A-5960
[1-6]

RESEARCH ARTICLE Indian Journal of Agricultural Research, Volume Issue : ()

Effect of Maize High Density Planting on Cluster Bean Performance under Maize-cluster Bean Cropping Sequence

R. Raja Priya, R. Krishnan, V. Sabareeshwari[1], R. Sureshkumar[1], Deepak Chandran[1], V. Marthandan[1]

10.18805/IJARe.A-5960

ABSTRACT

Background: Cluster bean was cultivated as a catch crop without external fertilization, solely to recharge the soil fertility and to harvest the residual nutrient after maize crop; clusterbean had been included as a succeeding crop. Doubling the fertilizer for maize would leave more residues. Even though maize is an exhaustive crop, since the nutrient uptake was need based, the excess fertilizers were effectively utilized by cluster bean.

Methods: A field research was carried out at Tamil Nadu Agricultural University, Coimbatore under irrigated conditions. Experimental trials were adopted to estimate the effect of high density with nutrient management practices on maize which influences the performance of succeeding cluster bean under maize-cluster bean cropping sequence during *Rabi* seasons of 2017-18 and 2018-19 by using cultivar Pusa Naubahar. No separate treatments were adapted to cluster bean crop.

Result: The results of cluster bean sown after the high density of 1,33,333 plants ha^{-1} maize with nutrient level of 200 per cent RDF produced taller plants, higher drymatter production (636 and 607 kg/ha), increased yield attributes, higher yield (6.58 and 6.81 t/ha) and better economics (B:C ratio -1.87 and 1.94) in both the seasons. Post-harvest available nutrient status revealed that the higher population by closer spacing with increased fertilizer levels (T_7) maintained its superiority during both the years. Moreover, this proved to be the most viable practice for production and residual nutrient uptake, by including pulse (cluster bean) as succeeding crop and soil health was effectively maintained by fixing atmospheric nitrogen by cluster bean.

Key words: Cropping sequence, Fertilizer, Succeeding cluster bean, Yield.

INTRODUCTION

Maize is the third most important cereal crop and it has worldwide demand for food, feed and fodder for livestock, especially poultry (Thakur *et al*., 2015). In general, area under cultivation of maize is decreasing now-a-days, due to dynamic climatic conditions and scarcity of water *etc.* Based on the above discussion, it is focused to improve the maize productivity. Due to less scope in increasing the area under cultivation (horizontally) to meet out the demand of maize, increasing the productivity per unit area (vertically) is an alternate way for which the best method is adopting higher number of plants per unit area (Raja Priya *et al*., 2019). A change with this background is to be made possible from optimum plant population to high density planting. Maize, being an exhaustive crop higher population, expects higher dose of fertilizer to meet its nutrient requirement. The nutrient allowance more than the crop requirement can be effectively utilized by growing a catch crop or pulse crop after maize as a succeeding crop. In Tamil Nadu, cereal-pulse is one of the most important cropping system. In Southern India guar (*Cyamopsis tetragonoloba* L.) is grown by marginal farmers as vegetable crop whilein cities, it is highly suitable for kitchen garden. Cluster bean occupies a major place in Indian economy due to its industrial importance mainly because of the presence of gum in its endosperm. It is an annual legume crop grown as green vegetable (pods), grains, forage, green manure crop and it is also drought tolerant. Cluster bean is a legume and green manure crop which is effectively used to harvest remaining nutrients in the soil and also recharge the soil fertility and hence it is included as a succeeding crop after maize. Keeping in view of the above facts, the present study was formulated to determine the effects of high-density maize cultivation influences succeeding cluster bean under cereal-pulse cropping sequence during *Rabi* seasons of 2017-18 and 2018-19.

Department of Agronomy, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India.
[1]Amrita School of Agricultural Sciences, Arasampalayam-641 032, Coimbatore, Tamil Nadu, India.

Corresponding Author: R. Raja Priya, Department of Agronomy, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India.
Email: rrajapriya364@gmail.com

How to cite this article: Priya, R.R., Krishnan, R., Sabareeshwari, V., Sureshkumar, R., Chandran, D. and Marthandan, V. (2022). Effect of Maize High Density Planting on Cluster Bean Performance under Maize-cluster Bean Cropping Sequence. Indian Journal of Agricultural Research. DOI: 10.18805/IJARe.A-5960.

Submitted: 17-01-2022 **Accepted:** 18-05-2022 **Online:** 27-06-2022

MATERIALS AND METHODS

The field experiment was conducted at Field No. 36 E during the years 2017-18 and 2018-2019 at Eastern Block Farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore for a period of two years during *rabi* seasons of 2017-18 (season I) and 2018-19 (season II) to study the effect of increased plant density and fertilizer levels on growth parameters, yield attributes and yield, nutrient content and economics of cluster bean under maize-cluster bean cropping sequence.

The experimental site was geographically situated in North Western agro-climatic zone of Tamil Nadu at 11°N latitude and 77°E longitude with an altitude of 426.7 m above MSL. The mean annual rainfall is 674.2 mm distributed over 47 rainy days during *rabi* cropping season of 2017-18 and 2018-19. During the two season cropping period, the average maximum and minimum temperature were 30.8, 19.7 and 29.7, 19.9°C, respectively. The total rainfall received was 0.3 and 0.7 mm, the mean relative humidity at 0722 hours and 1422 hours were 85.8, 47.1 per cent and 88.5, 51.9 per cent, respectively, with the mean bright sunshine hours of 7.0 and 6.1 with the evaporation of 4.7 and 5.0 mm day^{-1}. During both the seasons, rainfall and temperatures were optimum for cluster bean for better growth and development.

Pre-sowing soil samples were collected at 15 cm depth for analyzing various physio-chemical characteristics. The soil texture of the research field was sandy clay loam,classified taxonomically as*Typic U stropept.* The pre-sowing soilswas alkaline in pH (8.54 and 8.65) with low soluble salts (0.18 and 0.22 dSm^{-1}), medium in available organic carbon content (0.60 and 0.57 per cent), low in soil available nitrogen (246.5 and 226.1 kg ha^{-1}), medium in soil available phosphorous (11.5 and 12.4 kg ha^{-1}) and highin soil available potassium (421 and 425 kg ha^{-1}) during both the years of 2017-18 and 2018-19, respectively. Cluster bean was sown as succeeding crop after harvest of maize crop. Before taking up of cluster bean crop, the soil samples were collected from each plot from all the three replication.

The cluster bean crop was raised as irrigated crop during *rabi* seasons of (November-December) 2017-18 and 2018-19. Total duration of the cluster bean crop was 80-90 days. It was sown on 01.12.2017 and 01.11.2018 and multiple harvests were done and the first harvest was started at 45-55 DAS as vegetable.The cluster bean hybrid PusaNaubahar with a duration of 90 days used as test variety during *Rabi* seasons of both years. Two yearsof experimental trial was carried out by randomized block design with 9 treatments and replicated thrice. There were 9 plots in one replication, totally 27 plots and a row length of 3.6 m with a breadth of 6.0 m in each plot. The net plot size and plant population was same for all the plots. For each experimental plot, one border row and two sampling rows were allowed for taking destruction samples in all the sides. To minimize the experimental error, the replicated treatments were assigned at random. Measurements were taken from the border 1.2 × 6.0 m of each plot, allowing for a buffer channel between each experimental plot.

Maize was sown at different geometry and population. Higher dose of fertilizers was given to higher plant density of maize. Treatments applied to the maize crop were 60 cm × 25 cm - one seedling hill^{-1} with 100% RDF (T_1), 60 cm × 25 cm - two seedlings hill^{-1} with 150% RDF (T_2), 60 cm × 25 cm - two seedlings hill^{-1} with 200% RDF (T_3), 60 cm × 40 cm - two seedlings hill^{-1} with 125% RDF (T_4), 60 cm × 40 cm - two seedlings hill^{-1} with 150% RDF (T_5), 30 cm × 25 cm - one seedling hill^{-1} with 150% RDF (T_6), 30 cm × 25 cm - one seedling hill^{-1} with 200% RDF (T_7), 45 cm × 30 cm - one seedling hill^{-1} with 100% RDF (T_8) and 45 cm × 30 cm - one seedling hill^{-1} with 125% RDF (T_9).

- 100 per cent RDF - 250:75:75 kg $NP_2O_5K_2O$ ha^{-1}.
- 125 per cent RDF - 312.5:93.75:93.75 kg $NP_2O_5K_2O$ ha^{-1}.
- 150 per cent RDF - 375:112.5:112.5 kg $NP_2O_5K_2O$ ha^{-1}.
- 200 per cent RDF - 500:150:150 kg $NP_2O_5K_2O$ ha^{-1}.
- Full dose of phosphorus and potassium and 25 per cent of nitrogen was applied as basal. Balance 50 per cent of nitrogen was top dressed at 25 DAS and another 25 per cent of nitrogen was top dressed at 45 DAS.

After harvesting of maize crop without disturbing the soil by ploughing, cluster bean was sown as residual crop of about 10 kg ha^{-1}. Seeds of cluster bean were sown manually on the surface of flatbed, where maize was raised previously. Seeds were dibbled at a depth of 5 cm by adopting standard recommended inter and intra row spacing. No external source of fertilizer was applied to cluster bean planted at standard spacing in all the treatments without altering the land configurations. At 45th DAS one hand weeding was done manually.

Broad spectrum of information related to influence of different maize plant density and fertilizer levels on succeeding cluster bean crop growth parameters (plant height and dry matter production), yield attributes (No. of pods per plant, pod length), yield (pod and haulm yield) were recorded manually, with nutrient uptake and post-harvest soil nutrient status being analyzed in the laboratory. In each treatment**,** five plants were selected randomly in net plot area as a representation of the treatments and tagged in all the three replications for taking biometric observations. Plant samples were removed from the sampling area for taking drymatter production. Total expenditure and benefit was calculated.

Plant height

Measured in the tagged plants from ground level to tip of the main stem and the mean was expressed in cm.

Drymatter production (DMP)

Five plants were removed from the sample rows in gross plot area from each treatment and kept for air drying and then oven dried at 80° ± 2°C till a constant weight was attained and expressed in kg ha^{-1}.

Number of pods plant^{-1}

Number of pods from the tagged plants was taken in each harvesting to get the cumulative total number of pods produced plant^{-1}.

Length of pod

For each treatment, replication wise the length of five pods was measured and their mean was expressed in cm.

Pod yield

The pods from each treatment net plot area was harvested separately at every harvesting and weighed (kg ha^{-1}).

Haulm yield

The haulm of cluster bean in each treatment net plot area were pulled out and left in the field of three days for sun drying. Haulm weight from each plot was recorded and expressed as kg ha^{-1}.

Soil samples analysis

Before the initiation of experimental trail, soil samples were collected from the experimental site using screw auger for analysis. Soil samples were collected from each plot after the harvesting of maize crop was to study the effect of treatments on soil chemical properties. Collected soil samples were shade dried, powdered, sieved (2 mm) and preserved for further analyses. Soil nutrient status like available N (Asija and Subbiah, 1956), P_2O_5(Olsen, 1954) and K_2O (Stanford and English, 1949) were analyzed and expressed in kg ha^{-1}.

Plant samples analysis

Plant samples collected at each observation were shade-dried and then over-dried for drymatter estimation. Further, the samples were chopped and ground using Willey mill grinder. Powdered cluster bean crop samples were used total N (Humphries, 1956), P (Jackson, 1973) and K (Jackson, 1973) estimation. The nutrient status obtained as percentage from the lab analysis was computed to kg ha^{-1} by multiplying DMP (Humphries, 1956).

Economic indicators

The cost incurred for cluster bean cultivationfrom date of sowing to harvest was worked out and denoted as Rs. ha^{-1}. For each treatment, total income obtained from yield was calculated based on market price of the grain at the time of experimentation (Bhandari, 1993). Cost of cultivation and gross returns were worked out. By deducting the cost of cultivation from the gross returns, the net income was calculated. The benefit cost (BC) ratio was worked out by using the following formula:

$$\text{BC ratio} = \frac{\text{Gross return (₹ ha}^{-1}\text{)}}{\text{Cost of cultivation (₹ ha}^{-1}\text{)}}$$

RESULTS AND DISCUSSION

Growth parameters, yield attributes and yields of cluster bean

Cluster bean was sown where maize was planted at density of 1,33,333 (CS) plants ha^{-1} with 200 per cent RDF(T_7) recorded taller plants of 50.6 and 63.3 cm and higher dry matter production of 636 and 607 kg ha^{-1} during 2017-18 and 2018-19, respectively (Table 1). The next best treatments were 60 cm × 25 cm two seedlings hill^{-1} with 200

Table 1: Effect of different maize plant population and nutrient management practices on growth parameters and yield attributes of succeeding cluster bean during 2017-18 and 2018-19.

Treatments	Plant height (cm)		Dry matte production (kg ha^{-1})		No. of pods plant^{-1}		Pod length (cm)		Pod yield (t ha^{-1})		Haulm yield (t ha^{-1})	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
T_1: 60 cm × 25 cm - one seedling hill^{-1} with 100 per cent RDF	34.3	44.0	356.0	401.0	26.0	28.0	5.0	5.8	4.0	4.5	1.3	1.6
T_2: 60 cm × 25 cm - two seedlings hill^{-1} with 150 per cent RDF	45.9	58.6	563.0	548.0	34.0	35.0	6.3	6.9	6.0	6.2	2.3	2.7
T_3: 60 cm × 25 cm- two seedlings hill^{-1} with 200 per cent RDF	48.7	61.0	594.0	578.0	35.0	36.0	6.5	7.3	6.3	6.6	2.8	2.9
T_4: 60 cm × 40 cm - two seedlings hill^{-1} with 125 per cent RDF	39.2	49.1	415.0	459.0	30.0	31.0	5.5	6.3	4.9	5.2	1.7	1.9
T_5: 60 cm × 40 cm - two seedlings hill^{-1} with 150 per cent RDF	41.8	52.3	459.0	504.0	31.0	32.0	5.6	6.5	5.2	5.4	2.0	2.0
T_6: 30 cm × 25 cm- one seedling hill^{-1} with 150 per cent RDF	44.3	56.7	519.0	533.0	33.0	34.0	5.9	6.7	5.6	6.0	2.1	2.4
T_7: 30 cm × 25 cm - one seedling hill^{-1} with 200 per cent RDF	50.6	63.3	636.0	607.0	37.0	38.0	6.8	7.6	6.6	6.8	3.1	3.2
T_8: 45 cm × 30 cm - one seedling hill^{-1} with 100 per cent RDF	31.8	42.7	341.0	370.0	25.0	27.0	4.8	5.7	3.9	4.5	1.0	1.4
T_9: 45 cm × 30 cm - one seedling hill^{-1} with 125 per cent RDF	36.8	46.8	385.0	415.0	28.0	30.0	5.2	6.1	4.5	4.9	1.5	1.8
SEd (P=0.05)	6.6	8.4	80.0	79.0	5.0	5.0	0.9	1.0	0.9	0.9	0.3	0.4
CD	3.1	3.9	38.0	37.0	2.0	2.0	0.4	0.5	0.4	0.4	0.2	0.2

per cent RDF (T_3) and 60 cm × 25 cm - two seedlings hill^{-1} with 150 per cent per cent RDF (T_2).

Increased number of pods per plant (37 and 38), maximum pod length (6.8 and 7.6 cm), maximum pod yield (6.58 and 6.81 kg ha^{-1}) and higher haulm yield of 2.93 and 3.20 kg ha^{-1}, duringboth the seasons, respectively was observed under where maize crop was grown with a plant spacing of 30 cm × 25 cm - one seedling hill^{-1} with 200 per cent RDF (T_7). Maize planted at density of 1,33,333 (WS) plants ha^{-1} with 200 per cent RDF(T_3) placed next in its order.

Shorter plants of cluster bean, lesser drymatter production of 341 and 370 kg ha^{-1}, lesser number of pods plant^{-1}, lower pod length (4.8 and 5.7 cm), lower pod yield of 3.87 and 4.47 kg ha^{-1} and lower haulm yield (0.91 and 1.35 kg ha^{-1}), respectively were observed in cluster bean crop where maize was sown with the population of 74,074 plants ha^{-1} with 100 per cent RDF (T_8).

Nutrient uptake by cluster bean crop

Different plant density and nutrient management practices on maize crop had significantly influenced the nutrient uptake by clusterbean during both the years under maize-cluster bean cropping sequence. In 2017-18 and 2018-19, higher total nitrogen (15.38 and 14.70 kg ha^{-1}), phosphorus (3.30 and 3.16 kg ha^{-1}) phosphorus and potassium (8.34 and 7.97 kg ha^{-1}) uptake (Table 2) was observed in cluster bean plot where maize was planted at density of 1,33,333 (CS) plants ha^{-1} with 200 per cent RDF (T_7). Lower uptake of macro nutrients *viz*., 7.43 and 8.07 kg N ha^{-1}, 1.49 and 1.66 kg P ha^{-1} and 4.26 and 4.63 kg of K ha^{-1} was observed in cluster bean plot where maize was sown at plant population of 74,074 plants ha^{-1} with 100 per cent RDF(T_8).

Post-harvest soil available nutrient status

Cluster bean was sown where maize was planted at spacing of 30 cm × 25 cm - one seedling hill^{-1} with 200 per cent RDF maintained its superiority and recorded the maximum soil available nitrogen (351.5 and 339.7 kg ha^{-1}), phosphorus (14.9 and 14.5 kg ha^{-1}) and potassium (205.8 and 208.7 kg ha^{-1}) during both the seasons, respectively (Fig 1). This was on par with the treatment T_3 where maize was sown at spacing of 60 cm × 25 cm - two seedlings hill^{-1} with 200 per cent RDF. The lower soil available N of 184.0 and 232.0 kg ha^{-1}, P (6.4 and 7.2 kg ha^{-1}) and K (152.1 and 151.8 kg ha^{-1}), respectively was noticed under where maize was planted at spacing of 60 cm × 25 cm - one seedling hill^{-1} with 100 per cent RDF (T_1).

Economics of succeeding cluster bean

The mean data on gross return, net return and benefit cost ratio are given in Fig 2. During both the seasons, the cost of cultivation (35,095 ₹ha^{-1}) was same for all the treatments. Higher gross income (65800 and 68100 ha^{-1}), net return (30705 and 33005 ha^{-1}) and benefit cost ratio (1.87 and 1.94) was obtained in T_7 (geometry of 30 cm × 25 cm - one seedling hill^{-1} with 200 per cent RDF). It was followed by T_3 which recorded gross income of 62800 and 65800 ha^{-1}, net return of 27705 and 30705 ha^{-1}and benefit cost ratio of 1.79 and 1.87, respectively.

Lower gross return (38700 and 44700 ha^{-1}), net return (3605 and 9605 ha^{-1}) and benefit cost ratio (1.10 and 1.27) was noticed with cluster bean plot where maize was planted at the geometry of 45 cm × 30 cm - one seedling hill^{-1} with 100 per cent RDF(T_8), respectively.

Higher plant growth parameters like plant height, drymatter production; yield attributes *viz*., number of pods plant^{-1}, average pod length, pod and haulm yields, nutrient uptake by cluster beanand economics were observed in cluster bean plots, where maize was sown at density of 1,33,333 (CS) plants ha^{-1} with 200 per cent RDF, which was at par with T_3compared to all other treatments. This was due to double the recommended dose of fertilizers applied to this treatment and higher left over of macro nutrients in the soil by maize crop after harvest wasefficiently absorbed by succeeding cluster bean,thereby leading to better growth and yield. The remaining fertilizers in the soil was effectively utilized by cluster bean, a succeeding pulse crop and soil health was maintained by fixation of atmospheric nitrogen by cluster bean. The growth of groundnut plants increased

Table 2: Effect of different maize plant population and nutrient management practices on nutrient uptake (kg ha^{-1}) of succeeding clusterbean during season I and season II.

Treatments	Nitrogen			Phosphorus			Potassium		
	Season I	Season II	Mean	Season I	Season II	Mean	Season I	Season II	Mean
T_1	7.82	8.83	8.33	1.52	1.68	1.60	4.46	5.04	4.75
T_2	13.45	13.10	13.28	2.69	2.62	2.66	7.31	7.11	7.21
T_3	14.26	13.87	14.07	2.92	2.84	2.88	7.72	7.51	7.62
T_4	9.47	10.49	9.98	1.88	2.09	1.99	5.26	5.83	5.55
T_5	10.61	11.64	11.13	2.12	2.32	2.22	5.85	6.42	6.14
T_6	12.19	12.53	12.36	2.43	2.50	2.47	6.68	6.87	6.78
T_7	15.38	14.70	15.04	3.30	3.16	3.23	8.34	7.97	8.16
T_8	7.43	8.07	7.75	1.49	1.66	1.58	4.26	4.63	4.45
T_9	8.67	9.34	9.01	1.58	1.70	1.64	4.85	5.22	5.04
SEd	0.89	0.88	0.89	0.18	0.18	0.18	0.49	0.48	4.75
CD (P=0.05)	1.89	1.87	1.88	0.39	0.38	0.39	1.03	1.02	7.21

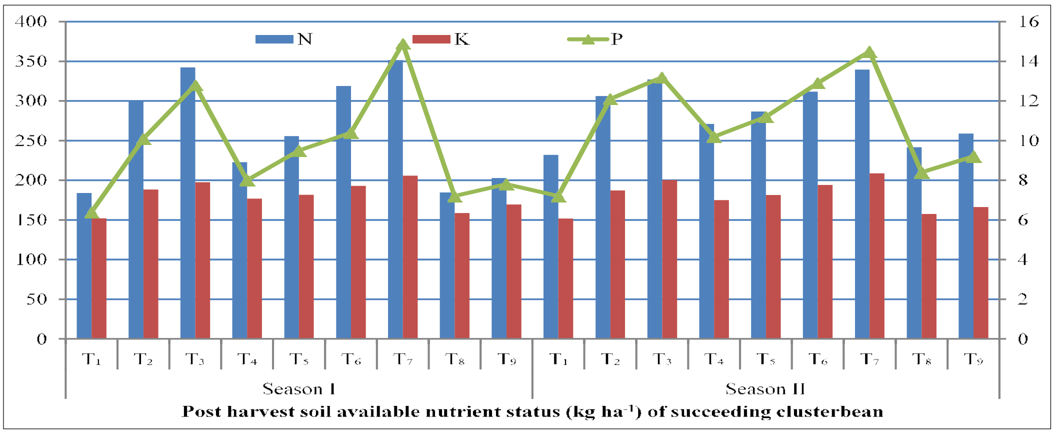

Fig 1: Effect of different maize plant population and nutrient management practices on post-harvest soil available nutrient status (kg ha^{-1}) of succeeding clusterbean during season I and season II.

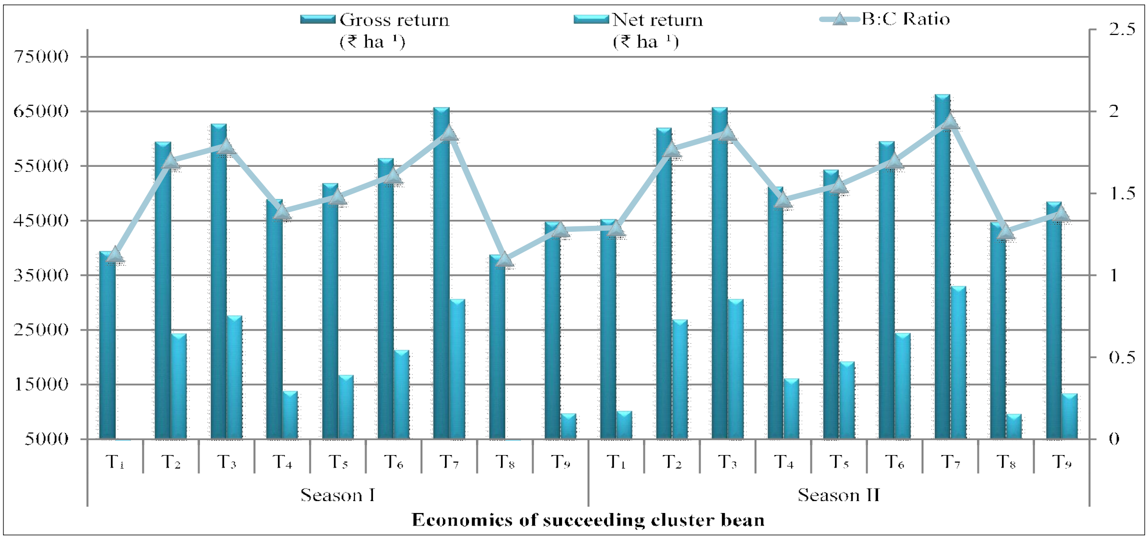

Fig 2: Economics of succeeding clusterbean during both seasons.

with the increasing N and P levels (Hasan *et al.*, 2021). Hasan *et al.* (2019) also reported a similar effect where plant height decreased with decreasing N and P fertilizer in pulse crop.

Similar findings were observed by Shekhawat and Shivay (2012), who reported that effective management of nitrogen in the sunflower-mungbean cropping system improved light interception, photosynthesis, growth, production of biomass and mungbean yield. Better photosynthates partitioning from source to sink enhanced mungbean yield attributes, seed and Stover yields. Because the fertilizer applied to one crop has residual eûects on the next crop, the available nitrogen, sulfur and boron in the soil after mungbean were also higher,when applied to the previous sunûower. Due to symbiotic biological N_2-fixation by the crop,the available nitrogen left after mungbean was harvested. Adeleke and Haruna (2012) also in their findings revealed an increase in total nitrogen after cropping, any of the legumes (cluster bean, soybean, cowpea, lablab and groundnut) can be included as succeeding crop and when the land was left fallow.

CONCLUSION

This manuscript concluded that higher plant density of 1,33,333 (CS of 30 × 25 cm) plants ha^{-1},with fertilizer levels of 200 per cent RDF inmaize significantly enhanced growth parameters, yield attributes, yields, nutrient uptake, post-harvest soil nutrient status and economics in both the seasons under irrigated conditions.

Conflict of interest: None.

REFERENCES

Adeleke, M.A. and Haruna, I.M. (2012). Residual nitrogen contribution from grain legume to the growth and development of succeeding maize crop. International Scholarly Research Notices (ISRN). https://doi.org/10.5402/2012/213729.

Asija, G.L. andSubbiah, B.V. (1956). A rapid procedure for the estimation of available nitrogen in soils. Curr. Sci. 25: 259-260.

Bhandari, A.S. (1993). Sustainability measures of rice-wheat system across agro-ecological regions in Nepal. 303.

Hasan, M., Uddin, M.K., Mohamed, M.T.M., Zuan, A.T.K., Motmainna, M. and Haque, A.N.A. (2021). Effect of nitrogen and phosphorus fertilizers on growth, yield, nodulation and nutritional composition of bambara groundnut [*Vigna subterranea* (L.) Verdc.]. Legume Research. 44(12): 1437-1442. DOI: 10.18805/LR-617.

Hasan, M., Uddin, M.K., Mohamed, M.T.M., Zuan, A.T.K., Motmainna (2019). Impact of nitrogen and phosphorus fertilizer on growth and yield of Bambara groundnut. Plant Archives. 19(1): 501-504.

Humphries, E.C. (1956). Mineral Components and Ash Analysis. In: Modern Methods of Plant Analysis. [Park, K. and Tracey, W.M. (eds.)]. Springer- Verlag: Berlin. PP. 468-502.

Jackson, M.L. (1973). Soil Chemical Analysis., (Prentice Hall of India Pvt. Ltd.: New Delhi, India). PP. 183-204.

Olsen Sterling, R. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate: United States Department of Agriculture; Washington.

Raja Priya, R., Krishnan, R., Srinivasan, K. and Shanmugasundaram, S. (2019). Pressure of high planting density and fertilizer levels on maize growth and yield. Int. J. Chemical Studies. 7(3): 2007-2010.

Shekhawat Kapila and Yashbir Singh Shivay (2012). Residual effect of nitrogen sources, sulfur and boron levels on mungbean (*Vigna radiate*) in a sunflower (*Helianthus annus*)-mungbean system. Archives of Agronomy and Soil Sci. 58(7): 765-776.

Stanford George and Leah English. (1949). Use of the flame photometer in rapid soil test for K and Ca. Agronomy J. 41(9): 446-447.

Thakur, Thakur, A.D.S., Patel, R.K., Pradhan, A. and Kumar, P. (2015). Effect of different plant geometry and nitrogen levels, in relation to growth characters, yield and economics on sweet corn (*Zea mays sachharata* L.) at bastarplaeau zone. The Bioscan. 10(3): 1223-1226.