Soil fertility, crop productivity, cropping intensity and livelihood enhancement in Titabar, Assam – a participatory approach through Farmer FIRST Programme

ABSTRACT

The performance of pea as relay crop into the prevailing rice-fallow system in Titabar development block of Jorhatdistrict in, Assam was demonstrated and evaluated in a participatory approach through the Farmer FIRST (Farm Innovations, Resources, Science and Technology) pProgramme during 2017-18 to 2021-22. The production and productivity of rice increased both in participatory and indirect beneficiary farms and ranged from 4000 to 4800 kg/ha with a mean yield of 4420 kg/ha in direct beneficiary farms during the five years. The increase was mainly due to use of good quality seed at optimum planting time and adoption of balanced fertilizer doses for rice cultivation. The yield of pea as a relay crop varied from 625 to 938 kg/ha with a mean yield of 744 kg/ha over the 5 years period. The available nutrient contents of soil increased in rice-relay compared to rice-fallow crop, but the organic carbon content was not affected during the period. The cropping intensity increased from 101% in 2016-17 to 112% in 2021-22 in participatory farms and 109% in 2021-22 in non-participatory farms. The farm income increased for both participatory and indirect beneficiary farms with an increase in per unit net return for rice sole crop and rice-pea relay cropping.

Keywords: rice-fallow, relay crop, cropping intensity, farm income

Introduction :

Winter rice is the principal crop of Assam covering 61% of the gross cropped area and contributes 96% of the total food grain production in the state.About 1.0 million hectares of the winter rice areaare kept fallow in the state during the rabi season (Anonymous 2022a), which comprises approximately 40% of the rice-fallow area suitable for a rabi and/or summer crop.Because of the rainfed culture, the rice-fallow areas in the state are suitable for short duration, low water-requiring grain legumes or oilseed crops which can utilize residual soil moisture left in the field after harvest of winter rice.Jorhat is one of the major districts where most of the rice-fallow areas of Assam are distributed (NAAS, 2013). In spite of increase in cropping intensity during 2005-06 to 2015-16, the corresponding change in crop diversification index was very low in Jorhat district (Deka *et al.*, 2018), implying challenging task of introducing scientific interventions to enhance sustainable farm income through double cropping.

The varietal diversification offers a better proposition for adaptation to climate variability and to enhance productivity and farm income of non-profitable rice fallows of South East Asia

(Lal *et al*., 2017). The use of registered pure seed every season can significantly overcome the yield gap in farmers' field for the high yielding rice varieties (Balasubramanian *et al*., 2000). The '*utera*' or rice-relay cropping is a unique practice of cultivating short duration pulses by broadcasting seeds in the standing rice crop at maturity (Yadav, 1992). The relay cropping, with low energy requirement and efficient resource utilization, had been adopted as profitable and sustainable system to existing rice-fallows in the state. The present study was accordingly carried out to evaluate the performance of high yielding suitable rice varieties and succeeding pea relay crop in selected villages of Titabor development block in Jorhat district of Assam in terms of sustainable yield, income and soil fertility status.

MATERIALS AND METHODS

Study area

The study was conducted in a village cluster comprising Adhalkhutia, PaninoraKhamjongia and few other contiguous villages of Titabor Development Block of Jorhat district. The villages were selected purposively where Farmer FIRST programme was implemented. The study area was situated about 25 km away from AAU Head Quarters and inhabited by people belonging to *Mishing* tribe, erstwhile tea garden workers, *Tai Khamyang* Buddhists, *Ahoms etc*. Among 8 agro-ecological situations identified in the Upper Brahmaputra Valley Agro-climatic Zone, this village cluster represents Humid Alluvial Flood Free situation characterized by warm humid climate with an average rainfall of more than 2000 mm. The maximum and minimum temperatures vary from 31-37°C and 9-10°C, respectively. The soils of the areabelong toEntisols and Inceptisols with sandy loam to loam to clay loam in textureandweakly to strongly acidic soil reaction. The village cluster is free from recurrent flood and almost every farm practices mixed farming system of livestock including poultry, fishery, other field/vegetable cropsand homestead garden integrated with the main crop winter rice with anaverage cropping intensity of 101%.

Methodology

The winter rice-pea relay cropping was introduced in the study area as a component of the project 'Participatory technology assessment for enhancing farming system productivity and developing entrepreneurship for sustainable rural livelihood' under *Farmer FIRST Programme* during 2017-18 to 2021-22. The interventions involving demonstrations on scientific cultivation of high yielding varieties of rice and relay cropping of pea as grain crop were implemented in randomly selected farms of the village cluster on a participatory mode, *i.e*. only certified seeds and parts of the recommended doses of fertilizerswere provided. The rest of the required fertilizers and critical crop protection chemicals were applied by the participating farmers with technical support in the form of training and advisory service from the project team for scientific cultivation of rice-pea relay cropping.

The yield data and other information were collected from randomly selected farms of the participatory farmer ranging from 15 to 30 in different years and thus total participatory farmer respondents were 137. The similar observations and information were also collected from the minimum number or 15 farms of non-participatory farmers, whichever is less, during the period and thus total non-participating farmers were 75.Experimental research design was followed for analysis of data.The non-participatory farmers included both non-beneficiary farmers and participatory farmer not receiving any input in the specific year of recording the observation. The surface soil samples from 15 randomly selected fields of participating farmers continuously practicing rice-fallow and rice-pea cropping were collected before initiation of the study and after completion of five years in 2021-22 and analyzed for soil pH, organic carbon content and available N, P and K status. The surface soil samples from 12 randomly selected fields of non-participatory farmers practicing rice-fallow and rice-pea cropping were also collected and analyzed for the parameters in 2021-22. However, in case of non-participating farmers, the rice-pea cropping was not followed in the same field continuously unlike the participating farmers.The income of individual farm was calculated for all the participatory farmers in each year based on information acquired through personal interview and interaction. The farm income for non-participatory farmers was calculated for 15 farms randomly selected for recording the yield data of rice and pea crop in each year. The sale prices of the commodities for each farm are considered as per the information provided by the respondent or the prevailing minimum support price in the specific year.

RESULTS AND DISCUSSION

RESULTS

Yield of rice

The number of farms covered and yield of rice recorded for both participatory and non-participatory farmers are presented in table 1. The highest rice yield (4800 kg/ha) was recorded in participatory farmer field in the year 2019-20 and the lowest yield of rice was observed in the year 2017-18 for non-participatory farmer.

Table 1: Area covered and yield of rice observed in the study area during 2017-18 to 2021-22

Parameter	2017-18		2018-19		2019-20		2020-21		2021-22	
	PF(+)	PF(-)	PF(+)	PF(-)	PF(+)	PF(-)	PF(+)	PF(-)	PF(+)	PF(-)
Area (ha)	29.0	0.0	30.8	5.0	11.5	16.0	12.4	51.0	14.0	52.0
Variety	Ranjit, Gitesh		Ranjit, Shrabani	Ranjit	Ranjit, Shrabani	Ranjit, Gitesh, Shrabani	Shraboni	Ranjit, Gitesh, Shrabani	Numoli, Shrabani	Ranjit, Gitesh, Shrabani
Farm (No.)	67	0	71	26	27	58	25	107	86	117
Sample No.	25	15	30	15	27	15	25	15	30	15
Yield (kg/ha)	4000	3450	4300	4150	4800	4550	4500	4250	4500	4300

PF(+) = participatory farmers under FFP receiving input

PF(-) = participatory farmer under FFP not receiving input and other non-participatory farmers

The higher mean rice yield of 4420 kg/ha was observed in participatory farmer field compared to 4140 kg/ha in non-participatory farmer field during the period from 2017-18 to 2021-22.

Yield of pea as relay crop

The performance of pea as relay crop after winter rice in terms of yield is shown in table 2. The yield of pea increased from 625 kg/ha in 2017-18 to 938 kg/ha in 2020-21 and declined to 712 kg/ha in 2021-22 for participatory farmer farm. In case of non-participatory farmer, the highest pea yield of 650 kg/ha was recorded in the year 2018-19 and 2020-21, while the lowest value of 562 kg/ha was observed in 2021-22. The mean yield of pea during the five year period was 744 kg/ha and 622 kg/ha for participatory and non-participatory farmers' fields, respectively.

Table 2: Area covered and yield of pea after rice in the study area during 2017-18 to 2021-22

Parameter	2017-18		2018-19		2019-20		2020-21		2021-22	
	PF(+)	PF(-)	PF(+)	PF(-)	PF(+)	PF(-)	PF(+)	PF(-)	PF(+)	PF(-)
Area (ha)	47.0	0.0	13.2	0.5	5.7	6.0	5.7	2.0	16.6	5
Farm (No.)	50	0	93	2	54	41	54	16	95	28
Sample No.	25	0	30	2	30	15	30	15	30	15
Pea yield (kg/ha)	625	0	712	650	735	625	938	650	712	562
REY (kg/ha)	1815	0	2034	1857	2227	1894	2762	1914	2019	1593

PF(+) = participatory farmer under FFP receiving input
PF(-) = participatory farmer under FFP not receiving input and other non-participatory farmers
REY = rice equivalent yield

Cropping intensity and mean farm income

The cropping intensity increased for both participatory and non-participatory farmers' farm during the study period (table 3).

Table 3: Cropping intensity and mean farm income in the study area during 2017-18 to 2021-22

Parameter	2017-18		2018-19		2019-20		2020-21		2021-22	
	PF(+)	PF(-)	PF(+)	PF(-)	PF(+)	PF(-)	PF(+)	PF(-)	PF(+)	PF(-)
Cropping intensity (%)	118	100	120	105	122	107	117	105	121	109
Income (`/ha/year)										
Mean farm income	67749	64493	68223	66235	82660	70684	84553	71258	92540	80428
Rice sole	46000	39675	49447	43815	56400	53800	61800	55860	73450	64224
Rice-pea	57184	--	62751	50451	73150	64528	76228	67278	86288	73926
B:C (rice sole)	1.54	1.34	1.74	1.57	1.71	1.62	1.80	1.65	1.85	1.67
B:C (rice-pea)	1.72	1.67	1.79	1.71	1.78	1.72	1.84	1.77	1.90	1.78

PF(+) = participatory farmer under FFP receiving input
PF(-) = participatory farmer under FFP not receiving input and other non-participatory farmers

In case of participatory farmer the cropping intensity increased from 101% before intervention to 118% in the first year (2017-18) to 121% in 2021-22 (table 3). The cropping intensity for non-participatory farmers' farm increased to 109% in 2021-22. The average farm income increased during the study period irrespective of category of farmers, *i.e.* both participatory and non-participatory farms.

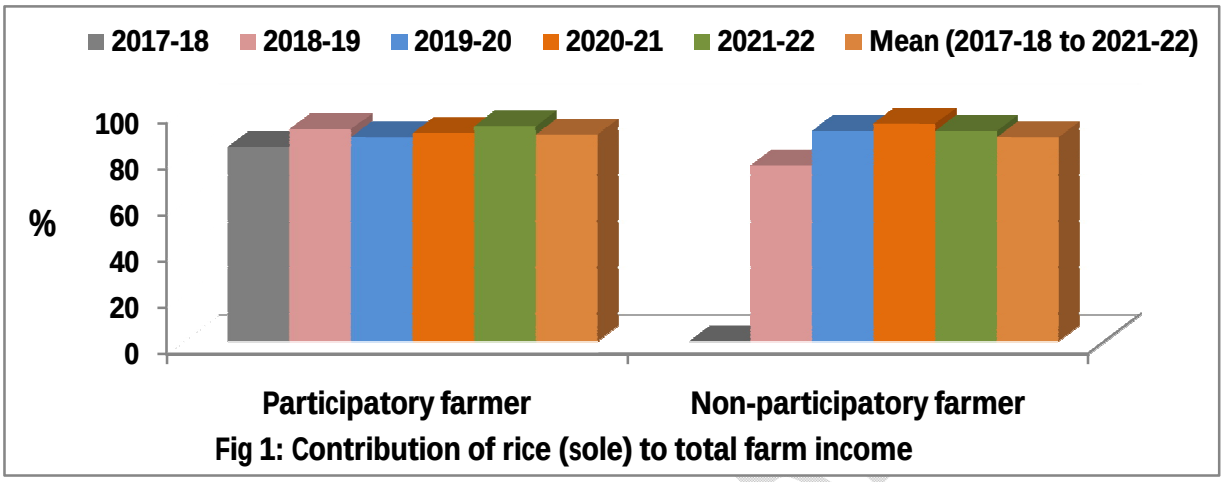

Fig 1: Contribution of rice (sole) to total farm income

The percent contribution of rice cultivated with introduced variety to the average total farm income (`/ha) increased for both participatory and non participatory farms (Fig 1), however the effect was little more pronounced in case of the later. The average contribution of rice sole crop to average total farm income was 72.2% and 72.4% for participatory farmer and non-participatory farmer, respectively during the five year period.

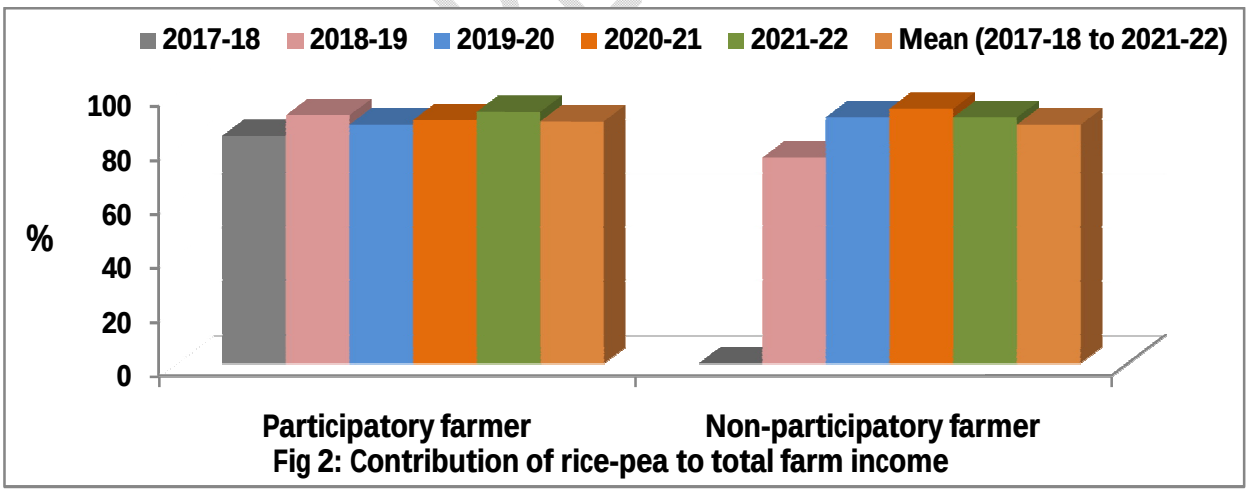

Fig 2: Contribution of rice-pea to total farm income

Similar to sole rice crop, adoption of rice-pea relay cropping increased the percent contribution to the average total farm income (`/ha) for both participatory and non-participatory farmers (Fig 2). The average contribution of rice-pea relay cropping to average total farm income was 89.7% and 88.5% for participatory farmer and non-participatory farmer, respectively during the five year period.

Soil fertility status

The soil pH, organic carbon content and available nutrient contents before intervention and after 5 years of cropping are presented in table 4. The soil pH was not much affected due to rice sole crop or rice-pea relay cropping during the study period. The organic carbon content of soil increased during the period from 9.3 g/kg in 2017-18 to 11.5 g/kg and 10.8 g/kg for rice sole crop and 11.4 g/kg and 11.1 g/kg for rice-pea relay cropping in participatory farmer and non-participatory farmer fields, respectively. The available nitrogen and potassium content of soils decreased from the initial values of 253.5 kg/ha and 172.5 kg/ha, respectively with rice sole crop irrespective of participatory or non-participatory farms. However, there was an increase in available nitrogen content of soil with rice-pea relay cropping for both participatory and non-participatory farms. In case of available potassium, the increase with rice-pea relay cropping was observed only for the participatory farms. Irrespective of cropping system or category of farmer, the available phosphorous content in soil increased during 2017-18 to 2021-22 due to the interventions.

Table 4: Changes in soil properties and nutrient status under rice sole crop and rice-pea

Parameters	2017-18	2021-22			
		Sole rice		Rice-pea relay	
		PF(+)	PF(-)	PF(+)	PF(-)
Number of samples	15	15	12	15	12
pH (1:2.5) soil:water	5.00	4.92	5.04	4.86	4.82
Organic carbon (g/kg)	9.3	11.5	10.8	11.4	11.1
Available N (kg/ha)	253.5	244.6	251.6	288.5	276.3
Available P (kg/ha)	6.8	7.45	7.18	7.85	7.36
Available K (kg/ha)	172.5	163.1	168.6	183.4	172.5

PF(+) = participatory farmer under FFP receiving input
PF(-) = participatory farmer under FFP not receiving input and other non-participatory farmers

DISCUSSION

The introduction of high yielding variety or certified pure seeds of the varieties of rice and pea increased yield in the study area. The positive change in yield was due to better quality of seeds and crop management practices by the farmers. The suitability of long and medium duration variety with sustainable or enhanced rice yield accommodating a second crop in rice growing areas has been reported for TTB 404 (Das *et al.*, 2018), Ranjit and Numoli. The better performance of pea compared to lathyrus or lentil as relay crop after winter rice was reported earlier (Sarmah *et al.*, 2017), which may be due to stronger adaptive ability of pea in rice fallow situation. The difference in yields between participatory and non-participatory farms may be attributed to corresponding nutrient management practices (Bharali and Thakuria, 2019). The rice and rice-relay crop in participatory farmer fields were cultivated with recommended doses of

fertilizers and technical advisory support from *Farmer FIRST Programme*, thus producing higher yield than the non-participatory farmers' fields.

The higher increase in cropping intensity of participatory farmer field was attributed to the input, advisory support and monitoring under the project. The change in cropping intensity following implementation of BGREI programme was reported to be marginal for beneficiary farmers and non significant in case of non-beneficiary farmers (Anonymous 2012; Gogoi *et al*., 2018). The crop diversification and cropping intensity are primarily dependent upon availability of irrigation water (Gogoi, 2018; Gogoi and Saikia, 2020) and farm mechanization (Barman *et al*., 2019). The relatively low impact of the interventions on cropping intensity was due to rainfed nature and limitation because of stray cattle in the study area. Further, Kanuya *et al*. (2013) observed that the success of tea cultivationamong the small farmers was one of the major factors significantly influencing the crop diversification in Kenya. The Jorhat district is reported to have about 6000 registered smallholder tea growers, and possibly the inclination towards tea as cash crop might have influenced the observed impact on cropping intensity for non-participatory farmers. The adoption of the improved practice and technology by the farmers was reported to be affected strongly by farmers' profile (Sambath *et al*., 2024), which might have influenced the acceptance of rice-pea relay cropping in place of sole crop in the FFP villages.The wage hike and non-availability of labour, non-availability of inputs, limited access to institutional credit, lack of marketdirectly or indirectly discourage the farmers from taking the second crop (Anonymous, 2022b). the farmers belonging to *Ahom* community have developed rice cultivation methods that are well suited to the physical environment of the rice fields, and also technologies to minimize the environmental hazards through risk dispersion (Asada, 2011), and accordingly show reluctance to change the cropping system.

The average farm income per unit area increased during the study period, irrespective of category of farmer or cropping system followed. The increase in farm income with high yielding varieties of rice and due to adoption of rice-pea relay cropping was attributed to enhanced crop productivity (Deka *et al*., 2020) and availability of market. The Titabar block is known for many small and large rice mills, thereby good market price and ease of marketing for rice grain. Besides, a few farmers were facilitated with training and awareness on selling rice grain at minimum support price through public procurement system.

The increase in organic carbon content, available nitrogen, phosphorous and potassium contents of soil with rice-pea relay cropping was due to higher biomass return and their consequent decomposition. The rice-pea relay crops were protected from stray cattle with bamboo fencing compared to rice sole crops, thereby ensured addition of crop residues of both the crops. The decline in available potassium content of soil with rice sole crop was because of crop removal and lesser quantity of K-fertilizer applied to soil compared to rice-pea relay

crop.Recent work had reported the benefit of yield increment with higher dose of potassium fertilizer in transplanted rice-based intensive cropping due to corresponding crop removal from soil (Ranjan and Singh, 2021).

Summary and conclusion

A study was conducted in farmer FIRST Programme implemented villages under Titabar development block of Jorhat district in Assam to evaluate the effect of rice-pea relay cropping on soil fertility status, crop productivity, cropping intensity and farm income over rice sole cropping as control, traditionally practiced by the farmers. The productivity of rice increased both in rice sole and rice-pea relay cropping due to quality seed and improved cultivation practices. This consequently enhanced farm income in rice sole crop and rice-pea relay crop complemented by increased cropping intensity and better market linkage. Except for a marginal decline in soil pH, the fertility status of the soils improved due to rice-pea relay cropping in the FFP villages.

COMPETINGINTERESTS

Authors have declared that no competing interests exist.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

References

1. Anonymous (2012).http://eands.dacnet.nic.in/Research-Study/Study-No-140.pdf
2. Anonymous (2022a). https://www.sentinelassam.com/editorial/rice-fallow-system-opportunities-for-pulse-production-in-assam-587758
3. Anonymous (2022b).https://timesofindia.indiatimes.com/city/guwahati/assam-move-for-cultivating-multiple-crops-in-rice-fallow-areas-to-enhance-productivity/articleshow/ 89208922.cms
4. Asada, H. (2011). Rice-based Cropping Systems of the Ahom: A Village Study in Assam, India. Japanese Journal of Human Geography, **63**: 42-59.
5. Balasubramanian, V., Bell, M. and Sombilla, M. (2000). Yield, profit, and knowledge gaps in rice farming: Causes and development of mitigation measures. *In* Papademetriou, M.K., Dent, F.J. and Herath, E.M. (Eds) *Bridging the Rice Yield Gap in the Asia-Pacific Region*, P 163-177.
6. Barman, S., Deka, N. and Deka, P. (2019). Impact of Farm Mechanization on Cropping Pattern and Cropping Intensity - A Case Study from Assam, India. *Asian Journal of Agricultural Extension, Economics and Sociology*, **32**: 1-7.

7. Bharali, P. and Thakuria, K. (2019). Crop establishment methods and nitrogen management in organically grown scented rice (*Oryza sativa*)- vegetable pea (*Pisum sativum*) relay cropping system.
8. Das, J., Saharia R.R., Chowdhury, P. and Nath D.C. (2018). Yield performance of medium duration *Sali* rice variety TTB 404 in Cachar District of Assam. *Journal of Krishi Vigyan*, **7**: 2013-215.
9. Deka, A.M., Debchoudhury, P.K. and Kalita, B. (2020). Rice-based cropping system approach for increasing farm family income. *Journal of Crop and Weed*, **16**: 129-135.
10. Gogoi, B. and Saikia, S. (2020). A panel data analysis model to assess the impact of institutional factors on crop diversification of Assam, India. *International Journal of Innovative Technology and Exploring Engineering*, **9**: 167-173.
11. Kanyua, M.J., Ithinji, G.K., Muluvi, A.S., Gido, O.E. and Waluse, S.K. (2013). Factors Influencing Diversification and Intensification of Horticultural Production by Smallholder Tea Farmers in Gatanga District, Kenya. *Current Research Journal of Social Sciences*, **5**: 103-111.
12. Lal, B., Gautam, P., Panda, B.B., Raja, R., Singh, T., Tripathi, R., Shahid, M. and Nayak, A.K. (2017) Crop and varietal diversification of rainfed rice based cropping systems for higher productivity and profitability in Eastern India. *PLoS ONE*, **12**: e0175709.
13. NAAS (2013). Improving productivity of rice fallows. *Policy Paper No. 64*, National Academy of Agricultural Sciences, New Delhi: Pp 16.
14. Pathak, P., Gogoi, P.B., Hazarika, J.P. and Deka, N. (2018). Impact assessment of BGREI programme on cropping intensity, production, productivity and income of farmers in Assam. *Indian Journal of Economics and Development*, **18**: 559-563.
15. Ranjan, R. and Singh, Y.V. (2021) Effect of Potassium Fertilization on Growth and Yield Attributes of Rice (Oryza sativaL.) Crop in an Inceptisol. *Journal of Scientific Research and Reports*, **27**: 52-57.
16. Sambath, S.R.,Cruzumuthub, C.F., Chandrasekaran, K.,Thamaraiselvid, S.P. and Srinivasan, M. (2024) Exploring the Relationship between Farmer Profiles and the Socio-economic Impact of Natural Farming Practices. *Journal of Scientific Research and Reports*, **30**: 95-104.
17. Sarma, D., Saikia, P., Sarma, P.K., Sarma, M.K.,Neog, P., Borah, P., Chhetri, P., Hazarika, M., Bhattacharjee,M. and Kakati, N. (2017). Crop intensification through relay cropping in rice fallows of Assam. *Indian Journal of Dryland Agriculture*, **32**: 75-77.
18. Singha, P. (2018). Cropping patterns, crop diversification and their spatial variations in Assam. *Pratidhwani the Echo*, **7**: 230-239.
19. Yadav, D.S. (1992). Pulse Crops (Production Technology), Kalyani Publishers. New Delhi-Ludhiana (Second edition). Pp 310.