Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 6 Special issue [3] 2017: 172-178

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804
NAAS Rating 4.95

FULL LENGTH ARTICLE **OPEN ACCESS**

Short Term Effect Of Conservational Agriculture On Fertility Of Rain Fed Sandy Loam Shallow Alfisol

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ABSTRACT
Soil under conservational agriculture systems recorded significantly higher fertility as compared to conventional agriculture system. Highly mobile bioavailable, nitrogen content was comparatively low in upper solum than in lower solum and was more conspicuous in conservational agriculture system where crop residue was retained over raised bed than in conventional agriculture system. Concentration of immobile phosphorous, less mobile potassium and sulphur in was comparatively more in upper solum than in lower solum in all the agriculture systems and however it was more conspicuous in conservational than in conventional agriculture systems as the former was rich in organic matter as compared to the later. Bioavailable nutrients were correlated significantly with most of the soil properties.
Key Words: *Tillage, Conservational agriculture, Bioavailable nutrients, Soil properties, and Organic carbon*

Received 31.07.2017 Revised 19.08.2017 Accepted 21.08. 2017

INTRODUCTION

The inherent capacity of soil to supply the nutrients to crop in right time, place and amount depends on physical, chemical and biological properties as well as process of soil and thus management of soil properties and process is utmost important to assure the adequate supply of nutrients to crop. Physical properties such as texture, structure, bulk density and available water etc., and physical processes such as erosion, infiltration, leaching, percolation, illuviation and surface crusting *etc*., influence the nutrients supplying capacity of soil through air and water movement as well as root proliferation. Soil reaction being a master determinant property of soil dictates almost all other properties of soil and hence nutrients availability to crops. Soil organic carbon the indispensable factor of soil productivity improves physical, chemical and biological properties and processes of soil and it adsorbs the nutrients on its surface and there by reduces nutrients toxicity and leaching loss of nutrients. Ion exchange, the most important and widely occurring natural process next only to the photosynthesis is the index of soil fertility. Mineralization, immobilization and transformation of nutrients, biological N fixation, P solubalization and increasing the availability of immobile nutrients to crop through increasing root volume take place in presence of soil microbes and enzymes. Soil restitution is the basic principle of soil fertility where whatever the nutrients are mined by crop from soil must be restored back through manuring and another basic principle of soil fertility is that soil should not be disturbed too much by tilling as it destroys soil structure and related properties of soil and thus conservation agriculture will do take care long lost soil health as well as soil fertility. Reduced tillage, raised beds with crop residue retention at soil surface have significant influence on addition of nutrients to soil as well as their transformation in soil. Less disturbance of soil and retention of crop residue at soil surface improves soil structure, soil moisture, soil temperature and microbial activity and thus transformation of nutrients in addition to reduced soil compaction, bulk density and soil erosion especially at a depth very close to the soil surface through building up of organic matter in conservational agricultural systems unlike conventional agricultural system. In the present context of soil degradation the age old conservational agricultural practices after being fine tuned with modern technology is need of an hour to improve long lost sustainable soil fertility and productivity. Thus present investigation was taken up to know the impact of conservational agriculture systems on vertical distribution of bioavailable nutrients in an alfisol.

MATERIAL AND METHODS

The experimental site is situated at agricultural college farm, Bheemarayangudi in Yadgir district of Karnataka and geographically situated between 16° 72' N latitude and 76° 79' E longitude and it enjoys semi-arid climate. Five years old five systems namely, T_1: conventional tillage and no retention of crop residue (CT), T_2: Zero tillage and raised bed with retention of crop residue (ZTRB +M), T_3: Zero tillage and raised bed without retention of crop residue (ZTRB -M), T_4: Zero tillage and flat bed with retention of crop residue (ZTFB +M) and T_5: Zero tillage and flat bed without retention of crop residue (ZTFB -M), established on slightly gravelly sandy loam shallow alfisol with red gram as a test crop were selected to study vertical distribution of bioavailable nutrients in alfisol under these systems. Each system was quadruplicated and thus there were 20 plots. From each plot six composite fourth year post harvest soil samples at an interval of 0-5, 5-10, 10-15, 15-20, 20-25, and 25-30 cm soil depths were collected and in total 120 composite soil samples were collected from experimental site. These composite soil samples were processed and analyzed for particle size class, bulk density available water, water stable aggregates in 2.0 mm sieved soil reaction, organic carbon, cation exchange capacity, microbial biomass carbon and dehydrogenase activity following standard procedures and available nitrogen content of soil was determined by alkaline potassium permanganate method [8] while available phosphorus in soil was extracted by Olsen's extractant using $NaHCO_3$ [6] and analyzed spectrophotometrically. Exchangeable potassium was extracted with 1N NH_4OAC (pH 7) and the potassium content in the extract was determined flamephotometrically. Soil sulphur was extracted by $CaCl_2$ and the sulphur in extract was determined turbedometrically following the standard procedures. Data pertaining to bioavailable nutrients was subjected to the statistical analysis using the statistical tool SPSS 16.00 windows and the significance differences in bio available nutrients among the different tillage and raised or flat beds with or without crop residue management systems were determined by Tukey test at $P < 0.05$. Bio available nutrients were also subjected to Pearson correlation with physical, chemical and biological properties of soil for better interpretation of data.

TABLE 1. INITIAL FERTILITY STATUS OF EXPERIMENTAL SITE AT PLOUGH (15 CM) DEPTH.

Bioavailable nutrients	**Value**
N (Kg/ha)	137.0
P2O5(Kg/ha)	23.0
K2O(Kg/ha)	245.0
S(mg/Kg)	14.8

RESULT AND DISCUSSIONS

Physical, chemical and biological properties of soil

All the soil properties (Table 2.) studied were better in conservational agriculture systems as compared to conventional agriculture system.

Bioavailable nutrients

Irrespective of the systems N showed increasing trend in upper solum and decreasing trend in lower solum down the depth and increasing trend in the upper solum with depth was due to nitrate nitrogen that can't be adsorbed on soil surface as the AEC of these soils is low as well as retention of ammonical nitrogen on soil surface is also less and was very conspicuous in T_2 (Table 3.) because of raised bed with crop residue at surface which provided better leaching environment. Irrespective of the systems, rest of the macro (P_2O_5 and K_2O) nutrients showed decreasing trend down the solum and this could be attributed to both decreasing trend of organic matter with depth as well as immobile nature of both P_2O_5 as well as less mobile nature of K_2O. At corresponding soil depths content of bioavailable nutrients in conservational agriculture systems was significantly more than that of conventional agriculture system and this could be attributed to minimum tillage as well as retention of crop residue at soil surface which reduced the rate of oxidation and conserved organic matter and even profused root growth added more of root biomass to soil and thus organic matter in conservational agriculture systems.

Nitrogen (N)

System mean N was comparatively more (143.73 to 177.57 Kg ha^{-1}) in conservational agriculture systems than in conventional agriculture system (125.53 Kg ha^{-1}) and N content in soils under conservational agriculture systems was also statistically superior (>143.09 Kg ha^{-1}) over that of conventional agriculture system. Among conservational agriculture systems N content recorded by T_5 and T_3 was statistically inferior (<151.29 Kg ha^{-1}) to that of both T_2 and T_4 which indicated that irrespective of raised or flat beds retention of crop residue at soil surface improved organic matter content by reduced oxidation of crop residue because of partial contact between soil and crop residue. Nitrogen content observed in T_2 was statistically superior(>165.22 Kg ha^{-1}) over that of T_4 because of raised bed in former which facilitated better air, water and temperature movement in soil and thus encouraged better root and microbial growth and hence more organic matter was added in the solum. Significantly higher N in permanently raised beds than in conventionally tilled plots [1][5]. Soil depth mean N suggested that N content recorded at 25-30 cm depth was statistically inferior (<131.20 Kg ha^{-1}) to that of rest of the soil depths. Significantly higher (>167.60 Kg ha^{-1}) N content in both 10–15 and 15-20 cm soil depths as compared to rest of the soil depths could be attributed to leaching of nitrate form of nitrogen to a greater extent and ammonical form of nitrogen to lesser extent as nitrogen is a highly mobile nutrient and it was very conspicuous in T_2 and T_4 where soil surface was covered by crop residue which improved the leaching environment of soil. Interactions indicated that N content due to the interactions of conservational agriculture systems with soil depths was significantly superior over the interactions of conventional agriculture system with the corresponding soil depths and this could be attributed to reduced tillage and retention of crop residue at soil surface as both these retarded rate of decomposition of organic matter and conserved more of organic matter and reverse was true in conventional agriculture system. Significantly higher available nitrogen due to the interaction between conservational agriculture systems and soil depths in the upper solum could also be attributed to higher organic matter content in upper solum of conservational agriculture systems as well as high mobility of nitrogen down the solum. These findings were further supported by Pearson correlation studies (Table 4). Higher N content in conservational agriculture systems was further confirmed by the Pearson correlation where N was significantly correlated with BD (-0.593**), pH (-0.641**), SOC (0.562**), MBC (0.506**) and DHA (0.600**). Thus conservational agriculture systems were better than conventional agriculture systems in improving available nitrogen content of soil. Higher concentration of highly mobile nutrient (N) in subsurface than in surface under zero tillage system than in conventional tillage system [2].

Phosphorous (P_2O_5)

System mean P_2O_5 was significantly higher (>20.72 Kg ha^{-1}) in soils under conservational agriculture systems with exception to T_5 as compared to that of conventional agriculture system Higher P_2O_5 in conservational agriculture systems could be attributed to higher organic matter content in conservational agriculture systems which reduced the chemical fixation of phosphorous[3],[4]. Among the conservational agriculture systems P_2O_5 observed in T_2 and T_4 was significantly superior over T_3 and T_5 as in the former two systems soil surface was covered by the crop residue which added more organic matter to soil through reduced oxidation of crop residue because of wider C/N ratio as well as lesser contact between soil and crop residue. Soil depth mean P_2O_5 of both 20-25 and 25-30 cm soil depth was significantly inferior (<20.36 Kg ha^{-1}) to that of rest of the soil depths and this could be attributed to the immobile nature of P_2O_5 in soil. Interactions of T_2, T_3 and T_4 with 0-5 cm soil depth recorded significantly higher available P_2O_5 as compared to rest of the interactions and this could also be attributed to less mixing up of soil due to minimum tillage and more organic matter content in addition to immobile nature of P_2O_5. These observations were further supported by significant positive correlation coefficient (0.904**) between available phosphorous and soil organic carbon and significant negative correlation between available phosphorous and both pH and bulk density (-0.784** and -0.854** respectively). Higher concentration of immobile phosphorous in surface than in subsurface in their studies on tillage systems [2]. Numerous studies have indicated that higher extractable phosphorus was recorded in soils under zero tillage [3].

Potassium (K_2O)

Statistical tool tukey test indicated that system mean K_2O in conservational agricultural systems was significantly superior (>228.18 Kg ha^{-1}) over that of conventional agriculture system. Among conservational agricultural systems, amount of K_2O observed in T_2 was significantly higher (286.63 Kg ha^{-1}) over that of rest of the conventional agriculture system. Statistical analysis indicated that soil depth mean K_2O in any soil layer was significantly higher as compared to that of its lower soil layers. Significantly higher amount of available potassium content in conservational agriculture systems and more so in T_2 as compared to conventional and rest of conservational agriculture systems, in 0-5 cm soil depth as compared to the remaining soil depths and due to the interaction between T_2 and 0-5 cm soil depth as compared to rest of the interactions could be attributed to minimum disturbance of soil and or crop residue retention at soil surface favored accumulation of more organic matter at soil surface in conservational agriculture systems and more over potassium is the only plant nutrient released quickly to soil upon decomposition of organic matter as compared to other plant nutrients as the potassium is not a structural component of any biomolecules of plant. Higher concentration of K_2O in no tilled soils with raised beds having crop residue at soil surface [5]. These findings were further confirmed by the strong significant positive correlation (0.853**) between available potassium and organic matter. Higher level of available potassium in soil under zero tillage than in soil under conventional tillage and they also reported decreasing trend of potassium down the solum [4].

Sulphur(S)

Available sulphur as indicated by system mean was significantly higher (>15.57 mg Kg^{-1}) in all the conservational agriculture systems as compared to that of conventional agriculture system and among conservational agriculture systems S recorded in T_2 was significantly superior (>21.28 mg Kg^{-1}) over the rest of the systems. Soil depth mean S observed in first three soil layers was significantly superior (>16.69 mg Kg^{-1}) over the rest of the lower soil layers. Interaction studies indicated that S content due to the interaction of systems with depths was significantly higher in conservational agriculture systems with exception to T_5 as compared to T_1 at corresponding depths and it was conspicuous in upper soil layers and this could be attributed to more of organic matter in conservational agriculture systems that too in upper soil layers due to less soil disturbance and reduced rate of decomposition of surface crop residue enhanced accumulation of organic matter as compared to that of conventional agriculture system, lower soil layers as well as interactions of conservational agriculture systems at lower layers. As organic matter is an important source of soil sulphur positive and significant correlation (0.809**) between available sulphur and organic matter indicated conservational agriculture systems improved available sulphur content in soil. Higher mineralizable sulphur in no tilled soil than in conventionally tilled soil [7].

TABLE 2. VERTICAL DISTRIBUTION OF PHYSICAL CHEMICAL AND BIOLOGICAL PROPERTIES OF SOIL

Soil properties	Depth (cm)	Different tillage and raised or flat beds with or without crop residue management systems				
		CT (T_1)	ZTRB + M (T_2)	ZTRB - M (T_3)	ZTFB + M (T_4)	ZTFB - M (T_5)
Sand (%)	00-05	68.93	66.16	67.65	66.03	66.41
	05-10	68.19	64.92	67.46	64.60	65.96
	10-15	66.65	63.85	66.92	65.12	65.40
	15-20	64.80	63.20	66.86	65.25	65.20
	20-25	65.44	62.80	66.48	65.72	66.86
	25-30	64.20	62.72	62.62	64.88	67.00
Silt (%)	00-05	15.50	16.60	16.00	16.82	16.49
	05-10	16.10	15.80	16.20	17.60	16.56
	10-15	16.50	15.40	16.10	16.98	16.20
	15-20	15.90	15.30	15.58	16.55	15.90
	20-25	15.20	15.20	15.20	15.10	15.34
	25-30	15.70	15.10	14.90	15.02	15.10
Clay (%)	00-05	15.57	17.24	16.35	17.15	17.10
	05-10	15.71	19.28	16.34	17.80	17.48
	10-15	16.85	20.75	16.98	17.90	18.40
	15-20	19.30	21.50	17.56	18.20	18.90
	20-25	19.36	22.00	18.32	19.18	17.80
	25-30	20.10	22.18	22.48	20.10	17.90
BD (Mg m^{-3})	00-05	1.42	1.30	1.39	1.35	1.38
	05-10	1.45	1.30	1.40	1.37	1.41
	10-15	1.50	1.36	1.41	1.39	1.42
	15-20	1.52	1.40	1.42	1.41	1.44
	20-25	1.54	1.43	1.42	1.43	1.46
	25-30	1.61	1.42	1.43	1.43	1.47
AW (%)	00-05	10.35	13.34	11.70	11.45	10.65
	05-10	10.08	12.05	12.01	10.73	10.91
	10-15	10.10	11.67	12.57	10.60	10.60
	15-20	10.70	12.45	13.55	11.90	11.25
	20-25	10.00	12.17	12.62	12.71	11.56
	25-30	10.25	12.05	12.10	12.85	11.60
WSA (%)	00-05	72.01	80.97	78.95	79.23	74.99
	05-10	72.69	74.81	75.50	78.75	69.72
	10-15	72.43	72.66	74.81	74.81	73.73
	15-20	73.40	74.02	74.02	76.57	77.52
	20-25	72.51	79.65	74.81	74.63	71.21
	25-30	71.76	73.62	72.51	74.86	71.11

Contd.....

Note: CT**:** Conventional tillage and no retention of crop residue (T_1) , ZTRB+M**:** Zero tillage and raised bed with retention of crop residue (T_2), ZTRB-M**:** Zero tillage and raised without retention of crop residue (T_3), ZTFB+M**:** Zero tillage and flat bed with retention of crop residue (T_4), ZTFB-M**:** Zero tillage and flat bed without retention of crop residue (T_5), SMV: System mean values.

Soil properties	**Depth (cm)**	**Different tillage and raised or flat beds with or without crop residue management systems**				
		CT (T_1)	**ZTRB+M (T_2)**	**ZTRB-M(T_3)**	**ZTFB+M (T_4)**	**ZTFB-M (T_5)**
pH (1:2.5)	00-05	6.71	6.22	6.33	6.43	6.48
	05-10	6.80	6.30	6.39	6.47	6.52
	10-15	6.84	6.41	6.41	6.57	6.72
	15-20	7.03	6.47	6.88	7.07	7.22
	20-25	6.97	6.56	6.98	7.24	7.06
	25-30	7.24	6.64	7.06	7.52	7.33
SOC (g/Kg)	00-05	4.28	5.85	4.95	5.18	4.28
	05-10	3.83	5.18	3.83	5.20	3.90
	10-15	3.45	4.80	3.68	4.28	3.30
	15-20	3.00	4.38	3.60	3.73	3.15
	20-25	2.78	4.37	3.60	3.50	2.93
	25-30	2.55	4.37	2.78	3.15	2.78
CEC {c mol (P^+) kg^{-1}}	00-05	14.50	21.10	16.20	21.50	17.30
	05-10	15.10	21.20	17.10	21.80	18.90
	10-15	16.85	22.26	18.10	22.00	19.63
	15-20	19.25	23.65	20.19	22.16	22.16
	20-25	19.90	24.12	22.89	22.23	22.25
	25-30	21.50	25.31	23.90	22.46	23.12
MBC (mg kg^{-1})	00-05	153.89	309.05	181.79	286.12	173.19
	05-10	137.66	282.36	168.09	236.12	159.67
	10-15	124.11	253.19	129.90	172.60	126.32
	15-20	108.45	134.33	122.75	157.45	112.98
	20-25	100.46	125.44	119.90	148.44	105.16
	25-30	92.38	112.98	99.19	141.36	99.82
DHA (mg TPF kg^{-1} 24^{-1}hr)	00-05	22.23	34.53	24.30	30.48	25.23
	05-10	21.58	33.53	21.58	30.06	22.85
	10-15	20.34	28.29	20.22	25.23	19.45
	15-20	17.68	23.82	18.69	20.11	18.99
	20-25	16.39	20.35	17.22	18.63	17.39
	25-30	15.03	16.17	14.39	15.57	15.27

TABLE 3 VERTICAL DISTRIBUTION OF BIOAVAILABLE NUTRIENTS IN SOIL

Available macronut rient	**Depth (cm)**	**Different tillage and raised or flat beds with or without crop residue management systems**					**SDM**
		CT (T_1)	**ZTRB+M (T_2)**	**ZTRB-M (T_3)**	**ZTFB+M (T_4)**	**ZTFB-M (T_5)**	
N (kg ha^{-1})	00-05	124.60	177.80	120.40	152.60	145.60	**144.20**
	05-10	140.00	177.80	190.40	165.20	179.20	**170.52**
	10-15	133.00	198.80	179.20	201.60	145.60	**171.64**
	15-20	124.60	208.60	175.00	151.20	137.20	**159.32**
	20-25	117.60	152.60	114.80	143.73	135.80	**132.91**
	25-30	113.40	149.80	100.80	131.60	119.00	**122.92**
	SM	**125.53**	**177.57**	**146.77**	**157.66**	**143.73**	
	System		**Depth**		**System × Depth**		
S.Em±	**2.70**		**2.96**		**6.61**		
C.D at 0.05	**7.56**		**8.28**		**18.52**		
P_2O_5 (kg ha^{-1})	00-05	24.40	36.10	32.80	34.80	25.50	**30.72**
	05-10	21.50	31.80	28.76	30.76	23.20	**27.20**
	10-15	20.10	28.30	25.86	27.86	21.70	**24.76**
	15-20	17.90	26.50	23.04	25.04	18.60	**22.22**
	20-25	15.80	22.90	20.85	22.85	15.29	**19.54**
	25-30	13.90	21.60	20.94	22.94	12.05	**18.29**
	SM	**18.93**	**27.87**	**25.38**	**27.38**	**19.39**	

	System		**Depth**		**System × Depth**		
S.Em±	**0.68**		**0.74**		**1.66**		
C.D at 0.05	**1.89**		**2.07**		**4.64**		
K_2O (kg ha $^{-1}$)	00-05	302.16	591.66	457.0	534.60	418.08	**460.70**
	05-10	300.64	370.0	319.25	339.72	344.58	**334.84**
	10-15	230.64	272.3	262.74	266.04	203.16	**246.98**
	15-20	194.52	246.0	219.42	184.32	136.86	**196.22**
	20-25	163.80	245.5	178.44	191.58	162.42	**188.35**
	25-30	156.30	251.0	161.58	182.52	155.14	**181.31**
	SM	**224.68**	**329.40**	**266.4**	**283.13**	**236.71**	
	System		**Depth**		**System × Depth**		
S.Em±	**1.25**		**1.37**		**3.06**		
C.D at 0.05	**3.50**		**3.84**		**8.58**		
S (mg kg $^{-1}$)	00-05	15.34	28.03	25.00	20.27	18.37	**21.40**
	05-10	14.77	25.38	22.16	19.32	16.48	**19.62**
	10-15	13.83	22.54	20.27	16.67	15.53	**17.77**
	15-20	13.45	17.99	17.42	15.72	15.15	**15.95**
	20-25	13.07	16.86	16.67	17.69	13.07	**15.47**
	25-30	12.69	15.53	14.96	15.91	14.96	**14.81**
	SM	**13.86**	**21.06**	**19.41**	**17.60**	**15.59**	
	System		**Depth**		**System × Depth**		
S.Em±	**0.61**		**0.67**		**1.50**		
C.D at 0.05	**1.71**		**1.88**		**4.20**		

Note: CT: Conventional tillage and no retention of crop residue (T_1), ZTRB+M**:** Zero tillage and raised bed with retention of crop residue (T_2), ZTRB-M**:** Zero tillage and raised without retention of crop residue (T_3), ZTFB+M**:** Zero tillage and flat bed with retention of crop residue (T_4), ZTFB-M**:** Zero tillage and flat bed without retention of crop residue (T_5), SWA: Solum weighted average

TABLE 4. CORRELATION COEFFICIENTS BETWEEN SOIL PROPERTIES AND BIO AVAILABLE NUTRIENTS

Soil properties /Bioavailable Nutrients	**Sand**	**silt**	**clay**	**BD**	**AW**	**WSA**	**pH**	**SOC**	**CEC**	**MBC**	**DHA**
N	-0.12	0.378*	-0.035	-0.593**	0.285	0.191	-0.641**	0.562**	0.067	0.506**	0.600**
P_2O_5	0.057	0.523**	-0.238	-0.854**	0.315	0.673**	-0.784**	0.904**	-0.143	0.869**	0.858**
K_2O	0.256	0.554**	-.419*	-0.685**	0.095	0.553**	-0.782**	0.853**	-0.327	0.824**	0.834**
S	0.106	0.292	-0.196	-0.808**	0.475**	0.598**	-0.733**	0.809**	-0.097	0.825**	0.791**

CONCLUSION

Soil under conservational agriculture systems recorded significantly higher fertility as compared to conventional agriculture system that too in plough depth as the systems are just four years young and still more time is required for the improvement in soil fertility both horizontally and vertically. Highly mobile bioavailable, nitrogen content was comparatively low in upper solum than in lower solum especially in conservational agriculture system where crop residue was retained over raised bed. Irrespective of agriculture systems concentration of immobile phosphorous, less mobile potassium and secondary nutrient sulphur was comparatively more in upper solum than in lower solum and it was conspicuous in conservational agricultural systems than in conventional system.

ACKNOWLEDGEMENT

International Maize and Wheat Improvement Centre (CIMMYT), NASC Complex, New Delhi 110012, India is duly acknowledged for financial assistance in the form of fellowship to the first author. Authors are also grateful to Dr. S. G. Patil former Director of Education and his team, UASR for the establishment of conservational agricultural systems at agricultural college farm Bheemarayanagudi, Karnataka, India

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CITATION OF THIS ARTICLE

Bheemanna, R., Rudramurthy, H. V. Kuchanur, P. H[1]., Jat, M. L., Chandragouda Girigoudar, C. Sudharshana and Yogeesh kumar Singh. Short Term Effect Of Conservational Agriculture On Fertility Of Rain Fed Sandy Loam Shallow Alfisol. Bull. Env. Pharmacol. Life Sci., Vol 6 Special issue [3] 2017: 172-178