**Conjoint effect of organic and inorganic amendments on yield, yield contributing characters, quality, soil nutrient and nutrient uptake in garlic (*Allium sativum* L.)**

 **ABSTRACT**

**The present study was undertaken with the objective** to evaluate the effect of different combinations of organic and inorganic fertilizers on growth, yield attributes, nutrient uptake, and quality of garlic (*Allium sativum* L.). Field experiments were conducted during the *Rabi* seasons of 2016 and 2017. Treatments included combinations of FYM, vermicompost (applied based on nitrogen equivalency to FYM), *Jeevamrit* (a traditional organic biostimulant), and recommended doses of NPK fertilizers. Among the treatments, the integrated application of 50% recommended FYM (125 q/ha) + 50% vermicompost (equivalent to the N content of 50% FYM) as a basal dose at field preparation, along with *Jeevamrit* (applied fortnightly), and 50% Recommended Dose of Fertilizers (RDF) of NPK, resulted in the best performance. This treatment significantly improved bulb weight, bulb diameter, yield per plot and per hectare, weight of 100 peeled and unpeeled cloves, peeling index, oleoresin content, dry matter content, soil nitrogen levels, and potassium uptake by plants. It also showed second-best performance in parameters such as the number of leaves per plant and number of cloves per bulb. No disease incidence was observed during the study period. Based on these results, the integration of 50% FYM + 50% vermicompost + *Jeevamrit* + 50% RDF of NPK is recommended for maximizing garlic yield and improving quality, with a suggestion to validate the findings through similar trials over the next two years.

**Key words: Integration, *Jeevamrit*, *Beejamrit*, Vermicompost, Garlic, B: C ratio**

# INTRODUCTION:

It is a well-established fact that the use of fertilizers help in increasing production and achieving maximum yields (Kumar *et al.* 2014). “The present farming system totally depends on use of chemical fertilizers, pesticides and growth regulators for enhancing crop productivity which gradually culminated in a situation where there is a need to reconsider the alternative to chemical agriculture developed in the western world” (Shukla, Y. R., Kaushal, M., & Shilpa, V. I. J. 2018). Modern agriculture largely depends on the use of chemical fertilizers but chemical fertilizers are jeopardizing the environment through nitrate poisoning and exterminating soil micro-flora by adversely altering the chemical and physical properties of soil. This has created huge problems and agriculture in India ceases to be sustainable. Moreover, the use of expensive commercial fertilizers as per the requirement of the crop is not much affordable to the average farmers, being costly and at times not readily

available. An alternative horticulture system which will help to overcome the problem of soil degradation and declining soil fertility and crop yield is integrated nutrient management (INM). “High yield and good quality of garlic can be obtained through efficient and balanced use of organic and inorganic compounds. Therefore, the importance of integrated nutrient management in sustaining productivity is emphasized to restore and sustain soil health and productivity in the long run which otherwise is likely to deteriorate due to continuous and intensive cultivation without adequate nutrient management” (Kumar, P., et al., 2019).

“Organic farming is gaining importance in view of sustained agriculture and maintaining ecological balance. It is also finding a place in the mainstream of development and shows great promise commercially, socially and environmentally. It is based on a simple principle of utilizing cheap and local inputs with zero utilization of chemicals like fertilizer, herbicide, pesticide, antibiotic, hormone etc. in any form. Organic manures can be used to promote the healthy population of beneficial organisms in the soil” (Jaipaul *et al.* 2011). “*Jeevamrit* is a low cost improvised preparation that enriches the soil with indigenous microorganisms required for mineralization of the soil” (Gore *et al.* 2011). “It is a time tested practice to use cow based products in agriculture. The research on vegetable crops confirms that VC improves seed germination, seedling vigor, plant growth, flowering, fruiting, tuberization, root development, color, shelf-life, and quality of the economic produce” (Alam *et al.* 2007; Ansari, 2008; Arguello *et al.* 2006; Atiyeh *et al.* 2000; Gupta, Pankaj, and Upadhyava 2008; Peyvast *et al.* 2008; Premsekhar and Rajashree 2009; Surendra, Choyal, and Sushma 2005). Integrated nutrient management envisages the use of chemical fertilizers in conjunction with organic manures, green manures, crop residues, legumes and locally available resources in a cropping system with the objectives of sustaining high yield and ensuring environmental safety. Hence, to maintain soil fertility in order to supply plant nutrients in balanced proportion for optimum growth, yield and quality of crop under different agro-ecological situations, an integrated use of inorganic and organic source of plant nutrients is to be practiced. With this objective this study was planned.

# MATERIAL AND METHOD

## Experimental site

The experimental farm of Horticultural Research and Training Station & Krishi Vigyan Kendra, Kandaghat where the field studies were conducted is located at an altitude of 1425 metres above mean sea level, having latitude of 30.59ºN and longitude of 77.07ºE. The area falls in the mid-hill zone of Himachal Pradesh, located at Ded Gharat which is 13 km away from Solan city on Kalka- Shimla National Highway and 2 km short of Kandaghat town. The laboratory studies were conducted in the Department of Vegetable Science, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni- Solan, (HP) India (PATHAK, S. 2018)

## Experimental design and treatment details

Ten combinations of different organic and inorganic amendments were replicated thrice in the form of ten treatments *viz.* T1- No application of manures and fertilizers (absolute control), T2- Recommended FYM (250q/ha) as basal dose at the time of field preparation, T3- Seed treatment with *Beejamrit* (overnight) + Recommended FYM (250q/ha) as basal dose at the time of field preparation, T4- Seed treatment with *Beejamrit* (overnight) + application of *jeevamrit* (fortnight application) + Recommended FYM (250q/ha) as basal dose at the time of field preparation, T5- Recommended FYM (250q/ha) as basal dose at the time of field preparation + application of *Jeevamrit* (fortnight application) + 50% RDF of NPK, T6- Vermi compost (Equivalent to N content of Recommended FYM) as basal dose at the time of field preparation + 50% RDF of NPK, T7- Vermi compost (Equivalent to N content of Recommended FYM) as basal dose at the time of field preparation + Application of *Jeevamrit* (Fortnight application) + 50% RDF of NPK, T8- 50% Recommended FYM (125 q/ha) + 50 % Vermi compost (Equivalent to N content of 50% FYM) as basal dose at the time of field preparation + 50% RDF of NPK, T9- 50% Recommended FYM (125 q/ha) + 50 % Vermi compost (Equivalent to N content of 50% Recommended FYM) as basal dose at time of field preparation + Application of *Jeevamrit* (Fortnight application) + 50% RDF of NPK, T10- Recommended dose of FYM (250q/ha) and NPK (125 Kg N, 75 Kg P and 60 kg K per hectare) (Control) \*Recommended dose of NPK ( 125 Kg N, 75 Kg P and 60 Kg K per hectare) in a plot with dimensions of 2 x 2m . The experiment was laid out in randomized block design with three replications involving a spacing of 20 x 10 cm (PATHAK, S. 2018).



## Figure 1: Metereological data of the experimental farm recorded during October, 2016-17 to May 2017-18

**Variety**

‘Kandaghat Selection’ variety was chosen for the studies. It is a local clonal selection from Himachal Pradesh. The plants are of long day type. Bulbs are creamish white having diameter ranging from 3.5-5.5cm. Bulbs have 13-16 yellowish white cloves having diameter of 1.1-1.7cm. The cultivar is suitable for cultivation in Northern hilly regions of India.

## Application of inorganic fertilizers

Calculated quantities of nutrients in the form of SSP and MOP were applied in individual plots before sowing of seed. Urea, however was applied in 2 equal splits; first half at the time sowing and the remaining half in two equal splits, first after one month of sowing and remaining after 1 month of first application.

## Applications of organics

Different traditional agricultural inputs based on *Vedic Krsihi* were prepared and evaluated. Flow chart shows the standardized techniques of preparing the traditional agricultural inputs namely ***Jeevamrit*** and ***Beejamrit*** as suggested by (Anonymous, 2008). ***Beejamrit* was** prepared by using Cow dung = 5g, Cow urine = 50 ml, Cow milk (fresh) = 50 ml, Lime stone = 2-3g, Water = 1L and ***jeevamrit*** prepared by using Cow dung = 5kg, Cow urine = 5L, Jaggary = 1 kg, Pulse

Jaggary

Flour = 1 kg, Fertile soil = ½ kg, Water = 50 L. No application of any pesticide was done to control insects or diseases.

**Flow chart 1: Flow chart for the preparation of *Jeevamrit***

Add fresh cow dung + cow urine in a plastic drum

Mix jaggery + pulse floor and live soil in water and make the final volume

Mix all the ingredients by stirring clockwise (morning and evening)

On fifth day, filter the solution and filtrate is ready for soil drench

*Jeevamrit* 5 per cent (5 l per 100 l of water) was applied as soil drench at fort nightly interval starting from seventh day of sowing, last application being fifteen days before harvesting

**Flow Chart 2: Flow chart for the preparation of *Beejamrit***

Take 5 g of local cow dung in a cloth and bound it by tape. Hang this in 1 L water up to 12 hours

Take 10 ml of water and add 2-3 g lime in it, let it stable down for a night

The next morning, squeeze this bundle of the cow dung in that water thrice continuously so that all essence of cow dung will accumulate in that water

Put some soil in that water solution and stir it well

Then add 50 ml deshi cow urine in that solution, add lime water and cow milk then stir it well

Soak the seeds overnight in this mixture (*beejamrit*)

Dry seeds in shade before sowing

##

##  Analysis of yield and contributing characters

The plant height was measured in centimeters from the neck of the bulb to the highest tip of the plant and the mean height was calculated. Total number of leaves of ten randomly selected plants was counted and average was worked out to calculate the mean value. The average weight of bulb was calculated by weighing ten randomly selected bulbs in each treatment and the mean value was calculated to express in grams. Bulb diameter of ten randomly selected bulbs from each treatment was recorded with the help of a vernier caliper and mean value was worked out to express in centimeters. Randomly selected bulbs from each treatment were weighed up to one kilogram and the number of bulbs in one kilogram was counted. Total weight of bulbs harvested from each plot was recorded and expressed as yield per plot. From this value, yield per hectare was calculated by multiplying with a suitable factor and expressed in quintal. Number of cloves from ten randomly selected bulbs was counted and average was worked out (PATHAK, S. 2018).

## Analysis of quality characters

The dried cloves were powdered and sieved to the finest particles. A sample of 10g of the finest particles was used for obtaining oleoresin content. The ethanol was used as a solvent and oleoresin content was determined as per standard procedure (AOAC, 1970). The solution was collected in the beaker and kept in the oven for overnight at 70ºC, so that the ethanol is evaporated and oleoresin is left in the beaker. The weight of the beaker was recorded before collecting the solution as well as after the solution has evaporated. The difference in the weight is the oleoresin content, which is then converted into percentage (PATHAK, S. 2018).

 Weight of oleoresin in the sample (g) Oleoresin (%) =  100

Weight of the powdered sample

## Disease severity (%)

The assessment of severity of purple blotch was done by visual observations and was categorized into five grades according to the scale designed by Honsfall and Barratt (1945) as detailed below:

|  |  |  |  |
| --- | --- | --- | --- |
| **Sr. No** | **Scale** | **Symptoms** | **Designation** |
| 1 | 0 | 0 % infected leaf area | Resistant (R) |
| 2 | 1 | 0-5% infected leaf area | Slightly resistant (SR) |
| 3 | 2 | 5.1-10% infected leaf area | Moderately resistant (MR) |
| 4 | 3 | 10.1-25% infected leaf area | Moderately susceptible (MS) |
| 5 | 4 | 25.1-50 % infected leaf area | Susceptible (S) |
| 6 | 5 | > 50% infected leaf area | Highly susceptible (HS) |

Table 1. Five Grades of the Disease Severity Based on Leaf Symptoms (PATHAK, S. 2018)

The per cent severity index was calculated by the formula given by Mckinney (1923) as shown below:

Sum of all disease ratings

Severity index

= Total number of leaflets in all the grades  maximum

 100

(%)

disease grade

Disease rating = Grade × Leaflets in a particular grade

## Peeling index (%)

The peeling index was computed as follows:

Weight of 100 peeled cloves

Peeling index (%) =  100

Weight of 100 unpeeled cloves

## Soil Sampling and analysis

Before laying out the experiment, random soil samples were collected from different locations at 0–15 cm depth and composite sample was prepared. Soil samples were also collected from each plot after final harvesting of crop during both the year. All the samples were processed and analyzed for pH, electrical conductivity (EC), organic carbon (OC) and available N, P, K. Soil pH was determined with the help of pH meter and EC by conductivity meter, organic carbon estimated by Walkely - Black method (1934), available N by alkaline potassium permanganate method (Subbiah and Asija 1956), available P by Olsen’s method (Olsen 1954), and available K by normal neutral ammonium acetate method (Merwin and Peech 1951).

## Nutrient Uptake

Plant samples collected at final harvest were oven dried at 65°C. The dried samples were powdered and analyzed for macro nutrients, i.e. N, P, and K. Nitrogen were analysed by by micro-Kjeldahl distillation (AOAC (1970), P and K byVanado-molybdo phosphoric yellow color method in diacid (9:4 nitric acid:perchloric acid) extract by Jackson (1973) and flame photometry (in diacid extract) by Jackson (1967), respectively.

The N, P and K content in plant (%) was then multiplied by its biomass on dry weight basis as given below for computing nutrient uptake in kg/ha.

Weight of dry plant x 10,000 Biomass (kg/ha) =

Area covered by the plant x 1000

Biomass (kg/ha) x nutrient content (%) Nutrient Uptake (kg/ha) =

100

## Viable count of bacteria present in the soil before start and after termination of experiment

Soil samples were collected from plant rhizosphere and screened through 2mm sieve. The serial dilution technique was employed for the isolation and identification of viable bacteria. The media was prepared for the estimation of desired microflora. The autoclaved and cooled (45ºC) medium was poured into sterile petri plates. The medium was then allowed to solidify. One gram of sieved (2mm) soil was added to 9 ml sterile water blank and shacked for 15-20 minutes. Serial dilutions like 10-2, 10-3, 10-4, 10-5, 10-6, 10-7 were prepared. One millilitre of aliquots of various dilutions was added over cooled and solidified medium in petri plates. These plates were rotated for uniform distribution of spores and incubated at 28º C for 3-5 days. Population count of bacteria was noted using dilution plate technique by employing nutrient agar medium as suggested by Rangaswamy (1966).

# STATISTICAL ANALYSIS

Analysis of variance for the experiment was done as per the model suggested by Panse and Sukhatme (2000).

## Results and discussion:

**Yield and yield contributing characters**

In the present findings, Table-2 maximum plant height (90.33 cm) was recorded in the treatment T8 which was at par with T10 and T9. The improvement in fertilizer’s supply resulted significant increase in plant height over control at all the stages (Kumar *et al.* 2014). The stimulating effect of NPK combination on plant height was also confirmed by Jilani *et al*. (2003). Similar are the results of Al-Madini *et al*. (2000), Abdul *et al*. (2003), Aliyu *et al*. (2007) and Islam *et al*. (2007) who concluded that increasing the application rate of NPK fertilizers increased growth parameters of onion plant. The maximum plant height as in T9 which was at par with T8 might be due the use of higher amount of nitrogen, phosphorus and potassium present in vermi compost and *Jeevamrit* which might have helped in inducing good vegetative growth and plant height (Atal, 2017). Maximum number of leaves per plant (10.57) was observed in T7 as basal dose at the time of field preparation + Application of *Jeevamrit* (Fortnight application) + 50% RDF of NPK} which was at par with T9 (10.40), T6 (10.40) and T4 (10.30). All these treatments were significantly superior over rest of the treatments and least number of leaves per plant (9.23) was recorded in T1 (absolute control). “By increasing the amount of fertilizers, there is a significant increase in number and length of leaves together with leaf area. *Jeevamrit* is a rich source of beneficial micro flora which support and stimulate the plant growth and help in getting better vegetative growth as well as good quality yield” (Devakumar, 2014).The results obtained in the present investigations confirm the earlier findings of Chattopadhyay *et al*. (2006), Gowda *et al.* (2007), Rohidas *et al.* (2011) and Puttaraju *et al.* (2011) who also reported more number of leaves and better growth of garlic and onion crops with the application of organic and inorganic sources of nutrients. Maximum bulb weight (Table 2) of 65.07 was recorded in T9 which was statistically at par with T4 (64.60g), T5 (64.13g), T8 (62.40g), T7 (62.30) and T10 (61.47g). The next best treatment was T6 (61.00g) which produced significant differences with T3 (53.20g) and T2 (49.97g) and minimum bulb weight was, however, recorded in T1 (44.24g). “The application of 50 per cent recommended dose of NPK favoured the metabolic and auxin activities in plant and ultimately resulted in increased bulb weight, bulb diameter, yield per plot (kg), clove weight, clove diameter, clove length, harvest index and finally the total yield” (Yadav *et al.* 2017). “The presence of beneficial microorganisms in the liquid formulation (*Jeevamrit*) as in T9 might be mainly due to their constituents such as cow dung, cow urine, legume flour and jaggery containing both macro and essential micro nutrients, many vitamins, essential amino acids, growth promoting substances like indole acetic acid (IAA), gibberlic acid (GA) and beneficial microorganisms which directly help to enhance the growth and development of the plants” (Sreenivasa *et al.* 2000; Palekar, 2006 and Neelima and Sreenivasa, 2011).Maximum (5.94cm) bulb diameter was recorded in treatment T9 {50% Recommended FYM (125 q/ha) + 50 % Vermicompost (Equivalent to N content of 50% Recommended FYM) as basal dose at time of field preparation + Application of *Jeevamrit* (Fortnight application) + 50% RDF of NPK} which was statistically at par with T8 (5.50cm) followed by 5.49cm in T7 {Vermi compost (Equivalent to N content of Recommended FYM) as basal dose at the time of field preparation + Application of *Jeevamrit* (Fortnight application) + 50% RDF of NPK} and 5.47 in T6 { Vermi compost (Equivalent to N content of Recommended FYM) as basal dose at the time of field preparation + 50% RDF of NPK} and all these treatments were found to be significantly better than rest of the treatments, however T1 being the treatment with the least bulb diameter (4.83cm).It appears that “the significant effect on yield parameters such as bulb weight and bulb diameter as a consequence of organic manures and chemical fertilization is due to the increased nutritional status of the soil resulting into increased growth of the crop. This may be attributed to favorable effect of organic sources on microbial activity and root proliferation in soil which cause solubilizing effect on native nitrogen, phosphorus, potassium and other nutrients. The application of 50 per cent recommended dose of NPK favoured the metabolic and auxin activities in plant and ultimately resulted in increased bulb weight and bulb diameter” (Yadav *et al.* 2017).Yield ranged from 159.80q/ha (control plot) to 235.24 q/ha in treatment T9 {50% Recommended FYM (125 q/ha) + 50 % Vermicompost (Equivalent to N content of 50% Recommended FYM) as basal dose at time of field preparation + Application of *Jeevamrit* (Fortnight application) + 50% RDF of NPK} which was 32.07 per cent more than T1. The treatment which produced maximum yield i.e. T9 also produced non significant effects with T4 (233.32 q/ha), T5 (231.62 q/ha) and T8 (225.46 q/ha). “This may be attributed to favorable effect of organic sources on microbial activity and root proliferation in soil which caused solubilizing effect on native nitrogen, phosphorus, potassium and other nutrients. The application of 50 per cent recommended dose of NPK as in T9 favoured the metabolic and auxin activities in plant and ultimately resulted in increased bulb weight, bulb diameter, yield per plot, clove weight, clove diameter, clove length, harvest index and finally total yield” (Yadav *et al.* 2017).

 Table 2: Effect of organic and inorganic amendments on growth and yield parameters

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameters** | **Plant Height (cm)** | **Number of leaves per****plant** | **Bulb Weight (g)** | **Bulb Diameter (cm)** | **Number of bulbs per kg** | **Bulb yield per hectare****(q)** | **Number of cloves per****bulb** | **Yield (q/ha)** |
| Treatments | Pooled | Pooled | Pooled | Pooled | Pooled | Pooled | Pooled | Pooled |
| T1 | 77.65 | 9.46 | 45.38 | 4.69 | 20.96 | 162.42 | 14.23 | 162.42 |
| T2 | 86.81 | 9.59 | 65.06 | 5.56 | 19.34 | 180.59 | 14.06 | 180.59 |
| T3 | 83.54 | 9.70 | 65.19 | 5.30 | 17.40 | 197.16 | 14.25 | 197.16 |
| T4 | 90.86 | 9.96 | 63.87 | 5.38 | 15.73 | 235.68 | 13.43 | 232.08 |
| T5 | 89.46 | 10.38 | 61.73 | 5.65 | 15.46 | 232.08 | 14.33 | 235.68 |
| T6 | 83.52 | 10.48 | 61.35 | 5.59 | 15.86 | 220.18 | 14.51 | 220.18 |
| T7 | 84.22 | 10.72 | 62.59 | 5.59 | 15.52 | 225.57 | 14.27 | 225.57 |
| T8 | 86.00 | 10.79 | 50.47 | 5.25 | 15.51 | 226.00 | 13.28 | 226.00 |
| T9 | 89.00 | 10.80 | 66.21 | 6.01 | 14.85 | 235.95 | 13.88 | 235.95 |
| T10 | 84.56 | 9.55 | 53.73 | 5.39 | 15.13 | 222.59 | 14.19 | 222.59 |

## Quality Characters

From the present studies, (Table 3) a perusal of the data shows that there was a significant effect of various organic and inorganic treatments on weight of 100 unpeeled cloves (g), peeled cloves (g), peeling index (%), dry matter (%), oleoresin (%) and disease severity (%). It appears that the treatment T9 which yielded more also had more weight of unpeeled and peeled cloves, dry matter, oleoresin as well as peeling index. It is very clear that there is a direct and positive correlation between weight of unpeeled and peeled cloves with the peeling index. Maximum values for weight of 100 unpeeled and peeled cloves were 366g and 347.33g, respectively observed in T9 (Table- 3). The next best treatments for both these characters were T7 (366g and 336.67g) and T10 (352.67g and 327.33g) and T7 showed significant differences with T9 for weight of unpeeled cloves. On the other hand, peeling index was, howevermore(94.90%) in T9 but this treatment showed non-significant effects with T7 (94.79%) and T4 (93.79%) and T2 (93.08%). The possible reason for more weight of 100 unpeeled cloves (g), peeled cloves (g) and more peeling index (%) may be ascribed to increased weight of cloves which is due to combined application of FYM, vermi compost, jeevamrit and integrated use of NPK fertilizers. “The presence of beneficial microorganisms in liquid formulation like jeevamrit and beejamrit might be mainly due to their constituents such as cow dung, cow urine, legume flour and jaggary containing both macro and essential micro nutrients, many vitamins, essential amino acids, growth promoting substances like indole acetic acid (IAA), gibberlic acid(GA) and beneficial microorganisms which might have played a great role in increasing weight of peeled as well as unpeeled bulbs and consequently more peeling index” (Palekar, 2006; Sreenivasa *et al.*2000 and Neelima and Sreenivasa, 2011). The present findings are in line with those of Farooqui *et al*. (2009) who also observed almost similar results under Mandsaur conditions probably due to more vegetative growth and more efficient use of available inputs owing to adequate supply of nitrogen which finally resulted in higher productivity. Almost similar results have also been shown by Naruka (2000), Naruka and Dhaka (2001), Sharma *et al*. (2002), Yadav *et al*. (2003), Banafar and Gupta (2005) and Naruka *et al*. (2005). “The application of 50 per cent recommended dose of NPK favoured the metabolic and auxin activities in plant and ultimately resulted in increased bulb weight, bulb diameter and ultimately dry matter content” (Yadav *et al.* 2017). Jaun *et al.* (2006) who showed that “vermi compost increased the bulb dry weight due to accumulation of non-structural carbohydrates whose distribution patterns change, thus favouring the metabolism of fructan precursors and accumulating as scorodose. They further explained this as reserve substance (scorodose) accumulation in the vermi compost treatment represented by scorodose polysaccharide, which occurs for a longer period due to the earlier start of bulbing. This response translates into 2-fold increase of the bulbs dry weight, increased size and therefore, higher quality and dry matter content including yield at harvest”. Similarly, Fenwik and Hanley (1985) reported that, in garlic, the fructan polysaccharide is the scorode which accounts for 53 per cent of garlic dry matter. No disease was reported during the research. “The fermented liquid organic manures also contain microbial load and plant growth promoting substances in addition to nutrients that help in improving plant growth, metabolic activities and resistance to pest and diseases” as also reported by Nileema *et al.* (2011). According to Sidhu and Sekhon (2000), “the improvement in quality attributes by various fertilizer treatments is directly correlated with physico-chemical and biological properties of soil which enable roots to proliferate more resulting into better utilization of nutrients required for enhancing the quality of crop”. The present findings are consistant with those of Mridula and Jayachandran (2001) and Velmurugen *et al*. (2008).

## Table 3: Effect of organic inorganic amendments on quality parameters

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameters** | **Weight of 100 unpeeled cloves (g)** | **Weight of 100 peeled cloves (g)** | **Peeling index (%)** | **Dry matter (%)** | **Oleoresin content (%)** |
| Treatments | Pooled | Pooled | Pooled | Pooled | Pooled |
| T1 | 285.33 | 231.33 | 82.41 (9.07) | 40.39 | 1.07(1.03) |
| T2 | 342.00 | 317.33 | 93.08 (9.65)\* | 36.67 | 1.32(1.15) |
| T3 | 330.67 | 298.67 | 89.93 (9.48) | 40.80 | 1.25(1.12) |
| T4 | 300.67 | 320.67 | 93.79 (9.68) | 39.02 | 1.43(1.19) |
| T5 | 350.67 | 320 | 91.27 (9.55) | 40.11 | 1.44(1.20) |
| T6 | 336.00 | 318.67 | 91.99 (9.59) | 38.64 | 1.08(1.03) |
| T7 | 366.00 | 336.67 | 94.79 (9.74) | 39.89 | 1.28(1.13) |
| T8 | 323.33 | 329.67 | 91.59 (9.57) | 40.49 | 1.27(1.13) |
| T9 | 366.00 | 347.33 | 94.90 (9.74) | 44.36 | 1.60(1.26) |
| T10 | 352.67 | 327.33 | 92.99 (9.64) | 40.05 | 1.42(1.19) |

**Soil Fertility**

Maximum available N (439.89 kg/ha) was recorded in the plots supplied with 50 % recommended FYM (125 q/ha) + 50% Vermicompost (Equivalent to N content of 50 % recommended FYM) as basal dose at time of field preparation + application of Jeevamrit (Fortnight application) + 50 % RDF of NPK. This treatment was statistically at par with vermicompost (Equivalent to N content of Recommended FYM) as basal dose at the time of field preparation + Application of Jeevamrit (Fortnight application) + 50% RDF of NPK (438.10 kg/ha) where highest phosphorus (44.35 kg/ha) was recorded. Maximum available K (378.13 kg/ha) was recorded in the plots supplied with 50% Recommended FYM (125 q/ha) + 50 % Vermi compost (Equivalent to N content of 50% FYM) as basal dose at the time of field preparation + 50% RDF of NPK (T8). This treatment was statistically at par with T9 (364.93 kg/ha), T5 (360.00) T4 (358.40) T7 (355.60 kg/ha) and T10 (334.40). Zhou *et al.* 2016 ascribed such “build up in the available N status of the soil due to mineralization of N from added FYM. The increase in available N status of the soil with combined use of fertilizers and FYM might be explained in terms of their residual effect and build up of inorganic N fractions of the soil due to biochemical degradation and mineralization”. Similar findings have also been reported by Srinivasan *et al*. (2000). Kumar (2004) was also of the opinion that “there is strong build up of available N in the soil with increased application of N in garlic crop. This may be due to increased activity of nitrogen fixing bacteria resulting in higher content of N in soil. Highest recovery of available phosphorus in organic manure treatments might be due to solubilization of soil phosphorus by organic acids produced during decomposition/mineralization of organic manures and release of phosphorus contained in the organic manures. It might also be due to the formation of soluble complexes between humic/fulvic acids and phosphate”. “The complex organic anions and hydroxyl acids such as tartaric, citric, malonic and malic acids liberated during the decomposition of organic matter might have chelated Al+,Fe+3 and Ca+2 and decreased the phosphate precipitating power of these cations thereby increased the phosphorus availability. This could possibly be attributed to direct K addition in available K pool of soil” (Srinivasan *et al.* 2016) Earthworm casts are reported to promote soil microbial nutrient mineralization and activation. Sharmil and Khan, 2017 demonstrated “the influence of vermi compost on available macronutrient and microbial populations in paddy as they noted that application of vermi compost enhances the activity of soil microbial populations and there was a high level of total N in experimental plot. This was due to higher N fixers in experimental plot than control, since earthworm casts alters microbial nutrient spectrum in soils”.

**Viable count of bacteria:** It is clear from the data (Table 4) that bacterial count was significantly affected by application of different combinations of organic and inorganic fertilizers. Among different treatments, maximum bacterial count (214 x 105cfu/g of soil) was observed in the treatment T9 {50% Recommended FYM (125 q/ha) + 50 % Vermicompost (Equivalent to N content of 50% Recommended FYM) as basal dose at time of field preparation + Application of Jeevamrit (Fortnight application) + 50% RDF of NPK} and T4{Seed treatment with Beejamrit (overnight) + Recommended FYM (250q/ha) as basal dose at the time of field preparation} which was closely followed by (206.66) in T3. It is a well known fact that soil biological properties were significantly influenced by application of different combination of organic and inorganic fertilizers. “The higher proportion of organic manures and lower proportion of chemical fertilizers in combination increased microbial population of the soil. This increase in microbial population might be due to the fact that organic manures provide food and micro environment to the microbes by releasing CO2 during the process of decomposition in the soil which helps in multiplication and growth of microbes” (Kumari and Kumari, 2002). Moreover, “organic manures act as an excellent substrate for soil microbes and increase the proportion of labile carbon and nitrogen, directly stimulating the population and activity of micro-organisms. The increase in microbial population in the presence of organic manures may also be attributed to greater availability of organic carbon and mineralized nutrients for their proliferation and further cellular development” (Marathe *et al.* 2012).

followed

closely

**Nutrient Uptake:** In the present studies, application of different combinations of nutrients significantly increased the N uptake (Table- 4 and Figure 3) in garlic plant. Maximum nitrogen uptake (80.95 kg/ha) was obtained in T7 {Vermicompost (Equivalent to N content of Recommended FYM) as basal dose at the time of field preparation + Application of *Jeevamrit* (Fortnight application) + 50% RDF of NPK} which was at par with T4 (80.53 kg/ha). Opala *et al.* (2015) indicated that “increasing N uptake by increasing N fertilizer application to the soil is due to the result of improved availability and uptake of N through increased root growth and effective absorption”. Nasreen and Hossain (2004) while studying with onion crop also observed “highest N, P, K and S uptake during all growth stages of onion from various fertilizer combinations”. Maximum phosphorus uptake (21.80 kg/ha) was obtained in treatment T7 {Vermicompost (Equivalent to N content of Recommended FYM) as basal dose at the time of field preparation + Application of Jeevamrit (Fortnight application) + 50% RDF of NPK} which was found statistically at par with T9 (19.77 kg/ha), T8 (19.37 kg/ha), T10 (18.79 kg/ha) and T6 (18.57 kg/ha). Tamirat (2006) reported that “P concentration of onion was consistently increased with the increasing rates of N and P fertilizers. Plants provided with adequate amount of P forms good root system, thus enabling plants to explore the nutrient in the soil and absorb them, consequently the concentration of the element becomes high in the crop tissues. This might be the case for increment of P concentration in garlic crop in their study at optimum level of nutrient application which confirms the sufficiency ranges of P”. Maximum uptake of potassium (62.82 kg/ha) was obtained in the treatment T9 {50% Recommended FYM (125 q/ha) + 50 % Vermicompost (Equivalent to N content of 50% Recommended FYM) as basal dose at time of field preparation + Application of Jeevamrit (Fortnight application) + 50% RDF of NPK} which was at par with T8 (62.55 kg/ha), T4 (59.71kg/ha), T7 (58.97 kg/ha) and T6 (56.37 kg/ha). “Potassium is a mobile element within the soil having higher moisture content and moves with water to different plant tissues. Potassium has a major role to play in plant metabolism as it activates some enzymes especially involved in the metabolism of carbohydrates. Under high levels, starch moves efficiently from sites of production to storage. In addition, it plays a potential role in the transport of water and essential nutrients throughout the plant in the xylem” (Mansour, 2006). Potassium is also known to regulate opening and closing of stomata which are essential for photosynthesis, water and nutrient transport and plant pooling. In the present case also, higher doses of K together with other nutrients might have increased the K uptake in the plant. Mallingowda *et al*. (1995) and Girigowda *et al*. (2005) were also of the opinion that highest uptake of N, P and K nutrients by onion was due to the supply of N, P and K fertilizers.

 Table 4: Effect of organic and inorganic amendments on soil parameters (PATHAK, S. 2018)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameters** | **Available nitrogen (kg/ha)** | **Available phosphorus (kg/ha)** | **Available potassium (kg/ha)** | **Bacterial Count****(x105****cfu/g of soil)** | N uptake (kg/ha) | P uptake (kg/ha) |  K uptake (kg/ha) |
| Treatments | Pooled | Pooled | Pooled | Pooled | Pooled | Pooled | Pooled |
| T1 | 230.98 | 30.16 | 209.00 | 100.00 | 30.80 | 9.54 | 32.04 |
| T2 | 263.89 | 33.15 | 230.00 | 186.67 | 49.02 | 17.84 | 45.91 |
| T3 | 348.87 | 33.89 | 305.93 | 206.66 | 68.55 | 19.69 | 50.00 |
| T4 | 339.08 | 37.63 | 358.40 | 214.00 | 80.53 | 18.09 | 59.71 |
| T5 | 330.98 | 40.61 | 360.00 | 183.00 | 63.06 | 13.85 | 51.69 |
| T6 | 359.72 | 36.88 | 327.60 | 149.00 | 72.77 | 18.57 | 56.37 |
| T7 | 438.1 | 44.35 | 355.60 | 164.67 | 80.95 | 21.80 | 58.97 |
| T8 | 380.1 | 37.63 | 378.13 | 186.33 | 51.18 | 19.37 | 62.55 |
| T9 | 439.89 | 39.87 | 364.93 | 214.00 | 73.41 | 19.77 | 62.82 |
| T10 | 348.87 | 35.39 | 334.40 | 137.67 | 45.57 | 18.79 | 46.99 |



## Figure 2: Effect of organic and inorganic amendments on available N, P and K content in soil

****

**Figure 3: Effect of organic and inorganic amendments on N, P and K uptake by garlic plant**

**Conclusion:** From the present studies, it can be concluded that T9{50% Recommended FYM (125 q/ha) + 50 % Vermicompost (Equivalent to N content of 50% Recommended FYM) as basal dose at time of field preparation + Application of *Jeevamrit* (Fortnight application) + 50% RDF of NPK} was regarded as the best treatment in terms of growth, yield, yield contributing characters, quality characters, soil parameters and nutrient uptake in garlic crop. This treatment can be recommended to the farmers after verification of results and thorough testing in multi location trials in the form of OFT in the farmer’s field.

**Disclaimer (Artificial intelligence)**

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1. No AI has been used

2.

3.

## References:

Abdul, G., S. J. Muhammad, K. Ghulam, and W. Kashif. 2003. Effect of different NPK levels on the growth and yield of three onion (*Allium cepa* L.) varieties. *Asian Journal of Plant Sciences* 2: 342-346.

Alam, M. N., M. S. Jahan, M. K. Ali, M. S. Islam, and S. M. A. T. Khandaker. 2007. Effect of vermicompost and NPKS fertilizers on growth, yield and yield components of red amaranth. *Australian Journal of Basic and Applied Sciences* 1 (4):706–16.

Aliyu, U., M. D. Magaji, A. Singh, and S. G. Mohammed. 2007. Growth and yield of onion as influenced by nitrogen and phosphorus levels. *International Journal of Agricultural Research* 2:937-944.

Al-Madini, A. M., S. S. Al-Thabat, and A. F. Hamail. 2000. Effect of different application rates of two compound fertilizers on growth, yield and yield mineral composition of onion. *Egyptian Journal of Applied Science* 15(10):520-525.

Anonymous. 2008. Organic farming newsletter. Ghaziabad: National Centre of Organic Farming.

Ansari, A. A. 2008. Effect of vermicompost and vermiwash on the productivity of spinach (*Spinacia oleracea*), onion (*Allium cepa*) and potato (*Solanum tuberosum*). *World Journal of Agricultural Sciences* 4 (5):554–57.

AOAC. 1970. *Official and tentative methods of analysis. Association of official Analytical Chemists*. Washington: William Star Wetglad.

Argüello, J. A., A. Ledesma, S. B. Núñez, C. H. Rodríguez, and M. D. C. D. Goldfarb. 2006. Vermicompost effects on bulbing dynamics, nonstructural carbohydrate content, yield, and quality of Rosado Paraguayo’garlic bulbs. *Hortscience* 41 (3):589–92. doi:10.21273/HORTSCI.41.3.589.

Atal 2017. Studies on effect of organic nutrient sources on bell pepper (*Capsicum annum* L.) production. M.Sc. Thesis Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan.

Atiyeh, R. M., J. Domínguez, S. Subler, and C. A. Edwards. 2000. Changes in biochemical properties of cow manure during processing by earthworms (*Eisenia andrei*, Bouché) and the effects on seedling growth. *Pedobiologia* 44 (6):709–24. doi:10.1078/S0031-4056(04)70084- 0.

Banafar, R. N. S., and N. K. Gupta. 2005. Effect of fertilizer mixture with and without sulphur on quality of onion. In: National Seminar on Agro-technology, Quality, Processing and Export of Spices J. N. K. V. V. Jabalpur. 60p.

Chattopadhyay, P. K., M. A. Hasan, K. K. Mandar, and S. Chano. 2006. Dynamics of growth of garlic (*Allium Sativum* L.) in variable planting time and applied nutrients. *Indian Journal of Horticulture* 63(3):298-301.

Devakumar, N., S. B. Shubha, Gouder, and G. G. E. Rao. 2014. Microbial analytical studies of traditional organic preparations *beejamritha* and *jeevamritha*. *Proceedings of the 4th ISOFAR Scientific Conference* 639-642.

Farooqui, M. A., I. S. Naruka, S. S. Rathore, P. P. Singh, and R. P. S. Shaktawa. 2009. Effect of nitrogen and sulphur levels on growth and yield of garlic*. Asian Journal of Food Agriculture and Industry* 5:18-23.

Fenwik, G. R., and A. B. Hanley. 1985. The genus *Allum* part 2. *CRC Crtical reviews in Food science and nutrition* 22(3):273-377.

Girigowda, J. R., N. C. Narsegowda, and H. C. Krishna. 2005. Effect of fertilization levels on uptake of primary nutrients and yield of onion hybrids. *Mysore Journal of Agricultural Sciences* 39(4):557-560.

Gore, N., and M. N. Sreenavasi. 2011. Influence of liquid organic manures on growth, nutrient content and yield of tomato (*Lycopersicon esculentum* Mill.) in the sterilized soil. *Karnataka Journal of Agriculture Sciences* 24:153-157

Gowda, M. C., M. Vijayakumar, and A. P. M. Gowda. 2007. Influence of integrated nutrient management on growth, yield and quality of garlic (*Allium sativum* L.) cv. G-282. *Crop Research Hisar* 33:144-147.

Gupta, A. K., P. K. Pankaj, and V. Upadhyava. 2008. Effect of vermicompost, farm yard manure, biofertilizer and chemical fertilizers (N, P, K) on growth, yield and quality of lady’s finger (*Abelmoschus esculentus*). *Pollution Research* 27 (1):65–68.

Honsfall, J. G., and R. W. Barratt. 1945. Grading system for measuring plant disease, phytopathology 35: 655.

Islam, M. K., M. F. Alam, and A. K. M. R. Islam. 2007. Growth and yield response of onion genotypes to different levels of fertilizers. *Bangladesh Journal of Botany* 36(1): 33-38.

Jackson, M. L. 1967. *Soil Chemical Analysis, 38*. Bombay: Oxford and IBH Publishing House. Jackson, M. L. 1973. *Soil Chemical Analysis*. New Delhi: Prentice Hall of India.

Jaipaul, S. S., A. K. Dixit, and A. K. Sharma. 2011. Growth and yield of capsicum (*Capsicum annum*) and garden pea (*Pisum sativum*) as influenced by organic manures and biofertilizers. *Indian Journal of Agricultural Sciences* 81 (7):637–42.

Jaun, A. A., L. Alicia, B. N. Selva, H. R. Crlos, and C. D. C. Maria del. 2006. Vermicompost effects on bulbing dynamics, non-structural carbohydrate content, yield and quality of ‘Rosado Paraguayo’ garlic bulbs. *HortScience* 41(3):589-592.

Jilani, M. S., A. Ghaffoor, K. Waseem, and J. I. Farooqi. 2003. Effect of different levels of nitrogen on growth and yield of three onion varieties. *International Journal of Agriculture and Biology* 6(3):507-510.

Shrimal, P., & Khan, T. I. (2017). Studies on the effects of vermicompost on growth parameters and chlorophyll content of Bengal gram (*Cicer arietinum* L.) var. RSG-896. *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, *11*(5), 12–16. <https://www.iosrjournals.org>

Khodabakhshzadeh, A. 2001. Effect of different levels of nitrogen on growth and development, yield and nitrate accumulation in three cultivars of garlic. M.Sc. Thesis, Horticultural Science. Isamic Azad University, Science Research Unit.

Kumar, A., B. Singh, D. Kumar, P. Kumar, T. Kumar, S. Kumar, and A. Goswami. 2014. Effect of balanced fertilizer and planting techniques on growth and yield of Garlic (*Allium sativum* L.). *Annals of Horticulture* 7(2):123-128.

Srinivasan, V., Thankamani, C. K., Dinesh, R., Kandiannan, K., Zachariah, T. J., Leela, N. K., Hamza, S., Shajina, O., & Ansha, O. (2016). Nutrient management systems in turmeric: Effects on soil quality, rhizome yield and quality. *Industrial Crops and Products, 85*, 241–250. <https://doi.org/10.1016/j.indcrop.2016.03.027>

Kumar, S. 2004. Effect of chemical fertilizers and FYM on yield and quality of garlic (*Allium sativum* L.) under mid hills of H.P. M.Sc. Thesis, CSK HPKV, Palampur, H.P.

Kumari, S. M., and U. K. Kumari. 2002. Effect of vermicompost enriched with rock phosphate on growth and yield of cow pea (*Vigna unguiculata* L.). *Journal of Indian Society of Soil Science* 50:223-224.

Mansour, F. Y. O. 2006. Physiological studies on garlic (*Allium sativum* L.). M.Sc. Thesis, Faculty of Agriculture, Minufiya University, Egypt.

Marathe, R. A., P. R. Bharambe, R. Sharma, and U. C. Sharma. 2012. Leaf nutrient composition, its correlation with yield and quality of sweet orange and soil microbial population as influenced by INM in vertisol of Central India. *Indian Journal of Horticulture* 69:317-321.

McKinney, H. H. 1923. Influence of soil temperature and moisture on infection of wheat seedlings by *Helminthosporium sativum*. *Journal of Agricultural Research* 26: 195-217.

Merwin, H. D., and M. Peech. 1951. Exchangeability of soil potassium in the sand, silt, and clay fractions as influenced by the nature of the complementary exchangeable cations. *Soil Science Society of America Journal* 15(C):125–28. doi:10.2136/sssaj1951.036159950015000C0026x.

Mridula, K. R., and B. K. Jayachandran. 2001. Quality of mango ginger as influenced by mineral nutrition. *Journal of Tropical Agriculture* 39(2):182-183.

Naruka, I. S. 2000. Effect of row spacing and nitrogen fertilization on growth, yield and quality of garlic cultivars. Ph. D Thesis, RAU, Bikaner.

Naruka, I. S., and R. S. Dhaka. 2001. Effect of row spacing and nitrogen fertilization on growth, yield and composition of bulb in garlic cultivars. *Journal of Spices and Aromatic Crops* 10(2):111-117.

Naruka, I. S., P. P. Singh, S. S. Rathore, and M. M. Singh. 2005. Response of garlic cultivars to nitrogen fertilization and crop geometry on composition of bulb. In: Seminar on Agro- technology, Quality, Processing and Export of Spices J. N. K. V. V. Jabalpur. 52p.

Nasreen, S., and A. K. M. Hossain. 2004. Nutrient uptake and yield of onion as influenced by chemical fertilizer and organic manure. *Indian Journal of Agricultural Research* 38(3):164- 170.

Nileema, S., Gore, and M. N. Sreenivasa. 2011. Influence of liquid organic manures on growth, nutrient content and yield of tomato (*Lycopersicum esculentum* Mill.) in the sterilized soil. *Karnataka Journal of Agricultural Sciences* 24(2):153-157.

Olsen, S. R. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate (No. 939). US Department of Agriculture.

Palekar, S. 2006. *Text book on Shoonya Bandovalada naisargika Krushi*. Swamy Anand, Agri Prakashana, Banglore.

Opala, P. A., Kisinyo, P. O., & Nyambati, R. O. (2015). Effects of *Tithonia diversifolia*, farmyard manure and urea, and phosphate fertiliser application methods on maize yields in western Kenya. *Journal of Agriculture and Rural Development in the Tropics and Subtropics, 116*(1), 1–9.

Panse, V. G., and P. V. Sukhatme. 2000. *Statistical methods for agricultural workers*. ICAR, New Delhi.

Peyvast, G., J. A. Olfati, S. Madeni, and A. Forghani. 2008. Effect of vermicompost on the growth and yield of spinach (*Spinacia oleracea* L.). *Journal of Food Agriculture and Environment* 6 (1):110–13.

Premsekhar, M., and V. Rajashree. 2009. Influence of organic manures on growth, yield and quality of okra. *American-Eurasian Journal of Sustainable Agriculture* 3 (1):6–8.

Puttaraju, T. B., H. B. Lingaiah, S. R. Padmaraja, G. N. Thygaraj, and B. Kumar. 2011. Effect of integrated nutrient management on growth and yield of garlic (*Allium sativum* L.) cv. G-282. *In: National symposium on Alliums: current scenario and emerging trends.* DOGR, Rajagurunagar, Pune: 206

Rangaswamy, G.1966. *Agricultural Microbiology*. Delhi: Bombay Asia Publishing.

Rohidas, S. B., V. P. Kamble, B. M. Kalalbandi, V. K. Patil. 2011. Effect of organic and inorganic fertilizers on growth, yield and quality of onion cv. N-53. Paper presented in National symposium on Alliums: current scenario and emerging trends, DOGR, Rajagurunagar, Pune.

Sharma, P. K., S. P. Dixit, S. K. Bhardwaj, and S. K. Sharma. 2002. Influence of potassium in balanced fertilization of the yield and quality of vegetable crops. In*: Proceeding International symposium on decade of potassium research,* Potash Research Institute of India, Gurgagon. 325-328.

Zhou, H., Fang, H., Mooney, S. J., & Peng, X. (2016). Effects of long-term inorganic and organic fertilizations on the soil micro and macro structures of rice paddies. *Geoderma, 266*, 66–74. https://doi.org/10.1016/j.geoderma.2015.11.018

Sidhu, A. S., and N. K. Sekhon. 2000. Effect of phosphorus and FYM application in potato sunflower sequence on an alkaline soil of Punjab. Paper presented at National Seminar for Development of Soil Science, NBSSLUP, Nagpur, Dec. 27-30.

Sreenivasan, V., A. K. Sadanandan, and S. Hamza. 2000. Efficiency of rock phosphate sources on ginger and turmeric in an ustic humitropept. *Journal of the Indian Society of Soil Science* 48(3):532-536.

Srinivasan, V., A. K. Sadanandan, and S. Hamza. 2000. Efficiency of rock phosphate sources on ginger and turmeric in an ustic humitropept. *Journal of the Indian Society of Soil Science* 48(3):532-536.

Subbiah, B. V., and G. L. Asija. 1956. Rapid method for estimation of available nitrogen in soils.

*Current Science* 25:259–60.

Surendra, S., R. R. Choyal, and S. Sushma. 2005. Stimulatory effect of earthworm body fluid (vermiwash) on seed germination and seedling growth of two legumes. *Journal of Phytological Research* 18 (2):219–22.

Tandon, H. L. S., and G. S. Sekhon. 1988. *Potassium and agricultural production in India*. New Delhi: Fertilizer Development Cooperation.

Velmurugan, M., N. Chezhiyan, and M. Jawaharlal. 2008. Influence of organic manures and inorganic fertilizers on cured rhizome yield and quality of turmeric. *International Journal of Agriculture and Science* 1:142-145.

Walkely, A., and T. A. Black. 1934. An experiment of the vegetative modification of the chromic acid filtration method. *Soil Science* 37:38–39.

Yadav, A. L., G. Vishwakarma, A. Kumar, A. Singh, and S. Kumar. 2017. Effect of integerated nutrient management on physic-chemical properties of Bael (*Aegle marmelos* C.) cv.

Narendra Bael-9. *Indian Journal of Current Microbiology and Applied Sciences* 6(6):287- 296.

Yadav, R. L., N. L. Sen, and B. L. Yadav. 2003. Response of onion to nitrogen and potassium fertilization under semi-arid condition. *Indian Journal of Horticulture* 60(2):176-178.

Shukla, Y. R., Kaushal, M., & Shilpa, V. I. J. (2018). Studies on the Effect of Macro and Micro Nutrients on Growth and Yield of Garlic (Allium sativum L.). Int. J. Curr. Microbiol. App. Sci, 7(8), 4787-4791.

Kumar, P., Kamboj, D., Sharma, R. R., & Thind, V. (2019). Effect of integrated nutrient management on growth and yield of garlic (Allium sativum L.). Journal of Pharmacognosy and Phytochemistry, 8(3), 2569-2572.

PATHAK, S. (2018). INTEGRATED NUTRIENT MANAGEMENT STUDIES IN GARLIC (Allium sativum L.) (Doctoral dissertation, UHF, NAUNI) (Unpublished Thesis)