Environment and Ecology 40 (4A) : 2277—2281, October—December 2022
ISSN 0970-0420

Performance of Garlic in North Western Himalayas: Comparative Assessment to Integrated Nutrient Management Practices

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Received 29 June 2022, Accepted 6 September 2022, Published on 4 November 2022

ABSTRACT

The present study was carried out on garlic cv. Kandaghat Selection in a Randomized Block Design with three replications. The experiment included thirteen treatments using various nutrient sources, such as organic manures and inorganic fertilizers. On the yield and soil nutrients of garlic, the effects of organic manures (farmyard manure, vermicompost and jeevamrit) alone and in combination with inorganic fertilizers were examined. The yield and soil nutrients of the crop were significantly impacted by the combined use of organic manure and inorganic fertilizers. According to the findings, there was a maximum bulb yield per hectare of 19.94 t/ha, as well as a viable microbial count of 197.64, 104 cfu/g of soil and available NPK of 397.48, 44.89 and 367.91 kg/ha. Our results might clarify the function of organic and inorganic fertilizers in sustaining soil fertility and consequently, enhancing crop production and nutrient uptake.

Keywords Farmyard manure, Jeevamrit, Garlic, Inorganic fertilizers, Yield.

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INTRODUCTION

Garlic (*Allium sativum* L.) is the species of *Allium* that is most widely cultivated and is a member of the Amaryllidaceae family. In terms of production and monetary value, it is one of the most well-known *Allium* vegetable crops in the world. It covers 1634 thousand hectares worldwide and produces 307,08 million metric tonnes (Anonymous 2019). In India, garlic is grown on 3.52 lakh hectares with a production of 2.94 million metric tonnes (Anonymous 2019), whereas it is grown on 7.19 thousand hectares in Himachal Pradesh with a production of 11.60 billion tonnes (Anonymous 2020). Heavy feeders, bulbous crops require adequate levels of nitrogen, phosphorous, potassium and sulfur, among other nutrients. If these nutrients are lacking in the soil, it can negatively affect bulb growth, production and quality (Chauhan *et al*. 2022). Garlic with a high yield and good quality can be produced with the effective and balanced use of organic and inorganic components. Poor nutrient management is a major contributor to low yield.

The sustainability of the system is currently in suspect following a magnificent increase in productivity brought on by various inputs used during the green revolution (Sandhu *et al*. 2020). The maintenance of soil health as well as the resolution of issues with sustainable crop productivity are made possible by effective nutrient management. Additionally, it facilitates in detecting any emerging nutrient deficiencies in plants. The problems of an increase in the cost of inorganic fertilizers and a decline in the fertility and productivity of the soil can be solved by the appropriate and integrated use of suitable nutrients through organic fertilizers alone or in conjunction with them. The term “integrated nutrient management” (INM) refers to a strategy for balancing soil fertility and giving plants the right amount of nutrients by using both organic and inorganic sources (Singh and Sadawarti 2021). The crop yield is increased by the application of nitrogen, phosphorus, and potassium (NPK) and manure, which suggests that INM has a positive impact on the increase in nutrient availability (Singh *et al*. 2021). Sulfur is the fourth most crucial nutrient for plants, behind nitrogen, phosphorus, and potassium. It is necessary for the production of certain enzyme systems in plants, as well as the synthesis of amino acids like cystine (27%) and cysteine (26%) and a component of vitamin (Havlin *et al*. 2004). Low bulb crop yields have frequently resulted from soil sulfur deficiencies because macro and micro-nutrients are not properly utilized. According to Thomas *et al*. (2000), sulfur stimulates plant growth when it is present in sufficient amounts in the soil. It also helps vegetables retain less cancer-causing substances like nitrates. Garlic plant growth and yield are significantly influenced by zinc, an essential component and activator of many enzymes involved in auxin biosynthesis and photosynthesis. The most prevalent micronutrient deficiency in Indian soils is zinc (Prusty *et al*. 2020). Due to its high-quality output, environmental safety, and lucrative livelihood, organic farming has become more popular in India in recent years (Thangasamy *et al.* 2018).

In addition to enhancing the soil with native microorganisms, the use of conventional farm-based products like jeevamrut, FYM and VC has also accelerated the mineralization of the soil’s nutrients (Amareswari and Sujathamma 2014). Since FYM production is simple at the farm level, there is good potential for its use as an organic source (Ali *et al.* 2020). The conversion of organic waste into useful nutrients is why earthworm rearing is becoming a significant industry (Hussain *et al*. 2018). By reviving helpful soil microbes and substances that promote plant growth, jeevamrut application increases the availability of nutrients (Gore and Sreenivasan 2011) and (Ukale *et al*. 2016). In order to maintain high yields and ensure environmental safety, integrated nutrient management envisions the use of chemical fertilizers alongside organic manures, green manures, crop residues, legumes and locally accessible resources in a cropping system. Therefore, an integrated use of inorganic and organic source of plant nutrients is to be practiced to maintain soil fertility in order to supply plant nutrients in balanced proportion for the best growth, yield and quality of crop under various agro-ecological situations. The full potential of a crop can only be judged when the nutrient supply system includes both organic sources and synthetic fertilizers.

MATERIALS AND METHODS

The present study has been conducted during the 2019–20 *rabi* at the Department of Vegetable Science Experimental Farm at the Dr YS Parmar University of Horticulture and Forestry in Nauni, Solan (HP). An experiment with three replications and thirteen treatments was set up using a Randomized Block Design (Table 1). FYM was applied to each plot at a rate of 250 q/ha (Except T_1). 10 kg of cow dung and 10 l of cow urine were mixed in 100 l of water for

Table 1. Treatment details.

Treatment code	Treatment details
T_1	Absolute control
T_2	100% RDN (125:75:60 kg per hectare of NPK)
T_3	90% RDN + 10% RDN through vermicompost
T_4	80% RDN+ 20% RDN through vermicompost
T_5	100% RDN + Zn @ 5kg/ha
T_6	100% RDN + Zn @ 7.5kg/ha
T_7	75% RDN + Zn @ 5kg/ha + 5% Jeevamrit @ 1l/m^2
T_8	75% RDN + Zn @ 7.5kg/ha + 5% Jeevamrit @ 1l/m^2
T_9	100% RDN + S @ 40kg/ha
T_{10}	100% RDN + S @ 50kg/ha
T_{11}	75% RDN + S @ 40kg/ha + 5% Jeevamrit @ 1l/m^2
T_{12}	75% RDN + S @ 50kg/ha + 5% Jeevamrit @ 1l/m^2
T_{13}	75% RDN + Zn @ 5kg/ha + S @ 40kg/ha + 5% Jeevamrit @ 1l/m^2

Table 2. Methods used for the determination of nutrients in soil.

Soil parameters	Method used
Soil pH	Digital pH meter (Jackson 1973)
Soil EC	Electrical conductivity meter (Jackson 1973)
Organic Carbon (%)	Rapid titration method (Walkley and Black 1934)
Available N (kg/ha)	Alkaline potassium permanganate method (Subbiah and Asija 1956)
Available P (kg/ha)	Olsen's method (Olsen *et al*. 1954)
Available K (kg/ha)	Neutral normal ammonium acetate (Merwin and Peech 1951)
Available sulphate Sulfur (kg/ha)	0.15% $CaCl_2$ extractant and turbidimetric method (Chesnin and Yien 1950)
Zinc mg/kg	DTPA extractable method (Lindsay and Norvell 1978)

about a week to produce the jeevamrit, which contains 1.42% N, 0.98% P and 0.09% K. After 15 days of sowing, the first jeevamrit is drenched, then it is repeated every two weeks (total 14 applications). To examine the characteristics of plant growth and yield, ten randomly selected plants from each treatment were tagged. The approaches listed (Table 2) were used to determine the nutrients.

RESULTS AND DISCUSSION

All inorganic and organic fertilizer treatments produced considerably more bulb yield than the control during the study year (Table 3). The data showed that 75% RDN + Zn @ 5kg/ha + S @ 40kg/ha + 5 % Jeevamrit @ 1 l/m^2, or T_{13}, recorded the highest bulb yield per hectare (19.94 t/ha), which was followed by 100% RDN + S @ 50kg/ha, or T_{10}, at 19.45 t/ha. According to Assefa *et al*. (2015), fertilizing plants with N, P, S and Zn increases yield. This finding may be related to the combined effects of N's contribution to chlorophyll, enzymes and protein synthesis, as well as P's contribution to root growth, phosphor-proteins, and phospholipids. For cost-effective physibility, NPK fertilization in a balanced ratio is therefore necessary. According to Kurubetta *et al*. (2017) jeevamrit application significantly affects yield parameters like bulb weight, bulb diameter and clove number.

Table 3. Effect of integrated nutrient management on yield and soil fertility of garlic.

Treatment code	Treatment details	Bulb yield/ha (t)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Available S (kg/ha)	Available Zn (mg/kg)	Viable bacterial count ×104 cfu/g of soil
T_1	Absolute control	13.28	257.24	24.12	302.24	21.26	1.42	98.00
T_2	100% RDN (125:75:60 kg per hectare of NPK)	15.83	354.06	34.59	324.76	31.72	1.67	138.14
T_3	90% RDN + 10% RDN through vermicompost	16.45	356.22	35.86	330.43	33.96	1.71	165.26
T_4	80% RDN+ 20% RDN through vermicompost	17.06	354.69	35.33	326.7	33.41	1.78	173.84
T_5	100% RDN + Zn @ 5kg/ha	17.88	360.84	38.75	340.58	35.06	2.15	142.44
T_6	100% RDN + Zn @ 7.5kg/ha	18.27	364.26	41.26	345.23	36.91	2.23	144.07
T_7	75% RDN + Zn @ 5kg/ha + 5% Jeevamrit @ 1 l/m^2	16.11	366.84	36.09	352.74	34.12	2.46	176.11
T_8	75% RDN + Zn @ 7.5kg/ha + 5% Jeevamrit @ 1 l/m^2	17.62	376.52	36.91	355.39	35.24	2.79	180.00
T_9	100% RDN + S @ 40kg/ha	19.16	365.23	43.26	347.24	42.34	1.75	148.28
T_{10}	100% RDN + S @ 50kg/ha	19.45	370.58	44.26	349.16	47.43	1.82	152.21
T_{11}	75% RDN + S @ 40kg/ha + 5% Jeevamrit @ 1 l/m^2	18.70	379.22	39.21	358.24	43.75	1.89	189.29
T_{12}	75% RDN + S @ 50kg/ha + 5% Jeevamrit @ 1 l/m^2	18.80	386.25	39.72	364.4	49.26	1.93	194.48
T_{13}	75% RDN + Zn @ 5kg/ha + S @ 40kg/ha + 5% Jeevamrit @ 1 l/m^2	19.94	397.48	44.89	367.91	48.47	2.62	197.64
	CD (0.05)	0.60	12.12	1.67	12.43	1.75	0.09	7.12

Manjutha *et al*. (2009) reported comparable outcomes in terms of increased yield. However, Chadha *et al*. (2012) found that applying jeevamrit as a foliar spray increased crop productivity and effectiveness against different plant pathogens.

Under 75% RDN + Zn @ 5 kg/ha, S @ 40 kg/ha, and 5% Jeevamrit at 1 l/m^2, the significantly highest available NPK content (397.48, 44.89 and 367.91 kg/ha) was revealed. Zinc addition to organic manures may have increased microbe growth, which may have catalyzed the transformation of organically bound nitrogen to inorganic form, increasing the amount of nitrogen that was available in the soil under treatment T_{13}. Favorable soil conditions produced by microbes may have facilitated in the mineralization of soil nitrogen that is available to plants, increasing the amount of nitrogen that is present in the soil (Vipinkumar and Prasad 2008). According to Devakumar *et al*. (2011), the growth of bacteria that can disintegrate nitrogen and phosphorus in soil may have been facilitated by fermented liquid organic manure like jeevamrit. In locally accessible farm manures like FYM and cow urine, which are used to make these organic liquid manures, Sreenivasa *et al*. (2010) observed naturally occurring microorganisms (bacteria, fungi and actinomycetes). It is patently obvious that the crop only utilizes 25 to 30 % of the applied phosphorus, with the rest remaining in the soil due to its inaccessibility. Inorganic fertilizers like nitrogen, phosphorus, and potassium may have increased the amount of phosphorus in the soil. This might be because inorganic fertilizers make nutrients more accessible. Similar results were reported by Fouda (2017) as well. Additionally, potassium availability in the soil may have been improved by zinc. This might be the case because increasing the amount of phosphorous in the soil after adding zinc improved soil conditions. The results of the present study are consistent with those from Khatemenla *et al*. (2018). Under 75% RDN + S @ 50 kg/ha + 5% Jeevamrit @ 1 l/m^2, or T_{12}, the maximum available sulfur content (49.26 kg/ha) was observed. By increasing the population of sulfur-eating microorganisms and accelerating the conversion of sulfur that is organically bound to the inorganic state, or sulfate, sulfur application may have increased the amount of available sulfur (SO_4^{2-}). Similar conclusions were attained by Chandel *et al*. (2012), Margray *et al*. (2017) and Singh *et al*. (2018). Significantly, T_8 had the highest Zn content (2.79 mg/kg) at 75% RDN + Zn at 7.5 kg/ha + 5 % Jeevamrit @ 1 l/m^2. By directly applying zinc fertilizes to the soil, Treatment T_8 may have increased the soil's zinc content. Because zinc is more water soluble and thus more accessible, it's also possible that its effects could be seen in the DTPA extractable micronutrient content of soil. Zinc availability in soil is determined in part by its solubility in water, according to Slaton *et al*. (2005).

Maximum viable bacterial count (197.64, 104 cfu/g of soil) was found under 75% RDN + Zn @ 5 kg/ha, S @ 40 kg/ha and 5 % Jeevamrit at 1 l/m^2, or T_{13}. According to Jeeny and Malliga (2016), the presence of jeevamrit increased the number of bacteria present. Liquid manures contain more enzymes, vitamins, and growth hormones than solid manures do. Better root growth may have increased soil microbial activity, which in turn increased the number of fungi and bacteria in the rhizosphere.

CONCLUSION

The integration of organic and inorganic fertilizer, specifically 75% RDN + 5% Zn + 40% S + 5% Jeevamrit @ 1 l/m^2 T_{13}, had a significant impact on soil fertility and crop productivity, according to the results. In order to increase soil fertility and garlic yield, it may be important to combine the use of organic and inorganic fertilizers, according to our findings.

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