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Yield and yield attributes of certified organic babycorn (*Zea mays* L.) as influenced by different sources of manures and intercropping with pulses

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Abstract

Field experiments were conducted at Eastern Block of Crop Research Farm, Department of Agronomy, Allahabad School of Agriculture SHIATS, UP during *Zaid* 2014 (March to July) and *Zaid* 2015 (March to July) seasons to study the impact of short duration legume intercrops and Organic Nutrient Management practices on yield and yield component of baby corn. Short duration intercrops (greengram and clusterbean) along with control (no intercrop) were taken in main plot. Different sources of organic manure and their combination [goat manure at the rate of 4615.3 kg ha^{-1} (M_1), Poultry manure at the rate of 4800 kg ha^{-1} (M_2), FYM at the rate of 24000 kg ha^{-1} (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 experiment was replicated thrice. Yield and yield attributes *viz.*, cob girth, number of cob per plant, cob length with husk and without husk, cob weight with husk and without husk, cob yield and green fodder yield were significantly higher at in intercropping babycorn with component crops. Whereas, substitution of poultry manure alone or either in combination with goat manure and FYM had significant influence on all yield parameters and also yield of cob and fodder of baby corn. Yield levels of intercrops were higher as compare to sole babycorn.

Keywords: Baby corn, intercrops, organic nutrient management practices, cob yield

1. Introduction

The greatest challenge in India during 21st century is to produce not only enough food, fiber and other raw materials from the limited available land for continuously increasing huge human and animal population but also to protect the environment. The availability of land for agriculture is shrinking everyday as it is increasingly utilized for non – agriculture purposes. Under this situation, one of the best strategies to increase agricultural output is the development of high intensity cropping systems including intercropping systems involving stress resistant, soil fertility building, protein containing and gum producing grain legumes.

Maize has been considered a third important crop in Afghanistan next to wheat and rice. The country has been dependent on imported food grain to meet its domestic needs. Maize has vast scope to contribute Afghan food security. In Afghanistan maize occupied about 0.4 to 0.5 m ha during sixties and seventies when the country was self-sufficient in cereal production, whereas presently we are cultivating maize over 180,000 ha only contributing only 7.0% of cereal production signifying huge gap productivity. Maize in Afghanistan is produced by farmers of east and south zone of Afghanistan where irrigation is not sufficient for rice cultivation with the productivity of 2.1 t ha^{-1}.

Maize (*Zea mays* L.) is considered as one of the most important world cereals crop which served as staple food more than any of the other cereal crops. Maize was originated from America which was domesticated almost 7000 years ago and it supply nutrients to both human and animal as well as used as a source of raw material for the production of oil, protein, starch, food sweeteners and alcoholic beverages as well as fuel source. It is growing across a wide range of climatic conditions of the world due to its wider adaptability (Amanullah *et al*., 2007 and Chennankrishnan, *et al*., 2012) [1, 3]. It's popularly called "Queen of cereals" due to high genetic yield potentials and wider adaptability than any other cereals counterpart (Kannan, *et al*., 2013) [8]. Babycorn is dehusked maize ear, harvested young especially when the silk have either not emerged or just emerged and no fertilization has taken place or we can say the shank with unpollinated silk is babycorn. Babycorn ears in light yellow colour with regular row arrangement, 10 to 12 cm long and a diameter of 1.0 to 1.5 cm arrangement are preferred in the market (Golada *et al*., 2013) [4]. Babycorn is an important crop of Thailand, Taiwan and India; recently, babycorn has gained popularity as valuable in Delhi, Uttar Pradesh, Haryana, Maharashtra, Karnataka, Andhra Pradesh, Rajasthan and Meghalaya States of India. In India its grown on 9.43 m ha area with the production and productivity of 24.35 m t and 2583 kg ha^{-1}, respectively (Government of India, 2014). The cultivation of babycorn shows a successful result in countries like Thailand and Taiwan despite being a recent development but in India more attention is given by both scientist and farmers in order to find out more about its potentials for obtaining more foreign earning as well as maximum returns to the growers. Firstly Thailand started the cultivation of this crop for export in 1970s. Latter on other countries like Taiwan, Sri Lanka, Indonesia, India, Zambabwe, South Africa, Guatemala and Nicaragua etc started its cultivation. Today Thailand and China are the world leaders in babycorn production (Kannan, *et al*., 2013) [8].

Babycorn is gaining importance as vegetable and salad. Being short duration in nature it facilitates to take up second crop simultaneously as intercrop and helps the farmer to get more returns from a unit area in a unit time by increasing cropping intensity. Self-sustaining, low-input and energy efficient agricultural systems in the context of sustainable agriculture have always been in the centre of attention of many farmers, researchers and policy maker's worldwide (Lithourgidis *et al.,* 2011) [9]. One of the key strategies in sustainable agriculture is restoration of diversity in an agricultural ecosystem. Intercropping not only enhance the productivity but also provides security against the potential risk of monoculture. It provides the diversified needs of the small farmers whose general practice is subsistence farming. Normally babycorn is planted in wider rows and a considerable portion of the incident solar radiation falls on bare ground in the early stages of growth. One of the cropping strategies adopted by farmers is intercropping cereals with legumes as a means of securing food in times of crop failure. Legumes hold great potential as sources of high protein food and feed, and have received considerable attention from research organizations. Above all, because of their ability to fix significant amounts of atmospheric nitrogen, legumes become more important and offer an alternative for increasing nitrogen input in various cropping systems and soil management practices. Intercropping is practiced in many parts of the world (Francis, 1986) [6].

Organic sources has become an established technique for sustaining yield level, enhancing nutrient use efficiency and restoring soil health besides environmental benefits. The ultimate in agricultural production is to develop a stable sustainable and continuous productive system. Inorganic fertilizer application has been the major means of ensuring the continuous productive capacity of the soil. However the "hang over" effect of inorganic fertilizer application on soil environment is making its use less and less desirable. Even if the use of chemical fertilizer makes farming easily sustainable with increased food availability, its increasing cost makes it unattractive to the farmers; chemical fertilizer may lead to hazardous effect on environmental health, besides increasing production cost due to its being expensive. Hence the use of organic sources in crop production is necessarily renewed attention worldwide. The usage of organic sources help to maintain soil organic matter content, influence soil micro flora, plant growth and also provide growth regulatory substance and will maintain the environmental sustainability for next generations used without affecting the environmental health**.** (Ranjan *et al*., 2013, Mahajan *et al*., 2007 and Dadarwal *et al*., 2009) [11, 15, 5]. The continuous use of chemical fertilizers will lead to environmental pollution and deterioration of soil health. Furthermore, availability of fertilizer at economic prices is another problem for the farmers. The need to increase food production is one of the major world problems, where physical areas under cultivation cannot be increased. The only way to increase the productivity is intercropping.

2. Materials and Methods

Field experiments were conducted during late *zaid* 2014 and late *zaid* 2015 season at Crop Research Farm, Sam Higginbottom Institute of Agriculture, Technology & Sciences (Deemed-to-be-University) Allahabad. The experimental site is located at 25°57 N latitude, 87° 19 E longitude and at an altitude of 98.0 m above mean sea level. The soil of the experimental area was sandy loam with moderately alkaline pH; low in organic carbon (0.37 and 0.39%) and available N (153.30 and 170.35 kg ha^{-1}), medium in available P (13.50 and 15.50 kg ha^{-1}) and high in available K (246.00 and 291.00 kg ha^{-1}) during late zaid 2014 and late zaid 2015 seasons respectively. Babycorn hybrid (F_1), Greengram (SAMRAT) and Clusterbean (Pusa Nawbahar) 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 babycorn, babycorn + greengram and babycorn + clusterbean) and in sub plots, different sources of organic manure and their combination with each other [goat manure at the rate of 4615.3 kg ha^{-1} (M_1), Poultry manure at the rate of 4800 kg ha^{-1} (M_2), FYM at the rate of 24000 kg 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. Babycorn and component crop seeds were pre-treated with biofertilizers, sown in line and covered with the soil. Lines were formed in between two babycorn rows and intercrops were sown. Babycorn, 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 yield observations on babycorn, a sample consisting of five plants was selected at random. Number of cobs from the sampling plants counted, from that mean number of cobs plant^{-1} were measured. Cob girth was measured by Varner caliper and expressed in cm and then computed with π x cob diameter, Length with husk and without husk and weight of cobs from the tagged plants were measured and mean length, girth and weight were calculated. Sheath of cobs was peeled-off and the length, girth and weight of cob were measured. Harvested cobs from the net plot were weighed and cob yield was recorded from individual plots and expressed in kg ha^{-1}. After harvest of cobs, the babycorn stalks were harvested from the net plot area, weighed and expressed as green fodder yield (t ha^{-1}). The data subjected to statistical analysis.

3. Results and Discussions

Yield attributes

During the period of investigation, yield attributes recorded higher values during late *zaid* 2015 than late *zaid* 2014 season. Data presented in Table 1and 2 revealed that yield attributes of babycorn as cob girth (cm), number of cobs plant^{-1}, cob length with husk and without husk (cm), cob weight with husk and without husk (g), cob yield (kg ha^{-1}) and green fodder yield (t ha^{-1}) were influenced by various treatments of cropping systems, organic manure and their interaction effect during both the years of experiment and also in pooled analysis. Cob girth was significantly higher (5.64 and 5.66 cm) in babycorn + cluster bean (1:1, additive series), over sole babycorn (5.20 and 5.25 cm) in both the years. Whereas, number of cobs per plant were significant during second year and pooled analysis, more and exactly same number of cobs plant^{-1} (2.77 and 2.77) were recorded in babycorn + cluster bean (1:1, additive series), and babycorn + green gram (1:1, additive series), as compared to sole babycorn (2.57) in 2015. However, significantly higher cob length with husk was recorded in the first year of experiment and also in pooled analysis. Longer cobs (14.98 and 15.09 cm) were observed in treatment babycorn + cluster bean (1:1, additive series), than sole babycorn (14.47 and 14.62 cm). The cropping systems could not affect the cob length without husk during both the years and also in pooled analysis. There was also no significant different among the treatment of cropping system in cob weight of babycorn during both the years of investigation but cob weight without husk was found significant during both the year of investigation, heavier cobs per plant (8.31 and 8.20 g cob^{-1}) were recorded in baycorn +

greengram (1:1, additive series), in the year 2015 and pooled analysis. The improvement in yield attributes was assigned to the synergistic effect of babycorn and component corps (Singh and Bajpai 1991) [17]. Further, the yield attributes also exhibited an improvement on account of the association of babycorn with clusterbean and greengram. It is presumed that there was a better source to sink relationship which finally improved of these parameters. These finding corroborated with the result of Jat *et al*. (2014) [7], Prasad and Brook. (2005) [14] and Yadav *et al*. (2016) [22].

Cob yield and green fodder yield of babycorn were influenced by different cropping systems. Babycorn + clusterbean (1:1, additive series), and babycorn + greengram (1:1, additive series), showed significantly maximum (1883.95 and 1911.99 kg ha^{-1}) and (1825.92 and 1871.74 kg ha^{-1}) over sole babycorn (1740.74 and 1799.49 kg ha^{-1}) in the year 2014 and pooled analysis. Babycorn + clusterbean (1:1, additive series), significantly increased green fodder yield (21.96 and 22.17 t ha^{-1}) over sole babycorn (20.10 and 20.23 t ha^{-1}) and remained at par with babycorn + greengram (1:1, additive series), (20.86 and 21.21t ha-1) during both the years of experiment. Improvement in yield attributes under intercropped stand over pure stand contributed to significant increase in cob yield under intercropping systems. This increase in cob yield was in order of 8.22 and 6. 25 % in babycorn + clusterbean (1:1, additive series), over sole babycorn, respectively. Similar result were also obtained by Thavaprakash *et al*. (2007) [18], Banik and Sharma (2009) [2] and Nataraj *et al*. (2011) [12].

Cob girth, number of cobs per plant, cob length with husk and without husk, cob weight with husk and without husk, and cob yield were significantly influenced by the organic nutrient management during both the years of investigation and also in pooled analysis. Babycorn yield parameters were maximum with poultry manure at the rate of 4615.30 kg ha^{-1} as compared to rest of the treatments in both the years (Table 1 and 2). Significantly higher cob girth, number of cobs per plant, cob length without husk and cob weight without husk (5.74 and 5.69 cm), (2.66 and 2.84 plant^{-1}), (8.42 and 9.03 cm) and (8.46 and 9.05 g cob^{-1}) were recorded in M_2. Significant and maximum cob yield was obtained with application poultry manure at the rate of 4615.30 kg ha^{-1} (1972.84 and 2026.90 kg ha^{-1}) which was followed by M_4 in 2014 and M_6 in 2015, which was found statistically at par values with M_2. The significant data on green fodder yield was observed in 2014 and pooled analysis, whereas, it was not significant in the year 2015. In the year 2014 and pooled analysis the significantly maximum green fodder yield (23.79 and 23.31 t ha^{-1}) was recorded in M2, which was closely followed (21.04 and 21.19 t ha^{-1}) by M6, respectively. The higher yield and yield attributes in poultry manure could be assigned to higher mineralization potential of poultry manure enabling it to actively and quickly release of its nutrients for plant uptake and use (Ogunbabjo *et al*., 2007) [13]. It also might be due to the fact that poultry manure and goat manure helped in maintaining higher nutrient level resulting in better plant growth. These might also due to better interception, absorption and utilization of radiation energy leading to higher photosynthetic rate and finally more accumulation of dry matter by the plants. The overall improvement reflected into better source – sink relationship, which in turn enhanced the yield and yield attributes (Madhavi *et al*., 1995) [10]. Further, the increase in yield could also be assigned to the improvement of yield attributes. Similar results were also reported by Thavaprakah *et al*. (2005) [19], Uwah *et al*. (2011) [20], Saleem *et al*. (2016) and Uwah *et al*. (2014) [21].

The non-significant results were obtained on yield and yield attributes of babycorn due to interaction of intercropping and different sources of organic manure and their combination with each other.

Table 1: Yield attributes of certified organic babycorn as influenced by different sources of manures and intercropping with pulses

Treatment	Cob girth (cm)			Number of cob plant^{-1}			Cob length with husk (cm)			Cob length without husk (cm)		
Cropping systems (C)	**2014**	**2015**	**Pooled**	**2014**	**2015**	**Pooled**	**2014**	**2015**	**Pooled**	**2014**	**2015**	**Pooled**
C_1 - Sole Babycorn	5.20	5.25	5.22	2.48	2.57	2.53	14.47	14.77	14.62	8.04	8.44	8.24
C_2 - Babycorn + Greengram	5.41	5.39	5.40	2.53	2.77	2.65	14.71	15.10	14.90	8.13	8.47	8.30
C_3 - Babycorn + Cluster bean	5.64	5.66	5.65	2.65	2.77	2.71	14.98	15.20	15.09	8.19	8.61	8.40
F.test	S	S	S	NS	S	S	S	NS	S	NS	NS	NS
SE(d) ±	0.07	0.07	0.02	0.06	0.03	0.04	0.10	0.22	0.05	0.14	0.12	0.05
CD (P=0.05)	0.21	0.21	0.06	-	0.10	0.11	0.30	-	0.16	-	-	-
Manures (M)												
M_1 - Goat Manure (4800.00 kg ha^{-1})	5.56	5.37	5.46	2.64	2.73	2.68	14.70	15.26	14.98	8.22	8.56	8.39
M_2 - Poultry Manure (4615.30 kg ha^{-1})	5.74	5.69	5.72	2.66	2.84	2.75	15.14	15.42	15.28	8.42	9.03	8.73
M_3 - Farm Yard Manure (24000.00 kg ha^{-1})	5.17	5.17	5.17	2.40	2.55	2.47	14.63	14.62	14.62	7.86	7.87	7.87
M_4 - Goat Manure (2400.00 kg ha^{-1}) + Poultry Manure (2307.65 kg ha^{-1})	5.29	5.43	5.36	2.57	2.75	2.66	14.48	15.55	15.02	8.10	8.48	8.29
M_5 - Goat Manure (2400.00 kg ha^{-1}) + FYM (12000 kg ha^{-1})	5.35	5.42	5.39	2.51	2.62	2.56	14.39	14.42	14.40	8.06	8.46	8.26
M_6 - Poultry Manure (2307.65 kg ha^{-1}) + FYM (12000.00 kg ha^{-1})	5.40	5.53	5.47	2.55	2.75	2.65	14.99	14.87	14.93	8.06	8.63	8.34
F. test	S	S	S	S	S	S	S	S	S	S	S	S
SE(d) ±	0.11	0.10	0.05	0.07	0.06	0.04	0.3202	0.32	0.24	0.20	0.1998	0.1303
CD (P=0.05)	0.24	0.22	0.11	0.15	0.13	0.08	0.6538	0.66	0.50	0.41	0.4081	0.2661

Table 2: Yield and yield attributes of certified organic babycorn as influenced by different sources of manures and intercropping with pulses

Treatment	Cob weight with husk (g)			Cob weight without husk (g)			Cob yield (kg ha^{-1})			Green fodder Yield (t ha^{-1})		
Cropping systems (C)	2014	2015	2014	2015	2005	Pooled	2014	2015	Pooled	2014	2015	Pooled
C_1 - Sole Babycorn	16.39	17.43	16.91	7.09	7.13	7.11	1740.74	1858.24	1799.49	20.10	20.36	20.23
C_2 - Babycorn + Greengram	18.08	18.72	18.40	8.09	8.31	8.20	1825.92	1917.52	1871.74	20.86	21.21	21.04
C_3 - Babycorn + Cluster bean	18.53	19.39	18.96	8.17	7.87	8.02	1883.95	1939.94	1911.99	21.96	22.17	22.06
F.test	NS	NS	S	S	S	S	S	NS	S	S	S	S
SE(d) ±	0.78	0.95	0.50	0.19	0.11	0.11	28.14	51.98	30.29	0.46	0.38	0.33
CD (P=0.05)	-	-	1.39	0.55	0.30	0.30	78.11	-	84.09	1.28	1.07	0.91
Manures (M)												
M_1 - Goat Manure (4800.00 kg ha^{-1})	17.77	19.20	18.48	8.09	7.40	7.74	1782.71	1897.11	1839.91	20.34	21.12	20.73
M_2 - Poultry Manure (4615.30 kg ha^{-1})	18.51	20.22	19.37	8.46	9.05	8.76	1972.84	2026.90	2000.00	23.79	22.82	23.31
M_3 - Farm Yard Manure (24000.00 kg ha^{-1})	17.02	17.02	17.02	6.97	6.76	6.87	1713.58	1809.05	1761.31	19.51	20.25	19.88
M_4 - Goat Manure (2400.00 kg ha^{-1}) + Poultry Manure (2307.65 kg ha^{-1})	17.70	18.40	18.05	7.68	7.99	7.83	1844.44	1890.53	1867.49	20.64	21.04	20.84
M_5 - Goat Manure (2400.00 kg ha^{-1}) + FYM (12000 kg ha^{-1})	17.84	18.08	17.96	7.92	7.50	7.71	1772.84	1863.37	1818.10	20.51	20.90	20.71
M_6 - Poultry Manure (2307.65 kg ha^{-1}) + FYM (12000.00 kg ha^{-1})	17.13	18.17	17.65	7.58	7.92	7.75	1814.81	1944.42	1879.67	21.04	21.34	21.19
F.test	NS	S	S	S	S	S	S	S	S	S	NS	S
SE(d) ±	0.62	0.71	0.39	0.44	0.41	0.19	42.17	64.81	43.46	0.76	0.95	0.70
CD (P=0.05)	-	1.46	0.80	0.90	0.85	0.40	86.12	132.35	88.76	1.56	-	1.43

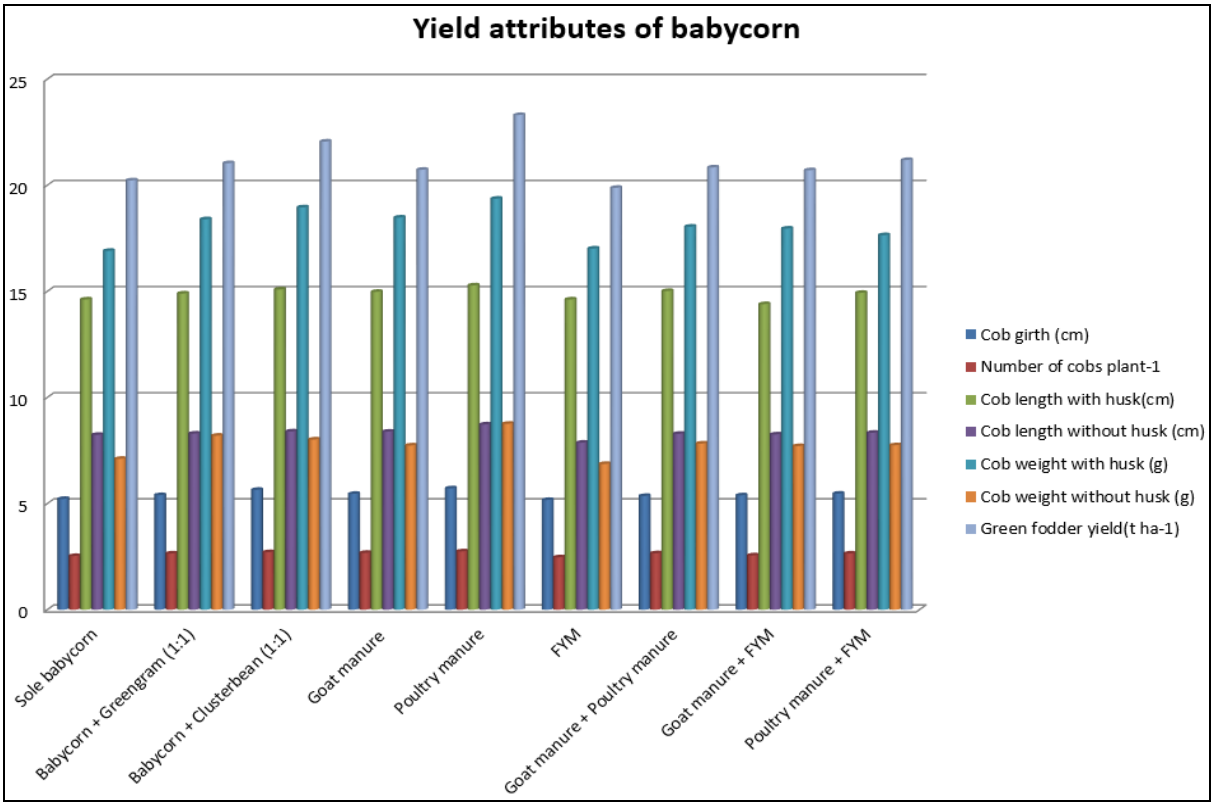

Fig 1: Yield attributes of certified organic babycorn as influenced by different sources of manure and intercropping with pulses

4. Conclusion

In babycorn + greengram and cluster bean intercropping system at Allahabad, babycorn + clusterbean (1:1, additive series) and Babycorn + greengram (1:1, additive series), were found most suitable and productive than sole babycorn. Organic nutrient management involving different sources of manures conclude that application of poultry manure alone or either in combination with FYM and goat manure was recommended for higher productivity of babycorn than FYM.

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