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Abdul Wahab Hekmat
Ph.D. Scholar in Department of Agronomy, SHUATS, Allahabad, Uttar Pradesh, India

Janbaz Khan Zafari
Assistant Professor, Department of Agronomy, Faculty of Agriculture, Paktia University, Gardez, Afghanistan

Thomas Abraham
Advisor and Professor Department of Agronomy SHUATS, Allahabad, Uttar Pradesh, India

Correspondence Author:
Abdul Wahab Hekmat
Ph.D. Scholar in Department of Agronomy, SHUATS, Allahabad, Uttar Pradesh, India

Production potential of greengram (*Vigna radiata* L.) as influenced by intercropping and manurial management under certified organic production system

Abdul Wahab Hekmat, Janbaz Khan Zafari and Thomas Abraham

Abstract
The experiments were carried out during *zaid* seasons of 2014 and 2015 at Crop Research Farm, Block E of SHUATS Model Organic Farm (SMOF), Department of Agronomy, Allahabad School of Agriculture, SHUATS, Allahabad, and Uttar Pradesh, India. The objective was to study the influence of short duration legume intercrops and organic nutrient management practices on growth, yield, and quality, nutrient status of the soil and nutrient uptake of baby corn and component crops under certified organic production system. Short duration intercrops [greengram (*Vigna radiata* L.) and clusterbean (*Cyamopsis tetragonoloba* L.)] along with control (no intercrop) were taken in main plot. Different sources of organic manure and their combination [goat manure (M_1), poultry manure (M_2), FYM (M_3), goat manure + poultry manure (M_4), goat manure +FYM (M_5) and poultry manure +FYM (M_6)] were assigned to sub plot in a split plot design, the experiments were replicated thrice.
Results of the experiments revealed that sole cropping of greengram under different treatments of organic manures gave significantly higher number of branches, leaf area index and number of nodules per plant during both the years and pooled analysis as compare to intercropping with baby corn. Intercropping of greengram with baby corn decreased the yield and yield attributes of greengram by 7.13% as compare to sole cropping. However, this marginal loss was compensated by additional harvest of baby corn crop.
Among the manurial treatments significantly maximum number of branches per plant and leaf area index was recorded in treatment M_6 and M_2 due to application of poultry manure alone or either in combination with FYM. While, different sources of organic manures did not affect the number of nodules per plant of greengram during both the years and pooled analysis. Yield attributes and yield of greengram was increased in M_2 (Poultry manure at the rate of 1.92t ha^{-1}) and M_6 (Poultry manure at the rate of 0.96t ha^{-1} +FYM at the rate of 5t ha^{-1}) respectively, as compared to rest of the manurial treatments.

Keywords: Baby corn, growth, intercrops, nutrient status and nutrient uptake, organic nutrient management practices, quality yield

Introduction
Greengram (*Vigna radiata* L.) popularly known as mungbean is an important pulse crop, extensively cultivated under varying agro climatic conditions. It is also known as mungbean and serves as a major source of dietary protein for the vast majority of people (Jat *et al*., 2014) [8]. In India, it is grown on 8.5m ha area with the production and productivity of 21.3mt and 2507kg ha^{-1}, respectively (GOI, 2011) [7]. This crop is hardly known or cultivated in Afghanistan and thus holds immense scope. Given the increasing demands for quality food and linking of enhanced food production with nutritional security, and the need to conserve the natural resources, diversification of agriculture is necessary. The interest of diversified agricultural production systems is to obtain production stability through improved crop protection, increased productivity, and profitability offered by many intercropping systems. Some of the established and speculated advantages of cereal-legume intercropping systems are higher yields, greater land-use efficiency, and improvement of soil fertility through N fixation by the component legume. The climate of India comprises a wide range of weather, however, with anomalies. Possibility of raising two or more crops on the same piece of land in a year needs to be explored for effective and efficient utilization of these natural resources.

Decisions about intercropping should be taken on the basis of present available resources, marketability and value of crops and objectives of the farmers. So in the present scenario of preponderance of small holding, surplus farm family labor, overlapping of growing season of crops, low productivity of most of the crops and practice of subsistence farming, intercropping seems to be a promising strategy for increasing crop productivity particularly at small farm level. Kamanga *et al.* (2010) [9] reported that maize +legume intercropping is more productive and profitable cropping system in comparison with solitary cropping.

The current availability of pulses in India is 36g head^{-1} day^{-1} as against the minimum and optimum requirement of 80 and 104g head^{-1} day^{-1}, respectively (Jat *et al.*, 2014) [8]. It may be noted that there is no possibility of bringing more area under pulse crops and the future prospects in this regard appear remote. Under such difficult and demanding situations, spatial or temporal intensification of cropping, particularly in the form of intercropping, provides an alternative of immense relevance and potential.

Systematic study of greengram in intercropping with baby corn under certified organic production system is lacking. Therefore, the present study aims to explore the possibility of growing baby corn as food and green fodder during the *zaid* season in an intercropping system with legumes, and to assess the means for better resource management with respect to land use efficiency and complementarities.

Materials and Methods

Field experiments were conducted during *zaid* seasons of 2014 and 2015 at Crop Research Farm, Block E of SHUATS Model Organic Farm (SMOF), Department of Agronomy, Allahabad School of Agriculture, SHUATS, Allahabad, Uttar Pradesh, India, which is located at 25^0 24' 42" N latitude, 81^0 50' 56" E longitude and at an altitude of 98 m above the mean sea level. The soil of the experimental area was sandy loam with moderately alkaline pH (7.60 and 7.40); low in organic carbon (0.37 and 0.39%) and available N (163.30 and 170.35kg ha^{-1}), medium in available P (14.80 and 15.50kg ha^{-1}) and high in available K (256.00 and 261.00kg ha^{-1}) during *zaid* 2014 and 2015 seasons respectively. Baby corn hybrid (Golden baby), Greengram (Samrat) and Clusterbean (Pusa Nawbahar) varieties were chosen for the study.

The experiments were laid out in split plot design with three replication on a plot size of 6.35 x 4.0 m. In main plots, cropping systems (Sole baby corn, baby corn +greengram and baby corn +clusterbean) and in sub plots, different sources of organic manure and their combination with each other [goat manure at the rate of 4.80 t ha^{-1} (M_1), Poultry manure at the rate of 4.62 t ha^{-1} (M_2), FYM at the rate of 24 t ha^{-1} (M_3), goat manure +poultry manure (M_4), goat manure +FYM (M_5) and poultry manure +FYM (M_6)] were assigned.

Before sowing, lines were formed in the field as per the spacing in treatments. Baby corn and component crop seeds were pre-treated with biofertilizers, sown in line and covered with the soil. Lines were formed in between two baby corn rows and intercrops were sown. Baby corn, greengram and clusterbean seeds were hand dibbled. Organic manures were applied as per the treatment (on equal N basis) and incorporated in lines uniformly. All the agronomic practices were carried out uniformly to raise the crop. To record various growths and yield observations on baby corn and component crops a sample consisting of five plants were selected at random.

Number of branches from the five randomly tagged plants from each plot was counted at 15 days interval; the mean number of branches per plant in each plot at aforesaid growth stages was worded out and recorded. The leaf area index is defined as leaf area (assimilatory source) per unit land area. It was calculated by dividing the leaf area per plant by the land area occupied by single plant. For counting the number of root nodules per plant at 30, 45 and 60 DAS five plants were uprooted with a ball of soil for with root portion intact; the ball of soil was washed gently with clean water followed by washing with camel hair-brush to dislodge any soil particles adhering to it. Nodules were removed from roots for counting their number. Numbers of pods were counted for sampled plants and then were averaged for calculating number of pods plant^{-1}. Similarly weight of 1000 seed was recorded for each plot on average basis. To avoid losses due to shattering of the pods of greengram the crop was harvested before it was dead rip, three picking of the mature pods were carried out separately for each treatment. Thereafter, the plants were cut with sickle and dried on the threshing floor for recording the biological yield, after sufficient sun drying of the harvested pods, threshing was done manually by beating the handpicked pods of each plot separately and seeds were collected in numbered bags, after winnowing, cleaned seeds were weighed to record seed yield kg m^2 then it was converted into kg ha^{-1}.

Result and Discussion

Growth and Growth Attributes: In general, the number of branches per plant, leaf area index and number of nodules per plant of greengram in pure stand maintained supremacy over the intercropping system due to lower proportion of sown area. On an average the number of branches in sole greengram increased by 1.39, 2.5 and 2.09 percent as compared to intercropping with baby corn. The lowest number of branches per plant of greengram under the intercropping system could be attributed to competition for the available growth resources in the intercrop environment. In addition, it might also be due to the lower inter and intera specific completion due to the lower population density in sole cropping and this might have provided a better soil resource with higher light availability for greengram to grow vigorously. These results are in conformity with Onuh *et al.* (2011) [20], Sharma and Banik (2013) [24] and Abuna (2015) [1].

The different treatments of manurial application influenced the number of branches significantly during both the years and pooled analysis. Among the manurial treatments the significantly higher number of branches plant^{-1} (6.86) was registered in treatment M_2 (Poultry manure 1.92t ha^{-1}) during the first year of the experiment. However, M_6 during the second year registered significant and maximum number of branches (6.40). Further, M_2 and M_6 in pooled analysis recorded significantly same number of branches plant^{-1}. More number of branches with application of different forms of the organic manures might be due to availability of micronutrients in organic manures, as well as improving soil physical, chemical and biological properties (Dwivedi *et al.*, 2012) [6]. It might also be due to the fact that FYM stimulate the growth and activity of microorganisms in the soil (Babhulkar *et al.*, 2000) [2]. The Improvement in plant growth attributed might be due to the fact that organic manures such as FYM, Poultry manure and Goat manure might enhanced the soil microbial activity which might have interned into higher improved the physical condition of soil in respect of granulation, friability and porosity an ultimately provided a balanced nutritional environment to the soil plant nutrition system (Kumar *et al*., 2003 and Thanunathan *et al*., 1997) [13, 27]. These findings corroborated with the results of Premanantharajah and Prapagar (2013) [22], Singh (2005) [25] and Meena *et al*., (2015) [16].

Sole cropping of greengram gave the highest leaf area index during both the years and pooled analysis at all crop growth stages. However, the lower value has been recorded in intercropping greengram with baby corn. The range of reduction value was between (1.73 to 4.47%) of greengram in pooled analysis during the successive stages. The reduction in leaf area index in intercropping treatments could be attributed to increased population pressure and inter-specific competition for the available growth resources. This could also be due to the shading effect of baby corn on lower canopy of greengram due to which photosynthetic efficiency of the intercropped greengram was affected adversely. These findings are in conformity with Mittal and Singh (1989) [17], Bhatti *et al*. (2008) [3] and Prasanthi and Venkateswaralu (2014) [21]. However, the reduction of values of leaf area index under intercropping of greengram with baby corn was comparatively less than intercropping of greengram with sorghum, wheat, maize and other cereal crops as earlier reported by different scientific studies in different parts of the world [(Woomer *et al*., 2004) [29], Prasanthi and Venkateswaralu (2014) [21], Saleem *et al*. (2016) [23] and Khan and Khaliq (2004)] [11]. Leaf area index of greengram did not significantly influenced by different treatments of manurial application during both the years and pooled analysis. However, maximum leaf area index (0.972, 0.980 and 0.976) was registered in treatment M_6 due to application of poultry manure at the rate of 0.96 t ha^{-1} +FYM at the rate of 5 t ha^{-1}, respectively.

Effective nodulation determines the nitrogen fixation ability of legume. Nitrogen fixation by legume is regaining attention as it contributes substantial amount of nitrogen in agricultural ecosystems. Nodule formation is characteristic of legume. Greengram +baby corn intercropping caused difference in number of nodules plant^{-1}. On an average higher nodule density (22.54) at 60 days after sowing was recorded in plots where greengram was sown alone. While, lower number of nodules plant^{-1} (20.12) was registered in plots where greengram was intercropped with baby corn. Zero competition and early root establishment in sole greengram might be the possible reason for improved number of nodules plant^{-1}. The lower nodule formation in intercropping of greengram with baby corn might be due to the fact that, baby corn has deep roots which are better competitor for available resource as compared to greengram (Moses *et al*., 2010) [18]. These results are in conformity with Khan *et al*. (2012) [10] and (Abuna, 2015) [1].

Table 1: Effect of intercropping and organic nutrient management on growth and growth attributes of greengram

Treatment	Growth attributes of greengram								
	Number of branches plant^{-1}			Leaf area index			Number of nodules plant^{-1}		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
Cropping system (C)									
C_1: Sole Greengram	6.54	6.15	6.35	0.942	0.933	0.937	22.64	22.44	22.54
C_2: Greengram +Baby corn	6.45	6.00	6.22	0.910	0.933	0.921	19.41	20.84	20.12
SE(d)±	0.01	0.20	0.06	0.0237	0.0064	0.013	0.68	1.12	0.45
CD (P=0.05)	0.08	NS	NS	NS	NS	NS	2.96	NS	1.95
Manures (M)									
M_1: Goat Manure (2.00t ha^{-1})	6.36	5.83	6.10	0.881	0.8858	0.883	20.73	21.53	21.13
M_2: Poultry Manure (1.92t ha^{-1})	6.86	6.33	6.60	0.936	0.9128	0.924	21.90	22.10	22.00
M_3: Farm Yard Manure (10.00t ha^{-1})	5.76	5.56	5.66	0.914	0.9334	0.923	19.40	20.73	20.06
M_4: Goat Manure (1.00 t ha^{-1}) +Poultry Manure (0.96t ha^{-1})	6.56	6.16	6.36	0.913	0.9369	0.925	21.46	21.60	21.53
M_5: Goat Manure (1.00 t ha^{-1}) +FYM (5.00 t ha^{-1})	6.63	6.16	6.40	0.939	0.9511	0.945	20.33	21.46	20.90
M_6: Poultry Manure (0.96 t ha^{-1}) +FYM (5.00t ha^{-1})	6.80	6.40	6.60	0.972	0.9802	0.976	22.33	22.43	22.38
SE(d) ±	0.23	0.25	0.21	0.0328	0.0391	0.0335	0.75	1.21	0.58
CD (P=0.05)	0.48	0.53	0.44	NS	0.0815	NS	1.58	NS	1.22
Cropping System x Manures (C x M)	NS	NS	NS	NS	NS	NS	NS	NS	NS

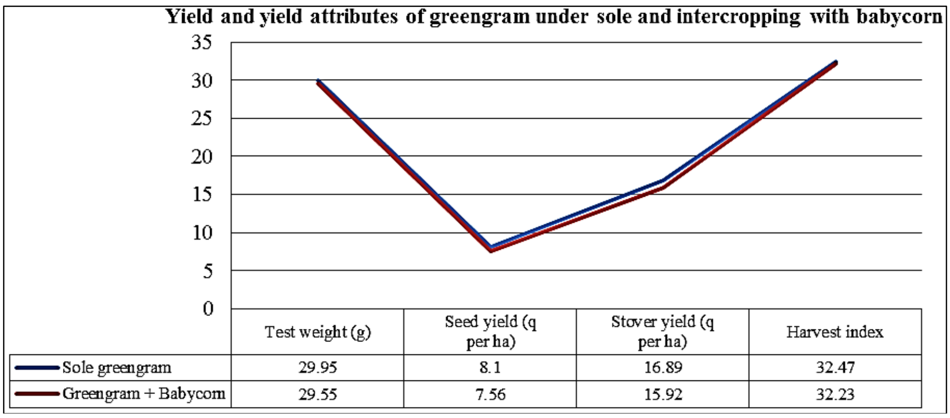

Fig 1: Growth attributes of greengram under sole cropping and intercropping with baby corn

Intercropping of greengram with baby corn in the present study resulted in 12.02% reduction in nodule formation, but the reduction was marginal in comparison with other cereal crops as base crop which has been reported by many researchers. A study conducted by Khan *et al.* (2012) [10] indicate that, nodule formation was 98% less than sole crop of greengram as compared to intercrop with maize, but under the current trails the reduction was much lower, and this might be due to the short duration of baby corn.

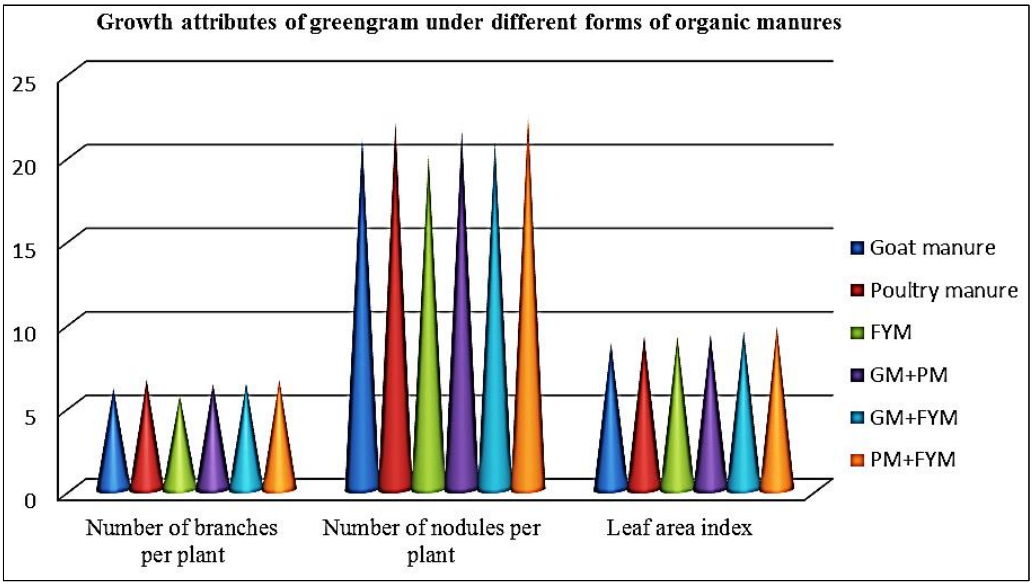

Fig 2: Growth attributes of greengram under different forms of organic manures at SMOF, SHIATS

A perusal of the table shows that, the number of nodules plant^{-1} in manurial treatments was differed significantly at 60 DAS during the first year and pooled analysis, while, there was no significant difference observed during the second year of the experiment. Among the manurial treatments M_6 (Poultry manure 0.96 t ha^{-1} +FYM 5 t ha^{-1}) registered significant and maximum number of nodules plant-1 during the first year and pooled analysis. Application of organic manures improved nodulation, this enhanced nodulation might be due to increase in exchangeable calcium (Ca). It has been observed that Ca content affects the attachment of rhizobia to roots (Smit *et al*., 1991) [26] and therefore enhances nodulation (Lawson *et al*., 1995) [14]. It might also be due to the fact that, addition of FYM stimulate the growth and microorganisms activity in the soil (Babhulkar *et al*., 2000) [2] The results are in conformity with Malik *et al.* (2015) [15] and Singh (2005) [25].

Yield and Yield Attributes

Yield component and yield of greengram was higher in the sole cropping system of greengram as compared to intercropping with baby corn. Since greengram plants in the sole cropping system recorded higher plant height, number of leaves, number of branches, leaf area, dry matter and number of root nodules, it may be deduced as consequential that yield attributes were enhanced.

Baby corn +greengram intercrop caused (7.13 and 4.26) per cent seed yield and stover yield reductions in greengram as compared to sole cropping. Possible reason for yield losses might be as a result of light interference by corn on greengram due to variation in plant architecture. Light capture could be considered the primary source of competition as the other major growth factors such as water and nitrogen were at adequate levels throughout the cropping system (Khan *et al*., 2012) [10]. Moreover, the yield of greengram in pure stand maintained supremacy over the intercropping system due to the obvious reason of lower proportion of sown area. This might also be due to limited disturbance of the habitat under sole cropping environment. The findings are supported by Tohura *et al*. (2014) [28], Khan *et al.* (2012) [10] and Abuna (2015) [1]. To compare the competitive effect of baby corn with greengram as compared to other crops like maize, sorghum, wheat etc. The reduction of yield in case of baby corn is much lower and it might be due to the fast growing habit and short duration of baby corn, which does not interfere with component crop till end of their life cycle. In a study conducted by Saleem *et al*. (2016) [23] the yield reduction of greengram was 42.81% less than sole greengram when it was intercropped with grain crop of maize.

Among the manurial treatments, significantly higher seed yield (807.00kg ha^{-1}), was registered in M_4 during the first year of experiment which was significantly superior to other organic manurial treatments. However, M_6 and M_2 were found statistically at par with M_4. During the year 2015 and pooled analysis M_2 registered significant and highest seed yield (813.33 and 806.66kg ha^{-1}), however, M_1, M_4 and M_6 were found statistically at par with M_2 respectively. The increase in yield of greengram due to application of poultry manure in combination with FYM and goat manure could be attributed to the supply of nutrients through mineralization of organic manures and improvement of physico-chemical properties of the soil. The increase in seed yield of greengram might also be due to the fact that, poultry manure and FYM improve soil fertility due to high nitrogen, phosphorus and organic matter content. The results are corroborated with Singh (2005) [25] and Khan and Khalil (2014) [11].

Table 2: Effect of intercropping and organic nutrient management on test weight, seed yield, and stover yield and harvest index of greengram

Treatment	Test weight (g)			Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})			Harvest index (%)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
Cropping system (C)												
C_1: Sole Greengram	29.75	30.16	29.95	820.00	801.11	810.92	1677.05	1702.77	1689.91	32.90	32.03	32.47
C_2: Greengram + Baby corn	29.26	29.84	29.55	736.00	777.77	756.94	1484.44	1700.00	1592.22	33.17	31.40	32.23
SE(d) ±	0.88	0.56	0.32	5.14	4.13	3.33	84.22	8.94	41.18	1.23	0.04	0.58
CD (P=0.05)	NS	NS	NS	22.12	17.79	14.34	NS	NS	NS	NS	01.9	NS
Manures (M)												
M_1: Goat Manure (2.00 t ha^{-1})	29.85	31.10	30.47	769.00	791.66	780.75	1512.83	1668.33	1590.58	33.67	32.20	32.90
M_2: Poultry Manure (1.92 t ha^{-1})	32.12	32.31	32.22	800.00	813.33	806.66	1642.16	1761.66	1701.91	32.76	31.60	32.16
M_3: Farm Yard Manure (10.00 t ha^{-1})	26.18	27.70	26.94	744.00	755.00	749.75	1468.83	1630.00	1549.41	33.70	31.68	32.62
M_4: Goat Manure (1.00 t ha^{-1}) + Poultry Manure (0.96 t ha^{-1})	30.06	29.98	30.02	807.00	791.66	799.50	1636.83	1681.66	1659.25	33.05	32.01	32.52
M_5: Goat Manure (1.00 t ha^{-1}) + FYM (5.00 t ha^{-1})	27.45	27.38	27.42	759.00	783.33	771.25	1579.00	1676.66	1627.83	32.56	31.88	32.21
M_6: Poultry Manure (0.96 t ha^{-1}) + FYM (5.00 t ha^{-1})	31.37	31.53	31.45	790.00	801.66	795.83	1644.83	1790.00	1717.41	32.49	30.95	31.67
SE(d) ±	1.29	1.29	1.14	13.62	12.31	11.98	41.55	38.40	38.57	0.61	0.62	0.55
CD (P=0.05)	2.70	2.71	2.38	28.42	25.68	25.00	86.68	81.85	80.45	NS	NS	NS
Cropping System x Manures (C x M)	NS	NS	NS	S	NS	S	S	S	S	NS	S	S

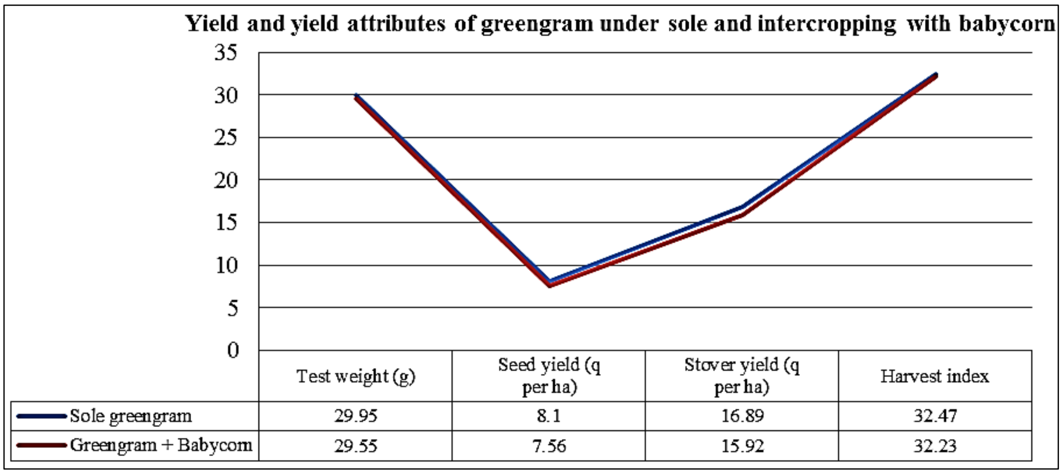

Fig 3: Yield and yield attributes of greengram under sole and intercropping with baby corn

The significant difference due to different treatments of manurial application on stover yield was found during both the years and pooled analysis. During both the years and pooled analysis, maximum stover yield (1644.83, 1790.00 and 1717.41kg ha^{-1}) was observed in treatment M_6, which was significantly superior to other manurial treatments. However, M_2 and M_4 were found statistically at par value with M_6 during the first year and pooled analysis. Further, M_5 during the first year and M_2 during the second year were found statistically at par with M_6 respectively. The increase of stover yield due to poultry manure and FYM could be assigned to N supply through different forms of manure application and N supply has substitution effect on plant growth and development because it is a fundamental constituent of leaf cell component, especially those associated with photosynthetic apparatus. It might also be due to improvement in physico-chemical and biological properties of the soil with constant and optimum supply of nutrients to the plant enhanced yield attributing characters. The results are in conformity with Khan and Khalil (2014) [12] and Bhathal and Kumar (2016) [4].

Test weight is an important yield contributing parameter of greengram which was not significantly influenced by intercropping with baby corn.

Among the manurial treatments, Treatment M_2 registered significant and maximum test weight (32.12, 32.31 and 32.22g) during both the years and pooled analysis. However, M_1, M_4 and M_6 were found to be statistically at par with M_2 during both the years and pooled analysis.

The heavier seeds of greengram obtained in M_2 (Poultry manure 1.92t ha^{-1}) and M_6 (Poultry manure 0.96 t ha^{-1} + FYM 5 t ha^{-1}) might be attributed to the increased and balanced supply of nitrogen to plant which promotes flowering and fruiting and supply of food material and its subsequent partitioning in the sink. It might also be due to the fact that, organic manures also improve the availability of phosphorus which plays a unique role in energy conservation and transfer. The balanced supply of nitrogen throughout the life cycle of the crop reduced leaf senescence and able to furnish the increased assimilate demand of plant sink which resulted in higher number of pods and test weight due to bold seed. These findings are in conformity with (Choudhary *et al.*, 2011) [5] and (Saleem *et al.*, 2016) [23]. Harvest index of greengram and clusterbean was not influenced by different treatments of manurial application during both the years and pooled analysis.

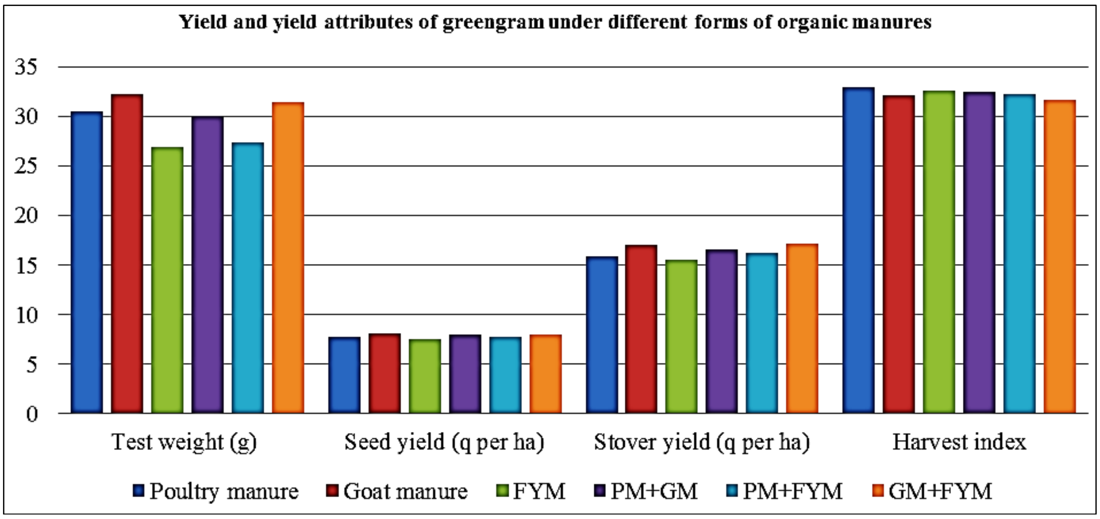

Fig 4: Yield and yield attributes of greengram under sole and intercropping with baby corn

Harvest index of greengram was not significantly influenced by cropping system during both the years and pooled analysis except second year of the experiment. Higher harvest index of greengram in monocropping as compared to intercropping with baby corn might be due to more space for light interception and air circulation and less shading of associated crop. Similar results are reported by Khan and Khaliq (2004) [11] and Khan *et al.* (2012) [10].

A perusal of the table showed that, there was no significant difference in harvest index among the manurial treatments during both the years and pooled analysis. Among the manurial treatments M_3 recorded higher harvest index (33.70%) during the first year and M1 during the second year and pooled analysis (32.20 and 32.90%) respectively.

Conclusion

From the results of the study during both the years, it may be concluded that, intercropping of greengram with baby corn decreased the yield and yield attributes of greengram with 7.13% decrease in grain yield as compared to sole cropping. However, this marginal loss was competed by additional harvest of baby corn crop. In addition, Yield attributes and yield of greengram was increased in treatment M_2 (Poultry manure at the rate of 1.92 t ha^{-1}) and M_6 (Poultry manure at the rate of 0.96 t ha^{-1} and FYM at the rate of 5 t ha^{-1}) respectively, as compared to rest of the manurial treatment.

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Research guide or chairperson of research: Prof Dr. Thomas Abraham

University: Sam Higginbottom University of Agriculture, Technology & Sciences, Allahabad, 211 007, Uttar Pradesh

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References

1. Abuna WG. A Study of the effect of intercrop row arrangement on maize and haricot bean yield on residual soil. International Journal of Agroforestry and Silviculture. 2015; 2(4):127-134.
2. Babhulkar PS, Wandile RM, Badole WP, Balpande SS. Residual effect of long-term application of farmyard manure and fertilizers on soil properties and yield of soybean. Journal of Indian Society of Soil Science, 2000; 48(1):89-92.
3. Bhatti IH, Ahmad R, Jabbar A, Virk ZA, Aslam M. Agro-economic performance of mungbean intercropped in sesame under different planting patterns. *Pakistan* Journal of Agricultural Sciences. 2008; 45(3):119-124.
4. Bhathal S, Kumar R. Response of integrated nutrient management on growth, yield and yield attributing characters of clusterbean (*Cyamopsis tetragonoloba* L.) under irrigated conditions of Amritsar. *International* Journal in Management and Social Science. 2016; 4(5):42-47.
5. Choudhary BR, Gupta AK, Parihar CM, Jat SL, Singh DK. Effect of integrated nutrient management on fenugreek (*Trigonella foenum graecum*) and its residual effect on fodder pearl millet (*Pennisetum glaucum*). Indian Journal of Agronomy. 2011; 56(3):189-195.
6. Dwivedi SK, Shrivastava AP, Singh, Lakpale R. Weeds and crop productivity of maize +balck gram intercropping system in Chhattisgarh plains. Indian Journal of Weed Science. 2012; 44(1):26-29.
7. GOI, New Delhi. Economics and Statistics of Indian Agriculture. Annual Report, Government of India, New Delhi, 2011, 17.
8. Jat PC, Rathore SS, Sharma RK. Effect of integrated nitrogen management and intercropping systems on yield attributes and yield of maize. Indian Journal of

Hill Farming. 2014; 27(1):91-99.
9. Kamanga BCG, Waddington SR, Robertson MJ, Giller KE. Risk analysis of maize-legume crop combinations with smallholder farmers varying in resource endowment in central Malawi. Experimental Agriculture. 2010; 46(1):1-21.
10. Khan MA, Naweed K, Ali K, Ahmad B, Jan S. Impact of mungbean-maize intercropping on growth and yield of mungbean. Pakistan Journal of Weed Science Research. 2012; 18(2):191-200.
11. Khan MB, Khaliq A. Study of greengram in cotton planted with different techniques. Journal of Research Science. 2004; 15(1):23-31.
12. Khan S, Khalil SK. Integrated use of organic and inorganic fertilizers in wheat and their residual effect on subsequent greengram. International Journal of Farming and Allied Sciences. 2014; 3(8):835-844.
13. Kumar S, Singh RC, Kadian VS. Performance of mungbean as influenced by seed inoculation. Indian Journal of Pulses Research. 2003; 16:67-68.
14. Lawson IYD, Muramatsu K, Nioh I. Effect of the organic matter on the growth nodulation and saline conditions. Soil Science and Plant Nutrition. 1995; 41:721-728.
15. Malik MA, Nadeem SM, Ibrahim M, Hussain S. Effective use of brackish water for improving soil properties and chickpea (*Cicer arietinum*) growth through organic amendments. Soil Environment. 2015; 34(1):65-75.
16. Meena AK, Paliwal, Meena KK. Effect of organic manures and bio-fertilizers on growth and quality attributes of Kharif onion in semi-arid region. Indian Research Journal of Genetic and Biotechnology. 2015; 7(1):73-76.
17. Mittal SP, Singh P. Intercropping field crops between rows of leucaena leucocephala under rainfed conditions in northern India. Agroforestry Systems. 1989; 8(02):165-172.
18. Moses GBK, Karimullah M, Mohammad S. Performance of maize in intercropping with legumes at different level of fertilizers. Crop Research (Hisar). 2010; 20(1):149-164.
19. Muthukumar VB, Velayudham K, Thavaprakaash N. Growth and yield of baby corn (*Zea mays* L.) as influenced by plant growth regulators and different time of nitrogen application. Research Journal of Agriculture and Biological Sciences. 2005; 1(4):303-307.
20. Onuh MO, Ohazurike NC, Ijezie A. Effects of mungbean/melon/maize intercrop on the growth and yield of mungbean (*Vigna radiata* L.) cultivated in owerri rain forest area. World Journal of Agricultural Sciences. 2011; 7(2):161-165.
21. Prasanthi K, Venkateswaralu B. Fodder quality in fodder maize-legume intercropping systems. Journal of Tropical Agriculture. 2014; 52(1):86-89.
22. Premanantharajah P, Prapagar K. Effect of poultry manure as partial substitute for P and S on the yield and quality of groundnut. In: *Proceedings of the 3rd International Symposium*, 06-07 July, South eastern University of Sir Lanka. 2013; 121:94-99.
23. Saleem R, Ahmed ZI, Anees MA, Majeed A, Ali A, Shah H. Relative impact of integrated use of poultry manure, NPK, and biofertilizers on yields of three cropping systems and studies on performance of systems for productivity, sustainability and economic viability of the systems. Academia Journal of Biotechnology. 2016; 4(4):153-163.
24. Sharma, Banik. Baby corn-legumes intercropping system: II weed dynamics and community structure. NJAS-Wageningen Journal of Life Sciences. 2013; 5(67):11-18.
25. Singh MS. Effect of *Rhizobium*, FYM and chemical fertilizers on legume crops and nutrient status of soil-A review. Agriculture Review. 2005; 26(4):309-3012.
26. Smit G, Tubbing DMG, Kijne KW. Role of Ca^{2+} in the activity of rhidoadhesin from *Rhizobium Leguminosarum* biovar *viciae*, which mediates the first step in attachment of *Rhizobiaceae* to plant root hairs tips. Archive of Microbiology. 1991; 155:278-283.
27. Thanunathan K, Natarajan S, Kumar RC, Arul-Murugan K. Effect of different sources of organic amendments on growth and yield of onion in mine soil. Madras Agriculture Journal. 1997; 84:382-384.
28. Tohura T, Ali MS, Rahman MM, Chowdhury LF, Mony TZ. Yield performance of mungbean maize intercropping grown under different planting geometry. International Journal of Sustainable Agriculture and Technology. 2014; 10(9):22-27.
29. Woomer PL, Gat ML, Tungani JO. Innovative maize-legume intercropping results in above and below ground competitive advantages for understory legumes. West African Journal of Applied Ecology. 2004; 6(3):85-94.