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Certified Organic Production of Babycorn (*Zea mays* L.) based Legume Intercropping System as a Substitute Pathway for Sustainable Agriculture - A Review

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ABSTRACT

Baby corn (*Zea mays* L.) refers to the whole, entirely edible cobs of immature corn harvested just before fertilization at 2-3 cm long silk emergence stage. The baby corn has a medium plant type and provides sweet, succulent and delicious green cobs within 65-75 days of sowing. Low quality yield of legumes and low yield of baby corn experienced due to continuous monoculture resulting from persistent soil depletion in the developing world have caused the need for a sustainable practice to improve quality and yield of aforementioned.

Keywords- Babycorn, Legumes, Intercropping, Organic Manures, Production, Quality, Soil Fertility.

I. INTRODUCTION

Intercropping is defined as the growing of two or more crops, simultaneously in the same field with a distinct row arrangement. Common characteristics of different forms of intercropping are (i) that they have the effect of intensifying crop production and (ii) exploiting the environment more efficiently or under limiting or potentially limiting growth resources (**Moradi *et al.*, 2014 and Papendick *et al.*, 1976**). The crops selected for intercropping are normally of different species with varying duration of lifecycle, canopy structures, rooting habits, water, nutrients and solar radiation requirement (**Rao, 1986**). Intercrops utilize the available resources more efficiently in order to realize maximum production per unit area. Intercropping is some sort of assurance under difficult weather conditions. Intercropping may not be practicable in all the principal crops mainly due to problems of crop competition for sunlight, nutrient and incidence of disease and pest etc. Benefit from intercropping can be expected only when the active growth period of base and intercrop do not coincide. Crops of varying maturity duration have to be chosen so that a quick maturing crop completes its life cycle before the grand growth period of the other crop starts (**Saxena, 1972**). Intercropping system involving maize either as main or subsidiary crop has been in practice since long time, but very little work has been done so far to evaluate the response of babycorn to different forms of organic manures and intercropping with Mungbean and clusterbean under certified organic production. Intercropping with legumes may maintain the system in a positive nitrogen balance and if there is good growth of legume, the N contribution can be significant.

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Application of N to a cereal-legume intercrop may enhance the cereal yield but it proves less conducive to growth and production of legumes (**Searle *et al.*, 1981**).

II. EFFECT OF INTERCROPPING ON BABYCORN

2.1. Effect of intercropping on growth and growth attributes of babycorn

Bavec *et al.* (2005) conducted an experiment to study the effect of maize (Zea mays L.) sown as a sole crop and maize/climbing bean (*Phaseolus vulgaris* L. cv. Cipro) mixtures on maize plant height, leaf area index and bean leaf area index on an organic farm following accepted rules of certification. The maize/climbing bean mixture increased maize plant height 139.00 cm as well as maize and bean leaf area index 5.00 in comparison with maize sown as sole crop 135.00 cm and *3.70* respectively. Results of the experiment showed that maize in mix cropping with bean increased maize plant height and leaf area index by 2.96 and 35.13 per cent over sole cropping of maize. The overall conclusion was that maize/bean mixture has promise for producing valuable yield of maize and bean, but mixtures needs further investigation. **Ennin *et al*. (2002)** conducted field studies during 1994 and 1995 at Mead, Nebraska, to investigate management practices that improve solar radiation capture and use, and to explore the nitrogen economy of legume/ non legume intercropping systems. The results of the investigation showed that dry matter production of the intercrops (17.92 and 5.42 Mg ha^{-1}) was more than sole crops (14.56 and 7.03 Mg ha^{-1}), during the year 1994 and 1995 and up to 38% more by close association of soybean and maize. **Sahu and Ambawatia (2003)** reported that, maize intercropped with soybean and blackgram in alternate rows registered significant and maximum plant height (170.45 and 171.16 cm), number of leaves plant^{-1} (16.01 and 16.47) dry matter production (139.80 and 139.10 g), leaf area index (3.50 and *3.74*) over to those of other intercropping systems and sole cropping of maize. Result of the experiment also showed that maize + blackgram in 1:1 row ratio increased leaf area index of maize by 7.16 per cent over sole maize. **Rana *et al.* (2006)** reported that maize paired row (40/80 cm) with 1 row of Mungbean recorded significantly higher plant height (138.00 cm) as compared to sole maize (121.00 cm). **Reddy *et al.* (2009)** reveled that, babycorn + cowpea (M_2S_2) recorded the highest growth components viz., plant height (150.10 cm), leaf area index (6.73) and dry matter production (14.21 t ha^{-1}) over sole babycorn plant height (122.87 cm), leaf area index (5.22) and dry matter production (8.08 t ha^{-1}), respectively. Result of the experiment also showed that babycorn + cowpea intercropping increased plant height, leaf area index and dry matter production of babycorn by 22.16, 28.92 and 75.86 per cent as compared to sole babyocrn. **Iqbal *et al.* (2012)** reported that maze intercropped with cowpea and clusterbean in 30 cm spaced lines in alternate rows registered maximum leaf area index (1.88 and 2.49) and (1.66 and 2.17) and dry matter yield of (2.03 and 2.42 t ha^{-1}*)* and (1.22 and 1.68 t ha^{-1}) during the first and second year of the investigation as compared to rest of the treatments**. Eskandari (2012)** reported that maize in intercropping with Mungbean and cowpea produced the significantly higher dry weight (15.20 and *14*.52 t ha^{-1}) as compared to sole cropping of maize (10.38 t ha^{-1}) respectively, and intercropping of maize with Mungbean and cowpea increased dry weight of maize by 46.43 and 39.88 per cent over sole maize. **Yadav and Dawson (2015)** reported that maximum plant height (71.63 cm), dry weight (32.67 g plant^{-1}), crop growth rate (14.42 g m^2 day^{-1}) and leaf area index (1.29) were registered with babycorn + cowpea (2:1). However, babycorn + Mungbean (1:1) were found statistically at par with babycorn + cowpea. Result of the experiment showed that babycorn intercropped with legumes component crop registered maximum growth and growth components as compared to sole cropping of babycorn and **Yadav *et al.* (2016)** noticed that intercropped maize with Mungbean gave significantly maximum plant height (208.80 cm) and dry matter production (138.13 g plot^{-1}), over sole crop of maize (203.61 cm) and (134.70 g plot^{-1}), respectively. Maize intercropped with Mungbean increased plant height and dry matter production of maize by 2.54 and 2.54 per cent as compared to mono cropping.

2.2. Effect of intercropping on yield and yield attributes of babycorn

Rana *et al.* (2001) found that intercropping maize with soybean, cowpea, frenchbean and urdbean resulted in 3.32, 22.04, 6.85 and 5.91 per cent increase in maize yield over sole cropping. **Sahu and Ambawatia (2003)** reported that maize + blackgram (1:1, additive series) registered higher number of cobs per plant (1.09 plant^{-1}), number of rows per cob (13.31 cob^{-1}) and number of grains per cob (256.30 cob^{-1}) as compared to sole maize number of cobs per plant (1.07 plant^{-1}), number of rows per cob (13.13 cob^{-1}) and number of grains per cob (256.10 cob^{-1}), respectively. **Sangakara *et al.* (2003)** noticed that intercropping of legumes increased yield attributes and yield of corn over the seasons. More importantly, seed yield and harvest index of corn intercropped with beans were significantly higher (254.00, 257.00 and *292.00 g m^{-1}) and (0.31, 0.33 and 0.35%) as compared to sole corn (211.00, 242.00 and 221.00 g m^{-1}) and* (0.27, 0.29 and 0.28%) during the first, second and third growing season respectively. Results of the experiment also showed that corn intercropped with bean significantly increased the seed yield of corn by *20.37, 6.19 and 32.12 per cent over sole cropping of corn, respectively.* ***Woomer et al. (2004)*** *conducted* an experiment of growing legumes in the resultantly wider inter-row, holding constant population of maize (44,444.00 plants ha^{-1}) and legume (88,888.00 plants ha^{-1}). This adjustment allows for intercropping

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legumes other than bean, particularly Mungbean and groundnut, both of which have higher light requirements and greater capacity for symbiotic nitrogen fixation than beans. Furthermore, Maize yield under intercropping with bean, Mungbean and groundnut was 25% higher (370.00 kg ha^{-1}) as compared to sole cropping. **Prasad and Brook (2005)** found that corn intercropped with soybean gave significantly higher grain yield (526.00 and 450.00 g m^{-2}) during both the season as compared to sole cropping of corn (513.00 and 433.00 g m^{-2}) respectively. Intercropping of corn with soybean significantly increased the grain yield of corn by 2.53 and 3.92 per cent, respectively in comparison to corn sole crop. **Iqbal *et al.* (2006)** reported that maximum mixed forage yield 55.75 and 65.10 t ha^{-1} during the first and second year of experimentation was obtained from maize + cowpea association when cowpea was intercropped in alternate lines with maize over rest of the treatments. Cowpea appeared to be more compatible with forage maize as it yielded significantly higher than clusterbean and ricebean, irrespective to sowing technique. The results further revealed that sowing of maize under intercropped legumes in alternate rows facilitated better circulation of air and light penetration leading to provide conductive conditions for crop growth and development than conventional system. **Thavaprakaash and Velayudham (2007)** found that intercropped babycorn with Mungbean produced higher cob yield (7349.00, *5402*.00 and 6374.00 kg ha^{-1}) and babycorn equivalent yield (9712.00, 8827.00 and 9269 kg ha^{-1}) over sole babycorn cob yield (7124.00, 5384.00 and *6250 kg ha^{-1}) and babycorn equivalent yield (8049.00, 7306.00 and 7677.00 kg ha^{-1}) during both the years* and pooled analysis respectively. Results of the experiment also demonstrated that babycorn in intercropping with Mungbean increased cob yield by 1.96 per cent over sole babycorn. **Banik and Sharma (2009)** reported that intercropping babycorn and legumes, particularly soybean, Mungbean, blackgram and groundnut, can increase total productivity per unit area. Intercropping babycorn with soybean, Mungbean, blackgram and groundnut significantly increased babycorn equivalent yield by 3.24, 5.80, 10.11 and 28.31 per cent over sole babycorn respectively. **Reddy *et al.* (2009)** reported that babycorn + cowpea and babycorn + dolichosbean intercropping increased cob yield of babycorn by 73.54 and 47.29 per cent as compared to sole babyocrn. **Nataraj *et al.* (2011)** reported that clusterbean, frenchbean and fieldbean intercropped with babycorn in 1:1 and 2:2 row proportions produced significantly higher babycorn equivalent yield of (11.30 and 11.47 t ha^{-1}) (16.67 and 16.97 t ha^{-1}) and (13.90 and 14.07 t ha^{-1}), respectively over sole cropping. Intercropping clusterbean, frenchbean and field bean with babycorn increased babycorn equivalent yield with 33.25, 96.95 and 63.70 per cent as compared to sole babycorn. **Dwivedi *et al.* (2012)** noticed that maize grain yield was significantly higher (3080.00 and 2235.00 kg ha^{-1}) under intercropping with blackgram in 1:1 row ratio during both the years of experiment over sole cropping of maize (2935 and *2114 kg ha^{-1}). Maize under intercropping with balckgram showed an increase of 4.94 and 5.72 per cent,* grain yield respectively over sole cropping. **Iqbal *et al.* (2012)** reported that maize intercropped with cowpea and clusterbean in 30 cm spaced lines in (1:1, additive series) registered maximum green fodder yield 13.31 and 9.47 t ha^{-1} as compared to rest of the treatments. **Shahbazi and Sarajuoghi (2012)** reported that 50% corn + 50% Mungbean seeding ratio recorded the maximum grain yield of maize (8.02 t ha^{-1}) as compared to 100% corn in sole cropping (7.46 t ha^{-1}). Intercropping corn with Mungbean significantly increased corn yield by 7.50 per cent over sole cropping. **Kumar and Venkateswarlu (2013)** found that babycorn + clusterbean and babycorn + cowpea intercropping produced significantly higher babycorn ear equivalent yield (10473.00 and 11044.00 kg ha^{-1}) as compared to sole cropping of babycorn (10437.00 kg ha^{-1}) during the period of investigation. **Latati *et al.* (2013)** reported that intercropping maize with legumes increased maize yield by more than 12.50 per cent over sole maize**. Matusso *et al.* (2013)** reported that grain yield, stover yield and harvest index of maize was significantly influenced by different treatments of cropping system during both the growing season. The results of the experiment showed that maize intercropped with soybean recorded significant and maximum grain yield (5.49 and 5.16 t ha^{-1}), stover yield (12.64 and 12.33 t ha^{-1}) and harvest index (31.80 and 42.22%) over sole crop of maize grain yield (4.95 and *4.58 t ha^{-1}), stover yield (11.73 and 11.36 t ha^{-1}) and harvest index (29.95 and 36.02%) during the year 2012* and 2013 respectively. Maize under intercropping with soybean increased grain yield of maize by 10.90 and 12.66 per cent respectively, as compared to sole cropping**. Sarkar et al. (2013)** reported that maize + gardenpea recorded the highest maize equivalent yield (14.96 t ha^{-1}), as compared to sole crop of maize (7.68 t ha^{-1}). Maize in intercropping with gardenpea increased maize equivalent yield by 94.79 per cent over sole cropping**. Sharma and Banik (2013)** found that babycorn equivalent yield was higher (5.58, *6.06 and 5.38 Mg ha^{-1}) and (5.99, 6.42 and 5.92 Mg ha^{-1}) under intercropping with chickpea, pea and* groundnut as compared to sole babycorn (4.88 and 4.91 Mg ha^{-1}) during both the years of experiment**. Jat *et al.* (2014)** reported that intercropping maize and Mungbean markedly influenced number of cobs plant^{-1}, *length of cobs, grains cob^{-1}, 1000 grains weight, grain yield t ha^{-1} and stover yield t ha^{-1} of maize. Maize* + one row of Mungbean (3736.00 kg and 3989.00 kg ha^{-1}) and maize + two rows of Mungbean (3909.00 kg and 4118.00 kg ha^{-1}) increased grain yield significantly over sole maize (3516.00 and 3756.00 kg ha^{-1}) during both the years of investigation. Maize + two rows of Mungbean (6576.00 kg and 6840.00 kg ha^{-1}) significantly increased stover yield over sole maize (5992.00 kg and 6161.00 kg ha^{-1})

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and remained at par with maize + one row of Mungbean (6515.00 kg and 6736.00 kg ha^{-1}) during both the years. **Rathika *et al.* (2014)** reported that significantly higher babycorn equivalent yield (7976.00, 7177.00 and 7577.00 kg ha^{-1}*) was obtained with babycorn + cowpea as compared to sole cropping of babycorn (7638.00, 6863.00 and 7251.00 kg ha*$^{-1}$*) during both the years and pooled analysis. However, babycorn + fenuegreek registered 6.76 per cent more cob yield of babycorn over sole cropping***. Dhakal (2014)*** *reported that, the maize grain* yield was significantly higher in case of maize intercropped with cowpea (3.97 t ha^{-1}) as compared to that of maize intercropped with millet (2.98 t ha^{-1}). Yield of grains in case of maize intercropped with Mungbean (3.83 t ha^{-1}) and balckgram (3.96 t ha^{-1}) were at par with that of the grain yield from the maize crop intercropped with cowpea.

Shri *et al.* (2014) reported that, intercropping of maize with soybean, ricebean and cowpea with 1:1 and 1:2 ratio gave higher maize equivalent yield 4.54, 2.46 and 2.67 t ha^{-1} than sole crop 1.85 t ha^{-1}. **Ali *et al.* (2015)** reported that legumes as preceding crop had significantly affected number of grains ear^{-1} (412.00), grain weight (268.33 g) and grain yield of maize (5104.00 kg ha^{-1}). While, fallow as preceding practice had significantly lowest number of grains ear^{-1} (301.00), grain weight (205.00 g) and grain yield (3185.00 kg ha^{-1}) as compared with legumes as preceding crops. **Nthabiseng *et al.* (2015)** noticed that, intercropping of maize with double rows of dry bean resulted in higher maize yield (1474.40 and 1501.10 kg ha^{-1}) during both the years and pooled analysis. **Yadav and Dawson (2015)** reported that babycorn + cowpea (2:1, row ratio) registered more number of cobs plant (2.87), cob length (8.13 cm), cob weight 98.73 g) and cob yield (18.55 q ha^{-1}), which was higher than sole cropping of babycorn. However, babycorn + Mungbean (1:1, additive series), was found statistically at par with babycorn + cowpea (2:1, row ratio).

Adhikary *et al.* (2015) reported that significantly higher babycorn equivalent yield was exhibited by babycorn + cowpea (150.80 q ha^{-1}) as compared to sole crop. **Saleem *et al.* (2016)** reported that, maiximum grain yield (3153.00 kg ha^{-1}) of maize recorded in maize + Mungbean intercropping over sole crop (2761.00 kg ha^{-1}). The results of the experiment indicated that maize intercropped with Mungbean increased maize yield by 14.19 per cent as compare to sole cropping. However, maize + Mungbean intercropping recorded the highest maize equivalent yield of 1819.00 kg ha^{-1} followed by sole Mungbean (1303.00 kg ha^{-1}). Total system productivity of maize + Mungbean-wheat system was the highest (3197 kg ha^{-1}) in terms of maize equivalent yield followed by Mungbean-wheat system (2514 kg ha^{-1}) and

Yadav *et al.* (2016) observed that maize + Mungbean intercropping recorded significantly higher value for grain yield and maize equivalent yield over sole maize. Maize + Mungbean registered higher grain yield (3.97 t ha^{-1}) and maize equivalent yield (6.21 t ha^{-1}) as compared to sole maize grain yield (3.82 t ha^{-1}) and equivalent yield (3.82 t ha^{-1}).

2.3. Effect of intercropping on competition functions of babycorn

Rana *et al.* (2001) reported that intercropping of maize with soybean, cowpea, frenchbean and urdbean recorded significantly higher land equivalent ratio 1.49, 1.46, 1.34 and 1.41 respectively as compared to sole cropping. **Ullah *et al.* (2007)** reported that maximum land equivalent ratio (1.62 and 1.07) was recorded in 90 cm spaced double row strips of maize intercropped with soybean. **Aynehband and Behrooz (2011)** reported that different intercropping systems had significant difference for land equivalent ratio (LER). Among the intercropping treatments higher LER (1.30) was registered for maize + Mungbean intercropping as compared to maize + amaranth (1.02). **Shri *et al.* (2014)** reported that intercropping of maize with soybean 1:2 ratio gave the higher LER (1.57) than sole cropping. Results of the experiment also showed that maize intercropped with soybean in 1:2 ratio increased LER by 57 per cent than sole cropping.

Koohi and Nasrollahzadeh (2014) reported that, the highest amount of LER (1.36) was observed in treatment sorghum + Mungbean (1:1, additive series) than monocropping, which indicated the superiority of intercropping over sole cropping. **Lulie and Bogale (2014)** reported that significantly higher land equivalent ratio (1.63 and 1.43) was registered in treatment (100% haricot bean: 80% Stevia) during the year 2011-12 and pooled analysis over rest of the treatments. However, during the year 2012-13 the maximum LER (1.39) was recorded in treatment (100% haricot bean: 60% stevia).

Adhikary *et al.* (2015) reported that babycorn + cowpea intercropping registered maximum land equivalent ratio (1.60) as compared to sole cropping. Result of the experiment indicated that intercropping babycorn with cowpea increased LER by 60 per cent over sole cropping and **Hekmat and Abraham (2016)** reported that, babycorn intercropped with mungbean and clusterbean enhances the yield (1912 and 1872 kg ha^{-1}) of babycorn as compared to sole cropping (1799 kg ha^{-1}). However, there was a marginal reduction (7.13 and *4.26%) in yield of mungbean and clusterbean under intercropping with babycorn, which was compensated* by additional yield of babycorn (112.5 and 72.25 kg ha^{-1}), intercropped with legume component crops (clusterbaen and mungbean).

2.4. Effect of intercropping on quality, nutrient status of soil and nutrient uptake of babycorn:

Li *et al.* (2001) reported that nitrogen, phosphorus and potassium accumulation rate in intercropped maize was higher (0.68, 12.40 and 1.16 g N per m^2 day^{-1}) at late growth stages as compared to sole maize (0.36, 6.40 and 0.87 g N per m^2 day^{-1}), respectively. While, N, P and K accumulation rate in

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sole maize were higher (0.28, 4.10 and 0.37 g N per m^2 day^{-1}) during the early growth stages of maize over intercropped maize (0.19, 2.70 and 0.24 g N per m^2 day^{-1}) respectively. **Rana *et al.* (2001)** found that soil available N content at harvest in intercropping system was higher by 30 kg N ha^{-1} as compared to sole stand of maize. Intercropping maize with soybean, cowpea, frenchbean and urdbean significantly increased soil residual nitrogen by 6.84, 7.05, 6.15 and 6.40 per cent over sole crop of maize. **Ram and Singh (2003)** observed that intercropping of sorghum with cowpea recorded significantly higher crude protein (13.43%) and nitrogen uptake (187.00 kg ha^{-1}) by sorghum over sole sorghum. **Sangakara *et al.* (2003)** reported that nitrogen concentration in root, shoot and cob of maize were higher under intercropping maize with bean (1.24, 0.30 and 1.01 per cent) and (1.24, 0.31 and 1.04 per cent) over maize monoculture (1.21, 0.28 and 0.91%) and (1.19, *0.28 and 0.92%) respectively.* ***Hossain*** **et al.** ***(2004)*** *noticed that in intercropping cereal with* legumes, long-term soil fertility is protected by maintaining soil organic matter levels to certain extent providing crop nutrient directly through soil biological activity by soil micro-organisms, nitrogen through the biological nitrogen fixation. **Sharma (2008)** reported that intercropping of maize with cowpea, ricebean and clusterbean was clearly evident in the total crude protein of the system. Intercropping of maize + cowpea in the ratio of 2:2 gave higher crude protein (13.37%) than sole stands of maize and cowpea.

Banik and Sharma (2009) reported that nitrogenase activity of legumes was higher under all the intercropped legumes with babycorn as compared to monocropped legumes. Nitrogen fixation was always higher under each intercropping system compared with their respective monocrops. There was 60.82%, *58.08%, 81.19% and 42.89% increase in nitrogenase activity in intercropping system as compared with* their respective monocrops in case of soybean, Mungbean, blackgram and groundnut, respectively. Dry weight of root nodules also followed the same trend as that of nitrogenase activity. **Dahmardeh *et al.* (2010)** reported that intercropping increased the amount of nitrogen (N), phosphorous (P) and potassium (K) contents as compared to sole crop of maize. High cowpea percentage in intercrop resulted in increased N, P and K content in soil. Results of the experiment also showed that 25% maize + 75% cowpea registered significant and maximum N (0.44%), P (35.05 ppm) and K (27.21 ppm) over 100% maize.

Rusinamhodzi *et al*. (2012) noticed that uptake of nitrogen by maize intercropped with Mungbean was significantly higher (284.00 kg ha^{-1}) than with cowpea (239.00 kg ha^{-1}) and soybean (247.00 kg ha^{-1}) and the nitrogen uptake was maximum in 1:1 row ratio (274.00 kg ha^{-1}) compared to 1:2 row ratio (251.00 kg ha^{-1}) respectively. **Latati *et al.* (2013)** reported that maximum nitrogen concentration in shoot, root and seeds of maize was recorded in intercropping maize + common bean (1:1) row ratio (29.60, 4.10 and 23.70 mg g^{-1}) as compared to sole maize (25.8, 3.8 and 18.4 mg g^{-1}) respectively. **Kumar and Venkateswarlu (2013)** found that babycorn + clusterbean and babycorn + cowpea intercropping produced significantly higher crude protein content (8.62 and 8.73%) and crude protein yield (940.00 and 1001.00 kg ha^{-1}) as compared to sole cropping of babycorn during the period of investigation. Results of the experiments indicated that, babycorn intercropped with clusterbean increased protein content by 5.12 per cent over sole babycorn. **Prasanthi and Venkateswarlu (2014)** reported that treatment combination involving maize + cowpea and maize + clusterbean produced the highest crude protein (7.81 and 7.44 mg g^{-1}*),* while the lowest values (6.38% and 2.21 mg g^{-1}) were recorded in sole maize. Results of the experiment also showed that intercropping babycorn with cowpea and clusterbean increased protein content by 20.91 and 14.61 per cent over sole babycorn. **Matusso *et al.* (2014)** reported that maize N uptake, soil available nitrogen and soil organic carbon was higher (1.66, 0.02 and 2.50%), in maize + soybean intercropping as compared to sole crop of maize (1.13, 0.01 and 2.48%), respectively during the course of study. **Yadav *et al.* (2016)** noticed that *maize* intercropped with Mungbean registered maximum protein content (8.38%) over sole maize (8.28%).

2.5. Effect of intercropping on economics of babycorn

Zaman and Malik (2000) revealed that maximum monetary benefits (benefit cost ratio 3.03) over sole cropping were obtained from maize intercropped with ricebean. **Upasani *et al.* (2000)** reported that intercropping of maize with blackgram registered maximum net return of 11091.00 ha^{-1}, benefit cost ratio *1.65, along with monetary advantage of 7843* ha^{-1}. ***Niringiye*** **et al.** *(2005) reported that total income from* the mixtures of maize + bean was 26.80% and 31.00% higher than income from sole bean and maize crops, respectively, during the first rains. However, income from the mixtures of maize + bean was 58.70% and *72.50% higher than income from sole bean and maize crops, respectively, during the second rains.* ***Tripathi et al.*** **(2009)** reported that maize in uniform row + Mungbean in 1:2 row ratio was the most productive and remunerative intercropping system with the highest maize equivalent yield, net returns and benefit cost ratio followed by maize in uniform row + urdbean in 1:2 row ratio. **Nataraj *et al.* (2011)** found that intercropping babycorn with frenchbean, clusterbean, cowpea and fieldbean registered maximum net returns (₹ 117320.00, ₹ 75410.00 ₹ 100870.00 and ₹ 9470.00 ha^{-1}, respectively) and B:C ratio (3.83, 2.78, *3.72 and 3.49) as compared to sole crop of babycorn net returns (₹ 59230.00* ha^{-1}*) and benefit cost ratio* (2.68) respectively. **Sarkar *et al.* (2013)** reported that the highest maize gross return (Tk. 224400 ha^{-1}), gross margin (Tk.166830 ha^{-1}) and benefit cost ratio (3.90) were obtained in maize

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Volume-2 Issue-2 || April 2023 || PP. 193-205
https://doi.org/10.55544/jrasb.2.2.28

+ gardenpea combination. While, the lowest maize gross return (Tk. 115200 ha^{-1}), gross margin (Tk. 64128 ha^{-1}) and benefit cost ratio (2.26) were obtained from sole crop of maize. Maize in intercropping with gardenpea increased benefit cost ratio by 72.56 per cent over sole cropping of maize. **Dhakal (2014)** noticed that there was significant influence of intercrops on gross return, net return and benefit cost ratio from the intercropping system. Intercropping of maize with cowpea, Mungbean and black gram recorded the maximum gross return (146.58, 120.27 and 117.96 thousand ha^{-1}), net return (₹ 98.08, 71.57 and 69.56 thousand ha^{-1}) and benefit cost ratio (2.02, 1.47 and 1.44) as compared to intercropping maize with millet gross return (₹ 95.33 thousand ha^{-1}), net return (₹ 53.18 thousand ha^{-1}) and benefit cost ratio (1.26) respectively. **Adhikary et al. (2015)** found that the highest benefit cost ratio (3.66) and monetary advantage index (MAI) was found for babycorn + pea (₹ 30753.40), intercropping system and concluded that it was the most profitable among all the intercropping treatments and sole crop. **Rani *et al.* (2015)** reported that, higher net returns (₹ 39022.00 ha^{-1}) was obtained, when cowpea was intercropped with babycorn than rest of the treatments. Babycorn intercropped with cowpea resulted in 30.34% more net return as compared to sole babycorn. **Saleem *et al.* (2015)** reported that Maize + Mungbean accrued maximum net benefit of (₹ *119589.92 ha^{-1}) over rest of the treatments and Yadav* et al. *(2016) reported that maize + Mungbean* registered maximum net return (₹ 31558.00 ha^{-1}) and B:C ratio (1.14) as compared to sole maize net return (₹ 9720 ha^{-1}) and benefit cost ratio (0.36), respectively.

III. EFFECT OF ORGANIC MANURE ON MAIZE/BABYCORN

3.1. Effect of organic manures on growth and growth attributes of babycorn:

Chandrashekar *et al.* (2000) reported that application of poultry manure along with RDF produced taller plants (187.50 cm) than application of only RDF. **Prasad *et al.* (2003)** reported that application of 5 t ha^{-1} vermicopost along with 14 and 10 t ha^{-1} Poultry manure and FYM resulted in significantly higher leaf area index and dry matter production of corn. **Karki *et al.* (2005)** reported that corn plant height and dry matter was found to be significantly higher through the application of 10 t ha^{-1} FYM than 5 t ha^{-1} FYM as well as control treatment**.** **Thavaprakaash *et al.* (2005)** observed that substitution of 50 per cent NPK through either poultry or goat manures along with Azospirillum and phosphobacteria had significant influence on all the growth and yield parameters of babycorn. Results of the experiment showed that substitution of 50% NPK through poultry manure registered taller plant (183.10 and 158.40 cm) higher leaf area index (3.47 and 2.75) and dry matter production (7543.00 and 5435.00 kg ha^{-1}) during the year 2002 and 2003 respectively. The result obtained in substitution of 50% NPK through goat manure was at par with the above. The treatment FYM recorded lower growth parameters than goat manure and poultry manure. **Ezeibekwe *et al.* (2009)** reported that poultry manure encouraged early flowering, fruiting and highest vegetative growth and fruit biomass than urea and control. The results also indicated that poultry manure significantly increase plant height, number of leaves, stem diameter, leaf area and dry weight of maize by 55.29, 24.46, 31.74, 19.90 and 62.50 per cent respectively as compared to urea and control. **Singh *et al.* (2009)** reported that growth contributing characters of sunflower (Helianthus annuus), viz., plant dry weight, crop growth rate, relative growth rate and diameter of capitulum differed significantly amongst various treatments. The maximum plant dry weight (17.53 g), crop growth rate (13.32 g g^{-1} day^{-1}), relative growth rate (0.078 g g^{-1} day^{-1}) and diameter of capitulum (9.48 cm) were recorded in T_3 due to application of 100 per cent N through poultry manure as compared to 100 per cent N through FYM plant dry weight (16.07 cm), crop growth rate (12.17 g g^{-1} day^{-1}), relative growth rate (0.076 g g^{-1} day^{-1}) and diameter of capitulum (9.28 cm), respectively. Poultry manure increased plant dry weight, CGR, RGR and diameter of capitulum by 9.08, 9.44, 0.021 and 2.15 per cent over FYM. **Aziz *et al.* (2010)** observed that organic manures help to improve soil physical, chemical and biological properties thus improve nutrient availability to crops. Results revealed that application of poultry manure recorded significantly higher plant height of maize (99.00 cm), shoot fresh weight (84.30 g pot^{-1}), root dry weight (9.95 g pot^{-1}) and plant dry weight (20.43 g pot^{-1}) respectively, as compared to FYM and control. However, maximum leaf area (5062.00 cm^2 plant^{-1}), shoot dry weight (11.44 g pot^{-1}) and plant fresh weight (133.00 g pot^{-1}) was registered in FYM amended plots which was significantly superior to rest of the treatments. **Uwah *et al.* (2011)** found that maximum plant height (124.00 cm) and number of leaves plant^{-1} (9.82) were obtained from plots amended with 10.00 t ha^{-1} PM as compared to rest of the treatment. **Wailare (2012)** reported that the combining ability of poultry manure with FYM resulted in positive increase in growth parameter of maize such as leaf area index and crop growth rate. **Gudugi *et al.* (2012)** reported that application of poultry manure at the rate of 15 t ha^{-1} produced higher plant height (120.40 and 117.50 cm) and number of leaves (942.60 and 930.30 in *12 m^2) respectively over rest of the treatments.* ***Memon*** **et al.** ***(2012)*** *noticed that application of* FYM at 10 t ha^{-1} recorded significant and maximum plant height (187.00 cm) over control or no use of FYM. **Amos *et al.* (2013)** reported that application of 15 t ha^{-1} chicken manure increased plant height by *81.00 %, leaf area by 60.00 % and crop growth rate by 67.00% as compared with the control.* ***Enujeke*** **(2013)** reported that maximum mean plant height of 209.30 cm, mean number of leaves of 13.10, mean leaf area of 682.60 cm^2 of maize was

ISSN: 2583-4053
Volume-2 Issue-2 || April 2023 || PP. 193-205

https://doi.org/10.55544/jrasb.2.2.28

registered in treatment received 30.00 t ha^{-1} of poultry manure at 8 weeks after sowing in 2008 and 2009 respectively. **Obi *et al.* (2013)** observed that addition of poultry manure (15 t ha^{-1}) significantly improved average corn plant height (189.70 cm), total leaf area (1678.10 cm^2) and crop growth rate (44.14 g m^2 day^{-1}). Results of the investigation revealed that application of 15 t ha^{-1} poultry manure increased plant height by 81.00 per cent, leaf area by 60.00 per cent and crop growth rate by 67.00 per cent over rest of the treatments. **Okoroafor *et al.* (2013)** reported that application of poultry manure recoded significantly higher plant height (226.68 cm), number of leaves (15.37) and stem girth (6.62 cm) as compared to rest of the treatments. Therefore, based on the findings, poultry dropping is recommended to farmers for optimum growth and yield of maize production. **Uwah *et al.* (2014)** observed that application of 15 t ha^{-1} goat manure (GM) and poultry manure (PM) maximized corn growth attributes, total dry matter (TDM) and also hastened days to 50% tasselling. On average, the application of 5, 10 and 15 t ha^{-1} PM, increased TDM by 8.50, 35.10 and 53.90%, whereas the corresponding values for GM were 15.60, 27.80 and 33.20% respectively compared with the unamended control plots. **Hariadia *et al.* (2016)** reported that renewable fertilizer such as cow and goat manure was important in increasing maize plant growth. A composition of 2/3 soil and 1/3 goat manure was optimal for the leaves growth followed by composition of *2/3 soil and 1/3 cow manure. Results of the experiment depicted that significant and maximum leaf area* (370461.00 cm^2) was registered in treatment T_4 (2/3S: 1/3 GM).

3.2. Effect of organic manures on yield and yield attributes of babycorn:

In maize over NPK fertilizer. **Chandrashekar *et al.* (2000)** reported that application of poultry manure along with RDF produced longer cobs (14.35 cm) with longer diameter of cobs (15.6 cm) and heavy weight of cobs (170.5 g cob^{-1}) than application of only RDF. **Pattinashetti *et al.* (2002)** noticed that, application of FYM resulted in significantly higher grains (3643.00 kg ha^{-1}) than rest of the treatments. **Channabasavanna *et al.* (2002)** reported that application of poultry manure at 1 t ha^{-1} recorded significantly higher seed yield (5046 kg ha^{-1}) of corn over control (4117 kg ha^{-1}). The data also revealed that application of poultry manure at 1 t ha^{-1} was at par with application of FYM at 10 t ha^{-1} (4749 kg ha^{-1}). **Nagaraj *et al.* (2004)** reported that among different forms of organic manures, application of poultry manure at 5 t ha^{-1} gave significantly higher grain yield (51.52 q ha^{-1}) in maize over rest of the treatments. The next best treatment was application of FYM at 10 t ha^{-1} (45.73 q ha^{-1}). **Boateng *et al*. (2006)** reported that poultry manure is a valuable fertilizer and can serve as a suitable alternative to chemical fertilizer in the forest zone of Ghana. Poultry manure treatments produced higher values for yield attributes. The 4 t PM ha^{-1} rate produced maize grain yield of 2.07 t ha^{-1} which was statistically not different from that of the chemical fertilizer rate (2.29 t ha^{-1}) and 6 t PM ha^{-1} (2.60 t ha^{-1}), while the 6 t PM ha^{-1} was not statistically different from the 8 t PM ha^{-1} rate. Split application of 4 t PM ha^{-1} (i.e. 2 × 2 t PM ha^{-1}) and 2 t PM ha^{-1} + *30-20-20 kg NPK ha^{-1} gave similar biomass and grain yields as the 4 t PM ha^{-1}. The study* recommends an application rate of 4 t PM ha^{-1} for maize on this type of soil in this agro-ecology. **Khan *et al.* (2008)** revealed that the use of organic manure (FYM, poultry manure, green leaf and spray of panchagavya) on sweet corn field resulted in significant increase of yield attributes (number of grains cob^{-1}, cob length and cob diameter). **Thavaprakaash and Velayudham (2007)** found that application of poultry manure and goat manure recorded significant and maximum cob yield (7707.00, 5598.00 and 6651.00 kg ha^{-1}) and (7668.00, *5608.00 and 6588.00 kg ha^{-1}) during both the years and pooled analysis as compared to FYM (7012.00, 5167.00 and 6090.00 kg ha^{-1}) respectively. **Thavaprakaash*** **et al.** ***(2008)*** *noticed that the treatments N_3* (50% NPK + Poultry manure) and N_4 (50% NPK + Goat manure) registered significantly higher babycorn (6652.50 and 6588.00 kg ha^{-1}) and fodder yields (26.35 and 26.10 t ha^{-1}) than N_1 100 NPK (5986.00 kg ha^{-1}*) and N_2 50% NPK + FYM (6090.00 kg ha^{-1}).* ***Kolawole*** **et al.** ***(2009)*** *observed that maximum grain yield* of 5.77 t ha^{-1} and 1000 grain weight was obtained from plants treated with 5.0 t ha^{-1} of poultry manure indicating the best poultry level for growth and yield of maize in the rainforest ultisol. **Thavaprakaash and Velayudham (2010)** observed that application of poultry manure or goat manure produced higher cob yield (8037.00 and 8004.00 kg ha^{-1}) and (7516.00 and 7521.00 kg ha^{-1}) when compared to FYM incorporated with inorganic and biofertilizers (7243.00 and 7126.00 kg ha^{-1}) and inorganic fertilizers alone (7335.00 and 7109.00 kg ha^{-1}) during kharif 2002 and summer 2003 seasons, respectively. **Haque *et al.* (2011)** found that yield attributes and yield of maize were the best with substitution of 25.00% of the recommended dose of fertilizers applied through poultry manure. The highest grain yield of corn (7.70 t ha^{-1}*) was recorded in treatment receiving 75.00% N from urea and 25.00% from poultry manure. The same* treatment produced 121.15% higher grain yield over control. **Uwah *et al.* (2011)** found that application of *10 t ha^{-1} PM rate increased total dry matter of maize (TDM) by 43.00 and 91.00 % and total grain yield by 101.00 and 34.00 % respectively, as compared with the control.* ***Akongwubel*** **et al.** ***(2012)*** reported that application of organic manure significantly improved maize biomass, yield components and grain yield. The use of 18.00 t ha^{-1} poultry manure gave the highest maize 1000 seed weight (273.50 and 270.70 g), as well as grain yields of (2.78 and 2.89 t ha^{-1}) during 2005 and 2006 cropping seasons, respectively. **Memon *et al.* (2012)** noticed that application of FYM at 10 t ha^{-1} recorded significant and maximum number of

ISSN: 2583-4053
Volume-2 Issue-2 || April 2023 || PP. 193-205
https://doi.org/10.55544/jrasb.2.2.28

grain cob^{-1} (241.00), 1000 grain weight (370.00g) and grain yield (5660.00 kg ha^{-1}) as compared to control or no use of FYM. **Javeed *et al.* (2013)** revealed that increasing order of poultry manure dose treatments produced the good and healthy seeds over the control treatment. Increased poultry manure dose as compared to other manures significantly improved the maize grain length. The longer maize grain was recorded in the plot where the poultry manure at 10 Mg ha^{-1} was applied (11.03 mm) followed by the 5 Mg ha^{-1} poultry manure treatment (10.63 mm). Significantly shorter maize grain was observed in the control treatment where no poultry manure was applied (10.37 mm) during 2010. **Obi *et al.* (2013)** observed that addition of poultry manure (15 t ha^{-1}) significantly increased maize kernel yield by 55.00 per cent compared to rest of the treatments. **Sangeetha *et al.* (2013)** found that the application of enriched poultry manure compost on equal N basis (2.30 $t{\cdot}ha^{-1}$) recorded higher yield attributes and grain yield of rice (4675.00 $kg{\cdot}ha^{-1}$ in 2007 and 4953.00 $kg{\cdot}ha^{-1}$ in 2008), which was however comparable with composted poultry manure. **Enujeke (2013)** reported that maize plant which received 30.00 t ha^{-1} of poultry manure recorded higher mean grain weight at 16 weeks after sowing of (2.14 t ha^{-1}) and mean number of grains cob^{-1} of (518.40). Based on the findings of the study, 30 t ha^{-1} of poultry manure was recommended to farmers as most appropriate rate of application to enhance growth and yield of maize in Asaba area of Delta State. **Khan *et al.* (2013)** reported that poultry manure and FYM significantly influenced yield attributes and yield of spring maize and among the manurial treatment poultry manure increased yield of maize by 92.05 per cent over FYM. **Amos *et al.* (2013)** found that yield parameters and the final yields increased significantly with increasing poultry manure levels. The performance of poultry manure was significantly better than other organic treatments and control at all application levels. Application of 15 t ha^{-1} chicken manure increased, fresh husked cob weight by 73.00 per cent, and maize kernel yield by 55.00 per cent compared with the control. **Uwah *et al.* (2014)** reported that application of 5, 10 and 15 t ha^{-1} poultry manure and goat manure rates, increased grain yield of corn by 11.20, 59.80 and 126.90% and 4.20, 20.00 and 45.80% respectively as compared to FYM. **Hellal *et al.* (2014)** reported that application of FYM combined with Effective Microorganisms (EM) recorded the highest 100 seed weight (37.97g), grain yield (6708.00 kg fed^{-1}), Stover yield (5180.00 kg fed^{-1})*, as compared to rest of the treatments.*

3.3. *Effect of organic manures on quality, nutrient status of soil and nutrient uptake of* babycorn.

Boateng *et al.* (2006) reported that Poultry manure application registered over 53% increases of N levels in the soil, from 0.09% to 0.14%. Exchangeable cations increased with manure application. **Thavaprakaash and Velayudham, (2007)** reported that all the integrated nutrient management practices showed higher NPK uptake than N_1 (100% NPK). Among the three INM practices, the treatments N_3 (50% NPK + Poultry manure) and N_4 (50% NPK + Goat manure) recoded significantly higher values of NPK uptake by babycorn (192.70, 25.00 and 379.50 kg ha^{-1}) and (193.40, 24.80 and 380.10 kg ha^{-1}) during both the years and pooled analysis than N_2 (184.80, 23.30 and 366.70 kg ha^{-1}) due to application of 50% NPK + FYM. **Thavaprakaash *et al.* (2008)** reported that 50% NPK + Poultry manure recorded significantly higher protein and carbohydrate content (3.37 and 3.47%) and (43.77 and 43.25%), respectively during both the years of experiment as compared to goat manure and FYM. Khan et al. (2008) observed that application of *12 t ha^{-1} poultry manure significantly increases the protein content of corn (8.15%) followed by 30 t ha^{-1}* FYM (7.99%), and was significantly superior to rest of the treatments. **Channabasanagowda *et al.* (2008)** found that application of 3.8 t ha^{-1} FYM along with 2.45 t ha^{-1} poultry manure resulted in significant increase in wheat crop crude protein content (13.41%) in comparison to rest of the treatments used in trial. **Ayoola and Makinde (2009)** reported that Poultry manure required lesser N-fortification to give comparable seed yields as cow dung. Although both organic manures increased the soil N and P, poultry manure gave higher values while the soil K, Ca and Mg contents were increased with the cow dung than poultry manure. Result of the experiment showed that urea enriched poultry manure increased soil macro nutrients as N 41.7%, P *1.8% and K 20.7%, respectively.* ***Haque* et al. *(2011) found that combined application of organic manures*** along with chemical fertilizers showed positive effects on N, P, K and S contents and their uptake by grain and stover of maize. The highest uptake of N (173.30 kg ha^{-1}), P (33.08 kg ha^{-1}), K (164.18 kg ha^{-1}) and S (20.36 kg ha^{-1}) by maize were observed in treatment receiving 75% N applied through urea in combination with 25% N applied through poultry manure. The effect of poultry maure was most pronounced than that of the cow dung and household wastes. **Hossain *et al.* (2012)** reported that application of poultry manure alone at 30.00 t ha^{-1} recorded maximum phosphorus (0.30, 0.30 and 0.57%), potassium (2.17, 2.35 and *0.97%), and magnesium (0.24, 0.22 and 0.06%) content in shoot, root and grain of corn as compared to* rest of the treatments. **Meena *et al.* (2013)** reported that addition of FYM at 5 t ha^{-1} along with chemical fertilizer increased protein yield of 327.08, 417.43 and 455.06 kg ha^{-1} respectively, over control or no use of FYM. Results of the experiment also showed that application of FYM registered maximum N uptake (75.00 and 79.00 kg ha^{-1}), Phosphorus (20.00 and 27.00 kg ha^{-1}) and (77.00 and 245.00 kg ha^{-1}) in grain and straw of maize as compared to control treatments or no use of FYM. **Khan *et al.* (2013)** noticed that application of poultry manure increased protein content of maize by 4.09 per cent over FYM. While, FYM increased maize oil content by 9.59

ISSN: 2583-4053
Volume-2 Issue-2 || April 2023 || PP. 193-205
https://doi.org/10.55544/jrasb.2.2.28

per cent as compared to poultry manure. **Hellal *et al.* (2014)** reported that application of FYM combined with Effective Microorganisms (EM) registered maximum N, P and K content in maize grain (62.39, 51.65 and 11.14 kg fed^{-1}) and stover (24.50, 10.36 and 16.42 kg fed^{-1}). Which was significantly superior over rest of the treatments and the lowest value was obtained in control. Similar trend was also observed with fababean. **Uwah *et al.* (2014)** reported that the application of poultry manure and goat manures significantly raised the soil pH (6.10 and 6.00), organic matter content (51.25 and *59.45%), total N (2.80 and 2.40 g kg^{-1}), available P (45.25 and 44.15 mg kg^{-1}) and exchangeable K (0.26* and 0.29 cmol kg $^{-1}$), Ca (4.63 and 4.94 cmol kg^{-1}) and Mg (2.33 and 2.55 cmol kg^{-1}) to enrich the nutrient status of the soil. **Saleem *et al.* (2016)** noticed that sole cropping and intercropping under poultry manure displayed increase in values of soil pH from 1-2%. This might be due to higher calcium content of poultry manure. Residual soil nitrogen was depleted in plots under sole maize in control plots (-9.35) and there was increase in residual NO_3 nitrogen when legumes were grown alone or in association with maize.

3.4. *Effect of organic manures on economics of babycorn:*

Lone *et al.* (2013) reported that cultivation of babycorn variety VL-78 under temperate conditions with an application of 6 t ha^{-1} FYM along with chemical fertilizer revealed a maximum B:C ratio of 1.00:1.59 with $ 703 ha^{-1} as cost of cultivation, the estimated gross returns from the cultivation practice were to the tune of $ 1825 giving a benefit of $ 1123 ha^{-1}. **Khan *et al.* (2013)** found that 25% N through PM along with chemical fertilizer and rhizobacteria resulted in highest gross income (100125.00 ha^{-1}), net income (₹55247.40 ha^{-1}) and benefit cost ratio (2.23) as compared to 25% N through FYM along with chemical fertilizer. Results of the experiment showed that application of poultry manure increase gross return, net return and benefit cost ratio by 48.51, 163.74 and 53.79 per cent over FYM, respectively and **Saleem *et al.* (2016)** reported that maize + Mungbean - wheat cropping system with complementary use of 50% poultry manure, 50% mineral and biofertilizers stands out superior combination to achieve higher productivity.

IV. CONCLUSION

From the results of the study, conducted during the year 2014 and 2015 at SHUATS, Uttar Pradesh, India, it may be concluded that, inclusion of legumes under certified organic production system, particularly clusterbean and Mungbean, enhances the yield (1912 and 1872 kg ha^{-1}) of babycorn as compared to sole cropping (1799 kg ha^{-1}). However, there was a marginal reduction (7.13 and 4.26%) in yield of Mungbean and clusterbean under intercropping with babycorn, which was compensated by additional yield of babycorn (112.5 and 72.25 kg ha^{-1}), intercropped with legume component crops (clusterbaen and Mungbean). Since interspecific competition coupled with complementarity increases crop stand ability to exploit natural resources efficiently, intercropping system were found to be beneficial in terms of atmospheric N_2 fixation. In addition, intercropping of babycorn + Mungbean and babycorn + clusterbean in 1:1 additive series was found to be the most effective treatments under experimental conditions, for obtaining higher gross return (107040.65 and 117009.29 ha^{-1}), net return (53325.34 and 61393.98 ha^{-1}) and benefit cost ratio (2.01 and 2.12) over sole cropping. The complementary use of different sources of organic manure increased the growth, yield, quality, soil available nutrient status, nutrient uptake and economic of babycorn, Mungbean and clusterbean, respectively. With regards to manurial treatments poultry manure and got manure alone or either in combination with FYM registered significant and maximum growth, yield, quality and nutrient uptake as compared FYM. There was increase in yield of babycorn by 13.55% due to application of poultry manure at the rate of 4.62 t ha^{-1} as compared to FYM alone. However, application of goat manure and poultry manure increased net return and benefit cost ratio by 76.17 and *89.78 per cent and 32.82 and 32.06 per cent respectively over FYM. The findings reported in this study* lessen the magnitude of prevalent issues to certain extent like implications of decreasing cultivated land can be addressed by enhancing per unit production, declining soil fertility can be restored by inclusion of legumes in cropping systems, reduced cropping intensity particularly in rainfed areas can be minimized by practicing intercropping.

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