International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; SP-9(9): 590-595
www.biochemjournal.com
Received: 09-07-2025
Accepted: 12-08-2025

Nikhilesh Baruah
AICRP on Dryland Agriculture, Biswanath College of Agriculture, AAU, Assam, Biswanath Chariali, Assam, India

Nupur Kalita
AICRP on Dryland Agriculture, Biswanath College of Agriculture, AAU, Assam, Biswanath Chariali, Assam, India

Pallab Kumar Sarma
AICRP on Dryland Agriculture, Biswanath College of Agriculture, AAU, Assam, Biswanath Chariali, Assam, India

Jayanta Kalita
AICRP on Dryland Agriculture, Biswanath College of Agriculture, AAU, Assam, Biswanath Chariali, Assam, India

Bikram Borkotoki
AICRP on Dryland Agriculture, Biswanath College of Agriculture, AAU, Assam, Biswanath Chariali, Assam, India

Arunjyoti Sonowal
AICRP on Dryland Agriculture, Biswanath College of Agriculture, AAU, Assam, Biswanath Chariali, Assam, India

Rupam Borah
AICRP on Dryland Agriculture, Biswanath College of Agriculture, AAU, Assam, Biswanath Chariali, Assam, India

Nikhita Kakati
AICRP on Dryland Agriculture, Biswanath College of Agriculture, AAU, Assam, Biswanath Chariali, Assam, India

Rupshree Borah
AICRP on Dryland Agriculture, Biswanath College of Agriculture, AAU, Assam, Biswanath Chariali, Assam, India

Rupsikha Goswami
AICRP on Dryland Agriculture, Biswanath College of Agriculture, AAU, Assam, Biswanath Chariali, Assam, India

Liza Barua Bharali
AICRP on Dryland Agriculture, Biswanath College of Agriculture, AAU, Assam, Biswanath Chariali, Assam, India

Corresponding Author:
Nikhilesh Baruah
AICRP on Dryland Agriculture, Biswanath College of Agriculture, AAU, Assam, Biswanath Chariali, Assam, India

Performance of maize based cropping system in upland rainfed condition of Assam

Nikhilesh Baruah, Nupur Kalita, Pallab Kumar Sarma, Jayanta Kalita, Bikram Borkotoki, Arunjyoti Sonowal, Rupam Borah, Nikhita Kakati, Rupshree Borah, Rupsikha Goswami and Liza Barua Bharali

DOI: https://www.doi.org/10.33545/26174693.2025.v9.i9Sh.5562

Abstract
An experiment was conducted under rainfed upland condition at the research farm of All India Coordinated Research Project on Dryland Agriculture, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali during *kharif, Rabi and summer* season of 2019-20, 2020-21 and 2021-22. The basic idea of the experiment is to study the physibility of increasing cropping intensity and to identify a best crop sequence suitable for a calendar year. The experiment was started from the *kharif* season and ended in summer season. In *kharif* season maize crop was grown in paired row system intercropped with greengram and blackgram in additive series of intercropping. After *kharif* maize, six *Rabi* crops (toria, linseed, buckwheat, *Niger*, rajmah and potato) were studied and after Rabi crops, the two summer crops (greengram and blackgram) were grown in summer season as the third crop the sequences. The twelve different cropping sequence including cereal, pulses, oilseed crops were the treatment of the study which were replicated thrice and their performance in terms of yield besides soil and cropping system evaluation parameters' were analyzed to identify the best cropping sequences under rainfed upland situation. After three years of experimentation it was found that the cropping sequence maize +greengram-rajmah-blackram with a B:C ratio of 2.63 was the best sequence which is closely followed maize+greengram-niger-blackgram with a B:C ration of 2.62. The available nitrogen, phosphorus and potassium was found to be improved after three years of study although no significant differences were recorded among the twelve different sequences in terms of improving Available N, P and K.

Keywords: Additive series, cropping intensity, intercropping, paired row system, sequential cropping, upland

Introduction
Maize (*Zea mays* L.) is one of the important crop occupying third position next to wheat and rice in cereal production in the world. India is the fifth largest producer of maize in the world, contributing 3% of the global production. The area under maize crop in India is about 11.14 M ha with a production of 42.20MT and productivity of 3.7 t/ha. It is a source of carbohydrate used for both human consumption and animal feed worldwide due to its high feeding value (Undie *et al*. 2012) [5]. Maize has been recognized as a common component in most intercropping system and it seems to lead as the cereal constituent of intercrop and is regularly combined with dissimilar legumes. Intercropping cereals with legumes have huge capacity to replenish soil mineral nitrogen through its ability to biologically fix atmospheric nitrogen. (Maitra *et al*., 2000; Giller, 2001) [2, 1]. In Assam, maize is the second most important crop next to rice and is mostly grown under rainfed upland conditions. In Assam, maize occupies an area about 40 thousand hectares and it is now in a status of emerging crop in the state and constant increase in acreage is being observed in recent years. Maize being a crop of high potential can give a boost to the economy of the state. The impact of maize based cropping system in terms of both intercropping as well as sequential was not studied much in Assam conditions. Moreover, increasing cropping intensity by growing two or more crops in a piece of land in a year is upmost importance in present context as average cropping intensity in India is only 156% and cropping intensity of Assam is 145.9%. Considering the importance, a study was undertaken on maize based triple cropping system under rainfed condition of Assam.

Materials and Methods

The present study was conducted at the Experimental farm of All India Coordinated Research Project on Dryland Agriculture at Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali during *kharif, Rabi and summer* season of 2019-20, 2020-21 and 2021-22. The experiment was started from the *kharif* season and ended with summer season. In *kharif* season Maize was grown in paired row system intercropped with greengram and blackgram in additive series of intercropping. In paired row planting, two adjacent rows of maize was paired. Thus, spaces between the successive closer rows (Pair rows) are widened and these spaces are utilized for planting intercrop i.e. greengram and blackgram. After *kharif* maize, six *Rabi* crops (toria, linseed, buckwheat, Niger, rajmah and potato) were sown in the *rabi* season and the 3rd crop (greengram and blackgram) is sown in summer season. In *kharif* season Maize and intercrops were sown in the month of July and harvested in first week/ fortnight of November in all the three years studied. After harvest of *kharif* crops, ploughing followed by harrowing and leveling was done immediately and the *Rabi* crops were sown within the month of November and harvested in last week of February/first week of march in all the years. After harvest of the *Rabi* crops, the 3rd crop of the sequence (greengram/blackgram) were sown within March / first week of April. The weather condition at Biswanath chariali is hot and humid during summer and cold and moist during winter. During *kharif* season i.e. in *maize* growing season total rainfall was 853.3mm in 2019, 866.2mm in 2020 and 773.7mm in the year 2021 distributed over 61, 53, and 42 numbers of rainy days, respectively. In *Rabi* season total rainfall received during the crop growing period was 92.0mm in 2019, 41.8mm in 2020 and 102.4mm, respectively. During growing period of summer season crops total rainfall received were 128.0mm in 2019, 89.8mm in 2020 and 35.8.mm, respectively. The soil of the experiments was sandy loam in texture with an initial P^H of 5.2 and 5.4 and 5.2 in 2019, 2020 and 2021, respectively. The organic carbon content was 0.59% and the initial available soil nitrogen, phosphorus and potash were in the range of Low (266.65 kg ha^{-1}), medium (27.02 kg ha^{-1}) and low (124.50 kg ha^{-1}). The experiment was laid out in randomized block design with 3replications and plot area was ploughed by tractor-drawn plough followed by one harrowing. Laddering was done properly to retain water uniformly in the field. Weeds and other stubbles were removed from the field at the time of final land preparation. The recommended spacing of Maize crop in Assam is 75cm x 25cm. In paired row systems, two rows are brought closer by 15cm and the spacing will be 90cmx60cmx25cm which was equivalent to 75cm x 25cm plant population. In 60cm spacing, two rows of greengram/blackgram was sown as intercrops. Recommended doses of fertilizers were applied in the plots. The variety used for maize was HQPM 1 (Hybrid) having duration of about 115-120 days. The varieties of intercrops were SGC-16 for greengram and PU-31 for blackgram. The variety of *Rabi* crops grown were Arun for rajmah, TS-38 for toria, T-397 for linseed, Kufri Pokhraj for potato, local variety for buckwheat and NB-1 for Niger. For summer season the variety used for greengram was SG-1 and PU-31 for blackgram.

The treatments were:-

T_1	Maize + Greengram --	Toria --	Blackgram
T_2	Maize + Greengram --	Linseed --	Blackgram
T_3	Maize + Greengram --	Buckwheat --	Blackgram
T_4	Maize + Greengram --	Niger --	Blackgram
T_5	Maize + Greengram --	Rajmah --	Blackgram
T_6	Maize + Greengram --	Potato --	Blackgram
T_7	Maize + Blackgram --	Toria --	Greengram
T_8	Maize + Blackgram --	linseed --	Greengram
T_9	Maize + Blackgram --	Buckwheat --	Greengram
T_{10}	Maize + Blackgram --	Niger --	Greengram
T_{11}	Maize + Blackgram --	Rajmah --	Greengram
T_{12}	Maize + Blackgram --	Potato --	Greengram

Results and Discussion

Results

Performance of maize and intercrops grown with maize:

In the year 2019, the average yield of maize crop (Average of the treatment T_1 to T_6) was 39.79 q/ha when greengram was grown as intercrop while in the year 2020 and 2021, the average yield (average of the treatment T_1 to T_6) of the maize crop was 42.87 q/ha and 38.80 q/ha, respectively when greengram was grown as intercrop. (Table 1.). The yield of Maize (pooled of 3 years) when greengram was grown as intercrop with the maize crop was 40.48 q/ha. (Table 1). On the other hand when blackgram was grown as intercrop with maize, the average yield of maize (average from the treatment of T_7 to T_{12}) was 31.08 q/ha in the year 2019, 44.28 q/ha in 2020 and 41.38 q/ha in 2021. The yield of maize was 40.58 q/ha (pooled of 3 years) when blackgram was grown as intercrop with maize crop. So there were no much differences of maize crop performance in terms of yield when greengram or blackgram was grown as intercrop in paired row system of planting.

Intercrops

The pooled yield of greengram recorded from three years study were 4.26 q/ha while the yield of blackgram was 3.62 q/ha. (Table 1). The greengram crop matures early (about 10 days earlier) than the blackgram having less time for competition with maize crop might be the main reason for this result. (Giller, 2001) [1]. The increase of greengram yield as intercrops with maize over blackgram was found to be 17.67% from the 3 years of experimentation. The intercrops yield was converted to maize equivalent yield as per the treatments based on the MSP of the products. The yield advantage in intercropping systems with legumes probably occurred from the difference in the timing of utilization of resources by the different crops from different soil layers, especially during peak vegetative and reproductive stages of growth, thus resulting in both temporal and spatial complementarities (Rana *et al.* 2001) [4]. Therefore greengram may be the first choice between the two crops to be grown as intercrop with maize crop in paired row system of planting. The reason for better yield although not significant may be due to cereal-legume intercropping system improving soil health, soil moisture and thereby overall output.

Rabi Crops

In *Rabi* season after *kharif* maize, six crops namely toria, linseed, buckwheat, Niger, rajmah and potato were grown in the experiment to evaluate the best Rabi crops in the study. The crops were sown within the month of November and harvested in last week of February/first week of March of next year. From three years pooled data of the *Rabi* crops

(Table 1), it has been observed that the yield of toria in the treatment T_1 (Maize+greengram-toria-blackgam) was 12.78 q/ha and in the treatment T_7 (Maize +blackgram-toria-greengram), the yield of toria was 13.79 q/ha, respectively with an average yield of 13.28 q/ha. Similarly the yield of linseed in the treatment T_2 (Maize +greengram-linseed-blackgram) and T_8 (Maize+blackgram-linseed-blackgram) was 9.15 q/ha and 11.33 q/ha, respectively with an average yield of 10.24 /ha. The yield of buckwheat in the treatment T_3 (Maize +greengram-buckwheat-blackgram) was 7.47 and T_9 (Maize+blackgram-buckwheat-greengram) was 7.07 q/ha. Similarly the yield of Niger (average of the treatment T_4 and T_{10}) was 8.71 q/ha, yield of rajmah (average of T_5 and T_{11}) was 14.22q/ha and the yield of potato (average of T_6 and T_{12}) was 119.95 q/ha. The yield of each Rabi crops of the all the treatment were converted to maize equivalent yield of the system based on MSP/market price of the crops per quintal.

Summer Crops

In summer season blackgram and greengram were sown as 3rd crop of the sequence. The crops were sown in last part of March or first week of April. The study revealed that performance of blackgram was better than the greengram in all the three years of study. The average yield of blackgram from three years was 4.77 q/ha whereas the average yield of greengram was 3.43 q/ha. (Table 1). For calculating the total system yield, this summer crops yield data were also converted into maize equivalent yield.

Total System Yield

All the crops studies in the experiment either as intercrop (greengram and blackgram with main crop maize) and sequence crops (Toria, Buckwheat, Niger, linseed, potato and rajmag *as rabi*) after maize and in summer crops (greengram and blackgram) grown under rabi were converted to maize equivalent yield and finally total system yield was calculated. (Table 2). From the three years study it has been observed that total system yield was more in the sequence where potato was grown in *Rabi* season. The highest system yield (115.10 q/ha) was recorded in the sequence T_6 i.e. Maize + greengram-potato-blackgram followed by treatment T_5 i.e. Maize+greengram-rajmah-blackgram sequence with a system yield of 101.21 q/ha. The lowest system yield (73.4 q/ha) was recorded in the treatment T_9 i.e. Maize+ blackgram-buckwheat-greengram sequence. Higher maize equivalent yield realized was attributed to better performance and yields of both component crops under intercropping system (Malakannavar *et al.*, 2020) [3].

- **Cropping duration:** Different combination of the cropping sequences showed significance influence on total duration of the sequence (Table 4). In the sequence where rajmah was grown in *rabi* season i.e. T_5 (Maize+ greengram-rajmah-blackgram) and T_{11} (Maize +blackgram-rajmah-greengram), the system duration was 307 which was highest among all the treatment combination and the sequence where toria was grown in *rabi* season, the system duration was 281 days which was lowest (Table 4). It has been observed that rest of the sequence was at par statistically in respect of system duration.
- **Land use efficiency (LUI):** LUI was calculated by dividing the total number of days the research field remained occupied by different crops by 365 days (Table 4). It has been observed that LUI was highest (84.11%) in the treatment T_5 i.e. Maize + greengram-rajmah-blackgram sequence which was significantly superior over the treatment T_1 (Maize+greengram-toria-blackgram), T_6 (Maize+greengram-potato-blackgram) T_7 (Maize+ blackgram-toria-greengram) and T_{12}. (Maize+blackgram-potato-greengram) and at par with rest of the treatments. The lowest LUI (76.71%) was recorded in the treatment T_7 i.e. Maize + blackgram-toria-greengram.
- **Economic efficiency**: The economic efficiency was calculated by dividing the net return of the sequence by total duration of the system. The highest economic efficiency of Rs. 352.95 $Rs.ha^{-1}day^{-1}$ and 352.79 $Rs.ha^{-1}day^{-1}$ was recorded in the treatment T_5 i.e. Maize+ greengram-rajmah-blackgram and T_{11} i.e. Maize+blackgram-rajmah-greengram. The lowest economic efficiency was recorded in the treatment T_6 and T_{12} where potato was grown in *Rabi* season (Table 4).
- **Production efficiency:** The production efficiency (PE) was calculated by dividing the system yield in kg by duration of the cropping sequences. From the three years study it has been that the production efficiency was highest in T_6 i.e. Maize + greengram-potato-blackgram (38.86 kg/ha/day) followed by 37.54 kg/ha/day in T_{12} Maize +blackgram-potato-greengram sequence. The lowest production efficiency of 25.75 kg/ha/day was recorded in T_9 i.e. Maize + blackgram-linseed-greengram sequence.
- **Rain water efficiency:** Rain water efficiency was calculated by dividing the system yield by total rainfall (mm) received during the crop growing period. (Table 4). There was no significant difference of rain water efficiency among the various treatments studied. The highest rain water efficiency (6.85 kg/ha/mm) was recorded in the T_6 i.e. Maize+greengram-potato-blackgram sequence followed by 6.62 kg/ha/mm in the treatment T_{12} i.e. Maize+blackgram-potato-greengram sequence. (Table 4). The lowest value was in the treatment T_9 (Maize+ blackgram-buckwheat-greengram) and T_3 (Maize+greengram-buckwheat-blackgram).
- **Soil parameters:** Soil sample were collected after completion of cropping sequence in every year and soil P^H, organic carbon, available nitrogen, phosphorus and potassium were analyzed in the laboratory. From the analysis of the data it has been observed that there was no significant differences of soil P^H and organic carbon after three years of the experimentation (Table 5). However in case of available soil nitrogen, phosphorus and potassium, the value was found to increase graduallay from the first year of experimentation up to third year of experimentation (Table 5). But among the twelve treatment combination, no significant effect of the treatment on soil available nitrogen, phosphporus and potassium was recorded. As maize is an exhaustive crop and consume high nutrient from the soil, perhaps in all treatments nutrient has been removed from the sol almost equally although pulse crop was included in all the studied in all treatments as intercrop as well as sequence crop.

- **Economics:** The cost of cultivation, Gross return, net return and B:C ratio was calculated in all the treatments of the experiment considering the MSP (for available crops) and present market price of the crops (where MSP is not available) (Table 3). The benefit cost (B:C) ratio was calculated by dividing the gross return by gross cost. Although highest system yield was in treatment T_6 i.e. Maize + greengram-potato-blackgram, the B:C ratio not found highest in the said treatment which is mainly due to more prices of potato tubers. Among the twelve treatments studied, highest B:C ratio of 2.63 was observed in the treatment T_5 i.e. in Maize +greengram-rajmah-blackgram which is almost equal to treatment T_4 i.e. Maize + greengram-Niger-blackgram with a B:C ratio of 2.62. The lowest B:C ratio was recorded in the cropping sequences where potato was studied as Rabi crops i.e. Maize + greengram-potato-blackgram and Maize + blackgram-potato-greengram with a B:C ratio of 1.35 and 1.21, respectively.

Table 1: Yield of different crops of the Maize based triple cropping system (q/ha)

Treatments	Main crop (Maize) yield				Intercrops yield				Rabi crops				Summer crops			
	2019	2020	2021	pooled	2019	2020	2021	pooled	2019	2020	2021	pooled	2019	2020	2021	pooled
T_1 : Maize + greengram-toria-blackgram	39.33	42.08	40.33	40.58	2.53	4.15	7.85	4.17	12.00	13.67	12.67	12.78	5.77	4.53	3.93	4.74
T_2: Maize + greengram-linseed-blackgram	40.67	42.95	32.67	38.76	2.46	4.07	7.90	4.14	10.13	9.17	8.17	9.15	5.23	4.30	3.67	4.40
T_3:Maize + greengram-buckwheat-blackgram	40.00	44.60	36.50	40.36	2.79	4.56	7.68	4.34	6.23	7.37	8.83	7.47	5.77	4.63	4.00	4.80
T_4 : Maize + greengram-niger-blackgram	39.67	41.45	38.00	39.70	2.99	4.50	7.62	4.37	8.03	8.33	9.33	8.56	5.50	4.53	4.23	4.75
T_5: : Maize + greengram-rajmah-blackgram	40.43	43.63	41.67	41.91	2.95	4.37	7.22	4.18	14.17	15.0	11.03	13.5	5.30	5.07	4.27	4.88
T_6: Maize + greengram-potato-blackgram	38.67	42.56	43.67	41.63	3.09	4.14	7.86	4.36	110.0	118.3	133.3	120.5	5.73	5.10	4.43	5.08
T_7: Maize + blackgram-toria-greengram	37.13	44.24	47.33	42.90	4.55	2.77	5.04	3.78	14.17	15.03	12.17	13.79	4.77	4.53	2.23	3.84
T_8: Maize + blackgram-linseed-greengram	36.77	46.51	47.31	43.53	4.33	2.67	4.54	3.84	10.90	11.93	11.17	11.33	3.83	3.47	2.40	3.23
T_9:Maize + blackgram-buckwheat-greengram	35.33	44.38	38.83	39.51	3.45	2.83	4.71	3.66	6.17	7.23	7.83	7.07	3.88	3.40	2.17	3.15
T_{10}: Maize + blackgram-niger-greengram	36.08	45.13	37.92	39.71	3.45	2.55	5.00	3.66	8.17	9.10	9.03	8.86	4.10	3.57	2.53	3.40
T_{11}: Maize + blackgram-rajmah-greengram	35.17	42.07	39.33	38.85	3.27	2.68	4.50	3.48	15.67	15.83	13.3	14.94	4.93	3.47	2.60	3.66
T_{12}: Maize + blackgram-potato-greengram	36.00	43.37	37.58	38.98	3.05	2.73	4.25	3.34	110.0	121.7	126.7	119.44	5.00	2.67	2.33	3.33
CD at 5%	1.03	2.80	2.12	NS	----	------	------	-----	------	-----	------	------	-----	----	-----	-----

Table 2: Main Equivalent yield (MEY) of the intercrops and sequence crops grown after Maize (q/ha)

Treatments	MEY of intercrops				MEY of rabi crops				MEY of summer crops				System yield			
	2019	2020	2021	pooled	2019	2020	2021	pooled	2019	2020	2021	pooled	2019	2020	2021	pooled
T_1 : Maize + greengram-toria-blackgram	6.34	10.38	19.36	12.11	24.00	27.33	25.33	25.55	14.42	11.33	9.83	11.86	84.09	91.12	94.85	90.0
T_2:Maize + greengram-linseed-blackgram	6.16	10.17	19.75	12.03	25.33	22.92	20.42	22.89	13.08	10.75	9.17	11.00	85.24	86.79	82.01	84.7
T_3 : Maize + greengram-buckwheat-blackgram	6.97	11.41	19.21	12.53	15.58	18.42	22.08	18.69	14.42	11.58	10.00	12.00	76.97	86.01	87.79	83.6
T_4 : Maize + greengram-niger-blackgram	7.49	11.25	19.04	12.59	20.08	20.82	23.33	21.41	13.75	11.33	10.58	11.88	80.99	103.5	90.95	91.8
T_5: Maize + greengram-rajmah-blackgram	7.37	10.92	18.04	12.11	42.50	45.00	44.00	43.83	13.25	12.67	10.67	12.19	103.5	95.75	104.38	101.21
T_6: Maize + greengram-potato-blackgram	7.74	10.35	19.64	12.58	44.00	47.33	53.33	48.22	14.33	12.75	11.08	12.72	104.7	112.9	127.72	115.1
T_7: Maize + blackgram-toria-greengram	11.38	4.45	12.61	9.48	30.53	32.48	26.50	29.83	11.92	7.75	5.58	8.41	90.96	88.92	92.02	90.6
T_8: Maize + blackgram-linseed-greengram	10.84	4.17	13.36	8.79	25.22	27.80	25.92	26.31	9.58	8.67	6.00	8.08	82.31	87.15	92.59	87.4
T_9: Maize + blackgram-buckwheat-greengram	8.63	4.57	11.78	8.33	15.42	18.04	19.58	17.68	9.69	8.50	5.42	7.87	69.07	75.49	75.61	73.4
T_{10}: Maize + blackgram-niger-greengram	8.63	3.88	12.50	8.33	20.42	22.75	23.33	22.16	10.25	8.92	6.33	8.50	75.38	80.68	80.08	78.7
T_{11}: Maize + blackgram-rajmah-greengram	8.17	4.20	11.26	7.88	47.00	47.50	40.00	44.83	12.33	8.67	6.50	9.16	91.64	102.44	97.09	97.1
T_{12}: Maize + blackgram-potato-greengram	7.62	4.30	10.63	7.52	44.00	48.67	50.67	47.78	12.30	6.67	5.83	8.26	99.92	103.01	104.71	102.5
CD at 5%	3.11	1.01	2.18	3.96	4.50	5.74	5.25	4.38	2.14	1.63	0.84	1.12	5.66	6.16	6.69	5.19

Price of Maize: Rs.2000/q, Rajmah: Rs. 6000/q, Toria: Rs.4000/q. Buckwheat: Rs.5000/q, Niger: Rs. 5000/q, Potato: Rs.800/q, Linseed: Rs.5000/q, Greengram and blackgram: Rs.5000/q

Table 3: Economic of the cropping system (Rs.ha^{-1})

Treatments	COC (Rs.)		Gross return (Rs.)				Net return (Rs.)		B:C ratio			
	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021	Average
T_1 : Maize + greengram-toria-blackgram	76090	76090	87240	184998	200464	208670	108908	124374	121430	2.43	2.63	2.39	2.48
T_2: Maize + greengram-linseed-blackgram	75620	75620	86770	187528	190938	180422	111908	115318	93652	2.48	2.52	2.08	2.36
T_3 : Maize + greengram-buckwheat-blackgram	74540	74540	85690	169334	189222	193138	94794	114682	107448	2.27	2.54	2.25	2.35
T_4 : Maize + greengram-Niger-blackgram	73620	73620	84770	178178	227700	200090	104558	154080	115320	2.42	3.09	2.36	2.62
T_5: Maize + greengram-rajmah-blackgram	85300	85300	96450	227700	240650	229636	142400	125350	133186	2.67	2.85	2.38	2.63
T_6: Maize + greengram-potato-blackgram	170680	170680	226830	230340	248380	280984	59660	77700	54154	1.35	1.46	1.24	1.35
T_7: Maize + blackgram-toria-greengram	76090	76090	87240	200112	195624	202444	124022	119534	115204	2.63	2.57	2.32	2.50
T_8: Maize + blackgram-linseed-greengram	75620	75620	86770	181082	191730	203698	105462	116110	116928	2.39	2.54	2.35	2.42
T_9:Maize + blackgram-buckwheat-greengram	74540	74540	85690	151954	166078	166342	77414	91538	80652	2.04	2.23	1.94	2.07
T_{10}: Maize + blackgram-Niger-greengram	73620	73620	96450	165836	177496	176176	92216	103876	79726	2.25	2.41	1.83	2.16
T_{11}: Maize + blackgram-rajmah-greengram	85300	85300	96450	201608	225368	213598	116308	140068	117148	2.36	2.64	2.21	2.40
T_{12}: Maize + blackgram-potato-greengram	170680	170680	226830	219824	226622	230362	49144	55942	3532	1.29	1.33	1.02	1.21

The COC was more in 2021 due to increased price of seed, fertilizer (COVID period) as well as increased wages of casual workers

Table 4: System parameters of the Maize based sequential cropping system

Treatments	System yield (q/ha)	Average duration (days)	Land use efficiency (%)	Production efficiency (Kg/ha/day)	Economic efficiency (Rs. ha-1 day-1)	Rain Water Efficiency (kg/ha-mm)
T_1 : Maize + greengram-toria-blackgram	90.0	281	76.99	30.84	297.23	5.36
T_2: Maize + greengram-linseed-blackgram	84.7	302	82.73	26.79	240.37	5.00
T_3 : Maize + greengram-buckwheat-blackgram	83.6	301	82.46	26.11	228.97	4.86
T_4 : Maize + greengram-niger-blackgram	91.8	303	83.01	26.85	249.17	5.03
T_5: : Maize + greengram-rajmah-blackgram	101.21	307	84.11	33.77	352.95	6.41
T_6: Maize + greengram-potato-blackgram	115.1	285	78.08	38.86	177.65	6.85
T_7: Maize + blackgram-toria-greengram	90.6	281	76.71	33.47	350.04	5.82
T_8: Maize + blackgram-linseed-greengram	87.4	302	82.73	29.67	298.07	5.54
T_9: Maize + blackgram-buckwheat-greengram	73.4	301	82.46	25.75	221.74	4.80
T_{10}: Maize + blackgram-niger-greengram	78.7	303	83.01	27.09	241.09	5.08
T_{11}: Maize + blackgram-rajmah-greengram	97.1	307	83.56	33.79	352.79	6.42
T_{12}: Maize + blackgram-potato-greengram	102.5	285	78.08	37.54	151.25	6.62
CD at 5%	5.19	7.12	3.24	3.15	37.15	0.98

Table 5: Available NPK (kg/ha) in soil after completion of the sequence in each year

Treatments	PH			OC (gkg^{-1})			Available N (Kg/ha)			Available P_2O_5 (kg/ha)			Available K_20 (Kg/ha)		
	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021
T_1	4.25	4.52	4.26	8.5	8.9	8.7	315.25	301.05	322.25	31.24	32.04	35.45	135.25	138.57	142.45
T_2	4.27	4.37	4.26	8.5	8.7	8.4	320.02	330.32	310.25	32.35	35.59	33.56	155.66	122.44	144.25
T_3	4.22	4.47	4.85	8.2	8.7	8.7	311.45	292.69	340.85	33.45	35.78	38.45	144.22	178.75	185.48
T_4	4.48	4.46	4.88	8.6	8.1	8.5	310.22	296.87	320.26	35.45	33.25	36.45	148.15	154.69	165.25
T_5	4.25	4.46	4.21	8.5	8.0	8.1	311.25	301.08	326.25	35.55	33.79	36.45	126.25	149.29	160.25
T_6	4.85	4.45	4.65	8.4	8.2	8.3	312.55	313.75	340.22	35.22	31.82	36.45	145.25	169.48	165.22
T_7	4.38	4.47	4.18	8.4	8.4	8.4	310.25	305.23	350.56	33.81	33.81	32.55	142.22	113.70	180.44
T_8	4.28	4.48	4.96	8.2	8.7	8.4	305.22	309.42	320.66	32.55	33.18	32.78	146.25	156.70	160.44
T_9	4.72	4.52	4.88	8.3	8.5	8.7	320.20	313.60	320.56	32.25	34.96	36.45	168.44	165.66	180.66
T_{10}	4.33	4.29	4.85	8.2	8.1	8.8	312.17	296.87	350.45	33.45	35.98	38.88	174.45	165.69	169.45
T_{11}	4.35	4.34	4.78	8.5	8.3	8.2	319.22	309.42	315.45	31.22	33.77	38.56	139.25	149.32	145.24
T_{12}	4.45	4.51	4.88	8.6	8.4	8.1	309.12	271.79	305.55	30.45	33.96	36.25	155.25	146.47	165.33
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 6: Month wise meteorological data for the crops growing period (2019-20, 2020-21 and 2021-22)

Period	Rainfall (mm)			Number of rainy days			Temperature(0C)						Relative Humidity (%)						BSSH (hrs.)		
	2019-20	2020-21	2021-22	2019-20	2020-21	2021-22	2019-20		2020-21		2021-22		2019-20		2020-21		2021-22		2019-20	2020-21	2021-22
							Max	Min	Max	Min	Max	Min	Mor	Eve	Mor	Eve	Mor	Eve			
June	183.6	424.7	459.0	16	14	13	32.1	24.1	31.0	23.0	26.4	23.3	93.0	74.6	94.0	76.0	92.9	74.6	4.50	3.30	3.48
July	317.9	285.6	270.5	23	15	14	30.9	24.0	32.0	24.0	31.9	23.7	92.8	80.6	94.0	81.0	94.4	73.3	3.50	2.30	3.54
Aug	166.4	175.6	343.8	7	13	21	33.9	25.2	33.5	24.4	31.9	23.7	92.7	71.0	92.3	74.6	95.1	78.6	6.40	5.56	3.20
Sep	289.2	241.8	155.0	21	15	5	31.1	24.1	31.9	23.8	33.3	23.3	95.6	76.9	95.0	71.0	91.1	68.7	4.30	3.40	6.81
Oct	69.80	144.8	0.0	8	9	0	30.1	20.0	31.6	21.6	31.9	21.1	93.5	70.0	91.1	69.1	93.1	68.5	6.00	7.06	7.19
Nov	10.00	18.40	4.40	2	1	2	28.7	15.7	29.9	13.8	27.7	12.1	93.7	62.9	91.8	62.5	91.3	64.6	7.10	7.50	8.21
Dec	17.00	4.80	0.00	2	1	0	23.9	9.80	24.7	9.11	25.4	8.93	95.3	61.9	93.8	61.0	92.4	58.3	6.33	7.01	7.56
Jan	11.00	17.2	26.00	2	3	3	22.0	8.00	23.1	5.30	23.3	7.98	94.0	60.0	94.0	61.6	93.4	58.8	5.00	5.13	5.72
Feb	54.00	1.40	72.00	3	0	4	26.0	10.6	26.9	10.0	22.9	8.39	98.0	60.0	91.5	50.8	92.7	60.7	5.13	6.27	6.09
Mar	8.40	48.4	52.6	4	5	3	29.0	15.0	29.6	15.3	30.9	14.0	88.0	53.0	89.1	51.3	91.1	55.9	6.15	4.94	5.56
April	119.0	41.4	306.0	6	6	14	30.0	18.0	31.4	16.6	25.9	17.9	86.0	58.0	83.6	48.2	93.2	75.9	5.88	6.38	2.52
May	34.0	138.0	432.0	12	10	13	30.0	21.0	30.6	20.9	29.9	20.5	91.0	71.0	90.7	67.2	92.7	73.4	4.57	3.61	4.02

Conclusion

From the present study it can be concluded in Assam under rainfedupland condition also we can successfully grow three crops in a year provided proper selection of crops like pulses having shorter in duration so that sowing time of the crops throughout the year can be adjusted. The best results was recorded in the treatment T_5 i.e. maize+greengram-rajmah-blackram with a B:C ratio of 2.63 which is closely followed by treatment T_4 i.e. maize+greengram-niger-blackgram with a B:C ration of 2.62. So farmers can practice this two sequence for higher economic benefit as well as for maintaining their soil health.

Acknowledgment

The authors are highly thankful to ICAR-Central Research Institute for Dryland Agriculture, Hyderabad for their valuable suggestion in formulating the technical programme and also their financial assistance for conducting the experiment.

References

1. Giller KE. Nitrogen fixation in tropical cropping systems. 2nd ed. Wallingford: CABI; 2000, p. 423.
2. Maitra S, Ghosh DC, Sounda G, Jana PK, Roy DK. Productivity, competition and economics of intercropping legumes in finger millet (Eleusine coracana) at different fertility levels. Indian J Agric Sci. 2000;70(12):824-828.
3. Malakannavar SM, Potdar MP, Chandrashekara CP, Kuligod VB. Effect of maize + pigeonpea intercropping system on yield, equivalent yield of maize and economics under delayed onset of monsoon in Northern

Transition Zone of Karnataka, India. Int J Curr Microbiol Appl Sci. 2020;9(4):867-876.
4. Rana RS, Singh B, Negi SC, Singh B. Management of maize/legume intercropping under mid-hill sub-humid conditions. Indian J Agric Res. 2001;35:100-103.
5. Undie UL, Uwah DF, Attoe EE. Growth and development of late season maize/soybean intercropping in response to nitrogen and crop arrangement in the forest agro-ecology of South Southern Nigeria. Int J Agric Res. 2012;7(1):1-9.