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# Review Article: Agro Morphological Trait Evaluation of Garlic (Allium Sativum L.) Response to Fertilizer

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**Abstract**

**As a review, garlic (*Allium sativum* L.) is one of the main *allium* vegetable crops known through worldwide with respect to its production and economic value. Garlic belongs to the genus *Allium* and family Alliaceous. Garlic has high morphological diversity and adaptable to different agro-climatic regions and environments. Morphological and agronomic variations in characteristics of garlic are shown such as color of the bulb, size of the bulb, plant height, number of cloves, size of the cloves, days to harvesting, resistance to storage capacity, dormancy and adaptation to agro-climatic conditions. Farmers endeavor to produce high yield and good quality garlic for consumption and economic value. Correlation between some quantitative traits of garlic showed the positive and significant correlation with yield and leaf length. All yield and yield-related traits were significantly influenced through the interaction of cultivar and nitrogen fertilizer except leaf length, leaf number per plant, bulb length and sizes of bulbs and cloves of different categories that were significantly influenced either by both cultivar and nitrogen or one of these.**

**Keywords:** Diversity, Morphological traits, Growth, Yield, Fertilizer and Nitrogen.

## INTRODUCTION

Garlic (*Allium sativum* L.) is one of the main vegetable crops known worldwide with respect to its production and economic value. Garlic is a species-rich and taxonomically complicated genus with more than 750 species. It is an important vegetable crop for its culinary, religious, grown and medicinal purposes [10], [32]. Garlic is the most widely produced for fresh market, dehydrated as an ingredient for food processing, essential oil, oil macerate and powder. Garlic has constituted significant amounts of element such as Ca, P and K, and their leaves sources of proteins, vitamins and contains antibiotics like garlicin and allistatin [16]. The principal conservation of gene bank is to maintain genetic diversity active and reduce the loss of genetic diversity of crop and plant species. Plants cannot be conserved as seeds because of their unmanageable nature and clonally propagated are traditionally conserved [19]. Phenotypic variability in the gene banks should be calculated in order to allow effective use of accession collection and studies on the agro-morphological characterization of cultivars [37]. Morphological traits diversity of crop genetic resources plays a significant role in the breeding

programs. Identifying appropriate indices for selecting garlic varieties and understanding the variation between accessions can be improve the efficiency of breeding programs [43].

Generally, the garlic is an important bulb crops produced for home consumption as a flavor, medicinal value and source of income in Ethiopia [12]. It grows mainly in the mid-altitudes and highlands of the country. Garlic is one of the high-value vegetable crops produced in rotation with pulses during the cold season [11]. Lack of improved high yielding varieties, low soil fertility, inappropriate agronomic practices and lack of improved postharvest technologies are among the well-known factors for limited productivity of garlic [13], [28]. Bulb yield and days to maturity of garlic were disposed to environmental changes resulting in variable yield due to the significant effect of genotype-by-environment interaction [38]. Lack of appropriate variety and plant population greatly affects garlic growth, yield and quality [12]. There are local improved garlic varieties under cultivation in the country. Varieties of garlic may differ in root architecture; foliage and a cultivar perform differently under different agro-climatic conditions [35]. This review was to evaluate the growth and yield related traits which could be suitable descriptors in future clonal selection programs regarding to agromorphological traits.

## BOTANICAL AND AGROMORPHOLOGICAL TRAITS DESCRIPTION GARLIC (*ALLIUM SATIVUM* L)

Botanically, garlic belongs to the genus *Allium,* family Alliaceous, which includes important vegetable crops such as onion (*Allium cepa*), leek (*A. ameloprisum*) and shallots (*A. asacloncum*). Garlic is propagated asexually and shows highly morphological diversity among cultivars. These diversity traits have a wide range of adaptations to different environments and agro-ecological zones. Garlic plants have thin tape-shaped leaves up to 30 cm long like that of onions. The roots have reached up to 50 cm depth and more. The bulbs and heads are white skinned which divided into certain types of sections called cloves and each bulb could have 6 up to 12 cloves covered by a white or reddish papery layer [16].

The sexual propagation of garlic has been facilitated the exchange of genetic traits from one genotype to others to improve garlic cultivars in classical breeding [18]. It does not produce true seed but propagates through planting cloves. The select seed bulbs should be large, smooth, fresh, and free from disease. Garlic bulb is the best for planting garlic because larger cloves yield larger size and mature bulbs at harvesting time. To plant the garlic properly dig a hole, place the unpeeled clove gently into the hole with the pointed side up the stem end down and cover the clove with smoothed soil and the setting of cloves has been in an upright position to make sure a straight neck [26].

## PRODUCTION AND PRODUCTIVITY OF GARLIC IN ETHIOPIA

Garlic is one of the important agricultural bulb vegetables grown and seasoning vegetables mainly used for flavoring and has many traditional and modern medicinal properties [1]. The small growers of garlic in the highlands are grown through traditionally faulty agricultural practices and the yields are low [6], [5]. Generally, garlic is adapted to cool climates and the amount of rainfall during the growing period (4 to 6 months) with 600 mm to 700 mm. It should not be planted at altitudes below 2000 m. a. s. l. The optimum temperature for growing garlic lies between 12°C and 24°C. It is essential to select land with high fertility and apply

considerable quantities of manure or fertilizers to obtain good yields of garlic bulbs [6]. Under the comparison of countries in garlic production, Ethiopia has been placed the 12$^{th}$ in the world ranking [7].

## ECOLOGY AND METHODS OF GARLIC PRODUCTION

Garlic has a wide area of adaptation and cultivation throughout the world. The ecological requirement of garlic is a mild winter season which has certain rainfall with a sunny dry summer season which is good for garlic production but very high humidity and rainfall are unfavorable to vegetative bulb formation and reduce its production [4]. The productivity of garlic in many parts of the world is low due to genetic variability, ago ecological and environmental factors affecting the quantity and quality of yield and yield-related traits. Yield and quality will vary with climate, altitude, soil, pH, cultural practices and the variety of garlic [30]. It is advisable to conversation with local growers who have experience growing garlic and experiment with different cultural practices and varieties. Water stress during the growing season can cause bulbs to be smaller and to cause a multiple stem disorder [2], [36]. The 'seeds' needed per hectare are very variable as the cloves of different species vary greatly in size. The upper 15-20 cm of the soil surface should be always moist, but not wet, because most of the root system will be grown in this depth [41].

### Development and Growthing of Garlic

Garlic is a cool season growth plant that all vitality and leaf growth when the temperatures are cool and the day is short. When the temperature becomes warm and the day is lengthen the growthing of garlic plant stop making leaves and activates to form bulbs. The life cycle of the plant under goes successive stages of growth and development the dormancy of mature cloves, induced through the temperature of 25-30 $^0$C is eliminated most quickly at 6-7 0C vegetative growth is optimal at 18-20 0C [27]. When 12-14 leaves have been produced, bulb swelling is induced at a temperature below 20 $^0$C. The total growing period varies from 4 months to 9 months. Garlic cloves require a period of 6-8 weeks of cool weather after planting in low winter temperatures. The clove will swell considerably forming a globular bulb with many fine roots and a pair of intertwined leaves will emerge from the terminal end of the bulb. Leaf development also will accelerate with flat and dark green leaves on stems reaching a height of 30 cm or more. As temperatures rise and day length increases, bulb formation begins. The results showed the following development stages in garlic: **Sprouting**: from sowing to 20-30 days, adventitious roots, leaf emergence, and total soluble carbohydrate assimilation in seed cloves are observed. **Shoot growth**: from the end of sprouting until 140 days after sowing. Translocation of photosynthesis to the bulb begins afterwards. **Bulb growth**: during the inductive stage from sprouting, no increase in dry weight of total soluble carbohydrates can be observed up to 90 days [22]. Garlic is a species of vegetative propagation, showing high morphological diversity and has specific adaptations to different agro-climatic regions and environments [31]. Extensive morphological and agronomic variations in the characteristics of garlic are shown such as color of the bulb, size of the bulb, plant height, number, of cloves, size of the cloves, days to harvesting, resistance to storage capacity, dormancy and adaptation to agro-climatic conditions [9].

**Irrigation and Farming Management of Garlic**

Most of the time, garlic likes moist soil and necessary to regularly water during germination and in dry climates. When the bulbs are finished off and the wrappers are drying out too much water is not good which can be created a mold or fungus problem. Some people like to heavily irrigate during drier climates at the pre planting phase to help build a deep soil moisture reserve. Nitrogen and water will have the greatest effect on the yield of garlic prior to bulbing. However, garlic requires around 2.5 cm up to 5 cm of water per week and sufficient moisture is needed after bulbing but irrigation should be stopped at least two weeks prior to the expected harvesting date. The late-season irrigation tends to stain the skin and reduce the quality of yield [14]. Water stress should be avoided in garlic crops prior to the first signs of maturity to achieve optimum yields and quality [17]. Cease irrigation when the first signs of maturity are evident yellowing or neck softening.

**Composition and Use of Nutrition Garlic**

The growth and yield of garlic were influenced by different nutrition management and other factors during their production in the field. The elements of freeze-boron, magnesium, phosphorus, potassium, and nitrate nitrogen are significantly different on the growthing and production of garlic bulb [42]. The garlic flavor is a group of sulfur-containing compounds and lachrymatory effect due to the high proportion of 2-propenyl L-cysteine sulphoxide (2-PECSCO) constitute. However, garlic is rich in sugar, protein, fat, calcium, potassium, phosphorus, sulfur, iodine, fiber, and silicon, in addition to vitamins. The garlic pungent flavor makes it used as a spice, seasoning and flavoring for food stuff involving both green tops and bulbs [20]. Although bulb consumption is more common, tender shoots and a delicatessen for sophisticated cuisine. These shoots may be prepared like asparagus. Each clove is able to develop a new plant, since they have an apical shoot bud that can elongate even though they are not sown. This shoot is apparent after three months of harvest, depending on the genotype. These stems produce a strong odor from two compounds: alliin and diallylsulfide.

## DIVERSITY AND DEVELOPMENT OF GARLIC SPECIES

The different garlic species are classified in four groups: *longicuspis*, *Ophioscorodon*, *sativum*, *subtropical,* and pekinense subgroup. The **Longicuspis group** is considered the oldest and it is postulated to be the original group. The **Ophioscorodon group** is distributed in Central Asia, the ***sativum* group** in the Mediterranean zone, and subtropical in the south and southeast of Asia. Finally, the ***pekinense* subgroup** comes from the east of Asia [23]. To develop specifically adapted and high yielding varieties of garlic has to be initiated through farmer experimentation, innovation, selection, improves of genotypes, development of appropriate management practices as well as production of bulb and quality seeds [34]. Characterize garlic for developing important ago production variety through ago morphological and molecular conserve of local and exotic germplasms. Germplasms of garlic were collected from domestic and exotic sources and the yield performances of these collected germplasms were assessed through field testing [34].

The effectiveness of garlic selection depends on the amount of variability present in the genetic material for yield and yield-related traits. The majority of traits are important for crop productivity which is controlled through the combined effects of a number of genes that

influence the trait [33]. The Mexican genotypes have a wide variation in clove size and number that reflects a good genetic pool for breeding through individual selection of plants. Some other characteristics are qualitative that may have a positive impact on worldwide market demand. Garlic cultivated in rural farms of South Italy is often a heterogeneous clone population, which can comprise different cytogenetic types and showing significant differences in yield were observed within and between ploidy levels. Discriminant analysis did show that four characters (leaf basal width, total number of leaves, clove diameter, and neck height) were able to correctly discriminate all germplasm accessions and the highest differences of bulb diameter were found among varieties [9],[16]. Plants showing a smaller number of cloves per bulb appeared to have greater clove weights. Varieties with greater bulb weight appeared to be taller than smaller bulb weights. The greatest bulb weight varieties showed more than 75% greater bulb weight than the lowest bulb weight varieties had a better tolerance to environmental conditions with its bulbs having fewer cloves (10-12), and the bulb and clove weights were favorably compared with those of commercial varieties in California [16].

**The Role of Diversity on Garlic Yield and Yield Components**

The variety of garlic must be selected from a list of recommended or local varieties. Depend on its adaptation; the variety should have high yield potential, tolerance to biotic and abiotic stresses, good marketability, and high consumer preferences. The agro-morphological character of yield reflects the performance of all plant components and plant contains an inherent physiological production capacity that operates on the energy required for normal plant performance while all accessions do not have the same inherent physiological capacity to yield [3]. Breeders commonly find yield to be a very complex array of plant-component interactions and through the manipulation of these genetic systems, yield is improved as a result of plant efficiency improvement.

**Function of Nitrogen in Growth and Development of Garlic**

Farmers endeavor to produce high yield and good quality garlic for consumption and economic value but soil fertility depletion is the major obstacle to sustained garlic production. Nitrogen has been identified as the most limiting nutrient in plant growth. However, plants obtain readily available N forms from different sources. The major forms of available N are biological nitrogen fixation by soil microorganisms, mineralization of organic N, industrial fixation of nitrogen gas and fixation as oxides of nitrogen, and mineralization of organic nitrogen to inorganic forms, level of soil moisture and supply of oxygen [40]. Nitrogen is a necessary and important element for increasing the yield and quality of vegetables [15]. As increased the level of N it increased the growth trend of the number of leaves, leaf length, and plant body that garlic has a high nitrogen requirement, particularly in the early stages of growth.

Availability of nitrogen is a prime importance for growing plants and essential source of protein and nucleic acid molecules. It is well known that the use of fertilizer helps in production and rapid method for achieving maximum yields [29]. Manure is a good supplier of organic matter but a low and slow supplier of nutrients as it releases over a year. This fact has made fertilizer management be an important aspect of crop production practices [21],[ 40]. At the highest application of urea, the highest yield was recorded and the application of increasing rates of nitrogen had a significant effect on fresh bulb yields [25]. The significantly application of

nitrogen fertilizer increased the growth attributes like plant height and neck thickness, bulb diameter, number of cloves per bulb, fresh weight of cloves, dry weight of cloves, fresh weight of bulb, dry weight of bulb and bulb yield ha-1[8]. Correlation between some quantitative traits of garlic showed the positive and significant correlation with yield and leaf length. Between performance and bulb diameter and length, diameter, and weight, cloves showed positive correlation observed. Leaf length, bulb diameter and length, and the mean number clove, negative clove, and significant bulb weight and number of leaves per plant were showed significant positive correlations [25]. The effect of N fertilizer levels on the performance of different onion varieties suggested that N levels significantly enhanced plant height, producing the bulbs of the greatest marketable yield, total bulb yield [24], [39].

## CONCLUSION

Garlic (*Allium sativum* L.) is one of the oldest cultivated crops. It is the most important vegetable bulb crops produced for home consumption as a flavoring agent for foods, medicinal value and as a source of income. Selections of cultivars based on morphological and agronomical characteristics of varieties that respond to fertilizer rates are essential to produce high yield; adaptable and high market acceptance. The growth and yield of garlic is influenced by different nutrition management and other factors during their production in the field. Appropriate nitrogen fertilizer rates are very significant factors to increase the productivity, bulb quality, and marketability of garlic. Farmers endeavor to produce high yield and good quality garlic for consumption and economic value, but soil fertility depletion is the major obstacle to sustained garlic production because of limited application of suitable soil fertility and sources of fertilizers. Significantly application of nitrogen fertilizer increased the growth attributes like plant height in cm and neck thickness, bulb diameter, number of cloves per bulb, fresh weight of cloves, dry weight of cloves, fresh weight of bulb, dry weight of bulb and bulb yield. Garlic is propagated asexually and shows highly morphological diversity among cultivars. Garlic has a wide area of adaptation and cultivation throughout the world. The optimum temperature for growing garlic lies between 12°C and 24°C. The productivity of garlic in many parts of the world is low due to genetic variability, ago-ecological and environmental factors affecting the quantity and quality of yield and yield-related traits. Morphological and agronomic variations in characteristics of garlic such as color of the bulb, size of the bulb, plant height, number of cloves, size of the cloves, days to harvesting, resistance to storage capacity, dormancy and adaptation to agro-climatic conditions. The different garlic species are *longicuspis*, *Ophioscorodon*, *sativum*, *subtropical,* and pekinense subgroup. The effectiveness of garlic selection depends on the amount of variability present in the genetic material for yield and yield-related traits.

## Declarations

### Authors' Contributions

The authors were involved in read, review, collecting and organizing data of the review and writing of the paper as well as approved the manuscript.

### Competing Interests

All authors declare that there are no competing interests.

## Availability of Data and Material

The recorded data used for review and supplementary information files is available at the author's hand and within the article.

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