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Research Article

Effects of different combinations of poultry manure and urea on growth, yield and economics of garlic (*Allium sativum L.)*

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ABSTRACT

A field experiment was carried out in garlic (*Allium sativum* L.) in Randomized Complete Block Design (RCBD) with four replications and five treatments in horticulture farm of Agriculture and Forestry University, Chitwan, Nepal to find out the efficacy of different combination of poultry manure and Urea as nitrogen fertilizers in its yield and yield attributes. The five treatments used for experiment were designed altering the recommended nitrogen dose through different sources i.e. (T1) 100% Urea, (T2) 7% Urea and 25% poultry manure, (T3) 50% Urea and 50% poultry manure, (T4) 25% Urea and 75% poultry manure and (T5) 100% poultry manure. The data regarding to the plant height, number of cloves, diameter of bulbs and fresh bulb weight were taken. In case of plant height, non-significant result was found between various treatments. The number of cloves was found highest in T5 (24.69±1.30), the diameter of bulb was found highest in T2 (3.93±0.39 cm), fresh bulb weight was found highest in T2 (14.32±0.39 gm) and total bulb yield was found highest in T2 (7.16±0.19 t/ha) which were significant at 5 % level of significance. The total bulb yield was found positively correlated (r=0.53) with diameter of bulb at 1 % level of significance. The benefit cost (B/C) ratio was found highest in T2 (1.54) and lowest in T3 (1.28). So 75% Urea and 25 % Poultry Manure stood one of the best combinations of nitrogen fertilizers providing higher economic yields.

Keywords: Garlic; Poultry manure; Urea; Bulb; Clove; Benefit cost ratio.

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INTRODUCTION

Garlic (*Allium sativum L.*) is the most important vegetable crop belonging to the family Alliaceae. Among various *Allium sps.*, crop garlic ranks second next to onion in the world (Voigt, 2004). In Nepal, the total area under garlic cultivation was 7205 ha in 2016/17 with production of 45390 mt and productivity was 6.3mt/ha (MoAD, 2016/17). Garlic is one of the main Allium vegetable crops in the world, which is used as a seasoning in many foods throughout the world. The oil of garlic is volatile in nature and contains Sulphur combining compounds that is responsible for its strong odor, unique flavor and pungency as well as for the benefit of health (Salomon, 2002). It is a multiple bulb, which consists of 6 – 20 smaller bulblets or segments called cloves. These cloves are covered with a protective thin membraneous sheath (Brewster,1994). Generally, a fresh bulb of garlic is composed of moisture (62.8%), protein (6.3%), fat (0.1%), fibre (0.8%) and is a good source of carbohydrates, Vitamin C, Selenium, Phosphorus and Manganese (Pamplona-Roger,2001). Many people perceived and appreciated garlic for its many medicinal attributes (Rabinowitch & Currah, 2002) as it is used for the treatment and control of various diseases like hypertension, worms, germs, bacterial and fungal diseases, diabetes, cancer, ulcer, rheumatism etc. (Kilgori *et al.*, 2007; Samavatean *et al.*, 2011).

For successful commercial cultivation of this crop, many factors such as climate, soil, irrigation, fertilizer and nutrient management, spacing, season of sowing, etc. should taken in consideration. Among these all management practices, fertilizer and nutrient management plays an important role for proper growth, yield and quality of the crop. Different nutrients like nitrogen, phosphorus, potassium, calcium, sulfur, etc. These nutrient sources can be supplied through the application of organic or inorganic fertilizers. Inorganic fertilizers make the quick release of the nutrients and results the maximum growth and yield of crops. Similarly, organic manure (poultry, cow, goat manure, vermicompost, etc.) use also results better yield of garlic crops as they acts as a store house of several macro, micro and plant growth regulators which are released during the process of mineralization to release plant nutrients present in the soil it increases the fertilizer use efficiency (Yadav, Bairwa & Gurjar, 2017).

Nitrogen is one of the major essential nutrients elements that contribute a lot for the production of crops. The crop growth and yield greatly depend on supply of soil N and its proper management (Saseendran *et al.*, 2004; Adhikari *et al.*, 2016). The rate, time and method of nitrogen (N) fertilizer application are strongly related to growth, development, and yield of a crop (Shrestha *et al.*, 2018). Imbalanced and poorly monitored nitrogen application limits yields and induces large losses of reactive nitrogen to the environment. (Cassman *et al.*, 2002). Nitrogen increased the rates of leaf initiation and extension of garlic in early growth (Garcia, 1980; Koltunov, 1984). It improved bulb growth and development (Buwalda & Freeman, 1987; Fritsch *et al.*, 1990; Hossain, 1997; Garcia, 1980). The dry matter production of bulb and bulb yield increased due to nitrogen application (Hedge, 1988). The positive and significant response of garlic to applied nitrogen has also been reported by many authors (Brabma and Yousuf, 2008; Talukder *et al.*, 2000; Uddin, 1993; Setty *et al.*, 1989; Soto, 1988).

Though agricultural productivity in general is constrained by several factors such as soil

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fertility, pests and diseases, Mbah (2006) asserts that soil fertility is a major superseding constraint that affects all aspects of crop production. As is the case in other regions in Nepal, local farmers use inadequate nutrient inputs, inappropriate quality and inefficient combinations of fertilizers, which in the end prove to be very costly. A consequence of this trend is a deeply unbalanced soil nutrient composition that ultimately leads to a reduction in crop yield potential (Tonfack *et al*., 2009).This research had been conducted in order to assess the efficacy of different combinations of poultry manure and Urea as the nitrogen fertilizer in the growth and yield of Garlic (*Allium sativum*) so that to provide the recommendations and suggestions to the farmers to make the economic combinations of organic manure and fertilizer to increase the productivity of Garlic.

MATERIALS AND METHODS

Experimental site and Design

The field experiment was carried out Horticulture farm of Agriculture and Forestry University, Chitwan, Nepal from December 2017 to May 2018 in randomized complete block design (RCBD) with five treatments (Table 1) and was replicated fourth. The soil of the experimental field was taken before the experiment and analyzed for different physical, textural and chemical properties and found that the crop was suitable to grow from the different aspects of soil (Table 2). Amounts of fertilizers for each treatment were calculated based on recommended dose of fertilizer for garlic i.e. 236:236:79 NPK Kg ha^{-1} (MoAD 2016/17) and NPK content of the respective fertilizer (Table 3). The treatments were designed with the different composition or ratio of poultry manure and urea in such a way that application of urea or poultry manure or combination of both meets the recommended dose of nitrogen required by the crop. Urea was applied in two equal splits first as basal and second as top dress at 45 DAP whereas full dose of phosphorus and potassium were applied as basal dose in the field. Similarly, the full dose of poultry manure was supplied. Nutrient content of all the fertilizers used in the experiment was tested before applying it (Table 3).

Table 1: Treatment symbols, combinations and amounts of fertilizers in each treatment

Treatment symbols	Combination of Fertilizers
T1	100% recommended dose of nitrogen through urea. (Chemical Fertilizer: 236:236:79 NPK kg ha^{-1})
T2	75% recommended dose of nitrogen through urea and 25% recommended dose through poultry manure. (Chemical fertilizer: 236:236:79 NPK kg $ha^{-1}$and Poultry manure: 15.73 ton ha^{-1})
T3	50% recommended dose of nitrogen through urea and 50% recommended dose through poultry manure. (Chemical fertilizer: 236:236:79 NPK Kg $ha^{-1}$and Poultry manure: 15.73 t ha^{-1})
T4	25% recommended dose of nitrogen through urea and 75% recommended dose through poultry manure. (Chemical fertilizer: 236:236:79 NPK Kg $ha^{-1}$and Poultry manure: 15.73 t ha^{-1})
T5	100% recommended dose through poultry manure. (Poultry manure: 15.73 t ha^{-1})

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Table 2: Physio-chemical properties of the soil of the experimental site

S.N.	Properties	Average content	Category
1.	Physical properties		-
	Sand (%)	76.1	
	Silt (%)	17.92	-
	Clay (%)	5.9	-
2.	Textural class (USDA textural triangle)	-	Sandy loam
3.	Bulk density	1.41	
4.	Chemical properties		
	Soil pH	5.64	Slightly Acidic
	Soil organic matter (%)	3.27	Medium
	Total nitrogen (%)	0.16	Medium
	Available phosphorus (kg ha^{-1})	46.33	Medium
	Available potassium (kg ha^{-1})	160.8	Medium

(Source: Lab test report)

Table 3: Nutrient content of different organic fertilizers

S.N.	Fertilizers	Nitrogen (%)	Phosphorus (%)	Potash (%)
1	FYM	0.65	0.51	1.05
2	Urea	46	-	-
3	MoP	-	-	60
4	SSP	-	16	-
5	Poultry Manure	1.5	0.9	0.5

(Source: Lab test report)

Cultural practice

Local variety of garlic crop collected from farmers of Chitwan was used to carry out experiment. Planting material used for sowing was cloves of garlic. Healthy and disease free bulbs of garlic were taken and broken down to the separate cloves. The required amount of healthy and uniform size cloves were taken for sowing. During sowing, plant to plant distance of 10cm and row to row distance of 20cm was made. About 150 numbers of cloves were sown in each plot. And all other scientific practices of cultivation of Garlic were done.

Collection of data and analysis

For the collection of data, 15 sample plants were selected and were tagged from each plot containing 150 plant populations. The data regarding to the plant height, number of cloves, diameter of bulbs and fresh bulb weight were taken from those sample plants along with economic analysis were done by the following methods:-

Plant Height: The height of plant was taken from crown region to its tip by using the geometric scale at 15 DAP (days after planting), 30 DAP and 45 DAP respectively.

Diameter of Bulb: The diameter of bulb of garlic was taken by using vernier caliper after harvesting of plant.

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Number of Cloves: The numbers of cloves were taken from each bulb through manual method by breaking the bulbs.

Fresh bulb weight: The weight of fresh bulbs was taken by the use of weighing machine.
The data collected in the experiment were statistically analyzed with R-STAT. Analysis of variance (ANOVA) was done on every measured parameter to determine the significance of differences between means of treatments. Means for each parameter were separated by the Duncan's multiple range test (DMRT) and the treatment means were compared by the Least Significant Difference (LSD) test at 5% level (Gomez & Gomez, 1984; Shrestha, 2019).

Economic analysis: For the economic analysis, cost of cultivation was recorded for all treatments according to the market price at experimental site during the research time. Price of fresh weight garlic bulbs was $ 1.8/ kg (1$= NRs.106). Keeping this market price, total gross return was calculated. Similarly, benefit-cost ratio (B/C) ratio was calculated by dividing gross return by cost of cultivation.

RESULTS AND DISCUSSION

Plant Height

In case of plant height, there was no any significant difference among the different treatments. At 15 DAP (days after sowing) the plant height was found highest for 75% urea+ 25% poultry manure (13.51 cm), which was statistically at par with all other treatments 100% urea(13.28 cm), 100% poultry manure (13.10 cm), 25% urea+ 75% poultry manure (13.04 cm) and 50% urea+ 50% poultry manure (12.97 cm) respectively. At 30 DAP, the plant height was found highest for 75% urea+ 25% poultry manure (19.19 cm), which was statistically at par with all other treatments 25% urea+ 75% poultry manure (18.58 cm), 50% urea+ 50% poultry manure (18.51 cm), 100% poultry manure (18.44 cm) and 100% urea(18.38 cm) respectively. At 45 DAP, the plant height was found highest for 100% urea(42.64 cm), which was statistically at par with all other treatments 100% poultry manure (42.16 cm), 75% urea+ 25% poultry manure (42.09 cm), 25% urea+ 75% poultry manure (40.59 cm) and 50% urea+ 50% poultry manure (40.13 cm) respectively (Table 4).

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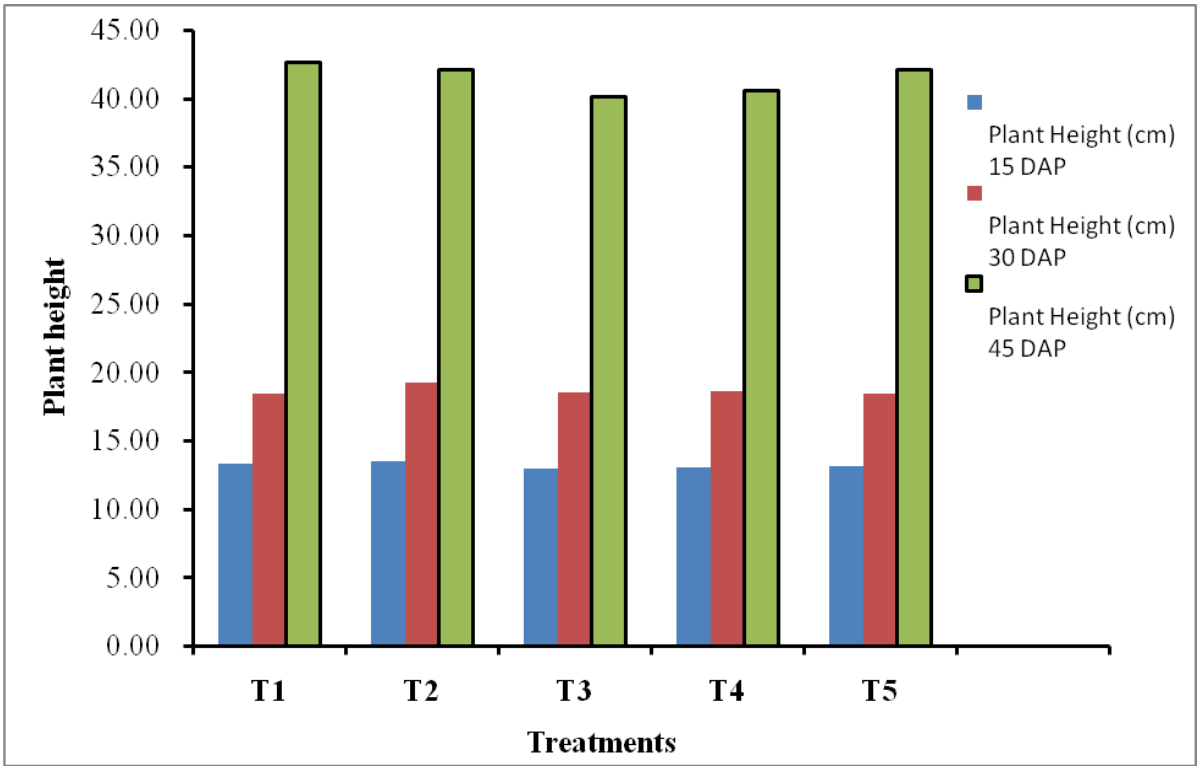

Figure 1: Effect of different treatments on plant Height of garlic at 15, 30 and 45 Days after planting (DAP) respectively.

Cloves number

There was significant effect of different fertilizer ratio on cloves number of garlic. The number of cloves was found significantly highest in 100% poultry manure (24.69), where 100% recommended nitrogen dose was supplied through poultry manure, followed by 25% inorganic fertilizer+ 75% poultry manure(23.65), where recommended nitrogen dose was supplied through 75% poultry manure and 25% through inorganic fertilizer. Lowest numbers of cloves was found in 50% inorganic fertilizer + 50% poultry manure (18.85) where recommended nitrogen dose was supplied through 50% poultry manure and 50% through inorganic fertilizer (Table 4). The high number of cloves in treatment with 100% poultry manure could also be attributable to the fact that organic manures improves both physical and chemical soil properties (Yahaya, 2008). Similar, finding was reported by Adewale (2011) and Zakari *et al.*, (2014). Sevak *et al.*, (2012) have also reported the highest number of cloves per bulb in garlic in treatment supplied with recommended dose of nitrogen fully through poultry manure.

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Table 4: Effect of different treatments in the plant height and number of cloves in garlic at Rampur, Chitwan

Treatments	Plant Height (cm)			Cloves Number
	15 DAP	30 DAP	45 DAP	
T1	13.28^{a}±0.71	18.38^{a}±0.25	42.64^{a}±1.58	20.84^{bc}±0.79
T2	13.51^{a}±0.83	19.19^{a}±1.11	42.09^{a}±4.07	20.39^{bc}±2.41
T3	12.97^{a}±0.49	18.51^{a}±0.73	40.13^{a}±1.50	18.85^{c}±2.02
T4	13.04^{a}±0.87	18.58^{a}±1.29	40.59^{a}±3.65	23.65^{ab}±4.30
T5	13.10^{a}±0.69	18.44^{a}±0.89	42.16^{a}±2.93	24.69^{a}±1.30
F-test	NS	NS	NS	*
LSD	1.18	1.21	4.79	3.42
SEM(±)	0.38	0.39	1.55	1.10
CV (%)	5.79	4.22	7.49	10.2

*(Figure in a column having common letter(s) does not differ significantly at 5% level of significance by DMRT (mean ± standard deviation) * indicates significant at 5 % level of significance.)*

Bulb diameter

There was significant difference on the bulb diameter due to various combinations of fertilizers. The diameter of bulb was found significantly highest in 75% urea + 25% poultry manure (3.93 cm) which was statistically at par with 100% urea (3.58 cm) and lowest in 25% urea + 75% poultry manure (3.25 cm) which was statistically at par with 50% urea + 50% poultry manure (3.39 cm), 100% poultry manure (3.45 cm) and 100% urea (3.58 cm) respectively (Table 5). The maximum bulb diameter in 75% urea+ 25% poultry manure might be due to proper supply of required nutrients that are required for the enlargement of bulb. Similar result was obtained by Kumar *et al.,* (2019). Sevak *et al.,* (2012) have also reported the highest bulb diameter in combined application of organic and inorganic fertilizer in garlic crop.

Fresh bulb weight

Bulb weight is an important yield contributing character for garlic. Bulb weight of garlic was influenced by different doses of poultry manure in combinations with inorganic nitrogenous fertilizer at maturity stages (Table 5).The weight of fresh bulb was found significantly highest for 75% urea+ 25% poultry manure (14.32 g) which was statistically at par with 100% urea(13.49 g) and lowest in 25% urea+ 75% poultry manure (11.37 g) which was statistically at par with 50% urea + 50% poultry manure (11.67 g), 100% poultry manure (12.01 g) and 100% urea(13.49 g) respectively (Table 5). This might be due to the combined supply of organic and inorganic fertilizer that maintain the soil fertility, availability of nutrients and microbial activities resulting in better growth and increase in bulb weight. The similar result was reported by Kumar *et al.,* (2019). Yadav *et al.,* (2017) had also reported maximum bulb weight in combined application of organic and inorganic fertilizer in garlic crop.

Total bulb yield

The total bulb yield was found significantly highest for 75% urea+ 25% poultry manure (7.16 t/ha) which was statistically at par with 100% urea(6.74 t/ha) and lowest in 25% urea+ 75% poultry manure (5.68 t/ha) which was statistically at par with 50% urea + 50% poultry manure (5.84 t/ha), 100% poultry manure (6.01 t/ha) and 100% urea(6.74 t/ha) respectively

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(Table 4). Reddy and Reddy (2005) has also reported increased bulb yield in the combined supply of organic and inorganic fertilizer in onion crop. Similarly, Singh *et al.*, (2012) in garlic also found that combined application of organic manure and fertilizers increased the overall growth of crop and finally the total yield in garlic.

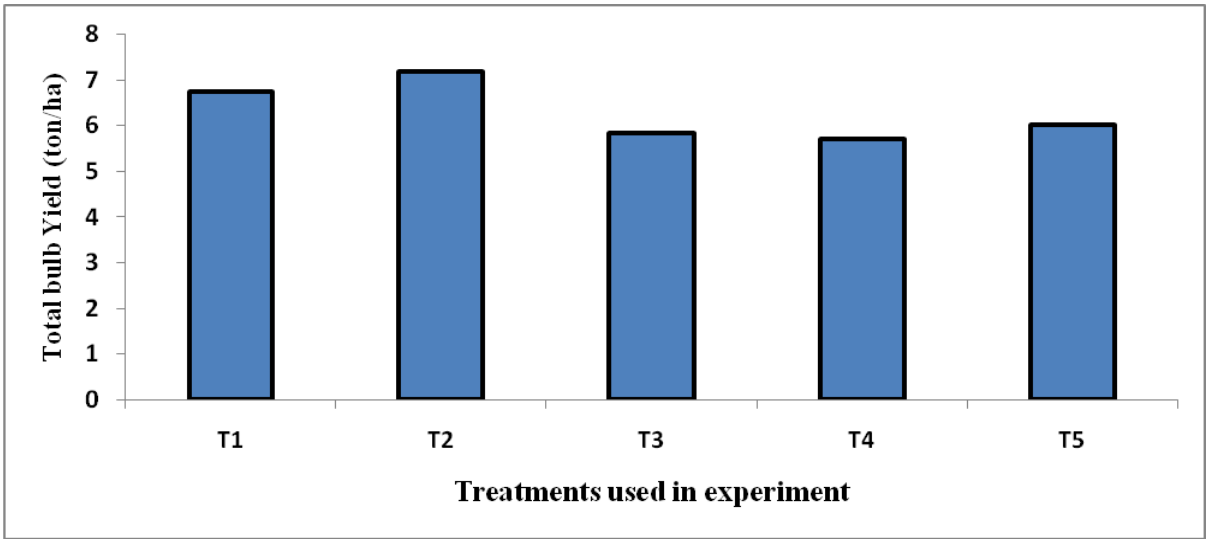

Figure 2: Effect of different treatments on total bulb yield (ton/ha) at Rampur, Chitwan.

Table 5: Effect of different treatments on bulb diameter, fresh bulb weight and total bulb yield of Garlic at Rampur, Chitwan

Treatments	Bulb Diameter (cm)	Fresh bulb Weight (gm)/plant	Total Bulb Yield (t/ha)
T1	3.58^{ab}±0.28	13.49^{ab}±0.42	6.74^{ab}±0.21
T2	3.93^{a}±0.39	14.32^{a}±0.39	7.16^{a}±0.19
T3	3.39^{b}±0.45	11.67^{b}±0.75	5.84^{b}±0.38
T4	3.25^{b}±0.32	11.37^{b}±1.61	5.68^{b}±0.81
T5	3.45^{b}±0.39	12.01^{b}±2.17	6.01^{b}±1.089
F-test	*	*	*
LSD0.05	0.43	2.14	1.07
SEM(±)	0.14	0.69	0.34
CV (%)	8.09	11.1	11.1

*(Figure in a column having common letter(s) does not differ significantly at 5% level of significance by DMRT (mean±standard deviation) * indicates significant at 5% level of significance.)*

3.6 Correlation between the growth and yield attributes

There was significant positive correlation(r=0.53) between the fresh bulb weight and bulb diameter at 1 % level of significance (Table 6). Fresh bulb weight was positively correlated with plant height but negatively correlated with number of cloves.

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Table 6: Simple correlation coefficient among the growth and yield attributes of garlic at Rampur , Chitwan

Parameters	*PH*	*BD*	*CLN*	*WF*
PH	1	0.12	0.015	0.13
BD		1	-0.44	0.53**
CLN			1	-0.097
WF				1

*(** indicates 1% level of significance. Here PH, BD, CLN, WF represent plant height, bulbs diameter, cloves number and fresh bulb weight respectively.)*

Economic analysis of different treatments

Amongst the various treatments, the highest gross return was obtained in 75% urea+ 25% poultry manure ($12890.16) followed by 100% urea($12136.50), 100% poultry manure ($10811.16), 50% urea+ 50% poultry manure ($10503.00) and 25% urea and 75% poultry manure. Similarly, the benefit: cost ratio (B/C) was observed from 1.28 to 1.54. Among the fertilizer treatments, highest B/C ratio was obtained highest in 75% urea+ 25% poultry manure (1.54) followed by 100% poultry manure (1.44), 100% urea(1.43), 25% urea+ 75% poultry manure (1.31) and 50% urea+ 50% poultry manure (1.28). The treatment 75% urea+ 25% poultry manure was found most economically efficient than other fertilizer treatment(Table 7). Similar result has been reported by Chandrashekhar S. Arahunashi (2011) in tomato.

Table 7: Economic analysis of different treatments in yield of Garlic at Rampur, Chitwan

Treatments	Cost of Cultivation ($/ha)	Yield(ton/ha)	Gross return($/ha)	B/C ratio
T1	8500	6.74	12136.50	1.43
T2	8350	7.16	12890.16	1.54
T3	8225	5.84	10503.00	1.28
T4	7800	5.68	10233.00	1.31
T5	7500	6.01	10811.16	1.44

CONCLUSION

Application of 3.93t/ ha of poultry manure was found to be useful to reduce 25% inorganic N in garlic cultivation. For yield maximization, poultry manure @ 3.93 t/ ha along with 75% recommended dose of inorganic N appeared to be the best in respect of fertility management by enriching the soil with organic matter and turning vegetable cultivation towards organic farming. Replacing the chemical fertilizers by poultry manure will considerably benefit the farmers both economically and ecologically.

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Authors contribution

H. P. Sitaula	Performed experiment, analyzed data and wrote the paper
R. Dhakal	Performed experiment, analyzed data and wrote the paper
C. Bhattarai	Performed experiment, analyzed data and wrote the paper
A. Aryal	Performed experiment, analyzed data and wrote the paper
D. Bhandari	Performed experiment, analyzed data and wrote the paper

Conflict of interest

The authors declare that there are no conflicts of interest regarding publication of this manuscript.

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