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EFFICIENCY OF FOLIAR FERTILIZATION OF TOCOPHEROL AND MICRONUTRIENTS ON CHEMICAL, BIOCHEMICAL PARAMETERS, YIELD AND YIELD ATTRIBUTING FACTORS IN CHICKPEA

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ABSTRACT

A research trail was planned to find out the effect of foliar application of tocopherol and micronutrients (Zn, Fe) in chickpea at farm of Botany, College of Agriculture, Nagpur, during *rabi* 2018-2019. The main objective of the study was on chemical, biochemical and yield attributing characters in chickpea. Randomized block design was followed with three replications and 18 treatments. Treatments consisted of five levels of tocopherol viz., 100 ppm, 200 ppm, 300 ppm, 400 ppm and 500 ppm whereas, micronutrients (zinc and iron) were used @ 0.5% individually and in their combinations. Spraying was done at 25 and 45 DAS.Significant increase was recorded in total chlorophyll content, nitrogen content, phosphorus content, potassium content, protein content, number of filled pods, number of unfilled pods and 100 seed weight. It was concluded that treatment T_9 (100 ppm tocopherol + 0.5% $ZnSO_4$) highly influenced the performance of chickpea regarding the chemical, biochemical and yield attributing factors.

(Key words: Foliar fertilization, tocopherol, micronutrients, chemical factors, biochemical factors and yield contributing factors)

INTRODUCTION

Chickpea is a herbaceous annual plant having branches from the base. It is almost like a small bush with diffused and spreading branches. It is a hardy, deep-rooted, dryland crop sown on marginal lands, which can grow to full maturity in conditions that would be unsuitable for most of the crops (Singh and Reddy, 1991). Somatic chromosome number of chickpea is 2n=16. Chickpea is a self-pollinated crop and cross-pollination is a rare event; only 0-1 % is reported. It is a *rabi* crop, grown in months of September-November and harvested in the months of February- April.

Chickpea can fix atmospheric nitrogen up to 140 kg ha^{-1} through its symbiotic association with *rhizobium* and meets its 80% requirement (Saraf *et al*., 1998). According to the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) chickpea seeds contain on an average 23% protein, 64% total carbohydrates, 5% fat,6% crude fiber and 3% ash.

Vitamins are diverse group of organic molecules. The fat-soluble vitamins, such as (vitamin e) tocopherol, are important antioxidants, which means it helps to protect the plant cells from damage caused by unstable molecules called free radicals. They provide essential nutrients for the plant growth. The type of vitamin required to increase the growth depends upon the type of plant.

Zinc sulphate is most commonly used source of zinc. Zinc affects several biochemical processes in the plant, such as cytochrome and nucleotide synthesis, auxin metabolism, chlorophyll production, enzyme activation and membrane integrity. It has an active role in production of an essential growth hormone i.e. auxin.

Iron sulphate is most commonly used source of iron for foliar spray. It contains about 20% of Iron. In plants, iron is involved in the synthesis of chlorophyll and it is essential for the maintenance of chloroplast structure and function.

This experiment aimed to investigate the effect of foliar applications of tocopherol and micronutrients on chemical, biochemical parameters and yield attributing factors of chickpea.

MATERIALS AND METHODS

The present field trial was conducted during *rabi* season of year 2018-19 at experimental farm of Agricultural Botany Section, College of Agriculture, Nagpur to study the effect of foliar sprays of tocopherol and micronutrients

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on chemical, biochemical parameters, yield and yield attributing factors in chickpea. This experiment was laid out in RBD with 3 replications and 18 treatments viz.,T_1 (control), T_2 (100 ppm tocopherol), T_3 (200 ppm tocopherol), T_4 (300 ppm tocopherol), T_5 (400 ppm tocopherol), T_6 (500 ppm tocopherol), T_7 (0.5% $ZnSO_4$), T_8 (0.5% $FeSO_4$), T_9 (100 ppm tocopherol+0.5% $ZnSO_4$), T_{10} (200 ppm tocopherol+0.5% $ZnSO_4$), T_{11} (300 ppm tocopherol+0.5% $ZnSO_4$), T_{12} (400 ppm tocopherol+0.5% $ZnSO_4$), T_{13} (500 ppm tocopherol+0.5% $ZnSO_4$), T_{14} (100 ppm tocopherol+0.5% $FeSO_4$), T_{15} (200 ppm tocopherol+0.5% $FeSO_4$), T_{16} (300 ppm tocopherol+0.5% $FeSO_4$), T_{17} (400 ppm tocopherol+0.5% $FeSO_4$) and T_{18} (500 ppm tocopherol+0.5% $FeSO_4$). Two foliar sprays at 25 and 40 DAS were given. JAKI-9218 cultivar of chickpea was used in the experiment. Observations on total chlorophyll content, nitrogen content, phosphorus content and potassium content were recorded at 25, 45, 65 and 85 DAS. Total chlorophyll content of oven dried leaves was estimated by colorimetric method as suggested by Bruinsma (1982). Nitrogen content in leaves was determined by micro kjeldhal's method as given by Somichi *et al*. (1972). Phosphorus content in leaves was determined by vanadomolybdate yellow colour method as given by Jackson (1967). Potassium content in leaves was determined by flame photometer by di-acid extract method given by Jackson (1967). Protein content in seed, number of filled pods, number of unfilled pods and 100 seed weight were calculated after harvest.

RESULTS AND DISCUSSION

Total chlorophyll content

Chlorophyll is an important photosynthetic pigment of the plant, largely determining photosynthetic capacity and hence plant growth. It is green in colour and present in chloroplasts. Chlorophyll content provides valuable information regarding physiological status of plant. They are essential photosynthetic pigments capable of absorbing light energy for carbohydrate synthesis. On a whole, it represents photosynthetic capacity of the plant.

The biochemical parameter like chlorophyll content in leaves at 45 DAS was found significantly high in treatment T_9 (100 ppm tocopherol + 0.5% $ZnSO_4$) followed by treatments T_{11} (300 ppm tocopherol + 0.5% $ZnSO_4$), T_{10} (200 ppm tocopherol + 0.5% $ZnSO_4$), T_{16} (300 ppm tocopherol + 0.5% $FeSO_4$), T_{15} (200 ppm tocopherol + 0.5% $FeSO_4$), T_{12} (400 ppm tocopherol + 0.5% $ZnSO_4$), T_{13} (500 ppm tocopherol + 0.5% $ZnSO_4$) and T_3 (200 ppm tocopherol). Similarly, treatments T-$_2$ (100 ppm tocopherol), T_4 (300 ppm tocopherol), T_{17} (400 ppm tocopherol + 0.5% $FeSO_4$), T_5 (400 ppm tocopherol),T_6 (500 ppm tocopherol) and T_7 (0.5% $ZnSO_4$) also registered significantly maximum chlorophyll content over control and other treatments. At 65 DAS maximum increase in chlorophyll content of leaves was observed with treatment T_9 (100 ppm tocopherol + 0.5% $ZnSO_4$) followed by treatment T_{11} (300 ppm tocopherol + 0.5% $ZnSO_4$). At 85 DAS significantly maximum leaf chlorophyll was recorded in treatment T_9 (100 ppm tocopherol + 0.5% $ZnSO_4$) followed by treatments T_{11} (300 ppm tocopherol + 0.5% $ZnSO_4$), T_{10} (200 ppm tocopherol + 0.5% $ZnSO_4$), T_{16} (300 ppm tocopherol + 0.5% $FeSO_4$) and T_{15} (200 ppm tocopherol + 0.5% $FeSO_4$) in a decreasing order when compared with control and other treatments.

The main function of anti-oxidants such as Vitamin E was protective of cell membranes and their binding transporter proteins, maintained their structure and function against the toxic and destructive effects reactive oxygen species (ROS) during stress, in turn, more absorption and translocation of minerals (Dicknson *et al*., 1991). Vitamin E is exclusively synthesized in photosynthetic organisms (Dellapenna, 2005). Zinc has important role in chlorophyll formation which enhanced chlorophyll content in leaf of the plants (Sharma *et al*., 2010).

In 2017, Sadiq *et al*. observed that, of all levels of tocopherol used, 200 and 300 mg l^{-1} were superior in raising chlorophyll a and b contents in both mung bean cultivars (Cyclone 7008 and Cyclone 8009).Sale and Nazirkar in 2013, found highest amount of chlorophyll (28.0 mg 100 g^{-1}) in treatment receiving foliar application of zinc (0.5%) and iron (0.5%) along with seed fortification of molybdenum in soybean.

Leaf nitrogen content

Nitrogen is so vital as it is a major component of chlorophyll, the compound by which photosynthesis occur. It is major component of amino acids, the building blocks of proteins. It has more influence on plant growth, appearance and quality than any other essential elements. The nitrogen present mostly as protein is constantly moving and under concentration of nitrogen is found in young, tender plant tissues like tips of shoots, buds and new leaves (Jain, 2010). Abundant of essential nitrogenous compound is required in each plant cell for normal cell division, growth and respiration.

At 45 DAS highest nitrogen content was recorded in treatment T_9 (100 ppm tocopherol + 0.5% $ZnSO_4$) followed by treatments T_{11} (300 ppm tocopherol + 0.5% $ZnSO_4$), T_{10} (200 ppm tocopherol + 0.5% $ZnSO_4$). Next to this, treatments T_{16} (300 ppm tocopherol + 0.5% $FeSO_4$), T_{15} (200 ppm tocopherol + 0.5% $FeSO_4$),T_{12} (400 ppm tocopherol + 0.5% $ZnSO_4$), T_{13} (500 ppm tocopherol + 0.5% $ZnSO_4$), T_3 (200 ppm tocopherol), T-$_2$ (100 ppm tocopherol), T_4 (300 ppm tocopherol), T_{17} (400 ppm tocopherol + 0.5% $FeSO_4$), T_5 (400 ppm tocopherol),T_6 (500 ppm tocopherol), T_7 (0.5% $ZnSO_4$) and T_{14} (100 ppm tocopherol + 0.5% $FeSO_4$) also exhibited significantly more nitrogen content when compared to control and other treatments. At 65 DAS and 85 DAS, treatment T_9 (100 ppm tocopherol + 0.5% $ZnSO_4$) was significantly superior in nitrogen content over control followed by treatments T_{11} (300 ppm tocopherol + 0.5% $ZnSO_4$), T_{10} (200 ppm tocopherol + 0.5% $ZnSO_4$) and T_{16} (300 ppm tocopherol + 0.5% $FeSO_4$) in a decreasing manner. At 65 DAS treatments T_{15} (200 ppm tocopherol + 0.5% $FeSO_4$),T_{12}

(400 ppm tocopherol + 0.5% $ZnSO_4$) and T_{13} (500 ppm tocopherol + 0.5% $ZnSO_4$) showed their significance over control. At 85 DAS treatments T_{15} (200 ppm tocopherol + 0.5% $FeSO_4$),T_{12} (400 ppm tocopherol + 0.5% $ZnSO_4$), T_{13} (500 ppm tocopherol + 0.5% $ZnSO_4$),T_3 (200 ppm tocopherol), T-$_2$ (100 ppm tocopherol), T_4 (300 ppm tocopherol), T_{17} (400 ppm tocopherol + 0.5% $FeSO_4$), T_5 (400 ppm tocopherol),T_6 (500 ppm tocopherol) and T_7 (0.5% $ZnSO_4$)) registered significantly maximum nitrogen over control and rest of treatments.

Younger leaves and developing organs such as seeds act as strong sink demand and may heavily draw nitrogen for their growth from older leaves. So, decrease in nitrogen content may occur in later stages of growth in a plant (Gardner *et al.,* 1988). The effects of zinc application on chlorophyll and leaf area mainly attributed to more availability of zinc both during seedling and subsequent stages of plant growth which has been known to increase photosynthates and 'N' fixation (Hegazy *et al*., 1990; Nayak, 1989). In 2002, Ved *et al*. also stated that foliar applied zinc enhances photosynthesis, early growth of plants, improves nitrogen fixation, grain protein and yields.

Nagwa *et al*. in 2013 observed that, the application of bio regulators and Vitamin E at 100 ppm resulted highest N content in bulb tissues of onion.

Leaf phosphorus content

Plants must have phosphorus for normal growth and maturity. It is an important constituent of protoplasm and nucleic acids and proteins. Thus, play a major role in photosynthesis, respiration, energy storage and transfer, cell division, cell enlargement and several other processes in plants.

At 45 DAS significantly more phosphorus was observed with treatment T_9 (100 ppm tocopherol + 0.5% $ZnSO_4$) followed by treatments T_{11} (300 ppm tocopherol + 0.5% $ZnSO_4$), T_{10} (200 ppm tocopherol + 0.5% $ZnSO_4$) and T_{16-}(300 ppm tocopherol + 0.5% $FeSO_4$) in decreasing trend compared to control and other treatments. At 65 DAS and 85 DAS significantly highest phosphorus content in leaves was found with treatment T_9 (100 ppm tocopherol + 0.5% $ZnSO_4$) followed by treatments T_{11} (300 ppm tocopherol + 0.5% $ZnSO_4$) and T_{10} (200 ppm tocopherol + 0.5% $ZnSO_4$) over control and rest of treatments in a descending manner.

The reason behind the increase in phosphorus content gradually up to 65 DAS may be because of the translocation of leaf phosphorus and its utilization for the development of food storage organ. Later phosphorus content was decreased at 85 DAS due to diversion of phosphorus towards developing organs.

In 2013, Nagwa *et al*. noticed that the application of bio regulators and Vitamin E at 100 ppm resulted highest P content in bulb tissues of onion during first season.

Leaf potassium content

Potassium triggers the activation of enzymes and essential for production of Adenosine Triphosphate (ATP) which is important energy source for many chemical processes taking place in plants. It is an essential macronutrient for plants involved in many physiological processes. It regulates opening and closing of stomata and therefore, regulates carbon-dioxide uptake. Potassium deficiency has a strong impact on plant metabolism.

At 45 DAS significantly superior potassium content was found in treatment T_9 (100 ppm tocopherol + 0.5% $ZnSO_4$) followed by treatments T_{11} (300 ppm tocopherol + 0.5% $ZnSO_4$), T_{10} (200 ppm tocopherol + 0.5% $ZnSO_4$), T_{16} (300 ppm tocopherol + 0.5% $FeSO_4$), T_{15} (200 ppm tocopherol + 0.5% $FeSO_4$),T_{12} (400 ppm tocopherol + 0.5% $ZnSO_4$) and T_{13} (500 ppm tocopherol + 0.5% ZnSO4) in a descending manner when compared with other treatments and control. Treatments T_3 (200 ppm tocopherol), T-$_2$ (100 ppm tocopherol), T_4 (300 ppm tocopherol), T_{17} (400 ppm tocopherol + 0.5% $FeSO_4$), T_5 (400 ppm tocopherol),T_6 (500 ppm tocopherol), T_7 (0.5% $ZnSO_4$),T_{14} (100 ppm tocopherol + 0.5% $FeSO_4$),T_8 (0.5% $FeSO_4$) and T_{18} (500 ppm tocopherol + 0.5% $FeSO_4$) also showed their significance over control. At 65 DAS treatment T_9 (100 ppm tocopherol + 0.5% $ZnSO_4$) gave significantly highest potassium content followed by treatments T_{11} (300 ppm tocopherol + 0.5% $ZnSO_4$), T_{10} (200 ppm tocopherol + 0.5% $ZnSO_4$) and T_{16-}(300 ppm tocopherol + 0.5% $FeSO_4$). Treatments T_{15} (200 ppm tocopherol + 0.5% $FeSO_4$),T_{12} (400 ppm tocopherol + 0.5% $ZnSO_4$) and T_{13} (500 ppm tocopherol + 0.5% ZnSO4), T_3 (200 ppm tocopherol), T-$_2$ (100 ppm tocopherol) and T_4 (300 ppm tocopherol) expressed their superiority by recording significantly higher potassium content overcontrol and other treatments. At 85 DAS significantly highest potassium content was noticed with treatment T_9 (100 ppm tocopherol + 0.5% $ZnSO_4$) followed by treatments T_{11} (300 ppm tocopherol + 0.5% $ZnSO_4$), T_{10} (200 ppm tocopherol + 0.5% $ZnSO_4$), T_{16-}(300 ppm tocopherol + 0.5% $FeSO_4$) and T_{15} (200 ppm tocopherol + 0.5% $FeSO_4$). Other treatments T_{12} (400 ppm tocopherol + 0.5% $ZnSO_4$), T_{13} (500 ppm tocopherol + 0.5% $ZnSO_4$), T_3 (200 ppm tocopherol), T-$_2$(100 ppm tocopherol), T_4 (300 ppm tocopherol), T_{17} (400 ppm tocopherol + 0.5% $FeSO_4$), T_5 (400 ppm tocopherol) and T_6 (500 ppm tocopherol) also showed their significance over control (T_1).

From the above data, it is evident that potassium content was initially increased and later got decreased. Decrease in potassium content at later stages of crop growth might be because of the diversion of potassium towards developing parts i. e. pods of chickpea crop at maturity stage.

K content was increased in bulb tissues of onion during first season with foliar application of bio regulators and Vitamin E at 100 ppm in the study conducted by Nagwa *et al*. (2013).

Protein content in seed

Protein content of the seed is one of the considerable factors to judge seed quality. The quality of crop products such as oil, protein and sucrose content and appearance can be genetically controlled but the nutrition of plants has considerable impact on the expression of quality. Therefore, it is essential to judiciously take care about nutrient supply at grain formation stage.

The maximum seed protein was recorded with treatment T_9 (100 ppm tocopherol + 0.5% $ZnSO_4$) followed by treatments T_{11} (300 ppm tocopherol + 0.5% $ZnSO_4$), T_{10} (200 ppm tocopherol + 0.5% $ZnSO_4$), T_{16} (300 ppm tocopherol + 0.5% $FeSO_4$), T_{15} (200 ppm tocopherol + 0.5% $FeSO_4$) and T_{12} (400 ppm tocopherol + 0.5% $ZnSO_4$) in a decreasing trend when compared to treatment T_1 (control) and remaining treatments.

Zn is required for the biosynthesis of plant growth regulator (IAA) and for carbohydrate and N metabolism which leads to improvement in seed quality components (Taliee and Sayadian, 2000).

The foliar application of 0.5 % $ZnSO_4$ in cluster bean at 25 and 45 DAS resulted in highest protein content (28.9%) in the study conducted by Selvaraj and Prasanna in 2012.

Yield and yield attributing parameters

In general, crop yield depends on the accumulation of photo-assimilates during the growing period and the way they are partitioned between the desired storage organs of a plant. It is a measurement of the amount of agricultural production harvested unit^{-1} of land area.

Seed yield plant^{-1} and plot^{-1}

Seed yield is a quantitative trait which is final result of physiological activities of plant. Seed yield plant^{-1}, plot^{-1} and ha^{-1} are combined effect of yield attributes and physiological efficiency of plant during the present investigation.

The maximum seed yield plant^{-1} and plot^{-1} were recorded in treatment T_9 (100 ppm tocopherol + 0.5% $ZnSO_4$) followed by treatments T_{11} (300 ppm tocopherol + 0.5% $ZnSO_4$), T_{10} (200 ppm tocopherol + 0.5% $ZnSO_4$) and T_{16} (300 ppm tocopherol + 0.5% $FeSO_4$). Treatments T_{15} (200 ppm tocopherol + 0.5% $FeSO_4$), T_{12} (400 ppm tocopherol + 0.5% $ZnSO_4$),T_{13} (500 ppm tocopherol + 0.5% ZnSO4) and T_3 (200 ppm tocopherol) also significantly enhanced seed yield plant^{-1} and plot^{-1} as compared to control and rest of the treatments.

Ved *et al*. (2002) stated that foliar applied zinc enhances photosynthesis, early growth of plants, improves nitrogen fixation, grain protein and yields.

Above results are in harmony with the experimental studies of many scientists. Kulchan *et al*.in 2016 observed that maximum increase in soybean seed yield was obtained by tocopherol (100ppm). Nagwa *et al*. (2009) reported similar effect of α-Tocopherol with the increase in yield in geranium. Pandey and Gupta in 2012, revealed that foliar application of 0.5% zinc sulfate ($ZnSO_4$) to black gram showed favorable results in yield.

Number of pods plant^{-1}

The output of total metabolic activities taking place in plant body is called pod. Pod yield mainly depends upon source sink relation. The economic part will obtain the assimilates synthesized by photosynthesis.

Data regarding number of pods plant^{-1} showed highest pods plant^{-1} in treatment receiving foliar spray of 100 ppm tocopherol + 0.5% $ZnSO_4$ (T_9) followed by treatment T_{11} (300 ppm tocopherol + 0.5% $ZnSO_4$). Treatments T_{10} (200 ppm tocopherol + 0.5% $ZnSO_4$), T_{16} (300 ppm tocopherol + 0.5% $FeSO_4$), T_{15} (200 ppm tocopherol + 0.5% $FeSO_4$), T_{12} (400 ppm tocopherol + 0.5% $ZnSO_4$), T_{13} (500 ppm tocopherol + 0.5% ZnSO4), T_3 (200 ppm tocopherol), T-$_2$ (100 ppm tocopherol), T_4 (300 ppm tocopherol), T_{17} (400 ppm tocopherol + 0.5% $FeSO_4$) and T_5 (400 ppm tocopherol) were also found significantly superior over control (T_1).

The enhancement effect on seeds pod^{-1} and pods plant^{-1} attributed to the favorable influence of the Zn application to crops on nutrient metabolism, biological activity and growth parameters. Hence, applied zinc resulted in taller and higher enzyme activity which in turn encourage vegetative branches and pods plant^{-1}. (Michail *et al*., 2004).

Above results are in agreement with experiments done by many scientists. Anitha *et al.* in 2005 conducted an experiment to study the effect of foliar spray iron and zinc on cowpea. Combined spraying of 0.5% $FeSO_4$ and 0.5% $ZnSO_4$ proved to be most effective and increased the pod yield by 14.12 % when compared with control. Gul *et al*. in 2011 studied the effect of N, P and Zn foliar sprays on Wheat and found that maximum number of tillers m^{-2} (527) was recorded in plots sprayed with 0.5% N + 0.5% P + 0.5% Zn solutions two times.

Number of unfilled pods plant^{-1}

With respect to number of unfilled pods plant^{-1} treatment T_9 (100 ppm tocopherol + 0.5% $ZnSO_4$) showed significantly lowest number of unfilled pods plant^{-1}followed by treatment T_{11} (300 ppm tocopherol + 0.5% $ZnSO_4$), T_{10} (200 ppm tocopherol + 0.5% $ZnSO_4$), T_{16} (300 ppm tocopherol + 0.5% $FeSO_4$), T_{15} (200 ppm tocopherol + 0.5% $FeSO_4$) and T_{12} (400 ppm tocopherol + 0.5% $ZnSO_4$) when compared with control (T_1) and rest of the treatments. In the same manner, significantly lowest number of unfilled pods plant^{1}was also observed in treatments T_{13} (500 ppm tocopherol + 0.5% ZnSO4), T_3 (200 ppm tocopherol), T-$_2$ (100 ppm tocopherol), T_4 (300 ppm tocopherol), T_{17} (400 ppm tocopherol + 0.5% $FeSO_4$), T_5 (400 ppm tocopherol),T_6 (500 ppm tocopherol), T_7 (0.5% $ZnSO_4$) and T_{14} (100 ppm tocopherol + 0.5% $FeSO_4$) in a decreasing manner over control (T_1).

100 seed weight

Significantly maximum 100 seed weight was recorded in treatment T_9 (100 ppm tocopherol + 0.5% $ZnSO_4$) followed by treatments T_{11} (300 ppm tocopherol + 0.5% $ZnSO_4$), T_{10} (200 ppm tocopherol + 0.5% $ZnSO_4$), T_{16} (300 ppm tocopherol + 0.5% $FeSO_4$), T_{15} (200 ppm tocopherol + 0.5% $FeSO_4$), T_{12} (400 ppm tocopherol + 0.5% $ZnSO_4$),T_{13} (500 ppm tocopherol + 0.5% ZnSO4) and T_3 (200 ppm tocopherol) compared to untreated control (T_1). Treatments T-$_2$ (100 ppm tocopherol) and T_4 (300 ppm tocopherol) also exhibited their significance over control (T_1).

Table 1.Effect of tocopherol and micronutrients on chemical and biochemical parameters in chickpea

Treatments	Total chlorophyll content (mg g^{-1})				Nitrogen content (%)				Phosphorous content (%)				Potassium content (%)				Protein content (%)
	25 DAS	45 DAS	65 DAS	85 DAS	25 DAS	45 DAS	65 DAS	85 DAS	25 DAS	45 DAS	65 DAS	85 DAS	25 DAS	45 DAS	65 DAS	85 DAS	
T_1 (Control)	0.85	0.83	1.29	1.58	1.00	1.28	2.42	1.80	0.206	0.602	0.656	0.619	0.35	0.37	1.05	0.85	23.54
T_2 (100 ppm tocopherol)	1.31	1.29	1.43	1.65	1.49	2.11	2.87	2.51	0.225	0.662	0.729	0.691	0.59	1.32	1.35	1.34	24.86
T_3 (200 ppm tocopherol)	1.32	1.34	1.44	1.65	1.51	2.15	2.88	2.55	0.226	0.669	0.739	0.693	0.60	1.35	1.39	1.37	25.35
T_4 (300 ppm tocopherol)	1.29	1.26	1.43	1.64	1.47	2.06	2.74	2.45	0.224	0.659	0.725	0.689	0.57	1.26	1.34	1.18	24.83
T_5 (400 ppm tocopherol)	1.19	1.25	1.43	1.63	1.40	2.01	2.65	2.35	0.218	0.652	0.719	0.677	0.56	1.15	1.24	1.14	24.24
T_6 (500 ppm tocopherol)	1.17	1.23	1.41	1.62	1.38	2.01	2.61	2.33	0.214	0.642	0.719	0.677	0.50	1.10	1.22	1.14	24.12
T_7 (0.5 % $ZnSO_4$)	1.06	1.12	1.40	1.61	1.32	1.94	2.59	2.24	0.213	0.635	0.713	0.669	0.47	0.99	1.22	0.96	24.07
T_8 (0.5 % $FeSO_4$)	1.03	1.04	1.39	1.60	1.13	1.53	2.54	2.18	0.209	0.625	0.690	0.648	0.42	0.89	1.12	0.92	23.90
T_9 (100 ppm tocopherol+0.5 % $ZnSO_4$)	1.46	1.54	1.57	1.78	1.78	2.69	3.74	3.14	0.247	0.736	0.835	0.786	0.72	1.57	1.74	1.69	26.89
T_{10} (200 ppm tocopherol+0.5 % $ZnSO_4$)	1.44	1.47	1.53	1.72	1.59	2.37	3.63	3.01	0.239	0.726	0.793	0.737	0.69	1.42	1.62	1.56	25.97
T_{11} (300 ppm tocopherol+0.5 % $ZnSO_4$)	1.45	1.48	1.56	1.73	1.70	2.66	3.71	3.09	0.239	0.734	0.821	0.771	0.69	1.46	1.65	1.57	26.08
T_{12} (400 ppm tocopherol+0.5 % $ZnSO_4$)	1.37	1.41	1.45	1.67	1.56	2.23	2.93	2.64	0.230	0.678	0.743	0.709	0.62	1.39	1.49	1.42	25.51
T_{13} (500 ppm tocopherol+0.5 % $ZnSO_4$)	1.34	1.40	1.44	1.66	1.55	2.18	2.92	2.58	0.227	0.673	0.742	0.702	0.61	1.37	1.42	1.39	25.49
T_{14} (100 ppm tocopherol+0.5 % $FeSO_4$)	1.06	1.04	1.40	1.61	1.17	1.93	2.55	2.21	0.210	0.634	0.691	0.665	0.46	0.93	1.15	0.93	23.90
T_{15} (200 ppm tocopherol+0.5 % $FeSO_4$)	1.42	1.41	1.50	1.70	1.56	2.25	2.93	2.65	0.232	0.689	0.750	0.713	0.63	1.41	1.50	1.48	25.52
T_{16} (300 ppm tocopherol+0.5 % $FeSO_4$)	1.42	1.42	1.52	1.71	1.57	2.31	3.25	2.94	0.232	0.710	0.777	0.733	0.66	1.42	1.61	1.52	25.84
T_{17} (400 ppm tocopherol+0.5 % $FeSO_4$)	1.23	1.26	1.43	1.64	1.43	2.02	2.67	2.37	0.222	0.654	0.721	0.680	0.57	1.17	1.28	1.18	24.72
T_{18} (500 ppm tocopherol+0.5 % $FeSO_4$)	1.01	1.00	1.38	1.60	1.08	1.49	2.51	2.07	0.206	0.611	0.675	0.639	0.39	0.83	1.11	0.91	23.85
SE(m) ±	0.395	0.075	0.084	0.032	0.452	0.124	0.171	0.148	0.071	0.039	0.043	0.041	0.178	0.072	0.081	0.076	0.673
CD at 5%	-	0.214	0.239	0.091	-	0.353	0.489	0.423	-	0.111	0.123	0.116	-	0.206	0.231	0.216	1.934

Table 2.Effect of tocopherol and micronutrients on yield and yield attributing parameters in chickpea

Treatments	Seed yield plant^{-1} (g)	Seed yield plot $^{-1}$ (kg)	Number of pods plant^{-1}	Number of unfilled pods plant^{-1}	100 seed weight (g)
T_1 (Control)	3.65	0.73	35.73	10.13	19.67
T_2 (100 ppm tocopherol)	4.82	0.96	47.13	8.27	21.87
T_3 (200 ppm tocopherol)	4.90	0.98	47.13	8.20	22.33
T_4 (300 ppm tocopherol)	4.79	0.96	47.07	8.33	21.73
T_5 (400 ppm tocopherol)	4.60	0.92	44.13	8.60	21.47
T_6 (500 ppm tocopherol)	4.50	0.90	42.20	8.67	21.43
T_7 (0.5 % $ZnSO_4$)	4.45	0.89	41.33	8.67	21.37
T_8 (0.5 % $FeSO_4$)	4.26	0.85	39.67	9.13	20.77
T_9 (100 ppm tocopherol+0.5 % $ZnSO_4$)	6.21	1.24	66.47	6.33	22.90
T_{10} (200 ppm tocopherol+0.5 % $ZnSO_4$)	5.70	1.14	54.00	7.33	22.69
T_{11} (300 ppm tocopherol+0.5 % $ZnSO_4$)	5.92	1.18	65.20	6.93	22.70
T_{12} (400 ppm tocopherol+0.5 % $ZnSO_4$)	5.15	1.03	48.27	7.60	22.53
T_{13} (500 ppm tocopherol+0.5 % $ZnSO_4$)	4.96	0.99	47.67	7.73	22.50
T_{14} (100 ppm tocopherol+0.5 % $FeSO_4$)	4.35	0.87	39.93	8.67	21.00
T_{15} (200 ppm tocopherol+0.5 % $FeSO_4$)	5.22	1.04	48.80	7.60	22.57
T_{16} (300 ppm tocopherol+0.5 % $FeSO_4$)	5.44	1.09	49.67	7.53	22.57
T_{17} (400 ppm tocopherol+0.5 % $FeSO_4$)	4.71	0.94	46.87	8.40	21.63
T_{18} (500 ppm tocopherol+0.5 % $FeSO_4$)	4.11	0.82	36.07	9.80	19.80
SE(m) ±	0.316	0.063	2.819	0.473	0.682
CD at 5%	0.909	0.182	8.045	1.350	1.959

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