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Effect of crop establishment methods on productivity and profitability of rice-wheat cropping system

RPN Singh and SK Tomar

Abstract
On farm trials in farmer's participatory mode were conducted for three years to evaluate the effect of crop establishment methods on rice and wheat productivity in Fatehpur, Pratapgarh and Raebareli district of Uttar Pradesh under rice wheat cropping system. Results revealed that the rice sown with drum seeder in puddled condition with sprout seeds gave highest grain yield among the rice establishment methods tested. On an average sowing sowing with drum seeder increased the grain yield of rice crop by 4.1, 11.4 and 25.7% over farmer practice at Fatehpur, Pratapgarh and Raebareli location respectively. In case of wheat highest wheat grain yield (44.5, 46.3, and 47.5 q/ha) was recorded with wheat sown by using zero till technology after mechanical transplanted rice in unpuddled field, which was 10.4, 13.4 and 12.6% higher over the farmers practice at Fatehpur, Pratapgarh and Raebareli location respectively. Highest rice equivalent yield 99.73 q/ha/year were obtained from the rice transplanted by mechanical in unpuddled field -wheat sown by using zero till technology. The maximum net return of Rs. 96961/ha/year and B: C ratio (2.47) was also obtained with the crop establishment method of rice (DSR) – wheat (ZT) followed by rice (DMS) –wheat (ZT) and rice (UPMTP) –wheat (ZT). The physico chemical properties pH, EC, OC, available NPK, secondary (S) and micro nutrient (Zn and B) exhibited differences due to crop estabshment methods. Rice sown either dry direct seeded or mechanical transplanted followed by wheat sown by using zero till technology proved superior in respect of build-up of these nutrients in soil.

Keywords: Crop establishment methods, drum seeder, unpuddled, puddled, DSR, zero till, rice and wheat

Introduction
In India, the rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.) are dominant crops across the Indo-Gangetic plains and in the Himalayan foothills. Approximately 10.5 million ha land under these crops contributes about 25% of total food grain production in India. Both crops of this cropping system are fertility exhaustive and need more water, labour, time, non-renewable energy, heavy farm machineries and other expenditure. Continued puddling for rice cultivation over decades has led to deterioration of soil physical properties through structural breakdown of soil aggregates and capillary pores and clay dispersion thereby restricting germination and rooting of succeeding crops (Hobbs & Gupta, 2000 and Tomar *et al.* 2006) [5, 14]. Intensive puddling in rice increase in soil strength in surface and subsurface layers due to illuviation of clay, iron and manganese compounds; decrease in hydraulic conductivity and infiltration leads to water stagnation, poor root development, and low recharge of aquifers (Gathala, *et al*., 2011) [4]. Non rice crop such as wheat require contrasting soil condition such as aerobic soil, good soil structure, and deep soil layer for root growth.
Therefore, it is imperative that alternate method of growing crops that are more water efficient and less labour intensive to be developed to enable farmers to produce more with less cost of production. Huge labours are needed to accomplish transplanting of rice seedlings and mostly it is delayed to a greater extent due to unavailability of adequate labours during transplanting peak period. Thus, late planted rice takes more time to reach the maturity, which not only reduces the rice yield but also delays sowing of succeeding crop particularly wheat but direct seeding of rice can reduce the labour and water requirement, shorten the duration of crop by 7-10 days and provide comparable yield with transplanted rice (Mishra *et al*. 2012) [11]. In plains of Eastern India, sowing of wheat gets delayed due to wet condition after rice harvesting which takes much time to come in working condition, also tillage in such soils require more time, labour and

energy. On the other hand, zero tillage minimizes loss on account of delayed sowing as it advances the wheat sowing by 10-15 days and also saves the time and cost involved in field preparation.
Conventional methods of wheat sowing, which requires excessive tillage delays the sowing and reduce the yield, but the same can be accomplished efficiently with use of improved machines, *viz*. zero till ferti-seed drill and rotavator etc. to save the time, fuel, energy and cost (Jha, *et al*. 2007) [9] concluded that the higher grain yields and economic benefit of CA was realized after 2-3 years as the adaptation of CA based practices evolved over the time Therefore, the present investigation was envisaged with an objective to identify a suitable combination of crop establishment method for maximum productivity and profitability from rice –wheat cropping system.

Material and Methods
Study on different crop establishment techniques in rice -wheat cropping system was conducted on the farmer's field through participatory mode at 15 farmer's field of 3 district namely Fatehpur, Pratapgarh and Raebareli of Uttar Pradesh during 2012-13 to 2014-15. The experimental soils sandy loam/ loam in texture having pH (7.80-8.60), EC (0.16-0.38dS/m), organic carbon (0.27 - 0.29%), available nitrogen (102-252 kg/ha), available Phosphorous(10.0-26.5 kg/ha) available potassium (110-265 kg/ha), available Sulphur (10.3-23.5 kg/ha), DTPA- extractable Zn (0.46-.62 mg/kg), Fe (2.90-6.25 mg/kg), Mn (3.44-8.60 mg/kg) and Cu (0.65-1.58 mg/kg) and available B (0.20-0.32 mg/kg).Five crop establishment methods *viz*. T_1=Rice (manual TP) – wheat (Conventional tillage broad cast methods of sowing) farmer practice,T_2=Rice (Direct wet seeded in puddled condition sown by drum seeder) - wheat (Zero till), T_3= Rice (Direct dry Seeding by ZT machine using stale bed technique) – wheat (ZT), T_4=Rice (Machine transplanting in un puddled condition) – wheat (ZT) and T_5= Rice (Machine Transplanting) - wheat (Rotavator once with broadcasting of seed) were tested in a randomized block design. No of farmer is treated as replication. Rice variety NDR 3112 and wheat variety HD 2967 was used for sowing / transplanting with recommended dose of fertilizer 150:60:40 kg NPK/ha. Rice transplanting completed between 20th June to 27th June and wheat sowing was completed within 15thNovember to 20th November during all the experimental year. The test crops were harvested at maturity and data on grain yield were recorded. The post-harvest soil samples were drawn from all the fields, and analysed for pH, electrical conductivity (Jackson 1973) [7], organic carbon (Walkley and Black 1934) [15]. Soil Samples were also analysed for available nitrogen (Subbiah and Asija 1956) [13], available phosphorus (Olsen *et al*. 1954) [12], available potassium (Hanway and Heidal 1952) [3] and CaCl2 extractable-S. The available micronutrients (Zn, Fe, Cu and Mn) in soil were extracted by DTPA (Lindsay and Norvell 1978) [10] and determined on atomic absorption spectrophotometer. Hot water extractable boron was determined by colorimeter methods (Berger and Truog 1939) [1]. The economics of various treatments was computed on the basis of prevailing market price of inputs and produces. Direct dry seeding of rice using stale bed technique was done after well preparation of field. Direct seeding of sprouted seeds through drum seeder in puddled field and mechanical transplanting after puddling and manual transplanting consisted of one disc ploughing, one rotavator and one puddling using rotavator. Mechanical transplanting in a treatment was also done in unpuddled field with proper tillage. Pretilaclor @ 1.5 ml/ha was applied as pre-emergence fb by post emergence application of bispyriback sodium @ 250ml/ha at 30 DAT weed control in transplanted rice. In DSR, pendimethalin @3.3litre/ha pre-emergence bispyriback sodium @ 250ml/ha at 30 DAS was applied for weed control. After harvesting of rice, a pre-sowing irrigation was given to ensure optimum soil moisture for different methods for wheat sowing. Under zero and rotavator till sowing of wheat was done directly without primary land preparation but sowing under conventional methods in wheat involved 1 cultivator, 2 harrowing and 1 planking. For weed control in wheat, Sulfosulfuran 33g + 20g/ha metsulfuron was applied at 30 DAS. For rice, recommended dose of fertilizer, i.e. 150 kg N + 60 kg P + 40 kg K + 25kg Zn/ha had applied through DAP, urea, muriate of potash and zinc sulphate. One third of recommended dose of N and entire dose of P, K and Zn was applied as basal and remaining N was applied in two equal splits through urea at maximum tillering and panicle emergence stage. In wheat, recommended dose of fertilizer i.e. 150 kg N + 60 kg P + 60 kg K were applied through DAP, urea and muriate of potash. Half of recommended dose of N and whole P were applied as basal and remaining doses of N applied in two equal splits through urea at maximum tillering and ear emergence stages. Full K in ZT plots was applied at the time of first irrigation.

Results and Discussion
Effect of crop establishment methods on rice
Significantly higher effective tillers /m^{2}and filled grains / panicle were recoded with rice sown by drum seeder in puddled condition (DMS) compared to other rice establishment methods tested. In general higher 1000 grain weight was recorded when rice sown/ transplanted after puddling either conventional transplanting, mechanical transplanting or sown by drum seeder (Table1). Grain yield differed significantly with different establishment methods. Rice sown with drum seeder recorded highest grain yield at all the three locations Fatehpur, Pratapgarh and Raebareli respectively.(49.2, 50.7 and 52.6 q/ha)which was significantly superior over farmers practice (CTP) and dry direct seeded rice (DSR)but at par with the rice transplanted by machine in un-puddled(UMTP) and puddled (PMTP) condition at all three locations *viz*. Fatehpur, Pratapgarh and Raebareli except at Raebareli where it was significantly superior over rice transplanted by machine in puddled condition. Machanical transplanting of rice in unpuddled, puddled condition and dry direct seeded method of crop establishment were at par but yielded significantly higher over conventional method of transplanting (FP) at Pratapgarh and Raebareli location but at Fatehpur difference was not makeable. On the basis of mean yield across the district crop establishment method of rice sown with drum seeder recorded highest grain yield followed by mechanical transplanting in puddled condition, mechanical transplanting in un-puddled condition and dry direct seeding by ZT machine using stale bed technique. Higher grain yield in drum seeder sown crop might be due to optimum plant population and depth of sowing with appropriate other yield attributes. Poor performance in conventional method of transplanting (FP) was due to less plant population /m^2.

Effect of crop establishment method on wheat
Different sowing method of wheat had significant variation in yield attributes *viz*. effective tillers /m^2,number of grains /spike, 1000 grain weight and grain yield (Table2). Wheat sown by ZT technology after puddled rice (UPMTP) recorded highest grain yield 44.5, 46.3 and 47.5 q/ha at Fatehpur, Pratapgarh and

Raebareli location followed by wheat sown with ZT after dry direct seeded rice. Irrespective of various rice establishment methods, sowing of wheat by ZT technology gave 5.93% higher yield over wheat sown after tillage. Higher grain yield with ZT wheat attributed to higher number of effective tillers and grain /panicle and test weight. The possible reason for higher yield attributes and grain yield in ZT wheat might be due to positive effect of residue retention in the field and better root development. Conventional sowing method with tillage (FP) recorded lowest wheat yield at all the three locations.

Effect of crop establishment method on system productivity

Total productivity of rice –wheat cropping was calculated in rice equivalent yield (REY) for the treatment (Table 3). Rice transplanted by machine in unpuddled condition fb wheat by ZT recorded highest REY (99.73 q/ha/year.) followed by the rice sown with drum seeder and wheat sown by ZT and rice(DSR) –wheat (ZT) respectively, being at par with each other recorded significantly higher over farmers practice. These observations were in contrast of the findings of Gangwar *et al.* (2010).

Economics

Maximum system net return (Rs. 96961/ha) and highest B:C ratio (2.47) recorded in the rice (DSR) – wheat (ZT) followed by rice (DMS) – wheat (ZT) and rice (UPMTP) – wheat (ZT) crop establishment methods respectively, (Table3). Rice (DSR) –wheat (ZT) crop establishment method recorded Rs. 24485/ha higher net return over farmers practice i.e. rice (CTP) – wheat (CS) and Rs. 9488/ha over rice (PMTP) –wheat (RTV). Brar *et al.* (2011) also reported similar results. Higher net return and B: C ratio in rice (DSR) –wheat (ZT) crop establishment method attributed to lowest cost of cultivation and comparable grain yield among the different crop establishment methods tested. Residue retention of both the crop in this system may be the reason of better yield in this system. Lowest net return of Rs. 72476/ha/ year and B: C ratio (2.18) was recorded with farmers practice.

Nutrient uptake

Highest NPK uptake on system basis was recorded with establishment method of rice (UPMTP) – wheat (ZT) followed by rice (DMS) – wheat (ZT) and rice (PMTP) – wheat (RTV). Higher NPK uptake in these treatments attributed to higher grain yield of rice and wheat and might be due to better concentration of nutrients in grain and straw.

Soil fertility

There was no marked difference in soil pH due to various crop established methods. There was also no marked difference in soluble salt content (EC) in the soil due to various treatments. It can be inferred that soil chemical properties do not get deteriorated by crop established methods (Table 4). Crop established methods did not cause any marked change in the organic carbon (SOC) content. However, the maximum amount of soil organic carbon in postharvest soil was noted with rice (DSR) –wheat (ZT) at all the experimental soils. Available nitrogen content showed marked differences at all the experimental sites after 3 cycles due to various crop established methods. The highest available nitrogen contents were obtained under rice (DSR) –wheat (ZT) followed by rice (UPMTP) –wheat (ZT), rice(DMS) –wheat (ZT), rice(PMTP)-wheat(ZT) and farmers practice (FP). The lowest available nitrogen content was recorded in FP. Available Phosphorus status recorded significant variation due to crop establishment methods (Table 4). Highest available P content of 34.6 kg/ha was recorded in rice (DSR) –wheat (ZT) treatment at Raebareli site. It was followed by rice (UPMTP) –wheat (ZT), rice (DMS) –wheat (ZT), rice (PMTP) - wheat (ZT) and farmers practice (FP). The lowest available P content of 12.5 kg/ha was observed under FP at Fatehpur site. Crop established method rice (DSR) –wheat (ZT) showed marked higher available potassium status at all the three sites. The lowest available potassium was recorded in FP treatment at Fatehpur site. Available S content was not affected by variations in the crop establishment methods. Lowest and highest contents of DTPA-Zn in postharvest soil were recorded under FP and rice (DSR) –wheat (ZT) respectively. This increase in available nutrients in postharvest soil may be attributed to retention of crop residue in the soil. Available Fe content in postharvest soil was not affected markedly by various nutrient management practices. However status of available Fe was higher under rice (DSR) –wheat (ZT). The status of Mn and Cu in postharvest soil did not vary markedly with various nutrient management practices.

Table 1: Yield and yield attributes of rice as affected by crop establishment methods. (Pooled data of 3 years of 3 districts)

Treatments	Effective tillers/m^2	Grain / panicle	1000 grain wt. (g)	Grain yield (q/ha.)	% increase in yield over FP
Fatehpur					
Rice(CTP) – wheat (CS) FP	322	120	20.46	45.3	--
Rice (DMS) – wheat (ZT)	357	126	19.78	49.2	4.1
Rice (DSR) – wheat (ZT)	301	110	18.23	46.3	0.2
Rice(UPMTP) – wheat (ZT)	333	118	18.63	47.6	2.9
Rice (PMTP) – wheat (RTV)	327	117	20.35	46.4	0.2
CD (*P=0.05*)	16	5	NS	2.4	
Pratapgarh					
Rice(CTP) – wheat (CS) FP	318	125	20.7	45.5	-
Rice (DMS) – wheat (ZT)	355	134	19.1	50.7	11.4
Rice (DSR) – wheat (ZT)	310	127	18.6	48.1	1.31
Rice(UPMTP) – wheat (ZT)	354	129	18.2	48.2	5.9
Rice (PMTP) – wheat (RTV)	334	125	20.5	49.8	9.5
CD (*P=0.05*)	18	6	NS	2.6	-
Raebareli					
Rice(CTP) – wheat (CS) FP	310	118	20.6	44.6	
Rice (DMS) – wheat (ZT)	375	139	20.1	52.6	25.7
Rice (DSR) – wheat (ZT)	350	129	18.8	49.2	10.7
Rice(UPMTP) – wheat (ZT)	359	134	18.6	50.8	19.3

Rice (PMTP) – wheat (RTV)	365	135	20.6	52.4	22.9
CD (*P=0.05*)	17	8	NS	2.7	

TP= Conventional manual transplanting, DMS= rice sown with drum seeder, DSR= Direct seeded rice, UPMTP= unpuddled Machine transplanting, ZT= wheat sown with zero till technology, PMTP= puddled Machine transplanting, CS= wheat sown with conventional tillage and broadcasting of seed and RTV= wheat sown after rotavater and broadcasting of seed

Table 2: Yield and yield attributes of wheat as affected by crop establishment methods. (Pooled data of 3 years of 3 districts)

Treatments	Effective tillers/m^2	Grain / panicle	1000 grain wt.	Grain yield (q/ha.)	% increase in yield over FP
Fatehpur					
Rice(CTP) – wheat (CS) FP	341	42	36.9	40.3	--
Rice (DMS) – wheat (ZT)	352	43	38.3	41.2	2.2
Rice (DSR) – wheat (ZT)	356	46	42.8	44.3	9.9
Rice(UPMTP) – wheat (ZT)	354	44	43.2	44.5	10.4
Rice (PMTP) – wheat (RTV)	345	42	38.7	42.7	5.9
CD (*P=0.05*)	12	3	2.7	2.4	
Pratapgarh					
Rice(CTP) – wheat (CS) FP	344	36	37.5	40.8	-
Rice (DMS) – wheat (ZT)	353	40	38.8	42.3	3.6
Rice (DSR) – wheat (ZT)	362	43	44.3	43.4	6.4
Rice(UPMTP) – wheat (ZT)	364	45	42.8	46.3	13.4
Rice (PMTP) – wheat (RTV)	346	40	39.9	42.5	4.2
CD (*P=0.05*)	12	4	36.8	2.6	
Raebareli					
Rice(CTP) – wheat (CS) FP	357	41	38.2	42.2	-
Rice (DMS) – wheat (ZT)	359	45	42.1	44.0	4.3
Rice (DSR) – wheat (ZT)	364	44	44.5	46.5	10.2
Rice(UPMTP) – wheat (ZT)	372	46	34.8	47.5	12.6
Rice (PMTP) – wheat (RTV)	355	42	3.2	43.2	2.4
CD (*P=0.05*)	17	4		3.5	

Table 3: Rice equivalent yield, economics and nutrient uptake of rice – wheat cropping system as affected by crop establishment methods. (Pooled data of 3 years of 3 district)

Treatments	REY (q/ha)	Cost of cultivation (Rs./ha)	Net return (Rs. /ha)	B: C ratio	Nutrient uptake (Kg/ha) N P K
Rice(CTP) – wheat (CS) FP	90.43	61000	72476	1.86	189 91 215
Rice (DMS) – wheat (ZT)	97.67	48200	95970	2.53	206 99 232
Rice (DSR) – wheat (ZT)	97.19	46500	96961	2.47	192 94 217
Rice(UPMTP) – wheat (ZT)	99.73	52800	94357	2.35	209 99 234
Rice (PMTP) – wheat (RTV) S	96.73	55300	87483	2.19	201 97 229
CD (*P=0.05*)	06.12				13 4 11

Table 4: Effect of crop establishment method on soil nutrient status after 3 cycle of rice - wheat cropping system (Pooled data of 3 district)

Crop establishment method	pH	EC (dS/m)	OC (g/kg)	Available nutrients (kg/ha)				Available micro-nutrients (mg/kg)			
				N	P	K	S	Zn	Cu	Fe	B
Fatehpur											
Rice(CTP) – wheat (CS) FP	8.12	0.38	0.27	202	12.2	140	18	0.64	0.37	3.84	0.20
Rice (DMS) – wheat (ZT)	8.10	0.37	0.29	214	14.6	155	20	0.72	0.42	3.80	0.20
Rice (DSR) – wheat (ZT)	8.10	0.38	0.31	226	18.5	169	24	0.74	0.44	3.52	0.24
Rice(UPMTP) – wheat (ZT)	8.12	0.36	0.30	216	17.2	159	22	0.72	0.42	3.66	0.22
Rice (PMTP) – wheat (RTV)	8.14	0.39	0.28	209	12.5	145	20	0.70	0.42	3.88	0.22
Pratapgarh											
Rice(CTP) – wheat (CS) FP	8.24	0.27	0.32	196	18.3	165	22	0.78	0.45	3.84	0.22
Rice (DMS) – wheat (ZT)	8.22	0.29	0.34	204	20.5	178	24	0.81	0.49	3.88	0.22
Rice (DSR) – wheat (ZT)	8.20	0.34	0.38	228	26.5	196	25	0.90	0.52	3.76	0.24
Rice(UPMTP) – wheat (ZT)	8.22	0.30	0.34	216	24.5	182	22	0.84	0.50	3.90	0.24
Rice (PMTP) – wheat (RTV)	8.22	0.33	0.34	208	22.3	170	22	0.82	0.48	3.87	0.22
Raebareli											
Rice(CTP) – wheat (CS) FP	7.90	0.32	0.35	212	20.3	172	19	0.80	0.60	3.92	0.26
Rice (DMS) – wheat (ZT)	7.88	0.33	0.41	216	27.2	186	20	0.84	0.62	3.95	0.29
Rice (DSR) – wheat (ZT)	7.86	0.36	0.44	228	34.6	194	25	0.91	0.63	3.89	0.30
Rice(UPMTP) – wheat (ZT)	7.86	0.34	0.40	220	29.5	188	23	0.84	0.62	3.95	0.29
Rice (PMTP) – wheat (RTV)	7.96	0.34	0.38	214	26.5	180	22	0.82	0.60	3.94	0.26

Conclusion

Based on the results of on farm trials, it may be concluded that for getting higher yield, rice (UMTP) – wheat (ZT) was the best crop establishment method in rice – wheat cropping system. For getting highest net return /ha/year and B: C ratio rice (DSR) – wheat (ZT) may be the best crop establishment method which can minimize the cost of cultivation and improve the soil health of eastern Uttar Pradesh.

References

1. Berger KC, Truog E. Boron determination in soils and lants.Ind. Eng. Chemio. Anal. Ed. 1939;11:540-5.
2. Bohra JS, Kumar R. Effect of crop establishment methods on productivity profitability and energetics of rice (*Oryza sativa*) –wheat (*Triticum aestivum*) system. Indian Journal of Agricultral Sciences. 85(2):217-23.
3. Hanway JJ, Heidal H. Soil analysis methods as used in Iowa State College. Agriculture Bulletin. 1952;57:1-13.
4. Gathala MK, Kumar V, Sharma PC, Saharawat YS, Jat HS, Singh M. Optimizing intensive cereal based cropping systems addressing current and future drivers of agricultural change in the Northwestern Indo-Gangetic Plains of India. Agriculture, Ecosystems and Environment, 187:3-46.
5. Hobbs PR, Gupta RK. Sustainable resource management in intensively cultivated irrigated rice- wheat cropping system of the Indo-Gangetic Plains of South Asia: Strategies and options. Paper presented at the Int. conference on Managing natural resources for sustainable production in 21st century. New Delhi. India; c2000. p. 14-18.
6. Rice – wheat Facilitation Unit, IARI, New Delhi, India and CIMMYT, Mexico.
7. Jackson ML. Soil Chemical Analysis. Prentice Hall of India Pvt Ltd, New Delhi; c1973.
8. Jat ML, Singh B, Gerard B. Nutrient management and use efficiency in wheat systems of South Asia. Advances in Agronomy. 125;171-259.
9. Jha AK, Sharma RS, Vishwakarma SK. Development of resource conservation techniques for tillage and sowing management in rice-wheat cropping system under irrigated production system of Kymore Plateau and Satpura hill zone of Madhya Pradesh. JNKVV Research Journal. 2007;41(1):26-31.
10. Lindsay WI, Norvell WA. Development of a DTPA soil test for zinc, iron, manganese and copper. Soil Science Society of America Journal. 1978;42:421-48.
11. Mishra JS, Singh VP, Bhanu C, Subrahmanyam D. Crop establishment, tillage and weed management techniques on weed dynamics and productivity of rice (*Oryza sativa*)-chickpea (*Cicer arietinum*) cropping system. Indian Journal of Agricultural Sciences. 2012;82(1):15-20.
12. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorous in soils by extraction with sodium bicarbonate. Circular US Department of Agriculture, Washington DC; c1954. p. 939.
13. Subbiah BV, Asija GL. A rapid procedure for the available nitrogen in soils. Current Science. 1956;25:259-60.
14. Tomar RK, Singh D, Gangwar KS, Garg RN, Gupta VK, Sahoo RN, *et al*. Influence of till age systems and moisture regims on soil physical environment, growth and productivity of rice-wheat system in upper Gangaticplains of Western Uttar Pradesh. Indian Journal of Crop Science. 2006;1(1-2):146-50.
15. Walkley AJ, Black IA. Estimation of soil organic carbon by chromic acid titration method. Soil Science. 1934;37:29-38
16. Baba S. A., Kolo S. A. "The role of small scale rice farmers in diversification programme in Lau local government area of Taraba, Nigeria " . International Journal of Agriculture and Plant Science, Volume 3, Issue 2, 2021, Pages 50-53.