Short Title: Fertilizer management of rainfed *utera* crops

Effect of fertilizer Application on Crop Growth, Yield And Water Use Efficiency of *Utera* Crops in the Lowland Rainfed Rice Ecosystem

ChandanBaskey[1],SarbajoyaGoswami[2] ,Ramyajit Mondal[3], Sanjib Mandi[4] andS.B. Goswami[1]*

***CorrespondingAuthor:[5]Professor,DepartmentofAgronomy,BidhanChandraKrishiViswavidyalaya Mohanpur, Nadia-741252, West Bengal, India E-Mail: sbg_bckv05@rediffmail.com.**

[1]M.Sc(Ag)Agronomy, Departmentof Agronomy,BCKV, Mohanpur

[2]Ph.DScholar,DepartmentofAgronomy,Visva-BharatiUniversity,Shantiniketan,Bolpur

[3]AssistantProfessor,DepartmentofAgronomy,SeacomSkillsUniversity,Birbhum-731236

4.SMS(Agronomy),KVK,Gajapati,OUAT,Bhubaneswar,Odisha, 761016

Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya
Mohanpur, Nadia-741252, West Bengal, India

Abstract

A field experiment was undertaken at Instructional Farm, Jaguli of Bidhan Chandra Krishi Viswavidyalaya, West Bengal to study the performances of *utera* crops as influenced by fertilizer management in rainfed rice ecosystem during *rabi* season of 2018-19 and 2019-20. The experiment was conducted with 3-main plot treatments consisting 3 *utera* crops viz. linseed, lentil and lathyrus; and 3 sub-plot treatments of fertilizer management viz. Suphala (NPK 15:15:15) @ 150 kg ha^{-1} (22.5 kg N), DAP (NP18:46) @ 125kgha^{-1} (22.5kgN) and DAP spraying at 20, 40 & 60 days after sowing @ 2g/lit of water respectively in Split-Plot design with 3 replications. The results of experiment in the lowland rainfed rice ecosystem revealed that lathyrus crop recorded the maximum yield of 725 kg ha^{-1} followed by lentil (721) and linseed (404) *utera* crops. In the experiment, soil application of Suphala (15:15:15) @ 150 kg ha^{-1} gave the highest grain yield (650 kg ha^{-1}) followed by DAP soil application (634) and DAP foliar spray(566).The variation in crop growth and yield attributes of *utera* crops were also similar in trend as noted crop yields. The variation in actual ET of utera crops was noted. Lathyrus crop has the lowest ETa (133.3 mm), whereas, linseed had maximum ETa value of 182.0 mm. Crop water use efficiency value was more in lathyrus (5.42kg/ha-mm) with suphala but least value was noted in linseed (2.42 kg/ha mm) with DAP foliar spray. The maximum benefit cost ratio (3.03) was obtained in lentil with DAP soil application. Considering the results of the experiment, linseed and lathyrus may be grown as utera crop with the fertilizer Suphala (15:15:15) @ 150 kg ha^{-1} but lentil crop may be with Diammonium Phosphate (18:46) @ 125 kg ha^{-1} in low land rice ecosystem of lower Indo-Gangetic Plains.

Key words: Fertilizer management, Rainfed rice ecosystem, *Utera* crops, Yield, Water use efficiency.

Introduction

The rainfed lowland rice ecosystem in the Lower Gangetic Plains of eastern India is characterized by high rainfall, fine-textured soils, bowl shaped topography, stagnation of rain water and chances of flash flood in the rainy season (Sarkar *etal*., 2007). Earlier, the area is mostly covered by long duration (140-155 days) transplanted rice during rainy seasons and there after lands remain mostly fallow. The moisture status of *aman* rice leaves has a great scope for growing a second crop in *rabi* in lowland situation. Sometimes, the farmers of the areas grow *utera* crops in post rainy season utilizing the in-situ soil moisture. In rainfed agriculture, water availability is the primary factor controlling crop productivity. Hence, there is a good scope of growing wheat, lentil, grass pea, oat, linseed, gram, mustard etc. *aspaira* crops after transplanted rice. Intensification of existing agricultural systems is the need of the hour to take care of the rising demand of food grain production in the country (Kumar *et al*., 2016). To grow lentil as relay crop with rice in rice-fallow during post-rainy season through utilizing the carry-over soil water and residual soil fertility (Bandyo padhyay *et al*. 2016). Timing of tillage operation is the main difficulty due to muddy condition or water stagnation in the fields at the time of rice harvest which results in delayed sowing. These problems could successfully be overcome by growing of *rabi* crops under no- tillage condition as *paira* crops by sowing seeds of different winter crops before the harvest of transplanted *kharif* rice in moist land. The land preparation of the winter crops is often difficult due to aberrant onset and withdrawal of monsoons (Parya *etal*.,2010).Under this situation, relaycroppingmay be helpful for getting proper time of sowing for succeeding crop after *kharif* rice (Sharma *et al*., 2014). In West Bengal, it is a general practice of the farmers to sow various winter crops like lentil, lathyrus, chickpea field pea and linseed in the standing rice crop field, just before the harvest to ensure germination using the residual moisture and to avoid tillage operations (Duary *etal*., 2013). Growing of *paira* crops makes the avenue of including more crops in sequences by omitting the time lag between two successive crops as well as reduces the total cost of cultivation. Thus, crops having low water requirement, should be fitted suitably in such situations. The nutritional management for maximizing yield in pulses and oilseeds is the need of the day to overcome the malnutrition of the people in the developing countries. Since *paira* crops in relay cropping with rice suffers from nutrientional stresses during the reproductive phase, late application of N is effective in reducing flower and pod drop in legume and in increasing seed yield. It is also known that active nodulation of pulse crop stops after 45 to 50 DAS and at that time, the positive effect of supplying legume plants with supplementary nitrogen was found to have beneficial effects on enhancing growth and increasing seed yield by quick supply of nitrogen. Legumes generally require higher amount of phosphorus as the process of symbiotic nitrogen fixation consumes a lot of energy. Therefore,the scope of fertilization becomes confined to foliar spray or top dressing (Gupta and Bhowmick, 2005). Foliar application of Di-ammonium phosphate (DAP) at such stages which is superior to basal nitrogen and phosphorus fertilization as the former provides a continuous supply of nutrients for a longer crop growing period, and thus possibly facilitates a steady translocation of the photosynthates resulting in an increase in crop yields (Sarkar *etal.*,2018). So, the present experiment was carried out to study the performances of *utera* crops to nutrient management in lowland rice ecosystem in Lower Indo-Gangetic Plains of West Bengal.

Materials and methods

Field experiment was conducted at the Agricultural Instructional Farm, Jaguli, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal (22°87'N latitude, 88°32' E longitude, 9.75m above mean sea level)to study the performance of *utera* (no-till) crops as influenced by nutrient management in rice ecosystem during *rabi* (winter) season of 2019-20 and 2020-21. The experimental site falls under sub-tropical sub-humid climate.

Table 1. Meteorologicaldata duringthe experimentalperiodduring2018-19and2019-20(mean)

Month	Temperature (°c)		Relative humidity (%)		Total rainfall (mm)	Pan evaporation (mm day^{-1})	BSS (hr)
	Max.	Min.	Max.	Min.			
November	29.48	14.76	96.96	59.56	44.3	2.03	7.77
December	32.48	10.41	96.61	57.06	26.8	1.40	5.78
January	23.34	9.97	97.19	51.80	0.0	1.55	8.85
February	29.45	12.99	97.21	46.10	0.0	2.22	12.05
March	33.99	18.04	94.06	44.93	0.0	3.93	6.59

Source: Department of Agricultural meteorology and Physics, B.C.K.V, Mohanpur Nadia

The average rainfall is 1450 mm, 75% of which is received during June to September. During the crop growth period maximum temperature ranged between 23.34° to 33.99°C and minimum temperature varied between 9.97 to 18.04 ° C (Table1). The maximum relative humidity varied from 94.06 to 97.21% and minimum relative humidity varied from 44.93 to 59.56%. The total rainfall was distributed throughout the experimental period but the highest rainfall received in the month of November (44.3 mm) followed by December (26.8 mm).

Table 2. Soil texture, bulk density and saturated hydraulic conductivity in the soil profile of lowland rice ecosystem

Soil layers (mm)	Textural group(percent)			B.D ($Mg\ m^{-3}$)	Saturated hydraulic conductivity(mmh^{-1})
	Sand	Silt	Clay		
0-150	46.14	24.25	29.61	1.41	4.6
151-300	38.23	26.32	35.54	1.46	1.8
301-450	32.13	29.19	38.68	1.51	1.5
451-600	45.32	23.42	31.26	1.48	2.8
601-1200	56.12	16.23	27.65	1.46	7.2

The texture of the experimental soil was sandy clay loam and belongs to the order in ceptisol with medium fertility and almost neutral in soil reaction (Table2). The experiment was conducted on a medium land, well-drained Gangetic alluvial soil. The experiment was laid down in split-plot design with three replications comprising of different *utera* crops in mainplots (C_1-LinseedcvNeela,C_2-Lentil cvMaitri, C_3- Lathyrus cv Ratan) while different nutrient management in sub plot i.e. (N_1- Suphala (NPK15:15:15) @ 150kgha^{-1},N_2-DAP (NP18:46) @ 125kgha^{-1}, N_3-DAP spray 3 times (at 20,40,60DAS).

Each plot had an area of 4.0 m × 3.0 m. The seeds of lentil, lathyrus and linseed were broadcast before the rice harvesting. Necessary field operations like weeding and control of diseases-pests were done as and when required by the crop. However, fertilizer application was provided according to the treatment details.

The crop was harvested when the plant become yellowish to brown and had around optimum moisture in the grain. Harvested crops were kept in the field for2-3daysforsun-drying. Thereafter, the bundle of the harvested crop of each plot was taken to a clean threshing floor and threshing was done plot-wise separately. Growth parameters *viz.* plant height, dry matter accumulation(DMA),crop growth rate (CGR), primary and secondary branch per plant at flowering stage, nodule per plant were recorded periodically at 30,45, 60DAS and at harvest. Yield components namely plant population at the time of harvest, number of pods plant^{-1}, number of seeds pod^{-1}, 10-pod weight, test weight (1000-seed weight) were recorded at harvest. After threshing the grains were properly sun-dried, cleaned, weighed and finally converted into kg ha^{-1}. Strover yield was also estimated as kg ha^{-1}.Estimation of available nutrient status of soil after harvesting of crop following standard methods. To study the water expenditure in terms of ET_a and water use efficiency (WUE). The data collected on growth parameters, yield components and yields were analyzed following the method of analysis for split-plot design as described by Gomez and Gomez (1984). The significance of different sources of variation was tested at probability level of 0.05. The standard error of mean (S.Em) and the value of CD were indicated in the tables to compare the difference between the mean values.

Results and Discussion

Effect on crop growth

The plant growth in terms of plant height of *utera* crops was significantly influenced by the nutritional management practices. Among the *utera* crops linseed, lentil and lathyrus, plant height increased progressively with the advancement of crop growth.Variations due to crop nutrition's were much noted at harvest (Table 3). At harvest plant height of linseed, lentil and lathyrus varied from 45.0 to 61.9 cm and the linseed crop recorded tallest plant height of 61.9 cm. In the experiment *utera* crops fertilized with Suphala (NPK 15:15:15) recorded the tallest plant height 67.6 cm followed by 56.4 cm and the shortest plant height 49.5 cm was recorded under DAP spray treatment. Higher plant height with proper nutrition to different *utera* crop was the indication of better internode elongation and good vegetative growth throughout the crop cycle.

Total dry matter production increased gradually with the advancement of crop age and reached its peak at the time of harvest. Among the *utera* crops linseed, lentil and lathyrus, dry matter accumulation increased progressively with the advancement of crop growth and their variations were due to crop nutrition.

Table 3. Effect of fertilizer management on growth parameters of *utera* crops in rice fallows (pooled data)

Treatments	Plant height at harvest (cm)	TDM at harvest (g/m^2)	CGR at 60-harvest ($g/m^2/day$)	Branching at flowering	Nodule $plant^{-1}$ at flowering
Utera crop					
Linseed	61.9	209.9	2.03	6.3	0.00
Lentil	45.0	256.4	2.32	8.4	24.8
Lathyrus	51.1	288.8	3.18	6.6	26.0
S.Em(±)	0.65	1.15	0.09	0.05	0.05
CD(*P*=0.05)	2.42	4.63	0.37	0.21	0.19
Crop Nutrition					
Suphala	54.8	243.8	3.19	7.5	17.8
DAPSoil	53.8	254.2	3.32	6.5	18.7
DAPSpray	49.5	257.1	2.80	7.3	14.3
S.Em(±)	0.34	1.15	0.14	0.13	0.07
CD(*P*=0.05)	1.07	3.59	0.44	0.39	0.23

TDM-Total dry matter; CGR-Crop growth rate

At harvest dry matter production among the *utera* crops like linseed, lentil and lathyrus varied to 209.9 to 288.8 gm^{-2} with 37.58% variation, the highest dry matter production (288.8 gm^{-2}) in lathyrus was recorded. In the experiment, *utera* crops fertilized with DAP foliar spray recorded the highest dry matter

Production of 257.1 gm^{-2} followed by DAP Soil (NP18:46) 254.2 gm^{-2} andtheleastvalueofdrymatter production 243.8 g m^{-2} was recorded under Suphala (NPK 15:15:15). Application of foliar nutrition at later stage was helpful for the plants to grow and produce higher amount dry matter.

The dry matter partitioning of crop growth with time in terms of crop growth rate (CGR) of utera crops was significantly influenced by the different nutrient management practices (Table 3). Although the CGR was slow during early initial stage (just after sowing), thereafter increased progressively with the increase in crop age upto active vegetative and reproductive stage (Table 3). At 60 DAS to harvest CGR-value of utera crops varied from 2.03 to 3.18 g m^{-2} day^{-1}with 56.65 % variation and the highest crop growth rate value found in lathyrus (3.18gm^{-2}day^{-1}).In the experiment *utera* crops fertilized with DAP (NP18:46) recorded the highest CGR value 3.32g m^{-2}day^{-1}followed by Suphala (NPK15:15:15) 3.19gm^{-2} day^{-1}.

The production of branches in *utera* crops like linseed, lentil and lathyrus at flowering time varied significantly with the variation of different nutritional management practices (Table 3). At flowering time number of primary branches of crop varied from 6.3 to 8.4 with 33.33% variation and more number of branches (8.4) in lentil crop and less number of secondary branches (6.3) in linseed were seen (Table 3). In the experiment *utera* crops fertilized with Suphala recorded the more number of secondary branches (7.5) followed by DAP-spray 7.3 and the less n umber of secondary branches (6.5) were recorded under DAP (NP 18:46).

Active nodule number at flowering stage of crop growth was significantly influenced by the different nutritional management practices (Table 3).Variations due to crop nutrition were much noted at the flower initial to 50% flowering stage after flowering nodule number continuously decreases. Among the *paira* crops like lentil and lathyrus, the nodule numbers per plant at the flowering stage varied from 24.8 to 26.0 respectively and the more number of nodules per plant recorded in lathyrus (26.0). In the experiment, *utera* crops fertilized with DAP (NP 18:46) recorded the more nodules per plant (18.7) followed by Suphala (NPK15:15:15) 17.8 and the least number of nodule per plant (14.3) was recorded under DAP spray treatment.

Effecton yield attributes and yield

There was significant effect on yield attributes and yield of *utera* crops under different nutrient management practices (Table 4). Plant population at harvest, an important parameter in *utera* crops, was significantly influenced by nutrient management in lowland rice ecosystem (Table 4). Maximum plant population was in 49.7 to the tune of 16.06% per m^2 and the least was in 42.8per m^2.Crop nutrition

With DAP soil fertilizer in *utera* crops had a distinctive impact on population. Maximum plant population was noted with Suphala fertilizer management in lathyrus crop.

The number of pods plant^{-1} of *utera* crops like linseed, lentil and lathyrus in rice ecosystem was significantly influenced by the nutrient management practices (Table 4). Among the *utera* crops lentil recorded the highest number of pods plant^{-1} (27.1) followed by lathyrus (25.4) but linseed crop gave the lowest number of pods plant^{-1}(8.7). In the experiment, *utera* crops fertilized with Suphala recorded the highest number of pods plant^{-1} (21.6) followed by DAP-soil (20.5) and the lowest number of pods plant^{-1} (19.0) was recorded in DAP-spray.

Table4. Effect of fertilizer management on yield attributes and yield of *utera* crops in rice fallows (pooled data)

Treatments	Plant population at harvest	No. of pods plant^{-1}	Seeds pod^{-1}	10 pod weight (g)	Test weight (g)	Seed yield (kgha^{-1})	Biomass yield (kgha^{-1})	Harvest Index
Utera crop								
Linseed	42.8	8.7	6.9	0.55	5.3	404	1508	0.27
Lentil	49.0	27.1	2.1	2.37	20.9	721	1970	0.37
Lathyrus	49.7	25.4	4.0	2.03	59.1	725	2481	0.29
S.Em(±)	0.16	0.28	0.27	0.11	0.67	9.22	9.36	0.05
CD(*P*=0.05)	0.63	1.15	1.10	0.44	2.69	37.17	37.73	0.19
Crop Nutrition								
Suphala	49.6	21.6	5.0	1.86	30.2	650	1910	0.29
DAPSoil	49.8	20.5	4.2	1.71	28.6	634	1965	0.25
DAPSpray	42.1	19.0	3.9	1.38	26.5	566	2084	0.26
S.Em(±)	0.21	0.58	0.136	0.10	0.34	14.73	7.94	0.007
CD(*P*=0.05)	0.64	1.83	0.423	0.31	1.04	45.91	24.74	0.023

The number of seeds per pod of *utera* crops also significantly influenced by the nutrient management practices (Table 4). Among the *utera* crops, linseed recorded the highest number of seeds pod^{-1} of 6.9 followed by lathyrus (4.1) but lentil crop gave very less number of seeds pod^{-1} of 2.1 seeds pod^{-1}. In the experiment, *utera* crops fertilized with Suphala recorded the highest number of seeds per pod (5.1) followed by DAP-soil (NP 18:46) the treatment (4.2) and the lowest number of seeds per pod (3.9) was recorded in DAP-spray treatment. Seeds per pod were not more influenced by nutrient management it varies from crop to crop. Linseed is a small seeded oilseed crop that produced more number of seed per pod than lathyrus and lentil.

The 10-pod weight of *utera* crops like linseed, lentil and lathyrus in rice ecosystem was significantly influenced by the nutrient management practices (Table 4).Among the *utera* crops, lentil recorded the highest pod weight of 2.37 g followed by lathyrus (2.03 g) but linseed crop gave very less (0.55g). In the experiment, *utera* crops fertilized with Suphala (NPK15:15:15) recorded the highest 10-

pod weight (1.86 g) followed by DAP (NP 18:46) soil application and the lowest pod weight (1.38 g) was recorded in DAP foliar spray treatment.

The plumpness or boldness of seed in terms of test weight (1000 grain weight) of *utera* crops grown under diversified nutrient management was found significant. Among the *utera* crops, lathyrus recorded the maximum test weight of (59.1) followed by lentil (20.9) but linseed crop gave very less test weight (5.3). In the experiment, *utera* crops fertilized with Suphala (NPK15:15:15) recorded the highest test weight (30.2) followed by DAP (NP 18:46) the treatment (28.6) and the lowest test weight was recorded in DAP spray (26.5).

The land productivity in terms of seed yield of *utera* crops like linseed, lentil and lathyrus grown in rice ecosystem was significantly influenced by the nutrient management practices (Table 4). Among the *utera* crops, lathyrus recorded the highest yield of 725 kg ha^{-1}followed by lentil (721 kg ha^{-1}) but linseed crop gave very less yield of 404 kg ha^{-1}. In harmony to our findings, Bandyo padhyay *etal.* (2018) also reported that higher yield of lentil was obtained in no tillage condition then conservation and minimum tillage condition. The yield variation among the utera crops was 79.45%. In the experiment, *utera* crops fertilized with Suphala (NPK15:15:15) @ 150 kg ha^{-1} recorded the highest grain yield (650 kg ha^{-1}) followed by DAP (NP 18:46) @ 125 kg ha^{-1} and the lowest seed yield (565.83 kg ha^{-1}) was recorded in DAP foliar spray treatment. The yield variation due to differential nutrition was 14.85% which was much less under zero-till situation.

Interaction effects of *utera* crops with different fertilizer management on seed yields and their yield attributes were significantly noted but not shown here. The seed yield of linseed cv Neela varied to the tune of 10.44 to 39.93% by the differential nutrient gradation. Similarly, lentil and lathrus recorded yield variation of 28.73 to 39.41% and 12.04 to 14.91% respectively. Among the fertilizer sources, Suphala was found most effective in lathyrus and linseed and similarly DAP in lentil on the basis of their yield performances. DAP foliar spray gave always least yield in these three *utera* crops.

The biomass productivity in terms of strover plus seed yield of *utera* crops like linseed, lentil and lathyrus in rice ecosystem was significantly in fluenced by the nutrient management practices (Table 4). Among the *utera* crops, lathyrus recorded the highest biomass yield of 2481 kg ha^{-1} followed by lentil (1970 kg ha^{-1}) but linseed crop gave very less biomass yield of 1508 kg ha^{-1}. In the experiment, *utera*crops fertilized with DAP foliar spray recorded the highest biomass yield (2084 kg ha^{-1}) followed by DAP (NP 18:46) the treatment (1965 kg ha^{-1}) and the lowest biomass yield (1909 kg ha^{-1})was recorded in Suphala treatment.

The source to sink ratio in terms of harvest index of *utera* crops like linseed, lentil and lathyrus in rice ecosystem was significantly influenced by the nutrient management practices(Table4).Among the

Utera crops, lentil recorded the highest harvest index of 0.37 followed by lathyrus (0.29) but linseed crop gave very less harvest index of 0.27. In the experiment, utera crops fertilized with Suphala (NPK 15:15:15) recorded the highest harvest index (0.29) followed by DAP spray the treatment (0.26) and the lowest harvest index (0.25) was recorded in DAP (NP 18:46) treatment.

Effect on available nutrients status in post-harvest soil

Data related with available nutrients in soil after harvest of crop are presented in (Table 5).The status of available N, P, K, and organic C in soil was significantly influenced by different nutrient management. Among the *utera* crops linseed lentil and lathyrus the results revealed that N, P and K and organic carbon content differ significantly.

Table5. Effect of fertilizer management on nutrient status in post-harvest soil of utera crops in rainfed rice fallows (pooled data)

Treatment	Nutrient status in post-harvest soil			
	Nitrogen ($kgha^{-1}$)	Phosphorus ($kg\ ha^{-1}$)	Potassium ($kg\ ha^{-1}$)	Carbon (%)
Utera crop				
Linseed	190.2	28.8	194.0	0.56
Lentil	227.9	42.2	207.4	0.65
Lathyrus	225.5	38.7	200.2	0.63
S.Em(±)	0.019	0.114	0.058	0.001
CD(*P*=0.05)	0.075	0.458	0.234	0.005
Crop Nutrition				
Suphala	216.8	35.2	228.5	0.62
DAPSoil	234.7	42.1	189.6	0.66
DAPSpray	192.23	32.5	183.6	0.61
S.Em(±)	0.028	0.141	0.043	0.003
CD(*P*=0.05)	0.087	0.438	0.135	0.009

Maximum content of available nitrogen, phosphorus, potassium and organic carbon % was noted under lentil crop grown field i.e. (227.9 kg ha^{-1}, 42.3 kg ha^{-1}, 207.4kg ha^{-1} and 0.65) followed by lathyrus grown field i.e. (225.5 kg ha^{-1}, 38.8 kg ha^{-1}, 200.2 kg ha^{-1} and 0.63) but linseed grown field gave less available nutrient status i.e.(190.2 kg ha^{-1}, 28.8 kg ha^{-1}, 194.0 kg ha^{-1} and 0.56). Among the different nutrient management practices available nitrogen, phosphorus and % of organic carbon were found maximum in the plot fertilized with DAP (NP18:46) soil application i.e.(234.7 kg ha^{-1},42.1kg $ha^{-1}$and 0.66%) and potassium status highest in the plot fertilized with Suphala (NPK15:15:15)i.e.(228.5kg ha^{-1}). Lowest nutrient status was recorded under only DAP foliar spray treatment.

Effects on actual evapo transpiration, water use efficiency and soil moisture extraction

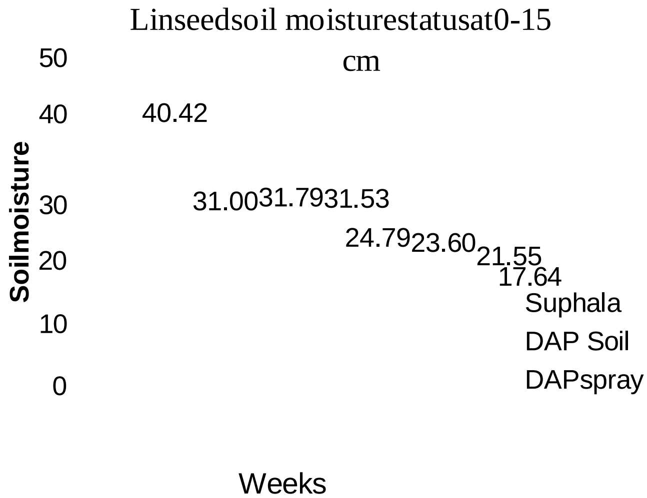
The variation in actual evapo transpitation (ETa) of *utera* crops was much influenced in no-till rice ecosystem (Table6).Lathyrus crop with huge ground coverage has the lowest ET a value (133.8mm) whereas, linseed crop characterised by deep root and less ground cover recorded highest water uptake showing ETa value of 182.0 mm. The variation of ETa was about 36.02% and this variation might be attributed to their variation in canopy cover and water extraction differences. Fertilizer application of DAP soil registered the highest ETa value of 187.7 followed by Suphala (156.5mm) and the least Eta was seen in DAP spray. Here, variation in ETa was noted up to 19.93% which might be caused by their nutrient mining capacity in utera cropping situation.

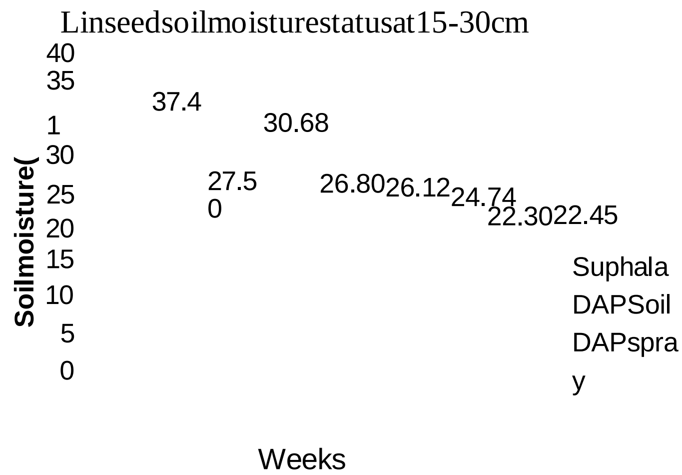
Table 6. Effect of fertilizer management on actual evapo transpiration(ETa) and water use efficiency (WUE) of utera crops in rainfed rice fallows (mean values of 2 years)

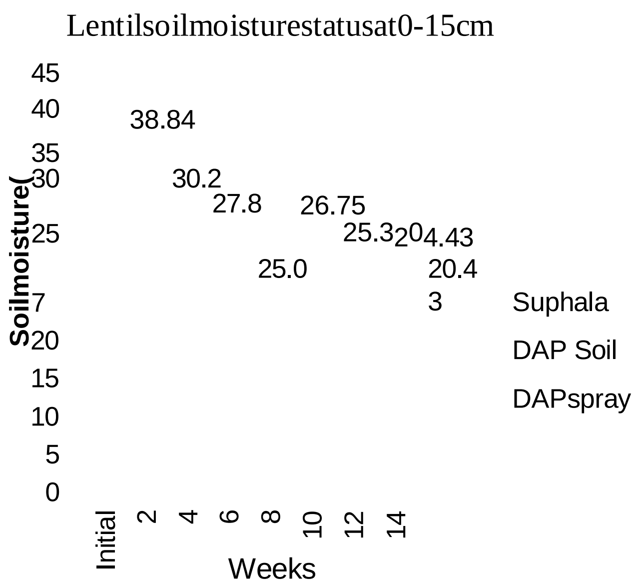
Treatment	ETa (mm)	Yield ($kgha^{-1}$)	WUE ($kgha\text{-}mm^{-1}$)
Utera crop			
Linseed	182.0	440	2.42
Lentil	157.4	721	4.58
Lathyrus	133.8	725	5.42
Crop nutrition			
Suphala	156.5	650	4.15
DAPSoil	178.7	634	3.55
DAPSpray	138.1	566	4.10

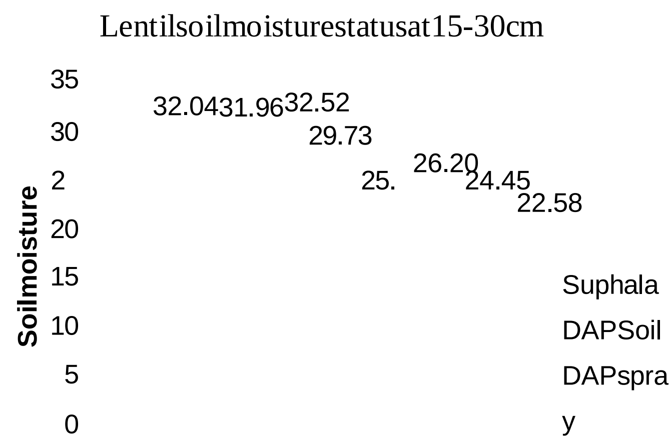
The water use efficiency (WUE) of *utera* crops like linseed,lentil and lathyrus in rice ecosystem was much influenced by the nutrient management practices (Table 6). The WUE of linseed cv Neela recorded2.42kg/ha-mm and the highest WUE value was achieved by Lathyrus (5.42kg/ha-mm and the variation was more than double (124%) in no-till rice ecosystem. The differential nutrient nutrient feeding of utera crops created narrow variation (16.91%) in WUE value. Among the fertilizer sources, Suphala was found most effective followed by DAP foliar spray on the basis of their WUE. DAP foliar spray gave always least yield in these three *utera* crops. Crop WUE was more in lathyrus and least value was noted in linseed.

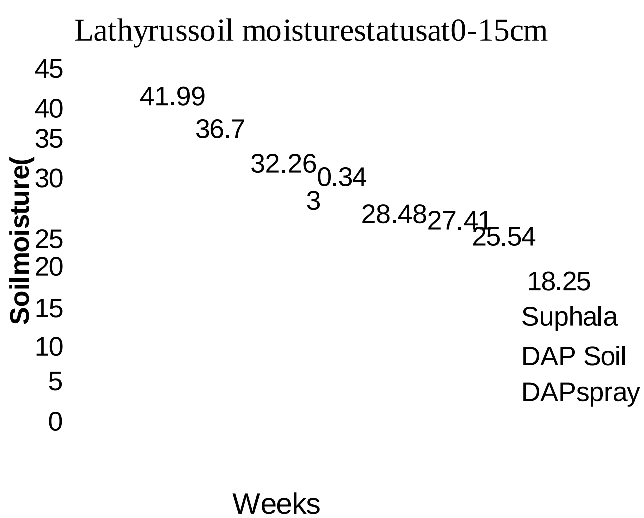
The soil moisture extraction pattern of utera crops like linseed, lentil and lathyrus was very much influenced by crop nutrition sources (Figure 1). *Utera* crops were sown on the saturated paddy soils in standing rice 10 days before harvest of the crop with the soil moisture content. Fertilizers like Suphala and DAP were applied 4 days before seed sowing of crops. The soil moisture varied from 38.84 to 41.99% at seed sowing stage and at the harvest of the utera crops soil moisture varied from 17.64 to 18.25 at 0-15 cm soil depth and at lower depth of soil (15-30cm) soil moisture was from 22.45 to 25.41% depending on the type of crops.


Linseedsoil moisturestatusat0-15 cm
50
40
30
20
10
0
Soilmoisture
40.42
31.00
31.79
31.53
24.79
23.60
21.55
17.64
Suphala
DAP Soil
DAPspray
Weeks


Linseedsoilmoisturestatusat15-30cm
40
35
30
25
20
15
10
5
0
Soilmoisture(
37.41
30.68
27.50
26.80
26.12
24.74
22.30
22.45
Suphala
DAPSoil
DAPspray
Weeks


Lentilsoilmoisturestatusat0-15cm
45
40
35
30
25
20
15
10
5
0
Soilmoisture(
38.84
30.2
27.8
26.75
25.07
25.3
20.43
24.43
20
Suphala
DAP Soil
DAPspray
Initial
2
4
6
8
10
12
14
Weeks


Lentilsoilmoisturestatusat15-30cm
35
30
2
20
15
10
5
0
Soilmoisture
32.04
31.96
32.52
29.73
25.
26.20
24.45
22.58
Suphala
DAPSoil
DAPspray


Lathyrussoil moisturestatusat0-15cm
45
40
35
30
25
20
15
10
5
0
Soilmoisture(
41.99
36.7
32.26
30.343
28.48
27.41
25.54
18.25
Suphala
DAP Soil
DAPspray
Weeks

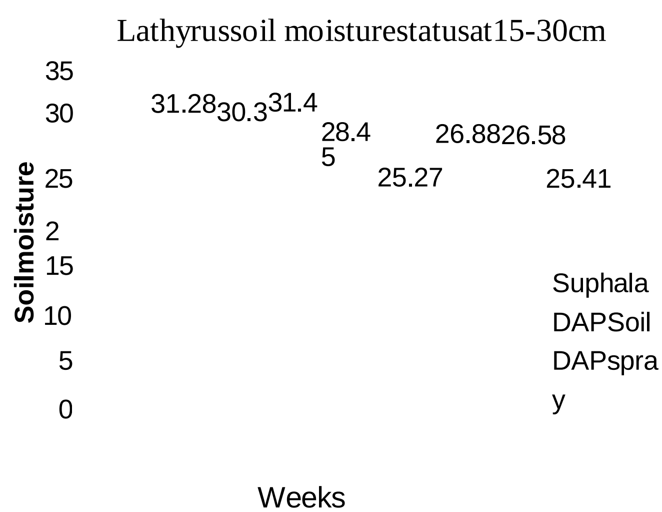
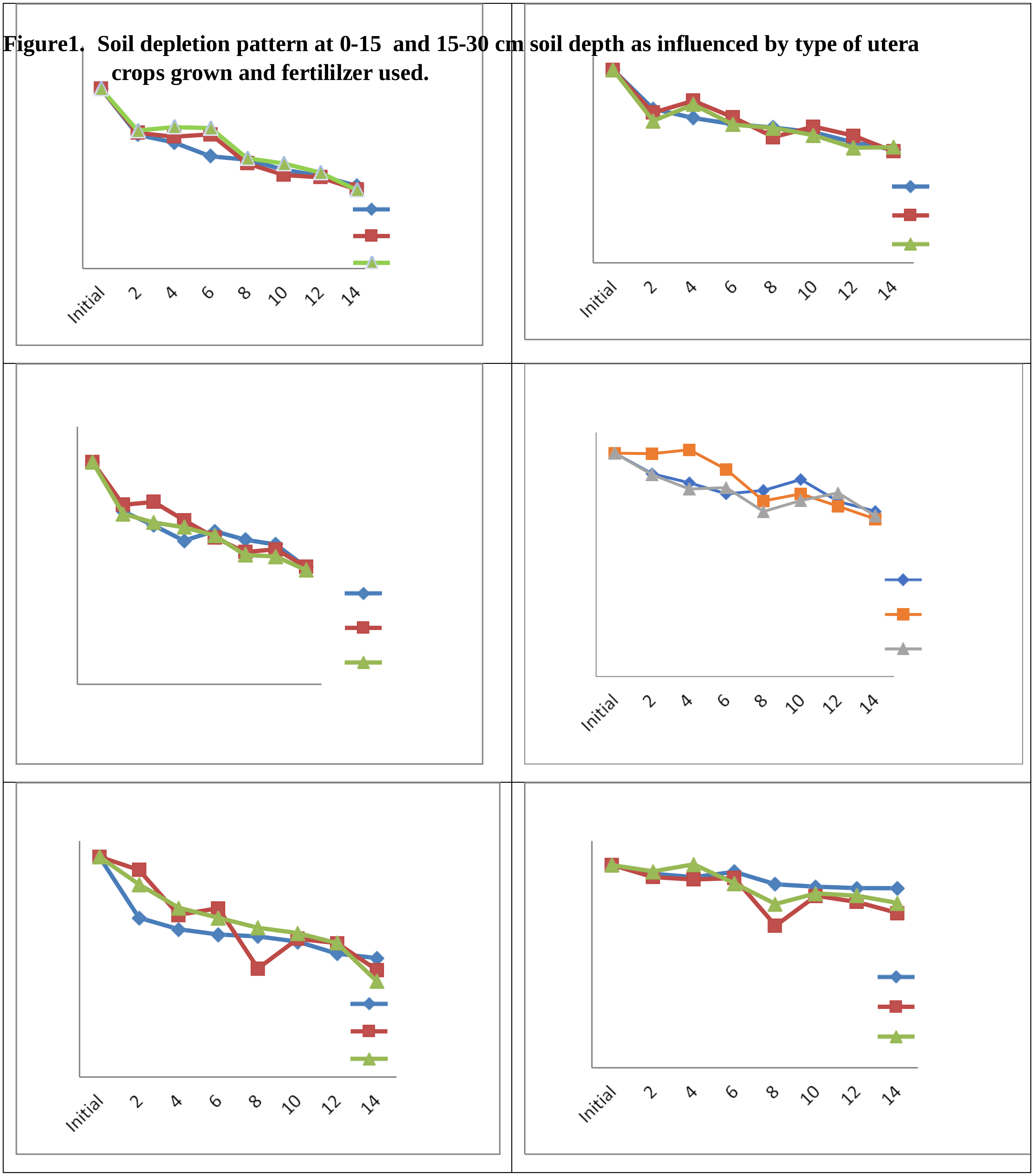

Lathyrussoil moisturestatusat15-30cm
35
30
25
2
15
10
5
0
Soilmoisture
31.28
30.3
31.4
28.45
25.27
26.88
26.58
25.41
Suphala
DAPSoil
DAPspray
Weeks

Figure1. Soil depletion pattern at 0-15 and 15-30 cm soil depth as influenced by type of utera crops grown and fertililzer used.



Lentil crop depleted more soil moisture than lentil and lathyrus. Regarding fertilizer sources, soil moisture depletion was more by the Suphala (NPK15:15:15) than DAP (NP18:46). DAP spray had little impact on soil moisture extraction. Soil moisture extraction differentiation was more pronounced at flowering to pod development (6-12 weeks) of utera crops. At harvest linseed crop recorded less soil moisture content of 17.54% at top layer (0-15 cm).

Production economics of utera crops

More acceptability of any research finding among small and marginal farmers depends on its economic viability. Economics of *utera* crops linseed, lentil and lathyrus production in terms of gross return and net return and benefit: cost ratio was calculated for different mode of nutrient treatments and data are presented in (Table7). It is evident from the tables that lentil crop had the highest net return of Rs.23024 per ha with the highest benefit-cost ratio of2.73 followed by lathyrus.The direct effect of fertilizer management on production economics was more pronounced in Suphala and DAP soil application than DAP spray. The combined effect so future crop and fertilizer application were studied as in case lentil with DAP (NP18:46) treatment combination (C_2N_2) recorded the highest gross return of Rs.40836/- and the lowest gross return of Rs.14793/- recorded under linseed with DAP (NP 18:46) foliar spray treatment combination (C_1N_3). In case of the net return among the *paira* crop so flinseed, lentil and lathyrus observed that net return of lentil with DAP (NP 18:46) treatment (C_2N_2) combination had the highest net return RS.27380/- recorded. But in linseed with DAP (NP 18:46) treatment (C_1N_2) combination was recorded the lowest net return RS.4316/-. Under same treatment combinations recorded highest benefit-cost ratio of 3.03 i.e. in lentil with DAP soil application (C_2N_2) treatment combination. In case of linseed with DAP (NP18:46) soil application recorded minimum benefit cost ratio (1.36) was observed.

Table7. Effect of fertilizer management on production economics of utera crops in rainfed rice follows (mean values of 2 years)

Treatment	Cost (Rs.ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs.ha^{-1})	B:C
Utera crop(C)				
Linseed(C_1)	11320	17151	5831	1.51
Lentil(C_2)	13374	36398	23024	2.73
Lathyrus(C_3)	12571	30223	17652	2.40
Crop nutrition(N)				
Suphala(N_1)	12807	29536	16728	2.29
DAPSoil (N_2)	12586	28663	16077	2.25
DAPSpray(N_3)	11872	25573	13701	2.10
Interaction effect				

C_1N_1	11756	20249	8493	1.72

C_1N_2	12096	16412	4316	1.36
C_1N_3	10110	14793	4683	1.46
C_2N_1	13706	29841	16135	2.18
C_2N_2	13456	40836	27380	3.03
C_2N_3	12960	38517	25557	2.97
C_3N_1	12206	28742	16536	2.35
C_3N_2	12546	23410	10864	1.87
C_3N_3	10560	20525	9965	1.94

Conclusion

Considering the results of the experiment in rainfed rice fallows of lower Indo-Gangetic Plains, it may be advocated that linseed and lathyrus may be grown with the fertilizer Suphala (15:15:15) @ 150 kg ha^{-1} but for lentil crop may be grown with Di-ammonium Phosphate (18:46) @ 125 kg ha^{-1}. The maximum benefit cost ratio (3.03) was obtained in lentil with DAP soil application in the alluvial soils in the Gangetic plains.

References

Bandyopadhyay, P.K., Halder ,S., Mondal, K., Singh, K. C., Nandi ,R. and Ghosh, P. K. 2018.Response of lentil (*Lens culinaris* Medik) to post-rice residual soil moisture under contrasting tillage practices. *Agricultural Research*, 7 (4): 463-479.

Bandyopadhyay, P. K.,Singh, K. C., Mondal, K., Nath, R., Ghosh, P.K.,Naresh Kumar, Basu, P. S., and Singh, S.S.2016.Effects of stubble length of rice in mitigating soil moisture stress and on yield of lentil (*Lens culinaris* Medik) in rice-lentil relay crop**.** *Agricultural Water Management*, 173: 91-102.

Duary, B. and Ghosh, A. K. 2013. Effect of different levels of nitrogen and foliar spray of dap on toria grown as utera crop in rice-toria cropping system. *International journal of Bio-resource and Stress Management*, 4 (1): 19-22.

Gomez, K.A. and Gomez, A. A. 1984. *Statistical Procedures for Agricultural Research*, 2ndedn. A Willey Inter-science Publication (John Willey and Sons), New York, USA. **.**

Gupta, S. and Bhowmick, M. K. 2005 Scope of growing lathyrus and lentil in relay cropping systems after rice in West Bengal, India. Editor's Comment, 28.

Kumar, N., Hazra, K. K., Singh, S. and Nadrajan, N. 2016. Constrains and prospects of growing pulses in rice fallows of India. *Indian Farming*, 66 (6): 13–6.

Parya, M., Dutta, S. K., Jena, S., Nath, R .and Chakraborty, P. K. 2010.Effect of thermal stress on wheat productivity in West Bengal. *Journal of Agrometeorology*, 12 (2): 217-220.

Sarkar, S. and Singh, S. R. 2007. Interactive effect of tillage depth and mulch on soil temperature: productivity and water use pattern of rainfed barley. *Soil & Tillage Research* , 92:79–86

Sarkar, S., Banerjee, H.,Ray, K. and Ghosh,D.2018. Boron fertilization effects in processing grade potato on an Inceptisol of West Bengal, India. *Journal of Plant Nutrition*, 41 (11): 1456-1470.

Sharma, R. K., Bhoi, S. K., Pandey, N., Shinde, S. and Pandey, V. K. 2014. *Agriculture at a Glance*, Astral International (P) Ltd., New Delhi, India**.**

BidhanChandra KrishiViswavidyalaya

DepartmentofAgronomy,Faculty ofAgriculture

Dr.S.B.Goswami **Professor**		Mohanpur,Nadia West Bengal, 741252, India Mobile:9433479441/8335917209 Mail:sbg_bckv05@rediffmail.com goswami.subhendubikash@bckv.edu.in
Ref:Agron-	**BCKV**	Date:31.12.2023 .

To
TheEditor-in-Chief,
RNT Journal of Agriculture and Allied Sciences
RNTCollegeofAgriculture,Kapasan,Chittorgarh
Rajasthan -

Subject: Submission of new Research Article on '*Effect of fertilizer application on crop growth, yield and water use efficiency of utera crops in the lowland rainfed rice ecosystem*' for your esteemed RNT Journal of Agriculture and Allied Sciences for publication.

Sir,

GreetingsfortheNewYear2024andBestwishes.

Here,Iamsubmittinganewresearcharticleon'*Effectoffertilizerapplicationoncropgrowth,yieldand water use efficiency of utera crops in the lowland rainfed rice ecosystem*' with due authorship of Chandan Baskey, Sarbajoya Goswami, Ramyajit Mondal, Sanjib Mandi and S. B. Goswamifor publication in your RNT Journal of Agriculture and Allied Sciences.

Earlyresponseis solicitedforfurtherimprovementofthearticle.

Thanking you

Yoursfaithfully,

Date:31/12/2023

(S.B.Goswami)