Vol. 42, No. 1, pp 46-53, 2014

Indian Journal of Soil Conservation

Online URL:http://indianjournals.com/ijor.aspx?target=ijor:ijsc&type=home

Unfolding the feasibility of *rabi* cropping through soil moisture characterization in Sibsagar district of Assam, India

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ARTICLE INFO

Article history :
Received : June, 2012
Revised : July, 2013
Accepted : August, 2013

Key words :
Field capacity,
Readily available water,
Soil available water,
Wilting point

ABSTRACT

Characterization of soil water retention properties coupled with feasibility of growing *rabi* crops during post *kharif* period were carried out in this study. Soil samples from profiles located at different physiography were collected. It was observed that water retention is high at the FC and minimum at PWP. Water retention study showed that the release behavior differed according to the soil texture. Bulk density was seen to be negatively correlated with 0.33 bar (-0.597**) and 15 bar (-0.637**). Clay hold significant and negative correlation with all the sand fractions and high positive and significant correlations with 0.33 bar (0.730**) and 15 bar (0.744**). Regression study showed that at 0.33 bar a maximum of 75.68% variability could be explained by bulk density, organic carbon parameters, silt, clay with some sand fractions whereas at 15 bar, bulk density, organic carbon and to a great extent clay played a key role to account for 74.5% variability. The total available water (TAW) and readily available water (RAW) for *rabi* crops like lentil, moong, bengal gram, sesame differed. The study indicated that light soils could supply water for a period of 10 to 13 days, medium soils for 29 to 33 days and heavy soils for 28 to 37 days. It was found that the light soils would suffer from severe water stress in the initial stage and the other soils at latter part of the growing periods causing failure of crops. Therefore, *rabi* cropping based on only AWC of soils would not be feasible during post- *kharif* period in the district.

1. INTRODUCTION

The amount of rainwater retained in the soil profile is most crucial. The amount of moisture retained in a particular soil and its subsequent availability to crop plants depends upon the type of soil and its properties. Rainfall distribution is very important characteristics that affect the agricultural productivity in the rainfed regions (Subash *et al.,* 2012). Many researchers have carried out analysis of rainfall pattern for crop planning (Jakhar *et al.,* 2011; Mukesh *et al.,* 2011; Subhudhi *et al.,* 2012). Therefore, understanding the water retention characteristics of soils is of utmost importance. Several researchers have studied soil moisture characteristics of various soil types for different parts of India (Singh and Nayak, 1995; Bhardwaj and Bhagat, 2004; Das *et al.,* 2005). Sushil Kumar *et al.* (2002) revealed that organic carbon, clay, water stable aggregates *etc.,* were the dominating factors influencing water retention characteristics. Experience has indicated that for many soils about half of the total water at field capacity is available for plant use. Agnihotri (1999) indicated high variability in rainfall during *rabi* season in Shiwalik foothills and recommended short duration crop as they reduce the chances of crop failure.

Shibsagar district in Upper Assam Brahmaputra Valley is a rainfed area. *Kharif* rice is the major crop. The area under more than one crop sown is only 6.8% (Statistical Hand Book of Assam, 2007). A vast area under Brahmaputra plains is mono-cropped (rain-fed paddy). The performance of *rabi* crops is not satisfactory and yield has declined dramatically. A vast tract remains uncultivated during *rabi* season due to inadequate soil moisture. Systematic studies on water storage and retention characteristics of soils to indicate the possibility of *rabi* crops in the district are lacking. Hence, a comprehensive study was undertaken in the district with the objectives to characterize the water retention properties of different soil types and to asses the feasibility of growing *rabi* crops during post-*kharif* period.

2. METERIALS AND METHODS

The study was undertaken in Sibsagar district of Assam located between 26°45' to 27°15' N and 94°25' to 95°25'E covering an area of 2668 sq km. The climate is hot humid with an annual rainfall of 1880 to 2100 mm. The study area comprises 18 locations for soil sample collection representing the physiography: active flood plain, recent flood plain and lower flood plain. Samples were collected at an incremental depth of 0-0.20 m, 0.20-0.40 m, 0.40-0.60 m, 0.60-0.80 m and 0.80-1.0 m.

Soil moisture content was measured by gravimetric method (oven dry and weight). Volumetric soil moisture was converted to total soil water by multiplying by the corresponding layer thickness. Organic Carbon (OC) content and particle size distribution were determined as per standard methods and bulk density of soils was measured using core method. Soil moisture at varied suction pressure (0.33, 1, 3, 5 and 15 bar) was determined using the Pressure Plate Apparatus as per procedure by Richards. (1949). Available Water Capacity (AWC) was computed by subtracting the amount of water held at 0.33 bar (FC) from that of 15 bar (WP). Percent moisture at field condition in different periods (February 2011; November, December and February 2012) was also determined on dry weight basis. Establishing the relationship between different soil parameters (OC, Sand, Silt, Clay, FC, WP) was carried out using the Statistical Package SPSS 17.0.

Total Available Water (TAW) and Readily Available Water (RAW) were estimated according to Allen *et al.* (1998) as follows :

I) $TAW = 1000\,(\theta FC - \theta WP)\,Zr$
Where, TAW is the total available soil water in the root zone (mm); θFC is the water content at field capacity ($m^3 m^{-3}$); θWP is the water content at wilting point ($m^3 m^{-3}$) and Zr is the rooting depth (m).

II) $RAW = p\,TAW$
Where, p is the average fraction of Total Available Soil Water (TAW) that can be depleted from the root zone before stress.

III) Water supply period was estimated by dividing the moisture supplying capacity of soils with the moisture depletion rate according to Brady and Well (2002).

3. RESULTS AND DISCUSSION

Physico -Chemical Characteristics of Soils

The physico-chemical characteristics of the soils are given in Table 1. The pH values of the profiles range from extremely acidic (pH <4.5) to very strongly acidic (pH 4.5 5.0) and strongly acidic (pH 5.0-5.5) with the mean values varying from 4.27 to 5.25. The low pH indicates the high leaching of the soils under humid climate with high rainfall. Chamuah *et al*. (1996) observed acidic soils in adjacent

Table: 1
Physico -chemical properties of some representative profiles of Sibsagar district

Profile No	Latitude	Longitude	Physio - graphy	pH (1:2.5)	Organic carbon (%)	Sand (%)	Silt (%)	Clay (%)	Textural sequence	Classification (USDA)
P1	26° 50' 21"	94° 29' 57"	Lower floodplain	4.20-4.54 (4.37)	0.34-1.03 (0.68)	18.60-24.40 (21.5 0)	38.3-55.60 (46.95)	20.0-40.00 (30. 00)	Sil-cl-cl-sil	Fluventic Dtstrudepts
P2	26° 49' 43"	94° 32' 56"	Lower floodplain	4.15-4.74 (4.44)	0.23-1.52 (0.87)	16.80-36.80 (26.8 0)	30.4-34.90 (32.65)	30.0-50.00 (40. 00)	C-c-cl-cl	Aeric Endoaquepts
P3	26 50 06	94 35 34	Lower floodplain	4.34-4.56 (4.45)	0.25-1.41 (0.83)	16.20-22.90 (19.55)	32.1-48.80 (40.45)	35.0-45.00 (40. 00)	Sicl-c-c-c	Typic Endoaquepts
P4	26 49 10	94 38 49	Lower floodplain	4.30-5.10 (4.70)	0.10-1.52 (0.81)	41.80-75.80 (58.8 0)	9.2-31.80 (20.5 0)	15.0-30.00 (25.0 0)	L-cl-scl-sl	Dystric Eutrudepts
P6	7° 01' 03"	94° 39' 19"	Recent flood plain	4.38-5.10 (4.74)	0.42-1.83 (1.12)	7.90-16.90 (12.4 0)	22.1-28.10 (25.10)	55.0-70.00 (62.5 0)	C-c-c-c	Fluvaquentic Endoaquepts
P7	26° 58' 59"	94° 53' 30"	Active flood palin	5.10-5.40 (5.25)	0.46-1.79 (1.13)	3.2-6.40 (4.80)	41.8-58.60 (50.2 0)	35.0-55.00 (45. 00)	Sicl-sic-sic-sic	Fluvaquentic Endoaquepts
P8	7° 02' 47"	94° 37' 58"	Recent flood plain	4.68-4.80 (4.74)	0.95-2.12 (1.53)	1.10-2.60 (1.85)	12.4-18.90 (15.66)	80.0-85.00 (82.5 0)	C-c-c-c	Typic Endoaquepts
P9	26° 54' 31"	94° 31' 24"	Lower floodplain	4.73-5.39 (5.06)	0.24-1.09 (0.66)	31.10-45.20 (38.10)	37.0-43.90 (40.45)	15.0-25.00 (20.0 0)	L-l-l-l	Oxyaquic Dystrudepts
P10	26° 54' 31"	94° 31' 14"	Low land	4.72-5.19 (4.95)	0.24-1.52 (0.88)	8.10- 81.20 (44.65)	4.8-46.90 (25.8 0)	10.0-45.00 (27.5 0)	Cl-sl-ls-sic	Dystric Eutrudepts
P11	26° 55' 28"	94° 46' 21"	Lower floodplain	4.63-5.85 (5.10)	0.76-2.48 (1.62)	1.0-5.20 (3.1 0)	25.5-44.00 (34.75)	55.0-70.00 (62.5 0)	Sic-c-c	Fluvaquentic Endoaquepts
P12	26° 54' 50"	94° 48' 14"	Lower floodplain	4.88-5.39 (5.13)	0.26-1.63 (0.94)	22.33-54.00 (38.16)	26.0-47.60 (36.8 0)	20.0-35.00 (27.5 0)	Cl-l-scl-cl	Oxyaquic Dystrudepts
P13	26° 56' 46"	94° 51' 01"	Active flood plain	4.43-4.85 (4.64)	1.35-2.58 (1.96)	2.90-5.70 (4.3 0)	32.1-49.30 (40.7 0)	45.0-65.00 (55.0 0)	Sic-c-c-sic	Dystric Eutrudepts
P14	26° 58' 57"	94° 53' 30"	Active flood plain	4.62-4.79 (4.70)	0.64-1.73 (1.18)	3.40-6.40 (4.9 0)	43.6-51.60 (46.6 0)	45.0-50.00 (47.5 0)	Sic-sic-sic	Typic Eutrudepts

Jorhat district with pH values ranging from 4.7 to 5.5 in the lowland and floodplain area. The organic carbon shows variation from 0.34 to 2.58% with the mean values ranging from 0.66 to 1.96%. Some profiles in the lower floodplain showed an irregular decrease in organic matter content with depth suggesting the deposition of fluvial deposit in different layers.

The Water Retention Characteristics of Soils

Available water (AW)

It is observed that the available water capacities for different soil textural groups differ. The light textured soils with textures of loamy sand, sandy loam and sandy clay loam show available water in the range of 46.0 to 82.0 mm m^{-1}. The medium textured soils *i.e.* clay loam, loam, silty clay loam are having available water in the range of 139.5 to 166.7 mm m^{-1} whereas for the heavy soils *i.e.* silty clay and clay, the available water ranges from 168.5 to 183.2 mm m^{-1} (Table 2).

Variation of water retention at field capacity (FC) and permanent wilting point (PWP)

The very fine soil shows the highest retention of water at field capacity ranging from 23.67 to 30.71% whereas the minimum retention of 11.82 to 16.35% is exhibited by moderately fine loamy soils. The retention by moderately fine and fine soils lies in between. The water retention at PWP for moderately fine and moderately fine loamy soils is comparatively less as compared to the retention for fine and very fine soils. The same is true for FC also (Table 3). The fine soils have higher WP because of greater clay content.

Water retention curve

The water retention for soils of different textures at different tensions *i.e.* 0.33, 1,3,5 and15 bar is presented in Fig. 1. It is observed that water retention is lowest for sandy loam (0.04 to 0.1m^3m^{-3}). Water retention by the other soils varies from 0.07 to 0.45m^3m^{-3}. At 0.33 bar lowest amount is retained by sandy loam soils and highest by clay soils. Similarly, at 15 bar highest amount is exhibited by clay followed by silty clay whereas other soils retain almost the same amount of water at this tension. The release behavior differs according to the soil texture.

Table: 2
Available water for different textural classes

Soil Texture	Av. Water (mm m^{-1}) (Range Value)	Av. Available water (mm m^{-1})
ls	28.0-64.0	46.0
sl	42.0-82.0	62.0
scl	68.0-98.0	82.0
cl	132.5-201.0	166.7
l	86.5-198.0	142.5
sicl	116.5-162.5	139.5
sic	135.5-201.5	168.5
c	142.0-224.5	183.2

Correlation and regression

Correlation

Bulk density recognized as a contributing factor for moisture retention is seen to be negatively correlated with 0.33 bar (-0.597**) and 15 bar (-0.637**). The correlation data also reveals that the bulk density is significantly and negatively correlated with organic carbon (-0.277*), clay (-0.716**) and positively and significantly correlated with sand (0.796**), medium sand (0.640**), fine sand (0.757**) and very fine sand (0.480**). Organic carbon is positively and significantly correlated with 0.33 bar (0.538**), 15 bar (0.325**) and also significantly and positively correlated with clay (0.444**) and negatively with all the sand fractions. High negative and significant correlations of sand is observed with 0.33 bar (-0.835*) and 15 bar (-0.781**). Silt shows insignificant positive relationship with 0.33 bar and 15 bar. Clay holds significant and negative correlation with all the sand fractions and high positive and significant correlations with 0.33 bar (0.730**) and 15 bar (0.744**). Jeetendra Kumar and Singh. (2008) also observed positive correlation at FC and WP with clay and negative correlation with sand fraction. Their study also indicated that the effect of silt on moisture contents at FC and WP could not be described by a linear relationship rather than other functions such as polynomial. The available water (AW) bears significant positive correlation with 0.33 bar (0.771**), silt (0.309**), organic carbon (0.527**) and clay (0.366**) and negative correlation with sand (-0.527**) and with all the sand fractions (Table 4).

Step-wise regression

To know the relationship of water content at 0.33 bar and 15 bar with other soil parameters, a step wise multiple regression was done. Magnitude of the coefficient of determination (R^2) indicates that 35.60% variability in 0.33 bar is explained by the bulk density alone. However, inclusion of organic carbon, silt and clay improves the prediction level up to the extent of 70.58%. After that, there is little improvement in R^2 level when different fractions of

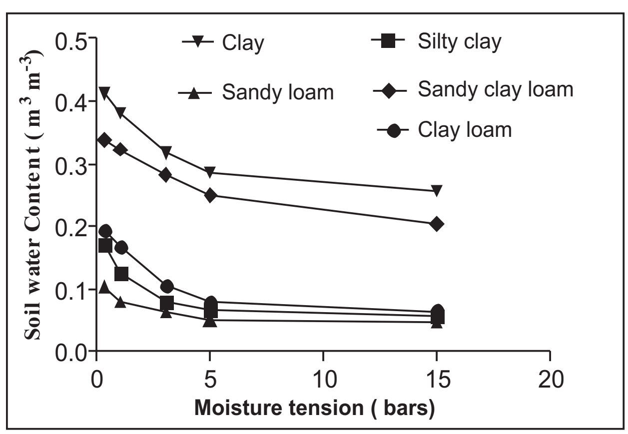

Fig. 1. Soil water retension curve for various textures

Table: 3
Variation in FC, PWP and available water (cm m^{-1}) for selected profiles for various depths (m)

Profile No.	Suction	0-0.20 m	0.20-0.40 m	0.40-0.60 m	0.60-0.80 m	0.80-1.00 m	Total
	Moderately fine loamy soils						
P9	FC (%)	14.95	11.83	11.82	16.35	12.67	
	WP(%)	3.21	4.11	5.07	3.57	3.89	
	AW (cm)	3.19	2.17	1.97	3.20	2.76	13.29
P12	FC (%)	21.3`	14.59	10.62	14.68	12.45	
	WP(%)	6.42	3.76	3.90	6.33	4.21	
	AW (cm)	3.90	3.01	1.12	2.23	3.04	13.29
					Average available water (cm m^{-1}) = 13.3		
	Moderately fine soils						
P3	FC (%)	19.52	17.32	16.65	15.48	14.67	
	WP(%)	8.96	9.62	8.21	6.36	7.32	
	AW (cm)	2.85	1.92	2.16	2.33	1.98	11.24
					Average available water (cm m^{-1}) =11.24		
	Fine soils						
P7	FC (%)	22.17	20.9	21.56	21.12	19.67	
	WP(%)	13.20	11.21	12.13	10.71	9.98	
	AW (cm)	2.26	2.04	2.76	2.91	2.78	12.75
P14	FC (%)	18.78	18.56	15.81	20.33	17.45	
	WP(%)	9.89	8.26	7.28	8.11	6.89	
	AW (cm)	2.97	2.53	2.54	3.32	1-98	13.34
					Average available water (cm m^{-1}) = 13.05		
	Very fine soils						
P8	FC (%)	29.94	28.27	25.24	25.26	23.67	
	WP(%)	16.21	15.16	14.22	15.26	14.08	
	AW (cm)	3.25	3.27	2.75	2.52	2.79	14.58
P11	FC (%)	30.71	24.86	25.95	25.52	26.32	
	WP(%)	11.29	12.53	13.41	14.69	13.56	
	AW (cm)	3.61	3.20	3.16	2.59	3.21	15.77
					Average available water (cm m^{-1}) = 15.17		

sands are entered. A maximum of 75.68% variability could be explained by the above soil parameters. It is observed that 40.50% variability at15 bar is explained by bulk density alone. It is to be noted that the inclusion of organic carbon does not seem to improve R^2 level to a great extent. The same is true when silt is included. However, there is a substantial increase in prediction level when clay is incorporated. Inclusion of all other sand fractions namely medium and fine sand fails to improve the R^2 value to a great extent with only 2.54% enhancement in prediction level. Inclusion of very fine sand fraction improves the R^2 value.

It is found from the regression studies that bulk density , organic carbon, silt and to some extent medium and fine sand plays a key role in improving the prediction level in case of 0.33 bar whereas clay and very fine sand are important predictor for moisture level at 15 bar. Kaushal *et al.* (1996) reported that texture and organic matter play significant and positive role in water retention. The differential level of prediction by soil parameter can be

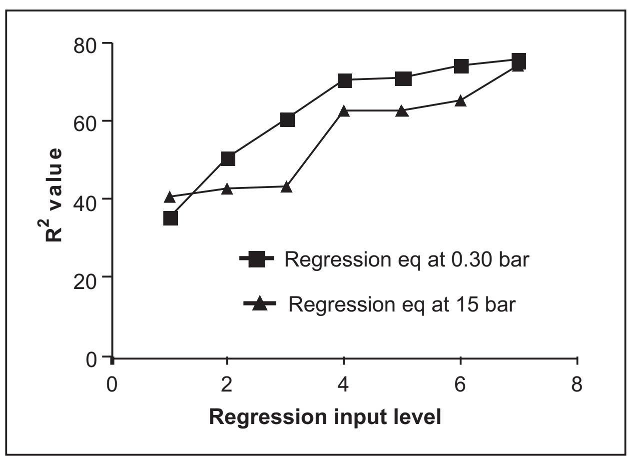

Fig. 2. Effect of different soil parameters on R value at two suction pressure

ascertained from Fig. 2 which reveals that in case of 0.33 bar, there is a gradual increase in R^2 value when bulk density, organic carbon, silt and clay are included. After that the R^2 value does

Table: 4
Pearson's correlation coefficient for different parameters

Parameter	Bulk density	OC	Sand	Silt	Clay	Medium sand	Fine sand	Very fine sand	F.C. (0.33 bar)	P.W.P. (15 bar)	Av. Water (0.33-15 bar)
Bulk density	1										
OC	-0.277*	1									
Sand	0.796**	-0.513**	1								
Silt	0.205	0.170	-0.451**	1							
Clay	-0.716**	0.444**	-0.749**	-0.216	1						
Medium sand	0.640**	-0.237*	0.710**	-0.494**	-0.424**	1					
Fine sand	0.757**	-.489**	0.969**	-0.462**	-0.701**	0.635**	1				
Very fine sand	0.480**	-0.500**	0.681**	-0.080	-0.657**	0.021	0.645**	1			
F.C. (0.33 bar)	-0.597**	0.538**	-0.835**	0.220	0.730**	-0.556**	-0.805**	-0.612**	1		
P.W.P. (15 bar)	-0.637**	0.325**	-0.781**	0.093	0.744**	-0.464	-0.737**	-0.676**	0.803**	1	
Av. water (0.33-15 bar)	-0.285**	0.527**	-0.532**	0.309**	0.366**	-0.403**	-0.529**	-0.298**	0.771**	0.274*	1

F.C. : Field Capacity: (0.33 bar)
P.W.P. : Permanent Witting Point (15 bar)

not change much. However, in case of 15 bar, there is a sharp

	Regression equation	R^2 x 100	Input level
0.33 bar	= 1.130 – 0.6365 B.D	35.60	1
	= 0.9254 – 0.5173 B.D + 0.05390 O.C	50.66	2
	= 0.4060 – 0.1868 B.D. – 0.0376 O.C + 0.0024 clay	60.51	3
	= – 0.2184 + 0.1552 B.D. + 0.0161 O.C + 0.0030 silt + 0.0043 clay	70.58	4
	= – 0.2360 + 0.1892 B.D. + 0.0175 O.C + 0.0026 silt + 0.0041 clay – 0.001 M sand	71.08	5
	− = – 0.0757 + 0.2471 B.D. + 0.0166 O.C + 4.757 silt + 0.0019 clay – 0.0015 M sand – 0.0055 F sand	74.14	6
	−= 0.0419 + 0.2803 B.D + 0.0131 O.C – 0.0014 silt + 0.0004 clay – 0.0039 M sand – 0.0054 F sand – 0.0036 Vfs	75.68	7
15 bar	= 0.6943 – 0.4269 B.D	40.50	1
	= 0.6429 0.0.3970 B.D + 0.0135 O.C	42.95	2
	= 0.6614 – 0.4038 B. D + 0.0141 O.C – 0.0002 silt	43.28	3
	= – 0.0405 + 0.0126 – 0.0090 O.C + 0.0014 silt + 0.0027 clay	62.92	4
	= – 0.0364 + 0.0046 B.D – 0.0093 O.C + 0.0015 silt + 0.0027 clay + 0.0002 M sand	62.98	5
	= 0.0542 + 0.0373 B.D -0.0099 O.C + 0.03477 silt + 0.0015 clay – 5.544 M sand – 0.0031 sand	65.46	6
	− = 0.2308 + 0.0880 B. D – 0.0152 O.C – 0.0021 silt – 0.0077 Clay 0.0037 M sand – 0.0029 F sand – 0.0056 Vfs	74.5	7

B.D. : Bulk Density; O.C.: Organic Carbon; M Sand: Medium sand; F sand: Fine sand; Vfs: Very fine sand

increase when clay is entered and to some extent when very fine sand is included.

Step wise regression equation

Feasibility for growing *rabi* crops

Total Available Water (TAW) and Readily Available Water (RAW)

The fraction of TAW that a crop can extract from the root zone without suffering water stress is the readily available water. These two properties differ from crop to crop and it depends on the rooting depth as well as type of soil. Estimation of the RAW and TAW values for some *rabi* crops in different textured soils reveals that on an average, about 40 to 60% of the TAW may be termed as RAW for all the crops (Table 5). However, as the soil becomes heavier, this percentage decreases somewhat for some crops. The TAW for rapeseed and sesame is very high because of consideration of effective rooting depth of 1.00-1.25 m as per Allen *et al*. (1998).

Water Requirements of Crops

Water requirements of *rabi* crops are calculated based on length of growing period and using kc values according to Allen *et al.* (1998). Here, the ET_0 represents an average value of 4 mm day^{-1} under the humid conditions. It is observed that bengal gram (chick pea) requires the highest amount of water compared to other crops whereas requirement for green gram (moong) is lowest. (Table 6).

Table: 5
TAW (mm) & RAW (mm) for some *rabi* crops in different types of soils in Shibsagar district

Crops	Loamy sands		Sandy loam		Loam		Silty clay loam		Silty clay		Clay	
	TAW	RAW	TAW	RAW	TAW	RAW	TAW	RAW	TAW	RAW	TAW	RAW
Bengal gram	27	13	46	23	91	45	102	51	131	66	168	84
Green gram	27	12	45	20	91	41	102	46	139	59	168	75
Lentil	24	12	40	20	80	40	90	45	115	57	157	58
Rapeseed	42	25	71	43	142	85	160	96	205	103	262	157
Sesame	42	25	71	43	142	85	160	96	205	103	262	157
Ground nut	25	12	43	21	85	42	96	48	123	61	157	68

Table: 6
Water requirement of crops

Crops	Growing period (days)	Av Et crop= kc x ET0 (4 mm day^{-1} under humid)	Total water requirement (mm) av.ETc x Growing period
Bengal Gram (chickpea)	120-130	0.76 x 4	364-395
Lentil	110-120	0.60 x 4	264-288
Moong (green gram)	70-80	0.63 x 4	176-201
Rapeseed	95-110	0.73 x 4	277-321
Ground nut	110-120	0.71 x 4	312-340
Sesame	90-120	0.78 x 4	280-374

(kc value adapted from Crop Evapotranspiration by Allen *et al.* (1998), FAO

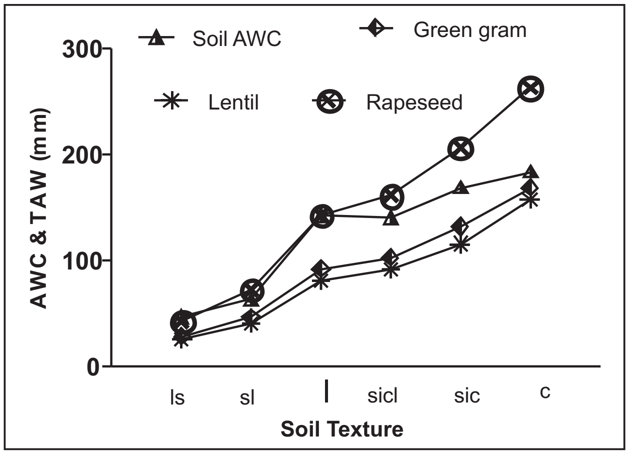

Fig. 3. Soil AWC Vs TAW of some crops

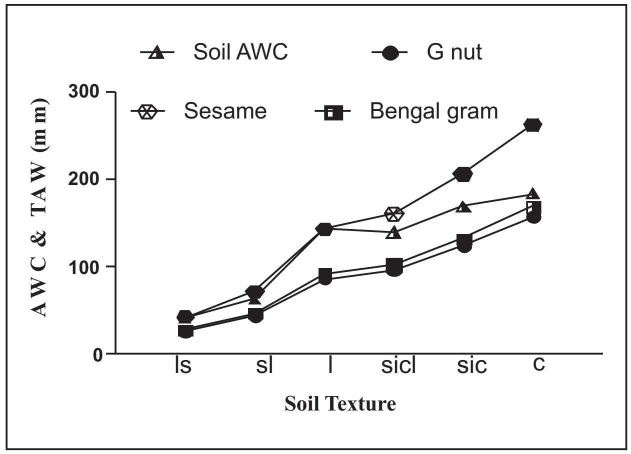

Fig. 4. Soil AWC Vs TAW of some crops

Soils AWC Vs TAW

Comparison of the two properties *i.e.* soil AWC & TAW based on rooting depth reveals the capacity of the soil to supply the amount of water required by the plant during its growing period. If soil AWC exceeds the TAW for crops, then it is to be assumed that the soil has got the capacity to supply the required amount of water by crops. It is seen (Fig. 3 and Fig. 4) that the soil AWC exceeds the TAW for green gram, lentil, sesame, bengal gram and groundnut indicating availability of water during its growth period. However, the reverse trend is observed for rapeseed and sesame because of their large effective rooting depth (1.0-1.5m) which indicates the unavailability of total water required by the crops and occurrence of severe water stress during its growth. It is also observed that the difference between soil AWC and TAW is narrow in soils with texture of loamy sand and sandy loam which are likely to result in water stress may be even in the initial stage of crop growth.

Estimation of Water Supply Period

When the root zone depletion exceeds the RAW (the water drops below the threshold limit) the root zone depletion is high enough to limit crop growth. Therefore, depending upon maximum rates of soil moisture use by crops coupled with moisture depletion, each soil has got a capacity to support crop growth for a certain period using the stored moisture after the cessation of rainfall. Molenaar (1960) calculated the maximum rates of soil moisture removal under hot humid climatic condition as 5 mm day^{-1}.

In the district *kharif* paddy is harvested in the 1^{st} or 2^{nd} week of November and after that the field remains fallow. Farmers will be benefited if they can grow some *rabi* crops using the stored moisture in the soil. It is found that there is a possibility of growing some crops like lentil, moong, bengal gram based on soil AWC and TAW without considering the moisture depletion or removal rate. Pulses like blackgram, peas are mainly cultivated as *rabi* crops in very small areas ranging from 300 to 350 ha (Statistical Handbook of Assam, 2007) in the district due to lack of irrigation water. As a result, this condition also does not warranty the cultivation of crops like moong, gram during *rabi* period. The only possibility of cultivating such types of crops must be through the use of short duration variety of *kharif* paddy leaving time for early sowing of *rabi* pulses (paira cropping) of short duration nature. It has already been shown that the moisture supplying capacity of light textured soils varies from 46 to 62 mm, of medium textured soils from 142 to 166 mm and of fine textured soils from 139 to 183 mm.

According to Velayutham *et al.* (1999) the Sibsagar district belongs to hot sub humid to humid agro ecoregion. Therefore, if we assume an average soil moisture removal rate of 5 mm day^{-1} these soils could supply water for a period of only 10 to 13 days for light soils, 29 to 33 for medium soils and from 28 to 37 days for heavy soils. The growing periods for almost of all the crops ranges between 95 to 130 days except for moong, a short duration variety; it ranges from 70 to 80 days. So comparing the days of growing periods with moisture supply period of soils it could be said

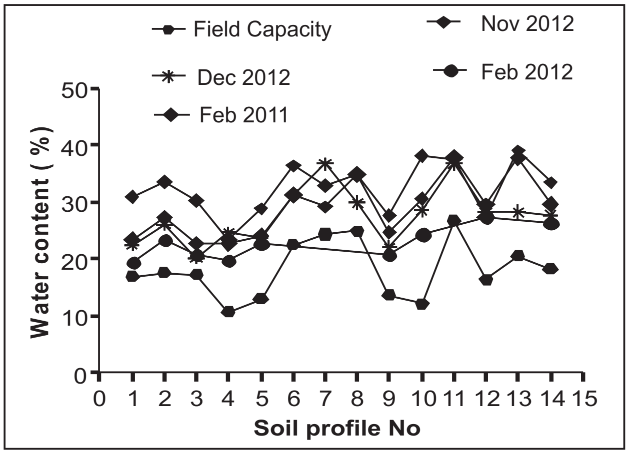

Fig . 5. Variation of water content (at field condition) during post- kharif periods against Field Capacity

that the light soils will suffer from severe water stress in the initial stage and the other soils at latter part of the growing periods and certainly there will be definitely crop failure. Therefore, *rabi* cropping based on only AWC of soils may not be feasible during post- *kharif* period in the district.

Comparison of Water Content at Field Condition and Field Capacity

It is known that if the water percentage remains at field capacity or slightly below it, there is a support for the crop growth. To examine it, we measured the percent water in the field itself for 14 profiles spread out in the district and compared with the water content held at field capacity. We started from November the time from which the fallow period starts. We plotted the average water percentage against average field capacity values for all the profiles (Fig. 5). From the figure, it is evident that the percent moisture at field condition remains always above the field capacity level due to erratic rainfall spanning over the four months. From this we could infer that *rabi* cropping is possible. Chand *et al.* (2011) have reported that crops like lentil, linseed and chickpea could be taken with residual moisture and with one or two life saving irrigations. Sharma and Dubey (2013) reported that for *rabi* crops early showing or pre-sowing through water harvesting in ponds and recycling is very good strategy for proper germination of *rabi* crops like mustard, lentil and barely.

4. CONCLUSIONS

The light soils will suffer from severe water stress at early stages of the growing period. Therefore, *rabi* cropping based only on AWC in these types of soils may not be feasible. The other soils are also likely to suffer from water stress at latter part of the growing periods in the absence of any rainfall. In rain-fed condition, raising of a second crop is possible, to some extent, in these soils if the crop and time of sowing are properly selected. Paira cropping/early sowing of short duration variety may reduce chances of water stress and will fetch a better yield.

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