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Productivity, Profitability and Energetic of Baby Corn - Chinese Cabbage - Onion Cropping System as Influenced by Nutrient Management

Short Title: Performance of Cropping System for Different Sources of Nutrients

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ABSTRACT: A long term experiment on 'nutrient management in Baby corn-Chinese cabbage-onion cropping system' was initiated in kharif 2003 and continued till 2014-15. Seven treatments involving organic nutrient, pure inorganic and integrated nutrient management were evaluated for production potential, economic feasibility, energy relations and effects on soil fertility in an unreplicated trial. To find out treatment differences, analysis of yield data from 2003 to 2014-15 was taken considering years as replicates. To minimize the year to year variation in yield, three years moving averages were worked out. The results revealed that the baby corn yield was maximum under INM treatment and was minimum under the pure inorganic treatment. Under INM treatment the mean yields of Chinese cabbage and onion were 2.06 and 10.3 times higher than pure inorganic treatment, respectively. The highest baby corn equivalent yield was recorded in INM (T_1). Organic treatments resulted in higher cost of cultivation than INM and pure inorganic. 50% NPK (inorganics) + 50% N (FYM) (T_1) gave significantly higher net return, B: C ratio and energy output. 50% N (FYM) + Azospirillum + Rock phosphate + PSB (T_5) resulted in highest energy output: input and energy productivity.

Key words: organic, inorganic, integrated, cropping system, Chinese cabbage, baby corn, onion

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INTRODUCTION

Experiments on cropping systems are ultimate solutions to overcome the drawbacks of monocropping system or seasonal experiments and to exploit the soil intensively for food production in view of growing population. There is limited scope of increasing production through expansion of cultivable land. Like whole country, Himachal too has almost reached a plateau in so far as cultivable land is concerned and there is no scope for increasing the area under cultivation. Hence, the emphasis has to be on increasing productivity levels besides diversification towards high value crops. Poor recycling of organic sources and application of high analysis fertilizers caused deficiency of several micronutrients in soil and also lead to environmental pollution [1]. This calls for substituting part of the inorganic fertilizers by locally available organic sources of nutrients in a synergistic manner. Hence, judicious nutrient management in cropping system perspective is the need of hour. Due to paucity of organic sources of nutrients, their integrated use with inorganic fertilizers becomes inevitable.

In the rainfed area of Himachal Pradesh, maize is the main *kharif* crop. In the recent past efforts were made to popularize baby corn – a specialty maize because of having demands in hotels. Baby corn production in India began when Agronomists realized that it was a potential crop that could improve the economic status of the farmers in India [2] through earning foreign exchange as well as meeting local needs. The application of chemical fertilizers may assist in obtaining maximum production of baby corn but these may lead to hazardous effect on the environment [3, 4, 5]. The extensive research on integrated nutrient management in different crops and cropping systems has emphasized its importance in achieving production, economic and environmental sustainability.

Cultivating onions after maize is a common practice in some pockets in the irrigated and limited irrigated water areas since onion is a major commodity. There is a wide interval between harvesting time of maize (September shortened by about month time in the case of baby corn) and planting time of onions (Jaunary). During this time interval it was worthwhile to adjust a short duration crop such as chinese cabbage (*Brassica rapa* var. *pekinensis*) as a green crop.

Chinese cabbage is low in calories, fats and carbohydrates but it is a good source of minerals, protein and antioxidants [6].

However, adoption of multiple cropping system needs more nutrients for the proper growth and development of each crop in the sequence. For a sustainable crop production system, chemical nutrients removed by the crop must be replenished and physical conditions of the soil maintained. The growing urgent need for sustainable agriculture has led to a renewed interest in recycling of nutrients through organic sources in restoring soil fertility and sustaining crop productivity. Balanced application of nutrients through any source is most important in increasing the agricultural productivity. Fertilizers have played a major role in replenishing the soil fertility and increasing the yield. But their escalating costs, stagnation in yields and the injudicious use is compelling to look for other alternatives. Secondly the use of chemical fertilizers (mainly NPK fertilizers) alone is leading to the deficiency of other nutrients particularly, the micronutrients. On the other hand, organics alone cannot meet the nutritional requirement of the crops as the nutrient contents in these are very low. Therefore, to sustain yield and maintain the soil health, the integration of organic and inorganic is the viable alternative. However, due to the adverse effects of chemicals on ecosystem/environment and quality of produce, the concept of pure organic farming has also come up. However, organic farming can only be practiced in high value crops at selected places to improve their quality.

Keeping the above facts in view, the present investigation was undertaken to study the response of organic, inorganic and integrated sources of nutrients on productivity and sustainability of baby corn - Chinese cabbage - onion cropping system.

MATERIALS AND METHODS

The present study was conducted from *kharif* 2003 to *rabi* 2014-15 at the research farm of Department of Agronomy, Forages and Grassland Management, CSK HPKV, Palampur (HP). The farm was situated at $32^0 3^/$ N latitude, $76^0 3^/$ E longitude and 1223.7 meters above mean sea level. The soil of the experimental site at initiation of experiment (2003) was silty clay loam in texture with soil pH 5.7, organic carbon 0.80%, medium in available N (505 kg ha^{-1}) and K (186 kg ha^{-1}) and high in available P (35.5 kg ha^{-1}). Seven treatments involving organic nutrient, pure inorganic and integrated nutrient management [50% NPK (inorganics) + 50% N (FYM) (T_1), 1/3rd N each through FYM, Vermicompost and Neem cake (T_2), 1/3rd N each through FYM, Vermicompost and Neem cake + mulching (T_3), 1/3rd N each through FYM, Vermicompost and Neem cake + Agronomic practices for WC (T_4), 50% N through FYM + *Azospirillum* + Rock phosphate + PSB (T_5), 1/3rd N each through FYM, Vermicompost and Neem cake + *Azospirillum* + Phospho-bacteria (T_6) and 100% NPK (inorganics) (T_7)] were evaluated for production potential, economic feasibility and energy relations in an unreplicated trial. The trial was un-replicated therefore; simple means were presented graphically or in the tabulated form in most of the instances. The past data on yield, economics and energy have also been analyzed to have a conclusive inference of the up to date findings. To reduce year to year variation three years moving averages have been worked out to reveal the general trends relevant to the treatment effects in a graphical form. Baby corn 'VL-78', Chinese cabbage 'Palampur Green' and onion 'Patna Red' were sown during June, October and January in respective years. Seed rate of 40 kg/ha at spacing 40*15 for baby corn, 0.60-0.75 kg/ha at spacing 45*30 for Chinese cabbage and 8-10 kg/ha at spacing 20*10 for onion was used. Nutrients were applied as per treatment and source of N were urea, FYM, vermicompost and neem cake. Average nitrogen content of vermicompost, nimala, and FYM was 1.54, 2.31and 1.19%, respectively. Azospirillium and PSB were used as seed/seedling treatment. Under agronomic practices soybean in baby corn, coriander in Chinese cabbage and onion (were grown along with and incorporated before the completion of their vegetative phase i.e. before flowering). Recommended dose for baby corn was 150, 60 and 40 kg/ha and for Chinese cabbage and onion it was 100, 48 & 30 and 125, 75 & 60 kg N, P (SSP) and K (MOP)/ha, respectively. Half dose of nitrogen and whole P_2O_5 and K_2O were incorporated in soil, as per the treatments, as basal dose and remaining half dose of nitrogen was top dressed at knee high and tasseling stage of baby corn. Sowing was done with pre sowing irrigation in baby corn. Gap filling was done within 19 days after sowing (DAS) to maintain the optimum plant population. Hand weeding was done twice in baby corn, once in Chinese cabbage and two times in onion. Chinese cabbage and onion were irrigated 4-5 times each by flood

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irrigation method. Baby corn equivalent yield (BEY) was calculated on the basis of market price of baby corn INR 10-15, Chinese cabbage INR 10 and onion INR 5-10/kg. B: C ratio was worked out by dividing gross returns (INR/ha) with cost of cultivation (INR/ha).

RESULTS AND DISCUSSION

Baby corn yield

The data on baby corn yield from 2003 to 2014 based on three years moving averages have been presented in Fig. 1a. A critical perusal of data revealed that in the initial years pure inorganic (T_7) resulted in higher baby corn yield which declined considerably than all other organic and integrated management practices in the later years. Integrated nutrient management treatment (T_1, 50% N through FYM + 50% NPK through fertilizers) excelled over all organic nutrient management treatments except T_2 (1/3rd N each through FYM, Vermicompost and Neem cake) in the later years. Fig 1b also indicated that excluding the two stabilizing years, 11 years mean data on baby corn yield was maximum under INM treatment. T_2 and T_3 (1/3rd N each through FYM, Vermicompost and Neem cake + mulching) also gave significantly higher pooled baby corn yield than inorganic nutrient management treatments. Eleven years average baby corn yield was significantly lower under the pure inorganic indicating the importance of organic matter in the sustainability. However, it was statistically at par to 1/3rd N each through FYM, Vermicompost and Neem cake + Agronomic practices for weed control (T_4), 50% N through FYM + *Azospirillum* + Rock phosphate + PSB (T_5) and 1/3rd N each through FYM, Vermicompost and Neem cake + *Azospirillum* + Phospho-bacteria (T_6).

Chinese cabbage yield (greens)

The data on green yield of chinese cabbage have been presented in Fig. 2a. The yield of Chinese cabbage was found to be higher under INM and organic nutrient management treatments in comparison to the application of 100% NPK through fertilizers (Fig. 2a). Fig. 2b depicts 2.06 times higher pooled Chinese cabbage yield under integrated nutrient management practice over the pure inorganic. T_3 and T_5 were comparable to the integrated nutrient management in terms of pooled Chinese cabbage yield. All the other organic nutrient management treatments were also superior to inorganics in influencing the pooled Chinese cabbage green leaf yield.

Onion bulb yield

The bulb yield of onion has been depicted graphically in Fig. 3a. The Fig showed that onion bulb yield was found to be higher under INM and organic treatments in comparison to the application of 100% NPK through fertilizers (Fig. 3a). A perusal of data given in Fig. 3b revealed that mean onion yield under the integrated nutrient management treatment was 10.3 times higher than pure inorganic. The organic nutrient management treatments T_5 was comparable to integrated nutrient management treatment in terms of pooled onion bulb yield. However, all the other organic nutrient management treatments were comparable to T_5.

Baby corn equivalent yield

The data on baby corn equivalent yield based on three years moving average starting from 2003-04 to 2014-15 have been depicted in Fig. 4a. Excluding the two stabilizing years, 11 years mean data on onion bulbs have been given in Fig. 4b. Owing to higher yield of crops, the baby corn equivalent yield was highest throughout under the INM treatment (T_1) (Fig. 4a), which was closely followed by organic treatments. High microbial activity and biomass addition through organic manures often lead to high nutrient availability to crops resulting in high yields [7].

Due to poor yield especially of onion and Chinese cabbage, baby corn equivalent yield under pure inorganic was tremendously lower throughout over INM and organic treatments. Pure inorganic gave only 27.5% of the total pooled baby corn yield under the INM treatment (Fig.

4b). INM treatment resulted in highest baby corn equivalent yield. The organic nutrient management treatments viz. T_2 T_3, T_5 and T_6 were comparable to each other in influencing pooled baby corn equivalent yield. However, T_4 gave significantly lower baby corn equivalent yield over T_5.

ECONOMICS STUDIES

Organic treatments resulted in higher cost of cultivation than INM and pure inorganic due to higher cost of application of organics as a sequel of their bulkyness (Table 1). 1/3rd N each through FYM, Vermicompost and Neem cake + mulching (T_3) treatment had highest cost of cultivation (INR 231649). 50% NPK (inorganics) + 50% N (FYM) (T_1) treatment proved significantly superior to rest of the treatments in respect of gross returns (INR 257242). Significantly lowest gross returns were obtained in 100% NPK (inorganics) (T_7). 50% N through FYM + *Azospirillum* + Rock phosphate + PSB (T_5) remaining at par with 50% NPK (inorganics) + 50% N (FYM) (T_1) gave significantly higher net return.100% NPK (inorganics) (T_7) resulted in lowest net return. 50% N through FYM + *Azospirillum* + Rock phosphate + PSB (T_5) remaining at par with 50% NPK (inorganics) + 50% N (FYM) (T_1) treatment resulted in significantly higher B:C (1.85) ratio over rest of the treatment whereas pure inorganic (T_7) treatment resulted in lowest B:C ratio.

ENERGY STUDIES

INM and pure inorganic nutrient management treatments had higher input energy as compared to the organic nutrient management treatments (Table 2). 50% N through FYM + *Azospirillum* + Rock phosphate + PSB (T_5) remaining at par with 50% NPK (inorganics) + 50% N (FYM) (T_1) resulted in significantly higher energy output than the rest of the treatments. On an average pure inorganic gave significantly lower energy output than the INM but was comparable to all nutrient management treatments. 50% N through FYM + *Azospirillum* + Rock phosphate + PSB (T_5) resulted in significantly highest energy output: input ratio owing to lower energy input in the treatment. Pure inorganic resulted in lowest energy output:input. The other treatments viz. were statistically at par with each other. 50% N through FYM + *Azospirillum* + Rock phosphate + PSB (T_5) had significantly highest energy productivity than other treatments. This was due to higher dry matter yield recorded in this treatment and lower energy input. Pure inorganic had lowest energy productivity. Other treatments were statistically equal in terms of energy productivity.

CONCLUSION

It may be concluded from the present study that integrated followed by organic nutrient management may be better option for higher productivity in Baby corn- Chinese cabbage-onion cropping system. INM treatment resulted in highest net returns and B: C ratio. Thus, organic and integrated nutrient management practices must be preferred over pure inorganic for enhancing the crop productivity and sustaining soil health.

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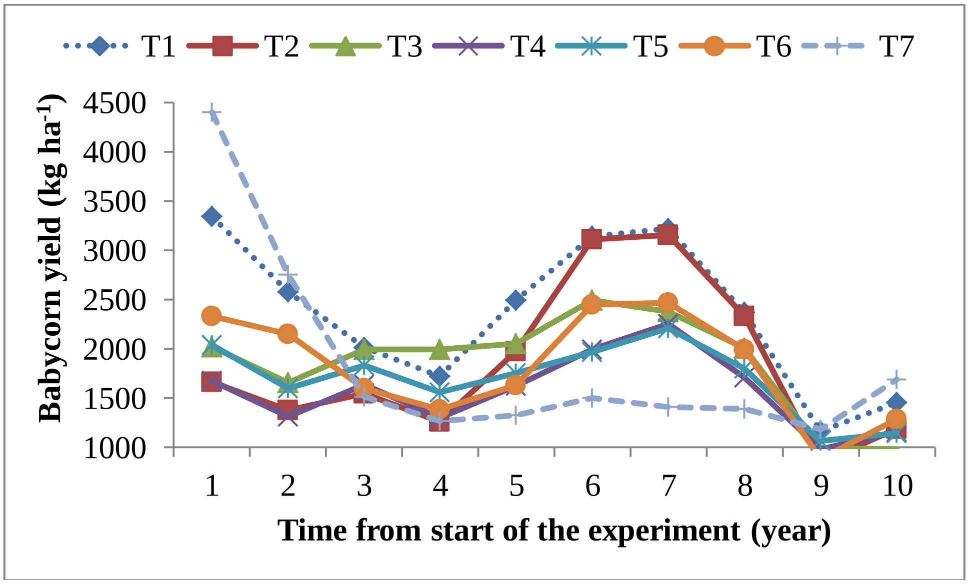

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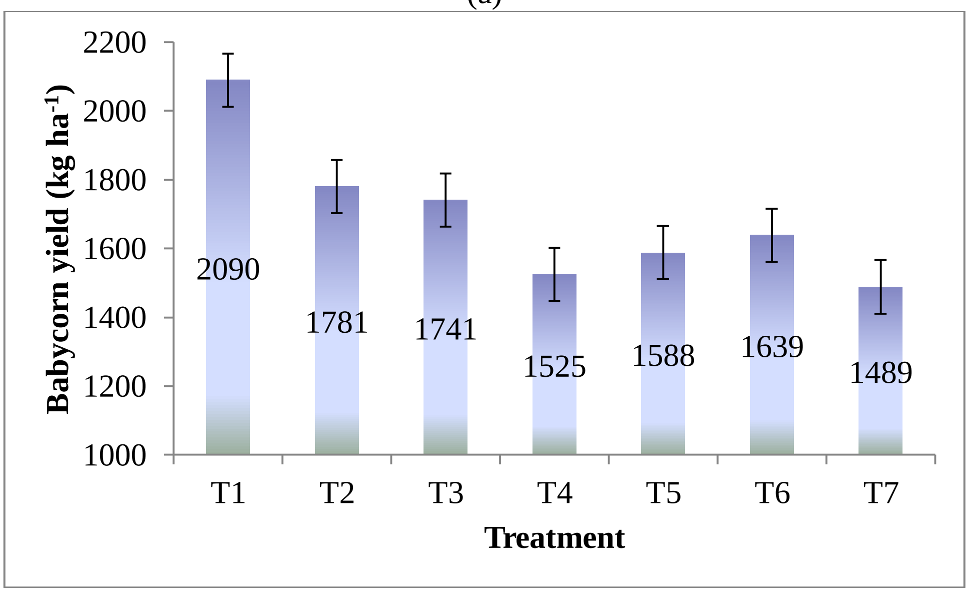
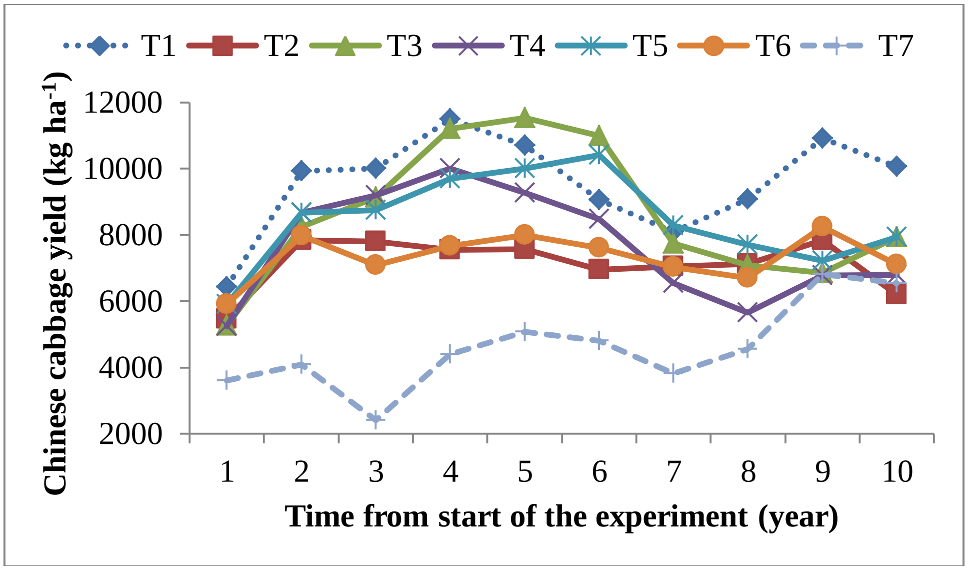


(b)

Fig. 1a Effect of treatments [50% NPK (inorganics) + 50% N (FYM) (T_1), 1/3rd N each through FYM, Vermicompost and Neem cake (T_2), 1/3rd N each through FYM, Vermicompost and Neem cake + mulching (T_3), 1/3rd N each through FYM, Vermicompost and Neem cake + Agronomic practices for WC (T_4), 50% N through FYM + *Azospirillum* + Rock phosphate + PSB (T_5), 1/3rd N each through FYM, Vermicompost and Neem cake + *Azospirillum* + Phospho-bacteria (T_6) and 100% NPK (inorganics) (T_7)] on baby corn yield based on three years moving average, beginning in 2003. **Fig. 3b** Effect of treatment on baby corn yield (pooled for 11 years excluding two stabilizing years, error bars indicate standard error (n=6); LSD (p=0.05) for treatment difference = 291 kg ha^{-1}.



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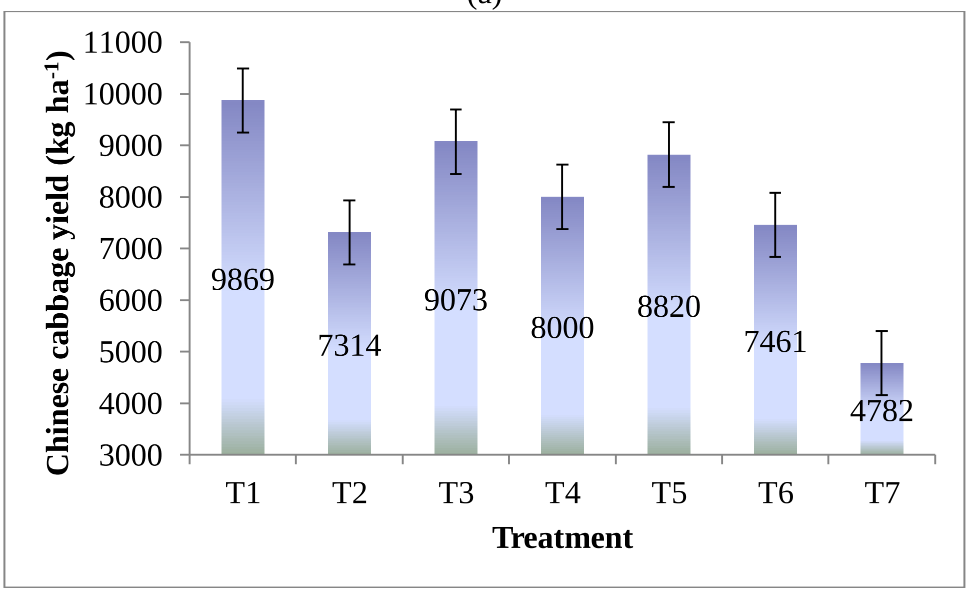

(b)

Fig. 2a Effect of treatments [50% NPK (inorganics) + 50% N (FYM) (T_1), 1/3rd N each through FYM, Vermicompost and Neem cake (T_2), 1/3rd N each through FYM, Vermicompost and Neem cake + mulching (T_3), 1/3rd N each through FYM, Vermicompost and Neem cake + Agronomic practices for WC (T_4), 50% N through FYM + *Azospirillum* + Rock phosphate + PSB (T_5), 1/3rd N each through FYM, Vermicompost and Neem cake + *Azospirillum* + Phospho-bacteria (T_6) and 100% NPK (inorganics) (T_7)] on Chinese cabbage yield based on three years moving average, beginning in 2003. **Fig. 2b** Effect of treatment on Chinese cabbage yield (pooled for 10 years excluding two stabilizing years, error bars indicate standard error (n=6); LSD (p=0.05) for treatment difference = 1203 kg ha^{-1}.

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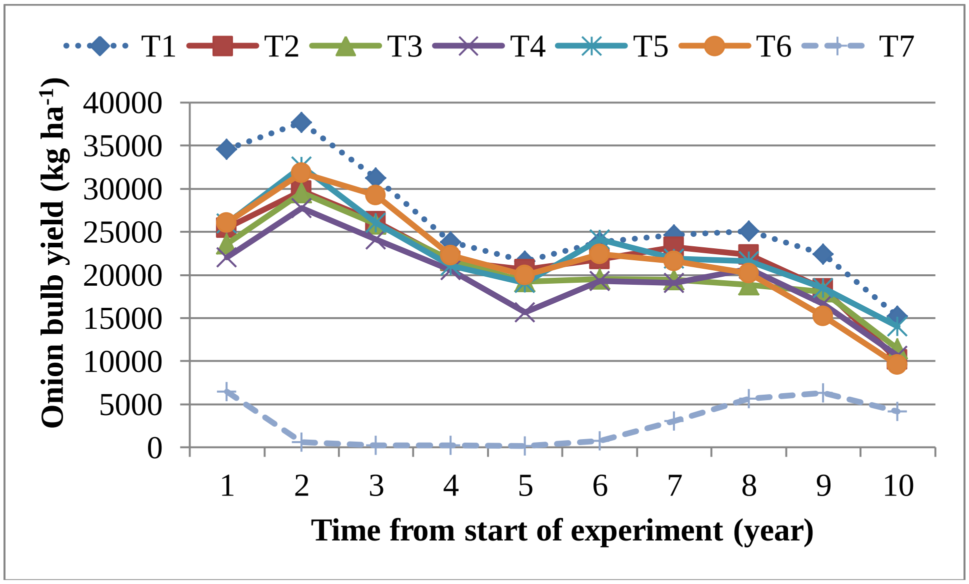

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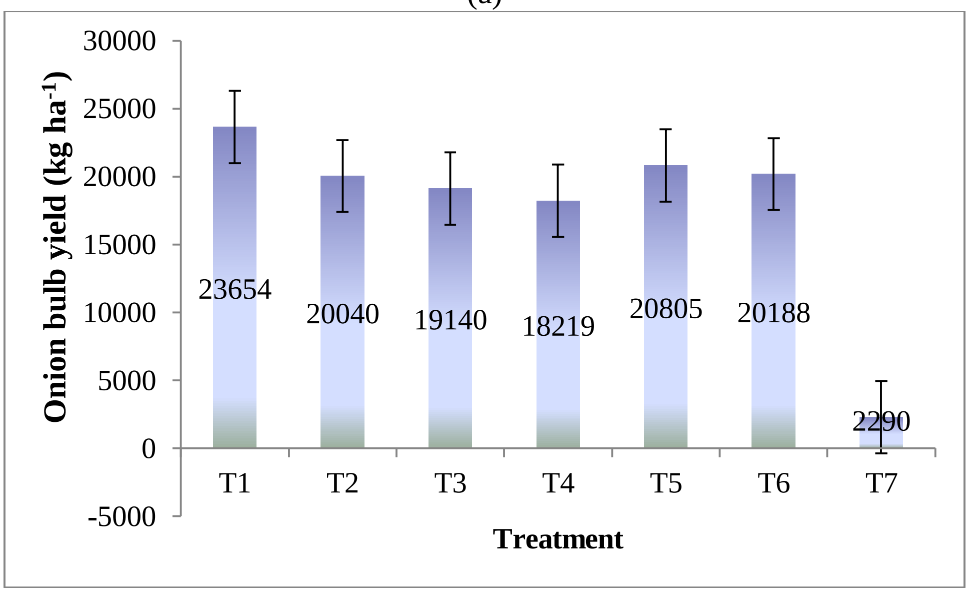

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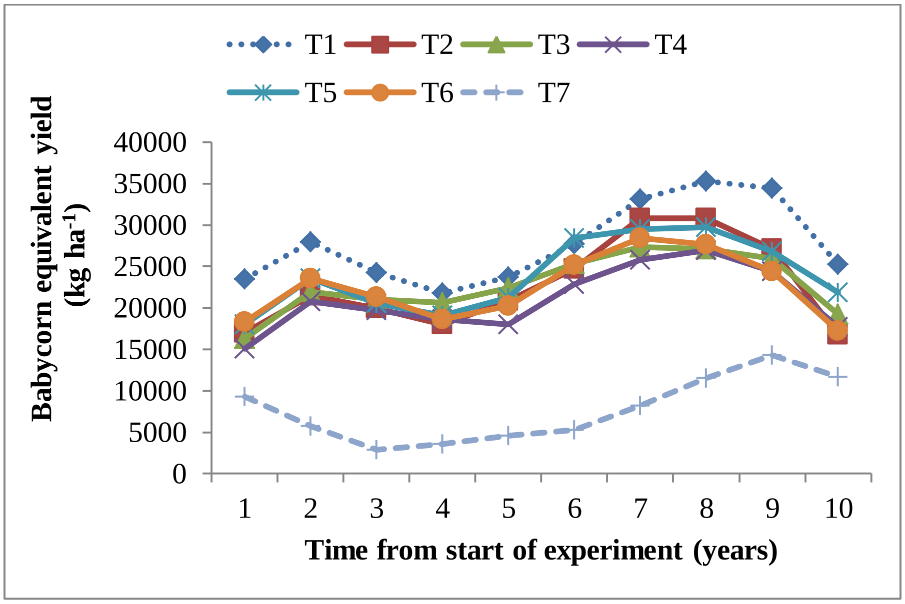
Fig. 3a Effect of treatments [50% NPK (inorganics) + 50% N (FYM) (T_1), 1/3rd N each through FYM, Vermicompost and Neem cake (T_2), 1/3rd N each through FYM, Vermicompost and Neem cake + mulching (T_3), 1/3rd N each through FYM, Vermicompost and Neem cake + Agronomic practices for WC (T_4), 50% N through FYM + *Azospirillum* + Rock phosphate + PSB (T_5), 1/3rd N each through FYM, Vermicompost and Neem cake + *Azospirillum* + Phospho-bacteria (T_6) and 100% NPK (inorganics) (T_7)] on Onion bulb yield based on three years moving average, beginning in 2003. **Fig. 3b** Effect of treatment on onion bulb yield (pooled for 10 years excluding two stabilizing years, error bars indicate standard error (n=6); LSD (p=0.05) for treatment difference = 3336 kg ha^{-1}.



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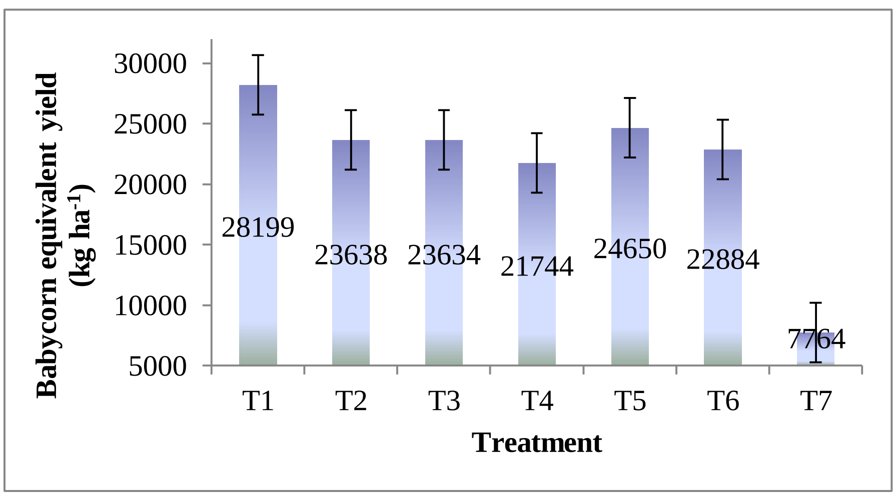

(b)

Fig. 4a Effect of treatments [50% NPK (inorganics) + 50% N (FYM) (T_1), 1/3rd N each through FYM, Vermicompost and Neem cake (T_2), 1/3rd N each through FYM, Vermicompost and Neem cake + mulching (T_3), 1/3rd N each through FYM, Vermicompost and Neem cake + Agronomic practices for WC (T_4), 50% N through FYM + *Azospirillum* + Rock phosphate + PSB (T_5), 1/3rd N each through FYM, Vermicompost and Neem cake + *Azospirillum* + Phospho-bacteria (T_6) and 100% NPK (inorganics) (T_7)] on babycorn equivalent yield based on three years moving average, beginning in 2003. **Fig. 4b** Effect of treatment on baby corn equivalent yield (pooled for 10 years excluding two stabilizing years, error bars indicate standard error (n=6); LSD (p=0.05) for treatment difference = 3107 kg ha^{-1}. Prices of produce: Baby corn- Rs.10-15 kg^{-1}, chinese cabbage Rs.5-10; onion- Rs.5.0-10 kg^{-1}

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	Cost of cultivation (INR ha^{-1})				Gross returns (INR ha^{-1})				Net returns	B:C
Treatment	Baby corn	Chinese cabbage	Onion	Total	Baby corn	Chinese cabbage	Onion	Total		
T_1	44173	37031	57633	138837	60852	98690	236536	396079		
T_2	69566	53636	77547	200749	50993	73145	200397	324535	257242	1.85
T_3	79866	63936	87847	231649	50929	90728	191397	333055	123785	0.62
T_4	73225	55717	79628	208570	48024	79996	182185	310205	101406	0.44
T_5	41699	35443	54517	131658	50090	88202	208050	346342	101635	0.49
T_6	69566	53636	77547	200749	48319	74615	201885	324818	214683	1.63
T_7	33302	30107	49820	113229	49954	47817	22902	120674	124069	0.62
					NS	13534	63294	67605	7445	0.07

Table 1 Cost of cultivation and gross returns of different treatments in Baby corn- Chinese cabbage-onion cropping system (average of from 2003-04 to 2014-15)

Table 2 Energy-relationship

Treatment	Energy input (MJ ha^{-1} $annum^{-1}$)	Energy output (Kcal)			Total (MJ ha^{-1} $annum^{-1}$)	Energy output: input	Energy productivity (kg dry biomass MJ^{-1})
		Baby corn	Chinese cabbage	Onion			
T_1	32975	42360784	2565952	9461451	227709	6.91	0.50
T_2	27617	34989860	1901766	8015873	188015	6.81	0.49
T_3	29741	35598026	2358940	7655896	190969	6.42	0.46
T_4	27654	35586200	2079889	7287415	188208	6.81	0.48
T_5	21963	37160296	2293240	8321995	200023	9.11	0.66
T_6	27617	33984917	1939977	8075397	184217	6.67	0.48
T_7	32923	38695260	1243254	916100	171047	5.20	0.32
LSD (P=0.05)	-	NS	351894	2531774	28283	1.12	0.07