni-tude	Rating		Magni-tude	Rating		Magni-tude	Rating	
		Lal's	Modi-fied		Lal's	Modi-fied		Lal's	Modi-fied		Lal's	Modi-fied		Lal's	Modi-fied
(A) Erosion related factors															
(i) Annual cumulative erosivity (MJ-mm ha^{-1} h^{-1} yr^{-1})	3459	5	5	7000	4	4	8000	4	4	12000	3	3	15000	2	2
(ii) Soil erodibility (Mg-ha-h ha^{-1} MJ^{-1} mm^{-1})	0.04	3	3	0.05	3	3	0.03	3	3	0.09	1	1	0.07	2	2
(iii) Soil loss tolerance (Mg ha^{-1} yr^{-1})	10.1	5	5	6	3	3	6.1	4	4	5.1	3	3	3	3	3
(iv) Slope (%)	1.7	5	5	7	2	2	4.9	3	3	3	4	4	11	1	1
(B) Hydrothermal regime related factors															
(i) Available water holding capacity (cm)	11.1	3	3	16.0	4	4	8-12	3	3	8-12	3	3	8.5	3	3
(ii) (a) Maximum soil temperature (°C) in *kharif*	38.4	2	2	28	4	4	35.7	2	2	42.6	1	1	20	2	2
(b) Maximum soil temperature (°C) in *rabi*	36	3	-	13	5	0	26.1	5	0	33.5	2	0	18	4	-
(c) Minimum soil temperature (°C) in *rabi*	12-15	-	3	5	0	1	18.6	0	5	9.3	0	2	8	-	1
(iii) (a) Probability of rainless period (>10 days in %) for *kharif*	40	4	4	20-40	4	4	40-60	3	3	20-40	4	4	<20	5	5
(b) Probability of rainless period (>10 days in %) for *rabi*	80-90	1	1	<20	4	4	40-60	3	3	20-40	4	4	>80	1	1

(iv) Soil permeability (µm s^{-1}) / Basic infiltration rate	25	1	1	2-5	4	4	3	4	4	5	3	4	1.5-5	4	4
(C) Compaction related factors															
(i) Change in bulk density (%)	6.5	1	1	20	2	2	30-40	4	4	10-20	2	2	8	1	1
(ii) Relative compaction (%)	80	5	5	20-30	3	3	20-30	3	3	30-40	4	4	30-40	4	4
(iii) (a) Ground cover for *kharif*	40-60	3	3	20-40	3	3	40-60	3	3	20-40	4	4	40-60	3	3
(b) Ground cover for *rabi*	40-60	3	3	40-60	3	3	20-40	4	4	20-40	4	4	40-60	3	3
(D) Nutritional and chemical properties															
(i) Soil pH	8.3	1	2	6.8	1	1	5.6	3	1	7.3	1	1	7.1	1	1
(ii) Clay content (%)	15	2	2	29.7	3	3	18.1	2	2	19.7	2	2	8.8	1	1
(iii) CEC [mmol (p^+) kg^{-1}]	70	1	1	20	2	2	85	1	1	<100	1	1	45	1	1
Accumulative tillage rating index (ATRI)															
(i) For *kharif*		41	42		42	42		42	40		36	37		33	30
(ii) For *rabi*		39	42		43	39		46	44		37	38		31	28

in bulk density etc., resulted in low ATRI values (36-37 in Lal's and 37-38 in modified method) were obtained for *kharif* and *rabi* crops, respectively. Soils should be cultivated with conservation tillage to reduce erosion and enhance moisture conservation.

Tillage rating of hill soils, Almora

The hill soils of Almora (Uttaranchal) have very high erosivity (15000 MJ-mm ha^{-1} h^{-1} yr^{-1}) and erodibility (0.07 Mg-ha-h ha^{-1} MJ^{-1} mm^{-1}) and less soil loss tolerance (3 Mg $ha^{-1}yr^{-1}$) (Table 2). These soils are near neutral in reaction with intermediate relative compaction. The ATRI of 33 (*kharif* crops) and 31 (*rabi* crops) were obtained by Lal's method. The ATRI values of 30 (*kharif* crops) and 28 (*rabi* crops) were computed through modified method. The clay content and CEC of these soils were very low. These implies that no tillage should be practiced and suitable soil and water conservation structures to prevent erosion and soil and water loss should receive priority.

Conclusions

Wide variability exists in tillage rating indices not only among major soil groups but within different soil series of a specific soil group because of variation in soil physical and chemical characteristics, crops, climatic conditions and management. The modified method holds promise in suggesting appropriate tillage systems for different crops under diversified soil and climatic conditions.

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