UNIVERSITY FOR DEVELOPMENT STUDIES

EFFECT OF ANTITRANSPIRANTS ON GROWTH AND YIELD OF MUTANT PEARL MILLET (*Pennisetum glaucum*) GENOTYPE

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FACULTY OF AGRICULTURE, FOOD AND CONSUMER SCIENCES

DEPARTMENT OF CROP SCIENCE

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BY

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DECLARATION

I, Iddrisu Muniru Mustapha, do hereby declare that this work is the result of my work. No previous submission for a degree or any certificate has been made here or elsewhere. However, information relevant to this work from other authors have been cited and duly acknowledged through references.

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I hereby declare that the preparation and presentation of this thesis were supervised in accordance with the guidelines on thesis supervision laid down by the University for Development Studies.

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ABSTRACT

Millet is cultivated and used as food for man and livestock in parts of of Africa and Asia. Drought is the principal abiotic stress reducing its productivity. Reduced transpiration can help in limiting excessive water loss to the atmosphere with the application of antitranspirants.

Pot and field experiments were conducted at Nyankpala, Northern Ghana to evaluate the effect of Kaolin and Phenylmercuric acetate as antitranspirants on five genotypes and water regime at two levels in a Randomized Complete Block Design with three replications for both pot and field studies. Growth and yield parameters were collected for statistical analysis. Genstat (12 edition) was used for the analysis. The Results showed that antitranspirants and mutagenesis had significant effects on genotypes growth and yield, water regime did not show much effect. Generally, 300 Gy responded positively than the other genotypes and can be recommended for farmers.

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DEDICATION

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LIST OF ACRONYMS

ANOVA	Analysis of Variance
CSIR	Council for Scientific and Industrial Research Institute
PMA	Phenylmercuric Acetate
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
Gy	Gray
IAEA	International Atomic Energy Agency
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
LSD	Least Significant Difference
MoFA	Ministry of Food and Agriculture
RCBD	Randomized Complete Block Design
SARI	Savannah Agriculture Research Institute
WAP	Weeks After Planting
LAI	Leaf Area Index

CHAPTER ONE

INTRODUCTION

1.1 Background

The name ‘millet' (*Pennisetum glaucum* (L) R. Br.) represents a cluster of cereal grains cultivated and used as food for man and feed for livestock in ancient times (Jukanti *et al*., 2016). Millet, a small-grained cereals, belong to the grass family and particularly can withstand adverse weather conditions This crop has not been recognized much by both researchers and users (Obilana, 2003). Millet is noted to be a reliable cereal crops in the semi-arid tropics' rain-fed regions (FAO, 2010). It is grown in the semiarid tropics of Africa and Asia, are extremely important, particularly in West Africa, it is rated high in poor nations where 97 percent production takes place. (Singh *et al*., 2016). Researchers and consumers have paid more attention to the harsh seasonal rainfall and other abiotic conditions, as well as restricted water resources, that impact millet production (Ceccon et al., 2006).

Millets are produced and supplied as food, feed, and fodder for animals in Asia and Africa's arid and semi-arid tropical climates. Finger millet, pearl millet, foxtail millet, and proso millet are the most important millets considering production area and productivity. It is a traditional food crop that is only sold as a last resort for money in most homes. Millet is one of the first crops on the field to be harvested after a long dry season, and therefore regarded as a hunger relief (Kudadjie *et al*., 2004). Pearl millet is the highest of all millet production in the world (Bhagavatula *et al*., 2013).

Climate change undoubtedly necessitates a number of pragmatic measures, including the development of new agronomic technology and cultivars that are resistant to high temperatures and drought. (Boote *et al*., 2011; Hammer *et al*., 2002).. Drought was observed by (Boyer, 1982) to be a key limiting factor in agriculture, resulting in decreased crop yields. Identifying genetic variables in crop production is important as plant drought stress response is critical for plant breeding. In Northern Ghana, despite receiving significant annual rainfall of 900-1120 mm, Millet production is severely impacted by annual water loss through evapotranspiration, soils with low water holding capacity and high prevalence of site-specific drought spells (Kasei *et al*., 2015).

Farmers all around the world are considering switching crops due to changing weather patterns, particularly to kinds that are resistant to droughts, floods, high temperatures, and salt intrusion (Zandalinas *et al*., 2018). Temperature is a major climatic component that influences the growth and development of pearl millet. Soil temperatures in farmers' fields in India and Africa frequently exceed 45 degrees Celsius, with temperatures as high as 60 degrees Celsius being recorded on rare occasions (Yadav *et al*., 2006).

Millets are better adapted to hot, dry climates than most crops, and maybe cultivated in a wide range of climatic circumstances. Because of their limited growing season, they have considerable utility, particularly in semiarid areas. They can either withstand drought and extreme heat, or they can grow to maturity quickly and avoid these conditions (Parasuraman, 2019).

Pearl millet, as a grain for human consumption, provides a significant portion of nutrients for large groups of people in Africa and Asia, and is frequently regarded as particularly tasty. Anti-nutrients (phytic acid and polyphenols) restrict protein and starch digestibility (Yoon *et al*., 1983), reduce mineral bioavailability, and block proteolytic and amylolytic enzymes (Sarwar Gilani *et al*., 2012).

Reduced transpiration can help in limiting excessive water loss to the atmosphere with the application of antitranspirants which help to increase drought tolerance by causing xeromorphy and/or stabilizing cell structure (Silva 2012). Kaolin is considered non-toxic aluminosilicate clay mineral. Kaolin application to plants results in less transpiration rate but more photosynthesis in plants by more action of leaf reflectivity (Ibrahim and Selim 2010). Chitosan is a natural polymer that can be used to reduce water stress in pearl millet. It is made from chitin, which can be found in insect exoskeletons, crustacean shells such as prawns, lobster, fish, crab, shrimp, and fungal cell walls. Chitosan is a biocompatible, environmentally safe, and non-toxic polymer. Chitosan is useful in a wide range of biotic and abiotic stress control techniques. It has been reported that foliar application of chitosan results in less stomatal conductance, transpiration, and improves water use efficiency by acting as an antitranspirant compound and promoting the synthesis of jasmonic acid by inducing plant water use as abscisic acid causes stomatal closure (Iriti *et al*., 2009; Bittelli *et al*., 2001).

1.2 Problem statement

Despite the economic importance of millet and its adaptation to numerous environmental conditions in West Africa, the production of pearl millet has involved many constraints such as poor adoption of improved varieties for planting, inadequate and erratic rainfall, rising temperatures, depleted soil fertility and downy mildew disease or prevalent Striga problems among biotic strains (Khairwal *et al*., 2007). In both Asia and Africa, these restrictions result in poor and extremely variable yields. Projected climate change in the dry and semiarid tropical regions would have a negative influence on crop production and sustainable food supply in these areas is in jeopardy (Fischer *et al*., 2007). According to Atkinson and Urwin (2012), these abiotic factors led to about 50% yield loss. As a result, millet production failed to satisfy the population needs in West Africa.

Changes in rainfall alongside temperature rise may have effect on the length of time crops will grow in the dry tropical regions (Cooper *et al*., 2008).

The Department of Crop Science at the University for Development Studies produced promising mutant pearl millet genotypes (potential varieties). Since, high temperatures and high transpiration leading to high loss of water, and drought stress hinders increased production of millet, these mutant genotypes were used as test crops in this study.

1.3 Justification

Droughts are becoming more common, necessitating the deployment of mitigation technology such as the use of antitranspirants in crop production. Droughts will grow more frequent and severe as a result of climate change, posing a danger to global food security. Despite the fact that antitranspirants reduce photosynthesis, research proves that they can help alleviate drought and enhance crop yield (Mphande *et al*., 2021).

1.4 Objectives

1.4.1Main objective;

To determine the effect of antitranspirants and drought stress on growth and total crop yield of five pearl millet genotypes in the Northern Region of Ghana.

1.2 Specific objectives;

1. To determine the effect of antitranspirants on growth and yield of genotypes.
2. To determine the effect of antitranspirants on water use efficiency
3. To determine the effect of water application regimes on growth and yield.
4. To determine the combine effect of moisture application and antitranspirants on growth and yield of genotypes.

CHAPTER TWO

LITERATURE REVIEW

2.1 Origin and distribution

About 5000 years ago, pearl millet was domesticated in Africa (Andrews and Kumar 1992), its cultivation widely spread across the continent with respect to the Sahelian countries (Sahara Desert Margin) in West Africa, through to South Africa. About 3000 years ago, pearl millet was introduced into India and has been widely cultivated since then to present age. According to archeological evidence, pearl millet was initially domesticated around 2500 BC on the southern edge of the Sahara Desert in West Africa (Manning *et al*., 2011).

In Ghana, pearl millet is predominantly grown in five administrative regions, which include Northern, North East, Upper West, Upper East and Savanna (Statistics Research and Information Directorate 2011). The Northern part of Ghana falls under the Guinea and Sudan Savannah zones also referred to as Interior Savannah or semi-arid zones). These zones account for about 41% of the total area cultivated in Ghana of pearl millet production (Bennett-Lartey and Oteng-Yeboah, 2008).

2.2 Economic Importance of Pearl Millet

It is the world's sixth most important grain. Pearl millet accounts for more than half of all millets grown worldwide. In terms of the world's most significant grain crops, pearl millet ranks sixth behind maize (Zea mays L.), rice (Oryza sativa L.), wheat (Triticum aestivum), barley (Hordeum vulgare L.), and sorghum [Sorghum bicolor (L.) Moench]. (Farrell *et al.*, 2002).

Millet is considered as a subsistence crop which is mostly grown for local consumption in most countries in the world. Millet is grown for grazing, green fodder, and silage, among other uses. Millet crop leftovers contribute significantly to feed supply, and livestock is one of the important components considered in most systems established for millet production.

After 1973, the area under millets worldwide began to decline, reaching 31.4 million ha in 2014-15, down from 43 million ha in 1961-62. However, output increased and peaked at 35 million t in 2003, before falling back to the initial level of 28 million tons. Productivity climbed from 600 kilograms per hectare in 1961 to 965 kilograms per hectare in 2008, but then fell to around 903 kilograms per hectare in 2014-15 (Kour *et al*., 2017).

2.3 Nutritional importamce

Millets have a nutritional value equivalent to other cereals, with somewhat higher protein and mineral content (Himanshu1 *et al*., 2018). Pearl millet is gaining favor as healthy food because of its high metabolizable energy and protein as well as its desirable level of iron and zinc densities. It has more balanced amino acid profile compared to maize or sorghum. Non-food applications for pearl millet grain include poultry feed, calf feed and alcohol extraction (Basavaraj *et al.*, 2010).

It is an essential food crop for the drier portions of Africa and India, and is adapted lower soil fertility than sorghum. Millets are a staple crop in many developing countries due to its capacity to thrive in arid climates with little rainfall. The crop is a vital source of energy and protein for millions of Africans. It is said to have a variety of nutritional and medicinal properties (Obilana and Manyasa 2002; Yang *et al.*, 2012).

In general, the amount of lysine and tryptophan in grain proteins, especially millets, is restricted and varies by cultivar. The essential amino acids, as well as vitamins and minerals, are found in millets (Devi *et al.*, 2014; FAO 2009). Plant nutrients are widely used in the food business, and cereal grains are a significant source of dietary nutrients around the world (Amadou *et al*., 2011; Izadi *et al*., 2012).

Millets are nutrient-dense, non-glutinous, and acid-free, like buckwheat and Guinea corn, making them calming and easy to digest. It is one of the least allergic and digestible grains available, and because it is a warming grain, it will aid in the healing of the body during cold or wet seasons and regions. Millet has a protein content of 10%, a fat content of 25%, and a carbohydrate content of 73%. Millets are high in B vitamins (particularly niacin and B6), calcium, iron, potassium, magnesium, and zinc. They are generally deficient in lysine (an amino acid) and must be supplemented with lysine-rich foods to maintain a balanced protein diet (Anitha *et al*., 2020). Millets have a crude fiber content of 4.5 to 6.3 percent (Singh 2012). In nine distinct types of barnyard millet, crude fiber levels ranged from 5.35 to 7.90 percent (Ugare *et al*., 2014).

2.4 Botanical description of pearl millet

The fruit (or caryopsis) is cylindrical, white, or pearl, or sometimes yellow or brown, and occasionally purple. The most cultivated varieties of millet are Pearl, Proso, Foxtail, Japanese Barnyard, Finger, and Kodo and are cultivated across the globe (Saxena *et al*., 2018). It comes in a variety of different types or races, each with its own set of characteristics, and it appears to be open to significant improvement (Webster and Wilson 1989). Millets are a cereal that is similar to wheat, rice, and maize. Millets are a key source of nutrition for millions of people, particularly those who live in hot, dry climates. They are mainly planted in marginal locations in agricultural situations where major grains fail to produce significant yields (Adekunle *et al.*, 2012).

2.5 Ecological and climate requirements

Poor emergence and seedling growth may be experienced if millets planted at soil temperatures below 23^0C. When trees and shrubs are slushed and burnt it leads to soil degradation and loss of nutrients in the semi-arid zone. When the land is tilled to break crust and hardpans, bury plant residues and to incorporate organic manure and other soil amendments like lime support plant growth and development.

Millets can thrive on shallow, low fertile soils with a pH range of 4.5 – 8.0. Millets, especially on acidic soils, might be a viable alternative to wheat. Millets such as pearl millet (*Pennisetum glaucum*) and finger millet, can grow up to 11–12 dS/m of soil salinity. Millets require very little water throughout the growing period. Pearl millet and proso millet are two types of millets that require as little as 20 cm of rainfall, which is several times less than rice which requires an average rainfall of 120–140 cm. (IRRI 2015). Millets are a water-saving crop since they mature in 60–90 days after seeding. Among millets, barnyard millet (*Echinochloa frumentacea*) matures in 45–70 days, which is less than half the time it takes rice to mature (120–140 days) (Hulse *et al.*, 1980).

2.6 Production constraints

Although pearl millet can withstand extreme circumstances, its yield potential is severely limited due to a wide range of abiotic and biotic stresses. The greatest limiting factor is precipitation, which results in flooding and/or dry spells in West Africa or the extremely varied distribution rainfall across the growing season (Haussmann *et al.*, 2012). Significant production losses in millets are caused by biotic agents such as insect pests and diseases. Abiotic stress, on the other hand, are the primary cause of annual losses. Although millets do better in semi-arid regions than other cereals like wheat and rice, these difficult climatic and soil conditions are far from ideal. Drought or insufficient moisture is the principal abiotic stress reducing millet productivity in semi-arid and dry settings where it is the dominating crop. Drought has been shown to affect growth, yield, membrane integrity, color, osmotic adjustment, and other aspects of pearl millet growth and production (Ajithkumar and Panneerselvam 2014).

The main issue with dry-season agriculture is water, which has a direct impact on growth and development because it is a necessary input for growing crop production. Both too much and too little water dramatically limit crop production. Water stress during active crop growth phases causes a halt in growth due to its effects on photosynthesis and other physiochemical processes, as well as death due to desiccation. The temperature increases to around 42℃ or higher throughout the dry season increases the crop water requirement due to increased evapotranspiration. Moisture stress causes poor plant stand and a reduction in the leaf area index, resulting in lower grain and feed yields (Hassan *et al*., 2014).

With an annual rainfall of 150–800 mm, most pearl millet growing locations are characterized by low-input, rainfed agriculture. (Spencer and Sivakumar 1987). The majority of farmers in Africa's semi-arid regions grow pearl millet on barren soils with no external nutrient inputs. Grain yields in drought-prone areas of Africa are as low as 150 kg ha^{-1} , with average rainfall for the past years yielding a little over half a ton per hectare (Mcintire and Fussell, 1989). Low soil nitrogen levels and a scarcity of water are the main factors limiting productivity in these areas (Diouf *et al.*, 2004; Mcintire and Fussell 1989).

While pearl millet can adapt to some extent to early drought, it is sensitive to terminal drought stress during the grain filling stage (Mahalakshmi *et al*., 1987). Climate change effects are projected to occur more frequently, resulting in pearl millet production losses of 10% (Cooper *et al*., 2008; Knox *et al.*, 2012). Drought stress can also limit the uptake of phosphorus (Gemenet *et al.*, 2016; Hash *et al.,* 2002; Sinclair and Vadez 2002), which is already in short supply in West African soils (Bekunda *et al.,* 2015). In Sahelian Africa, poor, sandy, severely worn soils with low pH levels are widespread (Kochian 2012) resulting in phosphorus fixation (Holford, 1997), leaching of nitrates (Bagayoko *et al.*, 2000), as well as aluminum toxicity (Kochian 1995).

A survey was carried out by Dugje *et al.*, 2006 and results indicated that striga infestation was considered as the most important productivity limitation by farmers along with insufficient soil fertility. The use of resistant pearl millet varieties will increase yield in farmers' fields, hence improving livelihood. (Emechebe *et al.*, 2004).

Environmental degradation caused by agricultural-related deforestation, soil erosion, nutrient mining, water depletion, soil/water/air pollution, biodiversity loss, and climate change are all examples of threats to agriculture and agro-ecosystems' long-term survival (Wambuga and Muthamia 2009).

On sorghum/millet plots, shorter fallows and extension onto marginal fields with little fertilizer application have resulted in declining soil fertility and yields (Foundation *et al*., 2013).. In millet-producing areas fallowing is common, but population growth has resulted in shorter fallow periods that do not restore soil fertility (Foundation *et al*., 2013)

2.7 Pest and disease

The millet head miner, which causes losses of 1 percent to 85 percent in Senegal, Burkina Faso, Gambia, and Mali, and two species of short-horned grasshoppers, which cause losses of 70 percent to 90 percent in bad years, which happen every five years on average, are the most serious pests of pearl millet in the African Sahel (Abate *et al*., 2000). In many parts of Africa, weeds (Striga) are a continual and major danger to pearl millet production (Ejeta 2007; Samaké *et al*., 2006). Efforts to breed cultuivars resistant to Striga have yielded mixed results, with pearl millet proving to be the most difficult to breed (Kountche *et al.*, 2016). Planting procedures in Africa worsen weed problems: millet is often planted by spreading seeds, which makes weeding time-consuming (Adeyeye, 2014).

Insect pest and pathogen attack are estimated to be responsible for 30% of production loss (Chandrashekar and Satyanarayana 2006). Pearl millet is reported to be severely harmed by the chinch bug and the European corn borer (MASON *et al*., 2015). In India, according to Sharma *et al*., (2013), more of this crop is sown with genetically homogeneous single-cross hybrids that are particularly susceptible to *Sclerospora graminicola*-caused downy mildew disease..

Blast, also known as leaf spot and produced by *Pyricularia grisea*, has been a problem in recent years.

Downy mildew attacks the foliage and panicles, causing significant losses. Blast and rust are foliar diseases that have impact on fodder quality and grain yield

The estimated annual grain yield loss due to downy mildew is approximately 20-40% (Hash *et al.,* 1999; Hess *et al.,* 2002). But, this could be much higher under favorable conditions of disease development (Singh, 1995; Thakur 2008) and where a susceptible cultivar is repeatedly grown in the same field. Genetically uniform single-cross F1 hybrids become susceptible more rapidly than heterogeneous open-pollinated varieties (Thakur *et al.*, 2006), leading to heavy production losses.

The pathogen has the ability to cause disease at all stages of crop development, from seedling to grain production, resulting in significant crop losses. *Magnaporthe grisea* is a heterothallic filamentous fungus that causes disease in over 50 plant species belonging to 30 Poaceae genera (Goud *et al.*, 2016). Five pathotypes of *M. grisea* infecting pearl millet have been observed indicating that pathogenic diversity in *M. grisea* populations suited to pearl millet exists (Sharma *et al.*, 2013).

2.8 Antitranspirant

Many writers have examined the benefits of antitranspirants in combating the negative impacts of extremely hot conditions on horticultural and other crops (Ahmed *et al*., 2012; Ebrahiem-Asmaa, 2012). Antitranspirant coatings increase stomatal resistance by increasing the resistance to water vapor diffusion from the pores. Evapo-Transpiration is the primary cause of soil moisture loss. As a result, favorable regulation is required to address the problem of soil moisture loss (Ansari *et al.*, 2012). Water loss from crop plants can be minimized by employing an antitranspirant like PMA (stomata closure type) or slowing overall plant development using a growth retardant like cystocele. .

The major hormone involved in the perception of numerous abiotic stressors is abscisic acid (ABA) (Madani *et al*., 2019). Abscisic acid (ABA), has a beneficial effect on biotic stress resistance (Yoshida *et al*., 2019). Under abiotic and biotic stress, ABA works in opposition to ethylene, causing the plant to become vulnerable to disease attack. Under abiotic stress, however, ABA levels rise, causing stomatal closure. As a result, biotic attackers are unable to enter through stomata. As a result, the plant is protected from both abiotic and biotic stress in such settings (Yoshida *et al*., 2019). Plant defense is enhanced when kinase protein signals int.eract with ROS and ABA (Yoshida *et al*., 2019). Drought resistance has been linked to wheat genotypes that accumulate less ABA in their leaves, while drought tolerance is the outcome of morphological adaptation as well as biochemical and physiological responses (Batlang, 2006; Grace and Levitt, 1982). Different processes contribute to drought resistance in plants such as avoidance of water shortfalls through drought escape, water conservation and more efficient water 75 percent uptake (Jones, 1983). As a result, plants close their stomata system and modify their leaf area, adjusting water loss from the canopy (Passioura 1997).

Kaolin films have been reported to protect crops against sunburn (Schupp *et al*., 2004). It's effects on the colour of the fruit have been inconsistent (Schupp *et al*., 2004). In several plant species grown at high solar radiation levels, kaolin spray was found to lower leaf temperature by enhancing leaf reflectance and reduced transpiration rate compared to photosynthesis (Nakano and Uehara, 1996).

Among other things, one of the most common antitranspirants for preserving soil water is Pinolene (Di-1-p-menthene) (Mikiciuk *et al*., 2015). Kaoline particle film is also available (Steiman *et al*., 2007). Pinolene is a medicinal polymer made from pine resin that forms a film.

It is biochemically inactive and limits plant transpiration physically (Lanari *et al*., 2018). Pinolene, in the form of a water emulsion, can be used as a foliar antitranspirant; it produces a thin layer on leaves that polymerizes under the effect of sunshine, achieving strong resistance and flexibility. Such a coating reduces water loss from the plant by lowering stomatal conductance and transpirational losses thereby enhancing plant water status, and reducing wilting and leaf abscission, while also being environmentally friendly (Pirasteh-Anosheh *et al*., 2016; Ouyang *et al*., 2017 ; Amarante *et al*., 2001).

Plants can strengthen drought resistance by closing their stomata, reducing transpiration, increasing root weight and length, and maintaining photosynthesis, respiration, and osmoregulation (Levitt, 1985). Reduced transpiration through the leaves of plants treated with antitranspirants increased plant water potential and water use efficiency. So that plants treated with antitranspirants did not experience water shortages when irrigation was interrupted. As a result, in dry and semi-arid areas where water is scarce, antitranspirants may be an appropriate tool to conserve water use in agriculture (Javan *et al., 2013*).

2.9 Mutagenesis

Because spontaneous mutation occurs at a slow rate, which makes it difficult for breeders to use it in crop breeding programs, induced mutation is necessary to enhance the rate of genetic variety. Multiple phenotypic mutants can be isolated with induced mutation, which is a big benefit. Information on the relative efficiency of the mutagens is needed before starting the mutation-breeding program so that the correct dose/concentration of the mutagens can be determined (Smith 1972).

Induced mutation is one of the finest options for crop improvement since it can help to build and regenerate the variability that is typically lost through the natural selection process and crop adaptation to various conditions (Khan *et al*., 2018). Plant breeders have a difficult time exploiting spontaneous mutations since their frequency is so low (Huang *et al*., 2016). As a result, induced mutagenesis is frequently used by breeders to add diversity to breeding programs. Induced mutation is used to increase the frequency of mutations so that acceptable variants can be evaluated and released as variety.

Due to their accessible availability and relatively high penetrating strength, gamma rays have shown to be a cost-efficient and effective mutagen when compared to other ionizing radiations. Gamma irradiation's high penetrating strength allows for a wide range of applications in plant improvement (Issa, 2011). The use of natural and induced genetic diversity in the development of plant varieties for long-term food supply is a key prerequisite for plant breeding (Huang *et al*., 2016). Plant breeders are frequently hampered by the absence or scarcity of desired genotypes. They have, however, used sexual hybridization to successfully recombine desired genes from the accessible gene pool and related plant species. This has aided in the development of novel cultivars with desired features including high yield and resilience to biotic and abiotic stress (Huang *et al*., 2016). Plant flowering times may be variable as a result of mutagenesis utilizing gamma irradiation, which may aid breeders in selecting early or late blooming plants for crop enhancement. According to Gray (2004), changes in cell division rates and activation of growth hormones like auxin in the treated populations are thought to be responsible for the stimulatory effect on plant growth.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experimental site

This study was conducted at Nyankpala, Northern Ghana in the Guinea Savanna agro-ecological zone. Northern Ghana experiences a uni-modal rainfall pattern that lasts from April/May to September/October, with an annual mean of 800 to 1,200 mm (Bennett-Lartey and Oteng-Yeboah 2008). Nyankpala falls within longitude 0°58’42W and latitude 9°25’14’N with an altitude of 183 m above sea level (Dzomeku *et al.*, 2016). The study area has a minimum mean temperature of 24 ° C and a maximum mean of 34° C from table 1. During the dry season, the relative humidity in the area reaches its mean highest level of 75 %. The study area soil was sandy-loam, moderately drained and is formed from Voltaian rocks and classified as lixisol, described as Nyankpala series (SARI Annual Report 2012), with a low accumulation of organic matter resulting from bush burning and high temperatures.

The vegetation is grassland with scattered woody perennials; Neem tree (*Azadiracta indica*), Baobab (*Adansonia digitata*), shea tree (*Vitlleria paradoxa*), Mahogany (*Khaya senegalensis*), Dawadawa tree (*Parkia biglobosa*), and Teak (*Tectonia grandis*). The common weeds of this area are; Broom weed (*Sida acuta*), Goat weed (*Andropogon gayanus*pig weed (*Boehevia difusa*), and Spear grass (*Imperata cylindrica*) (Blench, 1999). The temperature, relative humidity, and amount of rainfall at the experimental site during the experimentation as recorded are shown in Table 1.

Table 1: Rainfall, temperature, and relative humidity during the 2019/2020 cropping season at the experimental site.

Month	Rain Freq.	Total Rainfall (mm)	Average Rainfall (mm)	Temperature (°C)		Relative Humidity (%)	
				Minimum	Maximum	Minimum	Maximum
January	0	0	0	19.78	37.00	29.06	56.23
February	0	0	0	21.58	38.11	26.72	52.55
March	3	95.4	31.8	26.83	37.96	46.94	73.61
April	0	0	0	25.86	35.70	59.17	84.17
May	6	98.7	16.45	25.52	34.92	62.52	88.52
June	14	257	18.36	24.60	31.75	68.00	93.00
July	8	336.4	42.05	24.21	29.93	73.16	93.03
August	9	240.2	26.69	23.58	30.20	73.48	92.71
September	14	256.7	18.34	23.78	30.65	73.87	94.80
October	10	133.9	13.39	23.39	32.45	71.58	93.87
November	0	0	0	21.82	36.42	49.80	87.87
December	0	0	0	21.64	37.18	41.32	78.58

3.2 Experimentation

Two pot experiments and two field experiments were used in this study. The factors for pot establishment were three; namely genotypes, antitranspirants and water regime whilst the field experiment had two factors; namely antitranspirants and genotypes. These are labelled in this work as:

- Experiment one which was a pot experiment involving 5 genotypes, 3 kaolin levels and 2 water levels.

- Experiment two which was a pot experiment involving 5 genotypes, 3 phenylmercuric acetate levels and 2 water levels
- Experiment three which was a field experiment involving 5 genotypes and 3 kaolin levels.
- Experiment four which was a field experiment involving 5 genotypes and 3 phenylmercuric acetate levels.

3.2.1 Experiment one

A factorial treatment structure consisting of millet mutant genotypes, levels of antitranspirants and the design was 2x3x5 factorial, replicated three times in randomized complete block design. This consisted of five genotypes, three levels of kaolin antitranspirant applied at a concentration of 0.0g/l, 0.15g/l and 0.3g/l. The application of antitranspirants began two weeks after millet planting and was repeated every two weeks till eight weeks. Two levels of water regime at 50% and 100% water use efficiency for millet. FAO (1977) reported that 6.6 mm of water is needed for the period of millet growth water requirement. The five genotypes were 100 Gy, 200 Gy, 300 Gy (mutant gynotypes) which are lines yet to be released as varieties, while the other two are, zah and naara which are varieties chosen from the study area.

3.2.2 Experiment two

The second pot experiment is a factorial treatment structure consisting of millet mutant genotypes, levels of antitranspirants The design was 2x3x5 factorial, replicated three times in randomized complete block design. It consisted of five genotypes, phenylmercuric acetate antitranspirant applied at a concentration of 0.0 M, 0.0067 M and 0.0667 M. The application of antitranspirants began two weeks after millet planting and was repeated every two weeks till ten weeks. Water was applied at two levels: 50% water use efficiency and 100% water requirement.

3.2.3 Experiment three

The factors used in this experiment consisted of five millet genotypes and kaolin antitranspirant at three levels. The five millet genotypes were made up of three mutant genotypes; 100 Gy, 200 Gy, 300 Gy and naara and zah were used as standard check. Kaolin antitranspirant was applied at 0.0g/l, 0.15g/l and 0.3g/l,. All genotypes were planted late in the rainy season, that is, seeds were planted in mid-August to make growing of crops coincide with the dry-season when very little rainfall is available. The application of antitranspirants began two weeks after millet planting and was repeated every two weeks to eight weeks The design, therefore, was a 3 x 5 factorial experiment laid down in randomized complete block design with three replications.

3.2.4 Experiment four

The second field experiment is a factorial treatment structure consisting of millet mutant genotypes and levels of phenylmercuric acetae antitranspirants The five millet genotypes were made up of three mutant genotypes; 100 Gy, 200 Gy, 300 Gy and naara and zah were used as standard check. phenylmercuric acetate antitranspirant applied at a concentration of 0.0 M, 0.0067 M and 0.0667 M. The application of antitranspirants began two weeks to eight weeks after millet was planted and was repeated every two weeks. The design was 3x5 factorial, replicated three times in randomized complete block design.

3.3 Soil preparation

The soil was excavated from the Crop Science experimental field. Prior to filling of the pots with soil, Soils were air-dried, pulverized, and sieved using a 2 mm sieve to get rid of stones and gravels. Pots (nursery bags) were filled with the soil, and each pot and its contents were weighed to a weight of 4 kg. The pots were spaced 20 cm apart within rows and 100 cm apart between rows according to plant culture and agronomic practices

Millet was planted at 4 - 6 seeds per pot. Plants were thinned to one plant per pot 10 days after emergence. Hand-watering of pots was done in the evenings at100% and 50% water requirement Weed control was done manually.

3.4 Data collection

Every two weeks after planting (WAP), measurements of the following parameters were taken: plant height, leaf number, tiller number Leaf Area Index. Data were also collected on chlorophyll content, water use efficiency, panicle weight, grain weight and total grain yield at millet maturity stage. Weather parameters (rainfall, temperature, and relative humidity) for the period were also monitored.

3.4.1. Plant Height

A meter rule was used to measure the heights from the base of the plant to the flag leaf and their averages computed.

3.4.2 Number of leaves per plant

The number of leaves was obtained by counting the leaves of each plant. Then, their averages were computed and recorded to represent each treatment combination.

3.4.3 Leaf Area Index (LAI)

Leaf area index was calculated according to (Breda, 2003)

Width and length of the plants were taken at 8 weeks after planting (WAP). LAI was computed as:

Total Leaf Area (TLA) = Leaf length × leaf width…………………………………..1

$$\text{Leaf Area Index (LAI)} = \frac{\text{TLA} \times \text{nLv} \times \text{constant}}{\text{PD}}$$

Where:

LAI is the Leaf Area Index

TLA is the Total Leaf Area

nLv is the number of Leaves

PD is the planting Distance

3.4.4 Biomass Accumulation

At eight and ten weeks after planting (WAP), biomass accumulation was measured. Two tagged Plants were randomly selected for all treatment combinations and replications to determine the shoot and root dry matter. The roots were separated from the shoots at the ground level. The total fresh shoot and root weights were measured. The shoots and roots were oven dried and weights taken again.

The dry weights were determined as follows according to (Zeiller et al., 2007)

$$\text{DMY(Kg/ha)} = TFW(kg) \times \frac{1000\ (m^2/ha)}{H\ (m^2)} \times \frac{SDW\ (kg)}{SFW\ (kg)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 2$$

Where:

DMY is the dry matter yield

TFW is the total fresh weight

SFW is the shoot fresh weight

SDW is the shoot dry weight

H is the area from which the plant sample was harvested.

Root-Shoot ratio (dry weight) was also computed using

$$RS = \frac{\text{RDW}}{\text{SDW}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 3$$

Where:

RS is the root-shoot ratio

SDW is the shoot dry weight

RDW is the root dry weight

3.4.5 Chlorophyll Content

With the help of a chlorophyll meter, the chlorophyll content for each treatment was taken at six weeks after planting (WAP). Two Plants were tagged, from randomly selected pots for all treatment combinations and replications to determine the chlorophyll contents were taken from three levels of these plants, thus; top leaves, middle leaves and base leaves. The average chlorophyll content for each plot was then computed and recorded.

3.4.6 Water Use Efficiency (WUE) and Harvest Index (HI)

Amount of carbon assimilated as biomass/grain produced per unit of water used by the crop is termed water use efficiency.

Water use efficiency (WUE) of the individual treatments were calculated using the formula;

$$\text{eu} = \frac{Y}{WR} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots4$$

Where,

eu= water use efficiency, kg/ha

Y=Total biomass produced, kg

WR= Total amount of water supplied in pots, ml

3.4.7 Analysis of data from pot experiment

Data produced from pot experiments were subjected to descriptive analysis to determine the mean values, standard deviation, and the standard error of means. Statistical differences in the parameters among the various treatments were evaluated by two-way analysis of variance (ANOVA). Means separation was done using the least significant difference (LSD) at a 5% probability level. All data analysis was performed using GENSTAT 12 edition statistical tool and Microsoft Excel. Results are presented in Tables and Figures.

3.5 Field experiment

3.5.1 land preparation, planting, and cultural practices

Preparation of field experimental plot started with field marked out to 0.4 ha size, standard for tractor service in this area. It was ploughed, disc-harrowed by a tractor and field was levelled manually using a simple hand hoe. The tools used to prepare the plots were; a tape measure, a hoe, a ranging pole, garden lines, wooden pegs, a mallet, and a cutlass. All plots were demarcated and labelled prior to sowing. A total of ninety (90) treatments were established for both Kaolin and Phenylmercuric acetate.

The millet genotypes were planted on 18th August 2020 that is late planting. A planting distance of 80 cm × 40 cm was used. A plot size of 10m x 10m (100m^2) with a spacing of 0.5m between plots and 0.75m between blocks. six seeds were planted per hill and later thinned-out to one seed per hill. Ten days after planting, germination was found to be excellent

3.5.2 Weed control

Weeding was done by hand using a hoe on the 2nd, 4^{th,} and 6th week after sowing to control weeds. The third weeding on the 6th week after planting was accompanied by ridging to give much support to crops in all plots.

3.6 Data Collection

Data was taken on the following parameters at two weeks intervals: Plant height, number of leaves, number of tillers, and Leaf Area Index (LAI). Data was also taken on crop bio-mass at harvest, Average panicle weight, Average grain weight per plant, 1000 grain weight, total grain yield and water use efficiency were measured. Weather parameters (rainfall, temperature, and relative humidity) for the period of field experimentation were also recorded.

3.6.1 Plant Height

Plant height was taken from five tagged plants per plot at two weeks after planting and at two weeks intervals for four sessions using a meter rule. plants were selected and Tagged on the middle plants for each plot in order to prevent the border effect. The average height of measured heights computed to represent each treatment.

3.6.2 Leaf Number

Leaf number was determined from tagged plants in each plot by counting the leaves of these plants. Then, their average computed and recorded to represent each treatment. This was repeated at two weeks intervals for four sessions.

3.6.3 Leaf Area Index (LAI)

Three leaves were selected from each of the five randomly sampled plants in each plot. The leaves were selected from the top, middle and base leaves. The length and width of these tagged leaves were taken at six and eight weeks after planting (WAP).

The Leaf area index was computed according to (Breda, 2003) as Total Leaf area (TLA) = Leaf length * leaf width

Thus

$$\text{Leaf Area Index (LAI)} = \frac{\text{TLA}\times\text{nLv}\times\text{constant}}{\text{PD}} \ldots\ldots\ldots\ldots\ldots\ldots 5$$

Where:

LAI is the Leaf Area Index

TLA is the Total Leaf Area

nLv is the number of Leaves

PD is the planting Distance

LAI constant =0.70 for millet.

3.6.4 Tiller Count

Plant tiller count was done on five tagged plants per plot at two weeks after planting and at two weeks intervals for four sessions manually. The average tiller number of the selected plants was computed to represent each treatment.

3.6.5 Biomass Accumulation

At eight and tenth weeks after planting (WAP), biomass accumulation was measured. Three plants were randomly picked from each plot to determine the shoot and root dry matter, the roots were separated from the shoots at the ground level. The total fresh shoot and root weights were measured. They were kept separate in brown envelops, moved to the university for Development Studies laboratory and oven dried. The weights were taken with electronic weighing scale from the university laboratory.

The dry weights were determined as follows according to (Zeiller et al., 2007)

$$\mathrm{DMY(kg/ha)} = TFW(kg) \times \frac{1000\ (m^2\ /ha)}{H\ (m^2)} \times \frac{SDW\ (kg)}{SFW\ (kg)} \quad \ldots\ldots\ldots\ldots\ldots 6$$

Where:

DMY is the dry matter yield

TFW is the total fresh weight

SFW is the shoot fresh weight

SDW is the shoot dry weight

H is the area from which the plant sample was harvested.

Root-Shoot ratio (dry weight) was also given by:

$$RS = \frac{\mathrm{RDW}}{\mathrm{SDW}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 7$$

Where:

RS is the root-shoot ratio

SDW is the shoot dry weight

RDW is the root dry weight

3.6.6 Grain Yield and Yield Components

Matured panicles were harvested from individual plants and five panicles randomly selected. The five selected panicles were dried and used to determine the average panicle weight per plant, the average grain weight per plant, the 1000 grain weight and the total grain yield.

The matured harvested panicles were sun-dried in the open air . The weight of the panicles was determined. The average weight of panicle per plant was obtained. The average computed by dividing the sum of weights of selected panicles by 5 to obtain average panicle weight per plant for all treatments.

The average grain weight per plant is obtained by threshing the five dried panicles and winnowed to clean it of foreign materials from the grains. The grains were weighed with an electronic scale. The obtained weight for the five threshed panicles was divided by five to obtain average grain weight per plant for all treatments.

Weight of 1000 grains was obtained by counting 1000 grains randomly from the five threshed and winnowed panicles. This was selected from all treatments and the weights taken with an electronic scale from the university laboratory.

3.6.7 Total Grain Yield

The total grain yield was obtained from treatments by harvesting plants in a 5 m x 5 m plot from the main 10 m x 10 m plots and counted for all treatments. The panicles were opened dreied, threshed and winnowed to get rid of foreign materials. The cleaned grains were weighed with an electronic scale from the Sagnarigu Agriculture Department office. The obtained weight is the weight for the sampled plots harvested . To obtained total grain yield per hectare for each treatment combination was determined as follows according to (Zeiller et al., 2007)

$$TGY\ (kg/ha) = \frac{GYM\ (g)}{H\ (m^2)} \times \frac{10000\ (m^2/ha)}{1000\ (g/kg)} \quad \ldots\ldots\ldots\ldots\ldots..8$$

Where:

TGY is the final grain yield,

GYM is the grain yield from each plot

H is the area from which the plant sample was harvested.

3.6.8 Water Use Efficiency (WUE) and Harvest Index (HI)

Water use efficiency was measured by harvesting plants, determining the dry weight of the shoots. The roots and shoots were harvested separately as the roots needed to be washed clean of the soil. They were bagged and oven dried to constant weight. The WUE of the plants was calculated as the total dry matter (roots and shoots combined) divided by water used

Water use efficiency (WUE) of the individual treatments were calculated using the formula;

$$\mathrm{eu} = \frac{Y}{WR} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 9$$

Where,

eu= water use efficiency, kg/mm

Y= Crop yield, kg

WR= Total amount of water used on the field, mm

The harvest index for each treatment was also determined as follows according to (Zeiller et al., 2007)

$$\text{Harvest Index (HI)} = \frac{\text{Dry matter of economic harvest (yield)}}{\text{Total matter (Biomass)at physiological maturity}} \times 100 \quad \ldots\ldots\ldots 10$$

3.7 Data Analysis

Data collected from the field were subjected to analysis of variance (ANOVA) to compare crop growth and yield responses for the treatment combinations using GENSTAT 12 edition. Treatment means were separated at a 5% probability level using the least significant difference (LSD). Results are presented in Tables and Figures.

CHAPTER FOUR

RESULTS

4.1.0 Results from experiment 1

4.1.1 Plant height

There was significant difference at 5% level on probability. All genotypes exhibited good crop growth. The 'Zah' variety recorded the highest mean plant height of 13.81 cm but was not significantly different from 100 Gy, 300 Gy and Naara. The 200 Gy genotype had the lowest mean plant height of 11.50 cm (Figure 1).

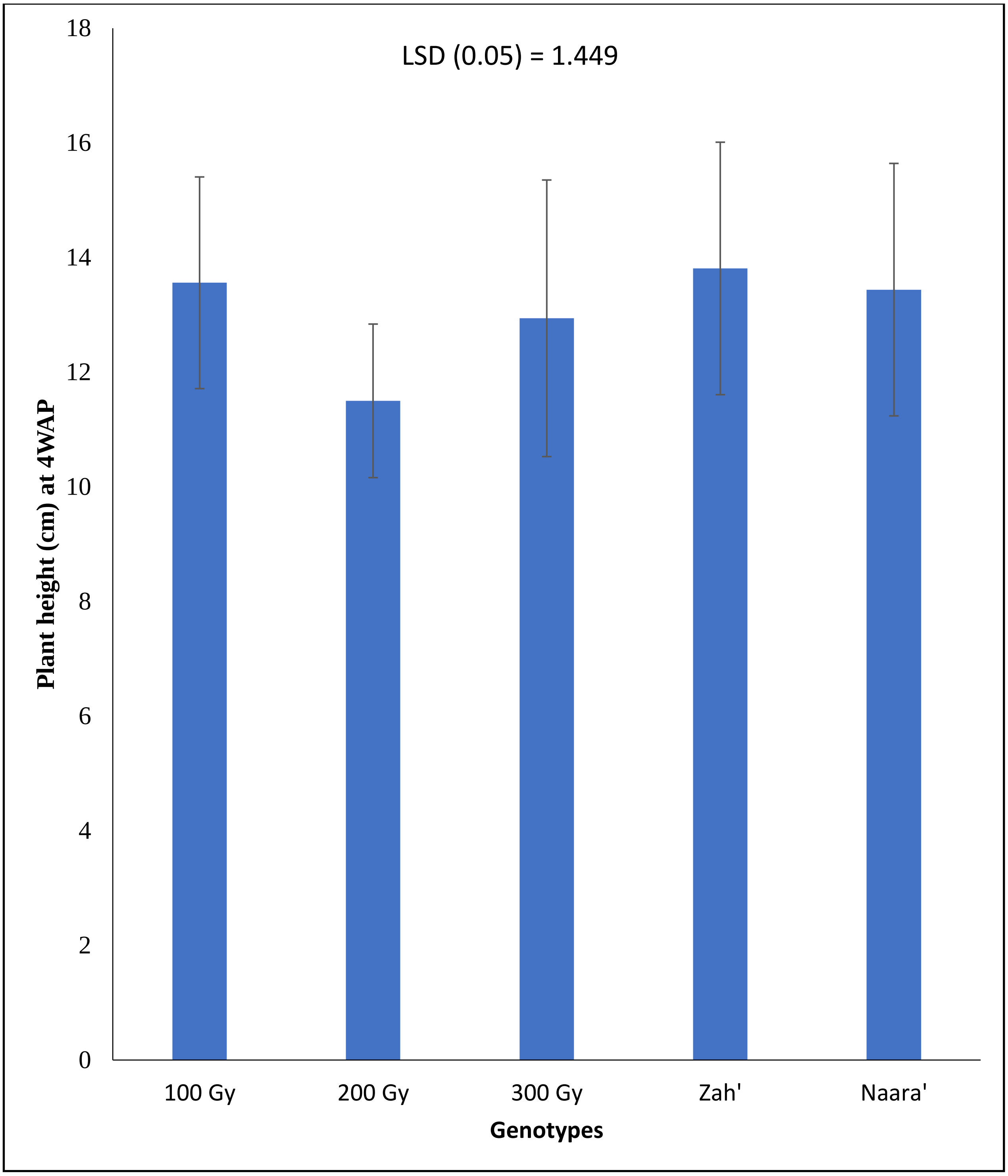

Figure 1:Effect of genotype on plant height at 4WAP. Error bars represent mean ± standard error.

Plant height at 6, 8 and 10WAP was significantly ($P < 0.05$) affected by levels of kaolin antitranspirant application. Kaolin antitranspirant applied at 0.3g/l gave the highest plant height at 119.8 cm at week 10 followed by kaolin antitranspirant applied at 0.15g/l. The lowest mean plant height was recorded by kaolin at 0.0g/l.(Figure 2).

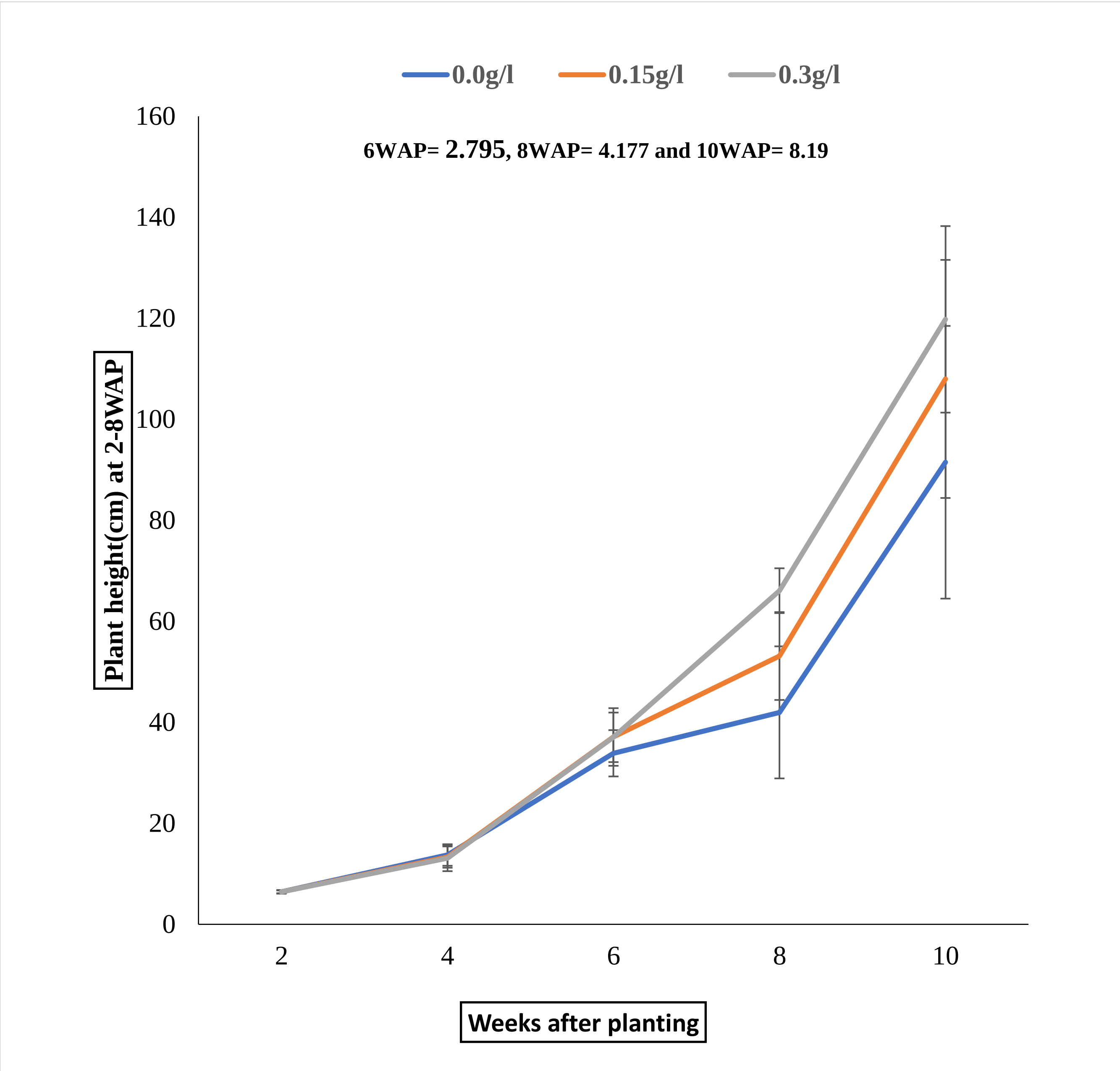

Figure 2:Effect of Kaolin antitranspirant on plant height of millet.

Plant height was significantly ($P < 0.05$) influenced by genotype x kaolin x water interaction at 8WAP. The interaction of kaolin antitranspirant, water application and genotype has impacted on the change in plant growth.

At 6WAP, the interaction recorded the highest mean plant height of 40.00 cm and least plant height of 37.67 cm. At 8WAP, the interaction recorded the highest mean plant height of 88.67 cm and least plant height of 64.67 cm. At 10WAP, the interaction recorded the highest mean plant height of 153 cm and least plant height of 112.00 cm (Table 1).

Table 2: Interaction of Kaolin antitranspirant x genotype x water application rate effect on plant height.

Weeks After Planting	Genotype	Kaolin Antitranspirant concentration					
		0.0g/l		0.15g/l		0.3g/l	
		% Water requirement		Water application %(WUE)		Water application %(WUE)	
		50	100	50	100	50	100
6	100 Gy	33.00	34.33	35.33	38.33	39.00	40.00
	200 Gy	34.33	35.00	35.67	36.67	37.33	38.67
	300 Gy	32.67	39.00	34.67	39.00	36.33	39.33
	'Naara'	31.67	32.00	37.67	38.33	37.33	38.33
	'Zah'	33.33	35.33	39.00	42.33	37.33	37.67
8	100 Gy	41.33	48.00	50.33	59.00	64.67	65.67
	200 Gy	42.33	44.67	45.67	57.00	62.00	68.33
	300 Gy	42.33	46.33	51.00	65.67	66.00	88.67
	'Naara'	40.00	40.67	51.67	53.33	57.33	67.67
	'Zah'	38.67	39.33	48.00	49.67	55.67	64.67
10	100Gy	82.00	98.70	105.30	127.00	117.30	124.30
	200Gy	90.30	91.00	94.00	120.70	114.70	123.00
	300Gy	91.70	106.70	100.00	129.30	129.30	153.70
	'Naara'	83.00	84.70	103.30	109.00	112.70	117.30
	'Zah'	88.00	99.30	92.70	99.00	104.00	112.00

LSD (0.05): Genotype x Kaolin x Water application; (6WAP)= 8.837, 8WAP =13.208, 10WAP = 25.89

4.1.2 Leaf Number

Kaolin antitranspirant significantly ($P < 0.05$) influenced leaf number at 6WAP. The application of different concentrations of kaolin antitranspirant recorded different leaf number. Plants from the highest antitranspirant concentration level of 0.3g/l recorded highest mean leaf number of 28, followed by those from 0.15g/l recording a mean leaf number of 27, with 0.0g/l antitranspirant level recording the least mean leaf number of 25.33 (Figure 3). The effect of genotype on the number of leaves was not significant (P 0.05). Water regime did not also influence number of leaves significantly ($P > 0.05$) at 6WAP.

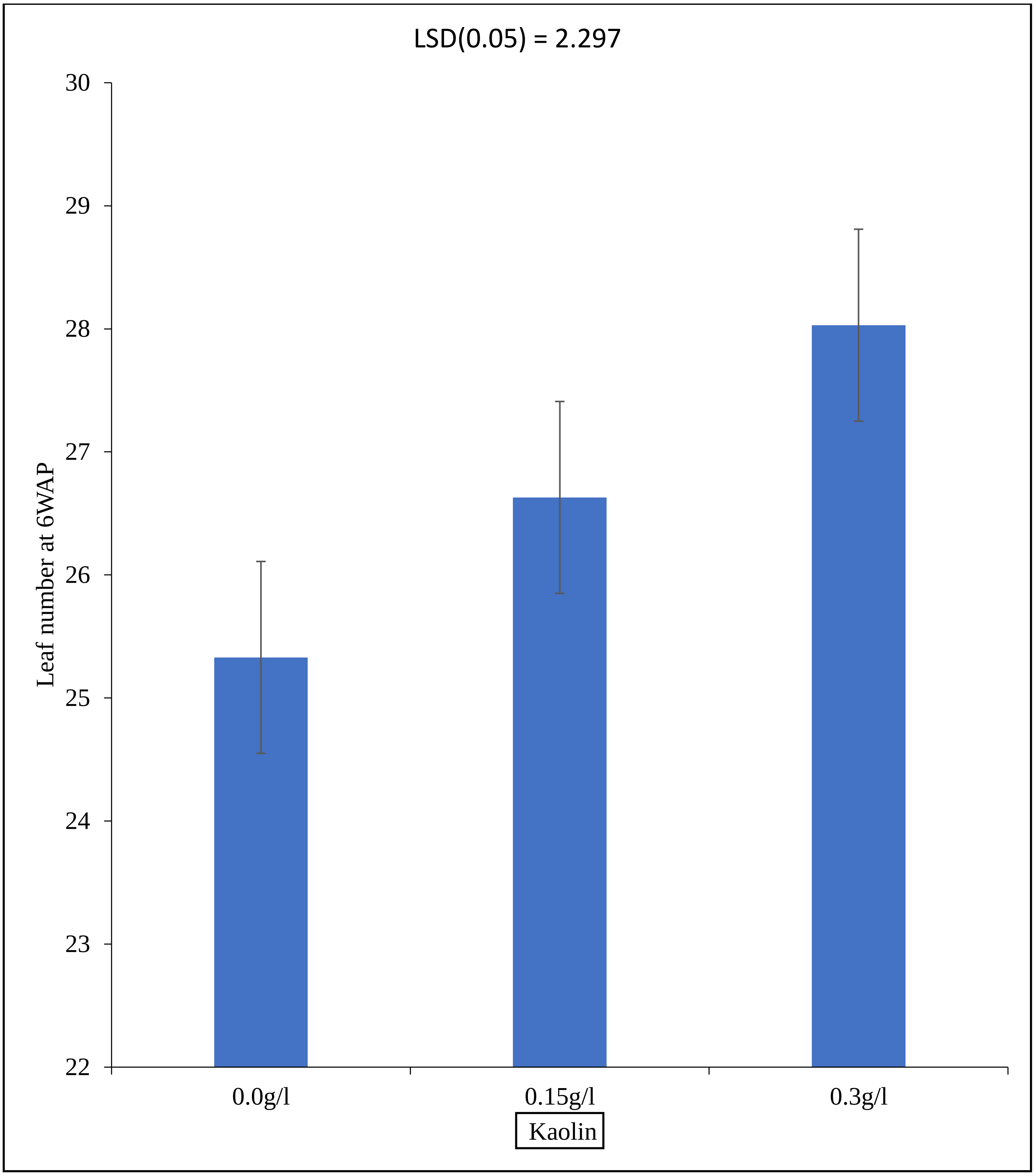

Figure 3:Effect of Kaolin as antitranspirant on leaf number.

Water application significantly ($P < 0.05$) influenced leaf number at 8WAP. Water application at 50% water requirement recorded leaf number of 49 and water application of 100% water requirement recorded a higher leaf number of 56 (Figure 4).

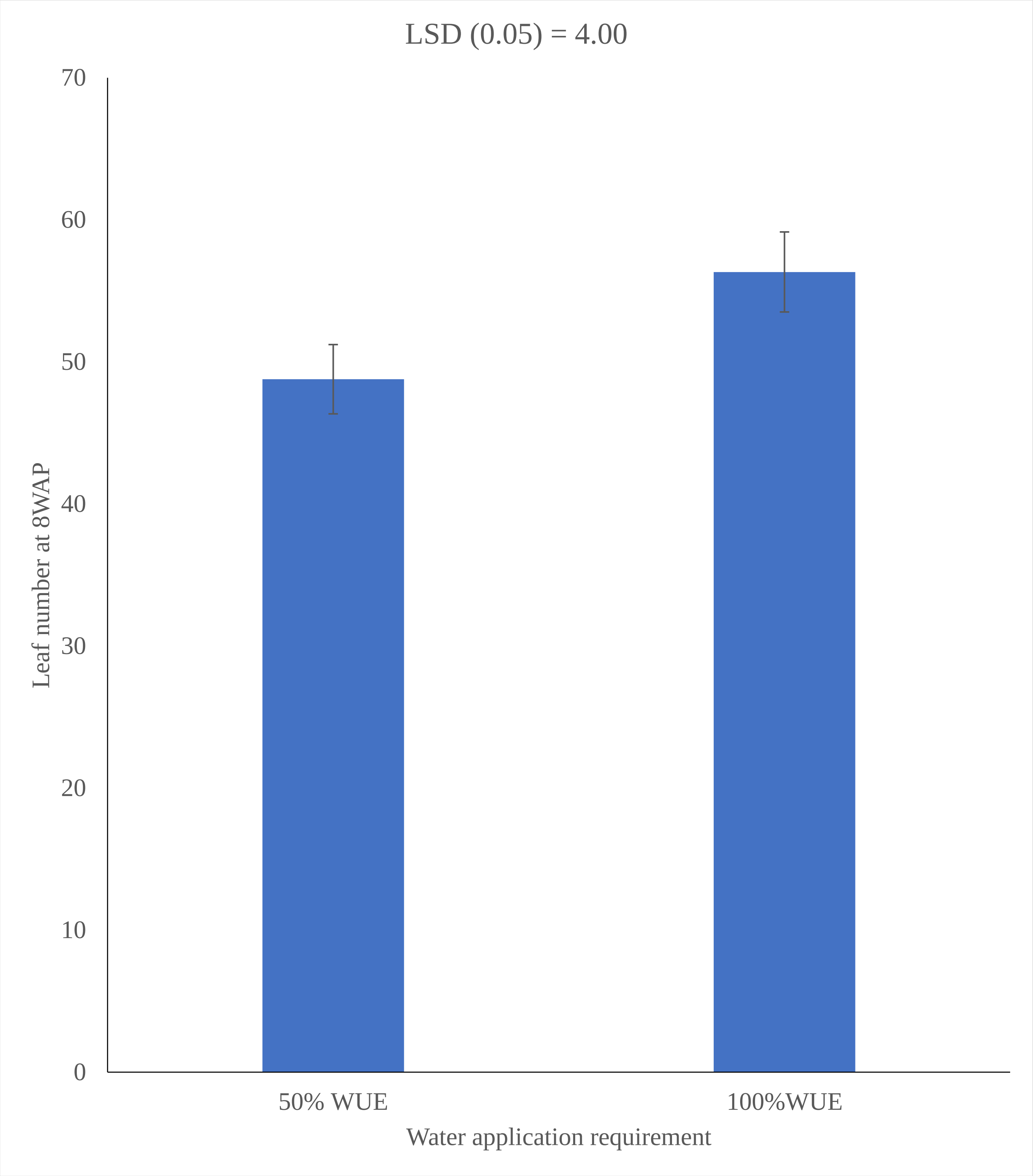

Figure 4:: Effect of water application on number of leaves 8WAP.

Leaf number was influenced significantly ($P < 0.05$) by genotype x kaolin antitranspirant x water application at 6, 8 and 10WAP. At 6WAP, the inerraction resulted in a highest mean leaf number of 38.33 and a least mean leaf number of 33.00. At 8WAP, the inerraction produced highest mean leaf number of 38.33 and a least mean leaf number of 33.00. At 10WAP, the inerraction resulted in a highest mean leaf number of 38.33 and a least mean leaf number of 33.00 (Table 3).

Table 3Effect of the interaction of kaolin antitranspirant x genotype x water application on leaf number.

Weeks After Planting		Kaolin Antitranspirant					
		0.0g/l		0.15g/l		0.3g/l	
		% Water requirement		% Water requirement		% Water requirement	
	Genotype	50	100	50	100	50	100
6	100 Gy	23.33	25.67	28.33	29.33	24.67	36.33
	200 Gy	24.00	27.00	26.33	30.00	24.00	38.33
	300 Gy	23.33	28.67	24.67	27.67	23.00	36.67
	'Naara'	20.33	27.00	28.00	30.67	26.33	32.00
	'Zah'	25.33	27.67	29.67	31.67	28.00	33.00
8	100 Gy	53.33	62.67	40.00	60.33	43.33	71.00
	200 Gy	47.00	51.00	49.33	60.67	46.00	68.67
	300 Gy	42.67	57.00	51.67	62.67	41.67	70.67
	'Naara'	50.00	53.33	44.67	59.33	48.67	60.00
	'Zah'	43.67	47.00	45.67	59.67	50.00	60.67
10	100 Gy	106.30	123.70	81.70	125.00	85.30	139.30
	200 Gy	100.70	102.70	98.70	112.70	105.30	131.70
	300 Gy	86.30	117.00	96.70	128.30	82.30	140.70
	'Naara'	95.70	107.70	95.00	117.70	100.30	128.70
	'Zah'	91.70	100.70	92.30	113.70	102.00	109.00

LSD (0.05): Genotype x Kaolin x Water application; - 6WAP = 7.264, 8WAP = 15.493, 10WAP = 27.94

4.1.3 Tiller number

Kaolin antitranspirant significantly ($P < 0.05$) influenced tiller number at 4WAP. Kaolin at 0.3g/recorded the highest mean tiller number of 3 followed by kaolin at 0.15g/l with the mean tiller number of 2. The kaolin level at 0.0g/l recorded the least mean tiller number of 1.467 (Figure 5). No significant ($P > 0.05$) interaction was observed at 4WAP.

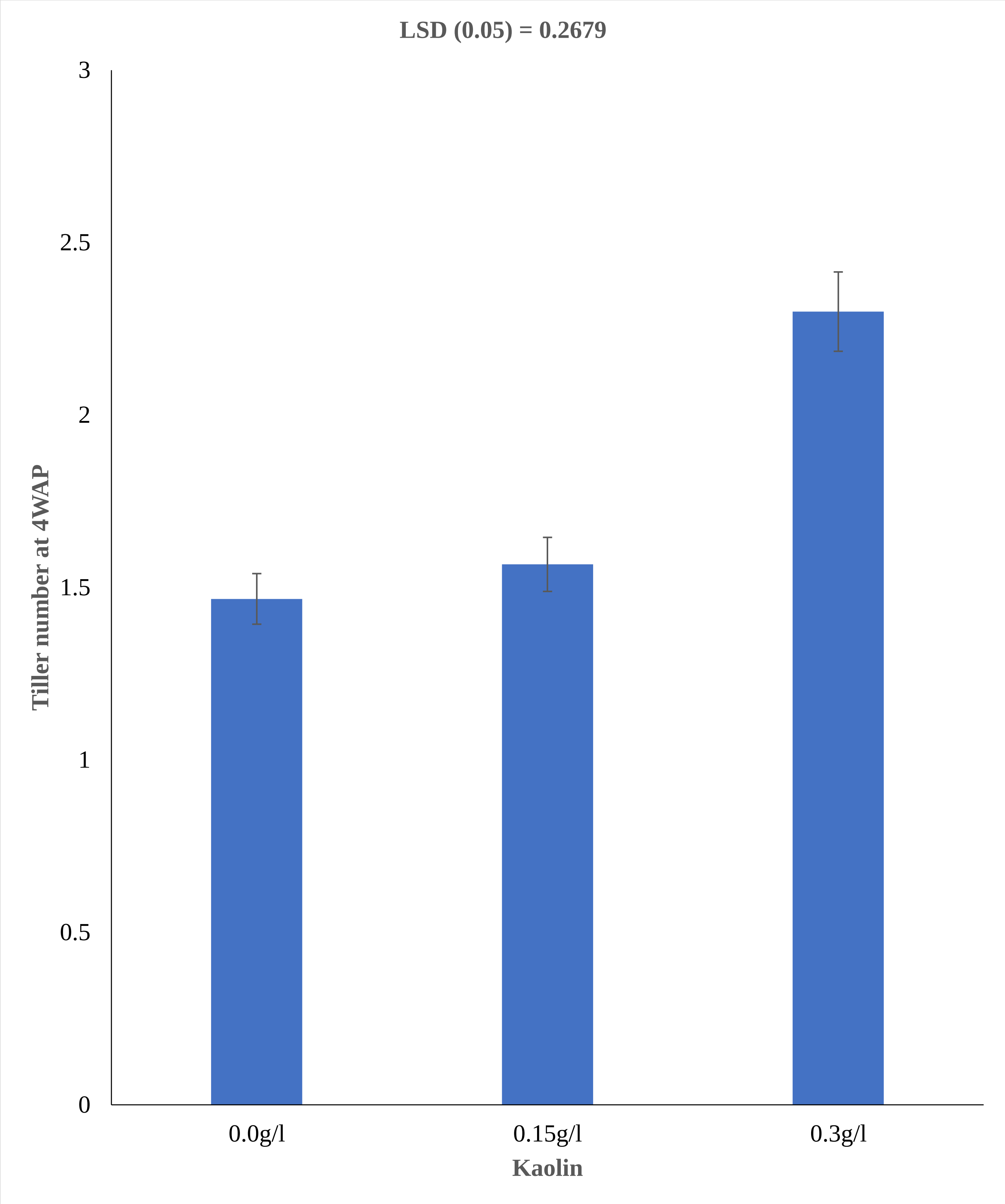

Figure 5: Effect of Kaolin as antitranspirant on tiller number of millet at 4WAP.

4.1.4 Leaf Area Index (LAI)

Water application significantly ($P < 0.05$) influenced leaf area index at 8WAP. In this study, mean leaf area index for 100% water requirement was 48.69 while the mean leaf area index for 50% water requirement was 42.56 (Figure 6).

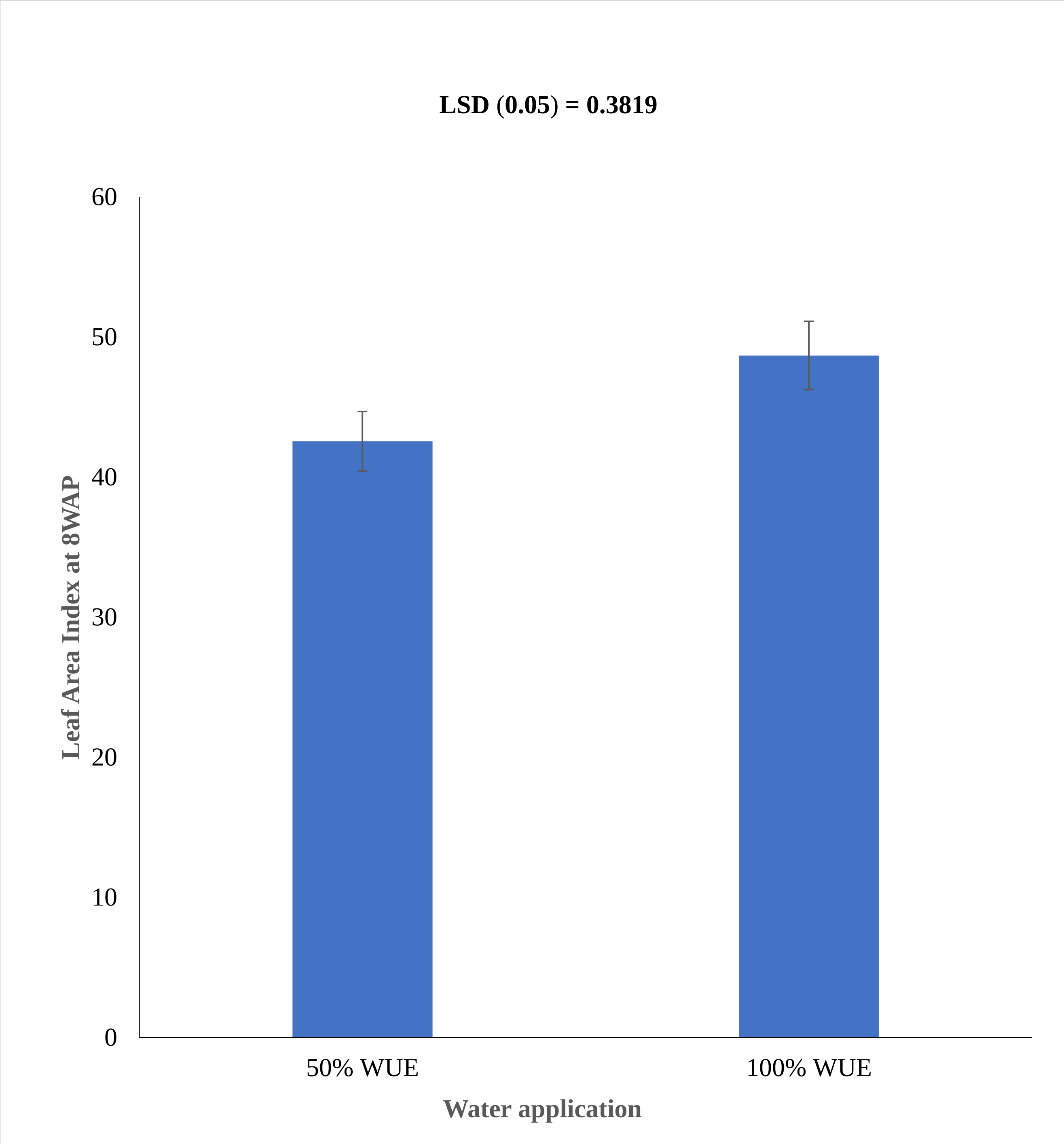

Figure 6:Effect of Water stress on leaf area index 8WAP.

Genotype and kaolin interaction significantly ($P < 0.05$) influenced leaf area index at 6WAP. The interraaction resulted in a a highest mean leaf area index of 2.88 and a least mean leaf area index of 1.85. 100 Gy genotype of Kaolin 0.3g/l concentration level recorded the highest mean leaf area index of 2.88. Genotype 200 Gy follows with a mean leaf area index of 2.750 from 0.3g/l Kaolin. Naara recorded the least mean leaf area index of 2.117 with 0.3g/l Kaolin (Figure 7).

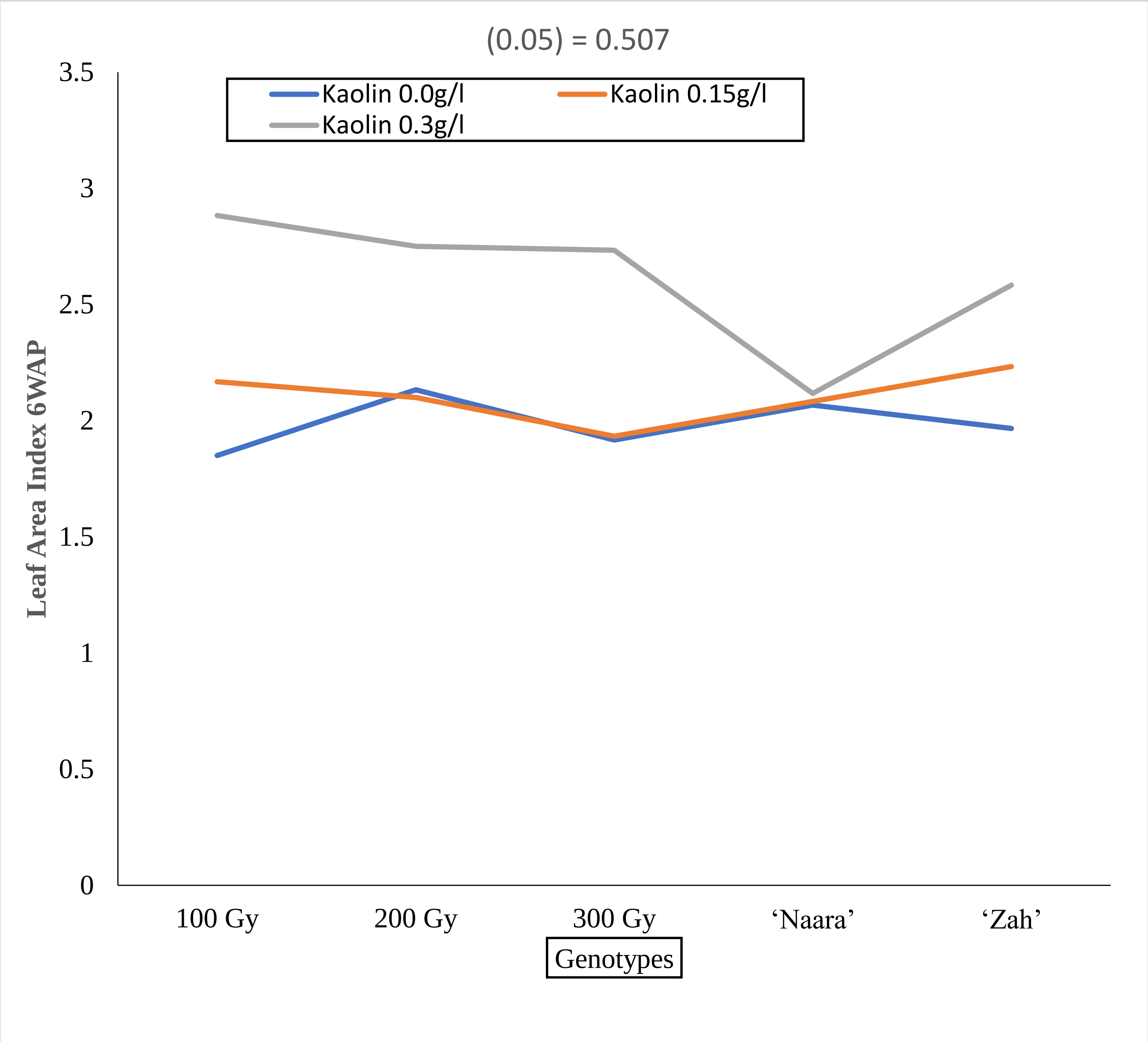

Figure 7:Effect of interaction of kaolin antitranspirant and genotype on leaf area index.

4.1.5 Chlorophyll Content

Effect of genotypes and water application interaction significantly (P < 0.05) affected chlorophyll content at 8WAP. The interaction of genotypes and water application produced a highest mean chlorophyll content of 47.26 SPAD Units and a least mean chlorophyll content of 40.53 SPAD units. Water application at 100% requirement x 'Naara' recorded highest mean chlorophyll content of 47.26 SPAD units. This was followed by water application at 100% requirement x 100 Gy with mean chlorophyll content of 45.21 SPAD units. Water application at 100% requirement x 200 Gy recorded the least mean chlorophyll content of 42.77 SPAD units. (Table 4)

Table 4: Effect of genotype x water application on chlorophyll content of millet (Pennisetum glaucum L.) 8 weeks after planting.

Genotypes	Water % application required	
	50%	**100%**
100 Gy	41.30	45.21
200 Gy	45.81	42.77
300 Gy	40.53	44.41
Naara'	42.54	47.26
'Zah''	42.52	43.22

LSD (0.05): Genotype x Water application = 3.257

4.1.6 Shoot Weight

At 8WAP. Genotype significantly influenced shoot biomass. Genotype 300 Gy recorded the highest mean shoot biomass of 150.7 grams. This was followed by 100 Gy genotype with mean shoot biomass of 138.3 grams. The least mean shoot biomass of 130.7 grams was recorded by 'Zah' genotype. There was no significant (P > 0.05) difference in shoot biomass between 100 Gy, 200 Gy, 300 Gy and 'Zah'. There was no significant (P > 0.05) difference in 'Zah' and Naara genotype Water application did not significantly (P > 0.05) influence shoot biomass (Figure 8).

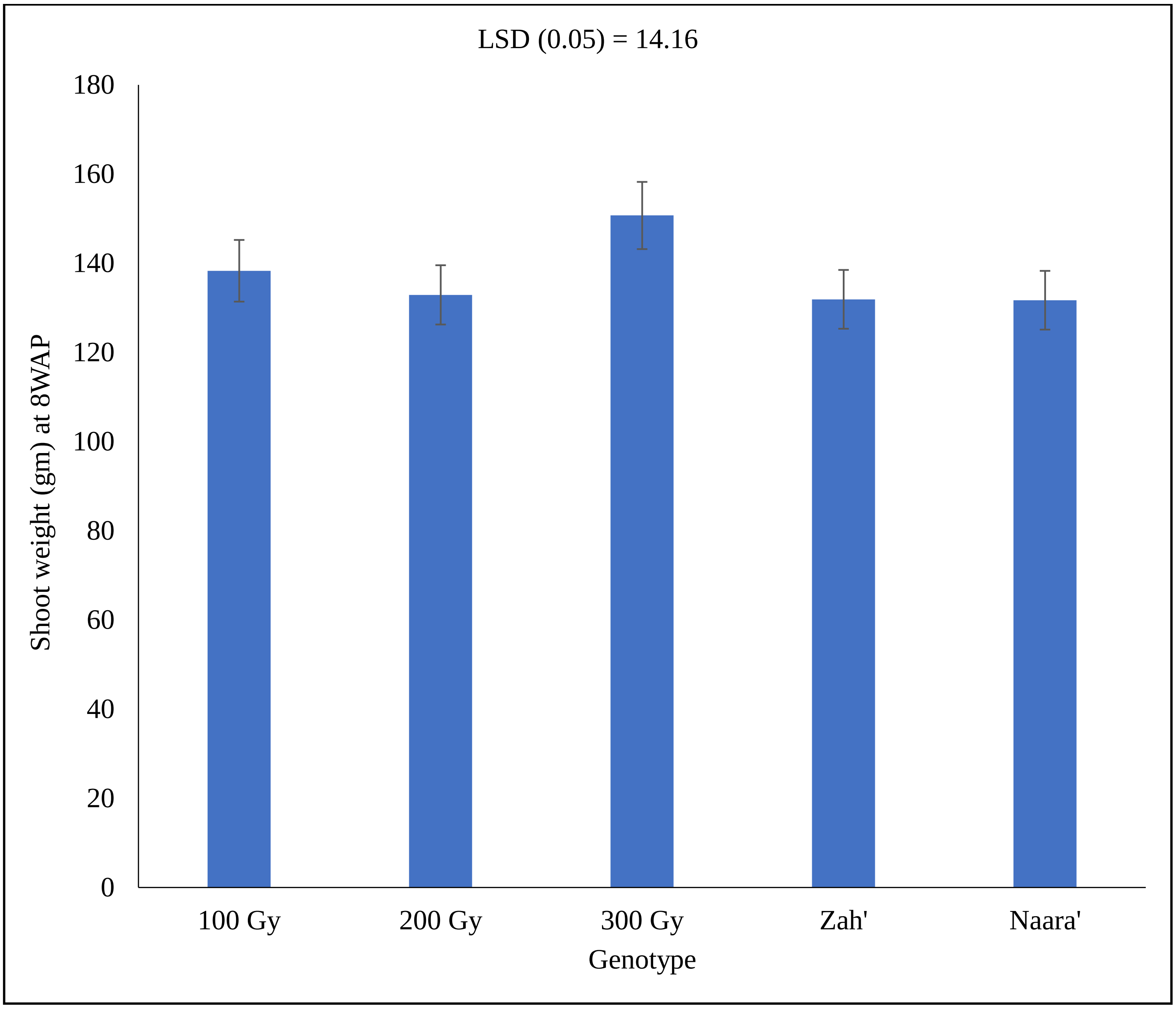

Figure 8:Effect of genotype on shoot weight at 8WAP.

Kaolin highly significantly (P < 0.001) influenced shoot weight at 8 and 10WAP. At week 8, the highest shoot weight of 81.5grams was increased to 267.5grams at week 10. At kaolin application rate of 0.15g/l for week 8, shoot weight of 69grams was increased at week 10 to 244.4grams. The least shoot weight for week 8 with kaolin application rate at 0.0g/l recorded 54.4grams was increased to 218.9 at week 10 (Figure).

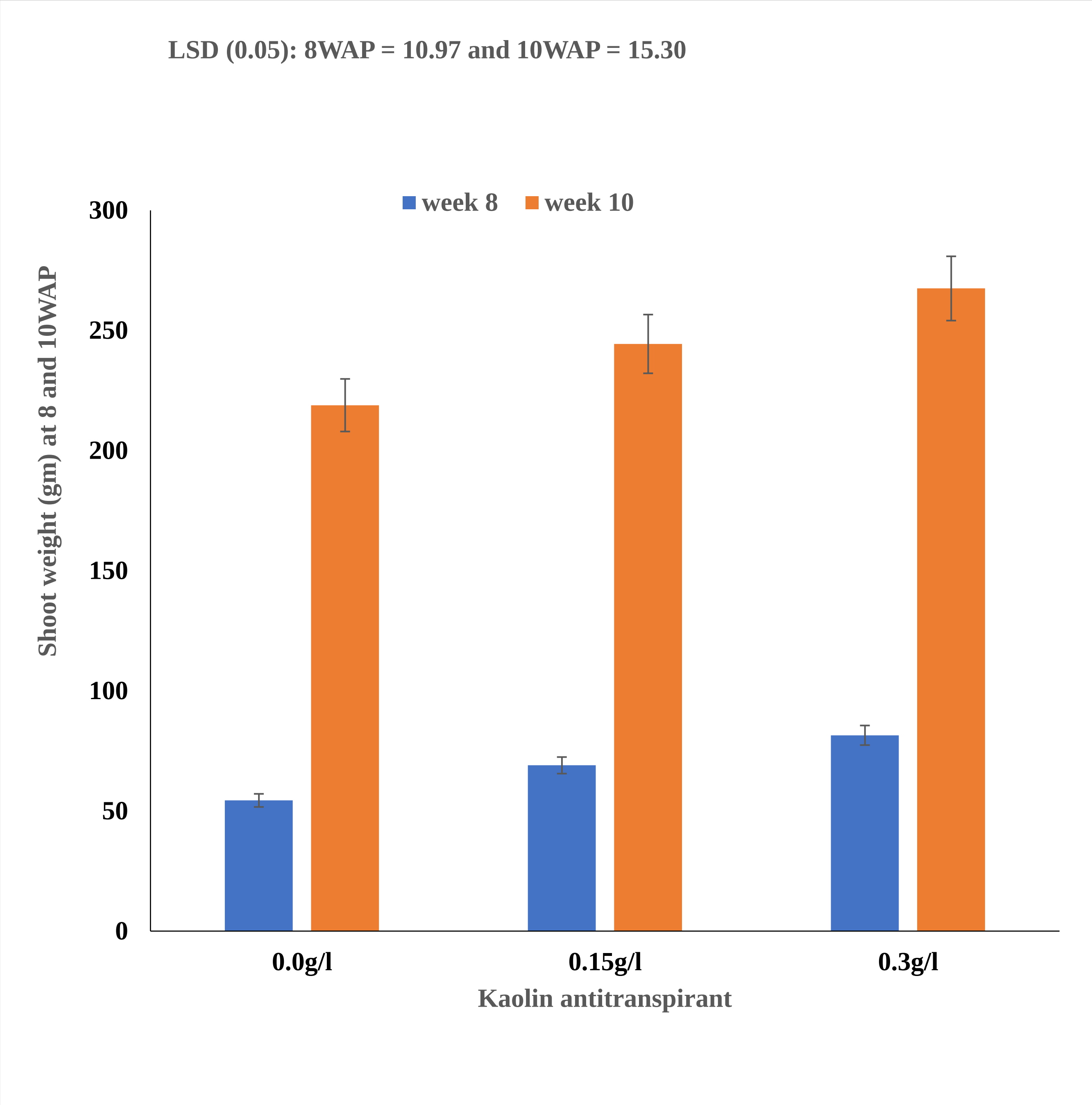

Figure 9:Effect of Kaolin antitranspirant on shoot weight at 8 and 10WAP.

4.1.7 Water Use Efficiency (WUE)-

At 8 and 10 WAP, kaolin as an antitranspirant had a highly significant (P 0.001) influence on 100 percent Water Use Efficiency (WUE). When At 10WAP, kaolin as antitranspirant was applied at a concentration of 0.3g/l the highest mean WUE of 63 was recorded, followed by kaolin at an applied concentration of 0.15 which recorded 57 WUE. The least WUE of 51was recorded by kaolin concentration at 0.0g/l. At 8WAP, the application of kaolin as antitranspirant at 0.3g/l concentration recorded 49WUE. At an application concentration at 0.15 of kaolin as antitranspirant WUE of 42 was recorded. The least WUE of 33 was recorded when kaolin was applied at a concentration of 0.0g/l (Table 5).

Table 5: Effect of Kaolin as antitranspirant on WUE at 8 and 10 weeks after planting.

Kaolin	**Water Use Efficiency 100%**	
	Week 8	**Week 10**
0.0g/l	33	51
0.15g/l	42	57
0.3g/l	49	63
LSD (0.05)	**0.033**	**0.04**

4.2.0 Results from experiment two

4.2.1 Plant height

Water application regime significantly ($P < 0.05$) influenced plant height. All genotypes exhibited good crop performance and plant growth was uniform. At 2WAP, water application at 50% water requirement recorded the highest plant height of 69.56, while water application at 100% WUE recorded the least plant height of 65.56 cm (Figure 10). At week 4, there was no significant ($P > 0.05$) difference in plant height between genotypes. Similarly, there was no significant ($P > 0.05$) difference in Phenylmercuric acetate antitranspirant application on plant height.

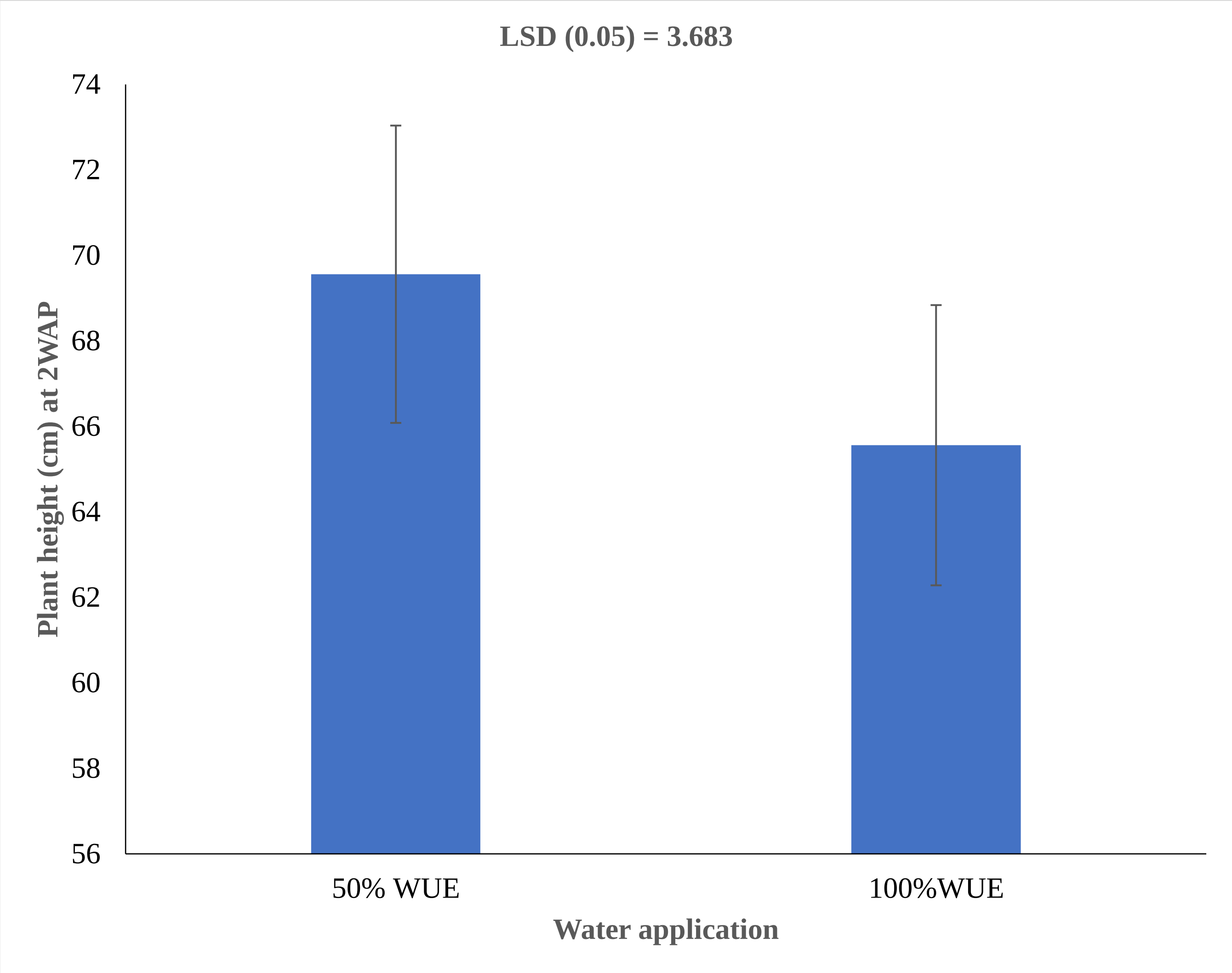

Figure 10:Effect of Water application on plant height at 2WAP

At 6WAP, it was observed that there was significant ($P < 0.05$) difference between genotypes. Interaction of phenylmercuric acetate and water application rates did not significantly ($P > 0.05$) influence plant height at 6 WAP (Figure 11).

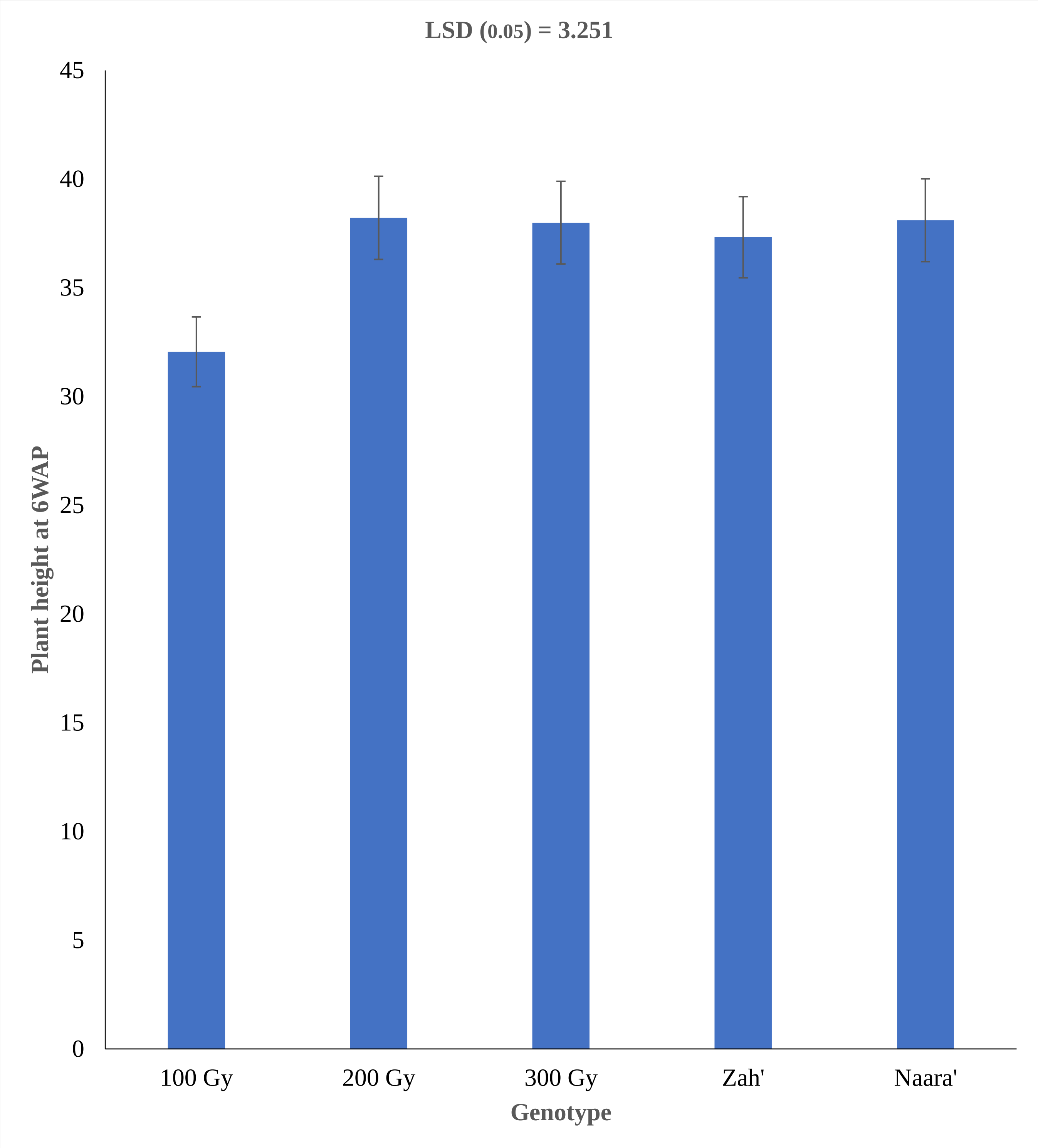

Figure 11:Effect of genotype on plant height at 6WAP.

Plant height was significantly ($P < 0.05$) affected by phenylmercuric acetate antitranspirant application at 8 and 10WAP. Plant height was highest (83.07) at 8 WAP and (156.4) at 10WAP when phenylmercuric acetate as antitranspirant was applied at 0.0667M, The antitranspirant concentration of 0.0067M recorded the next highest plant height of 66.93 at 8WAP which increased to 126.8 at 10WAP. The least plant height of 57.63 at 8WAP and 98.5 plant height at 10WAP was recorded with the antitranspirant concentration at 0.0M (Figure 12). Phenylmercuric acetate antitranspirant did not significantly ($P > 0.05$) influence plant height.

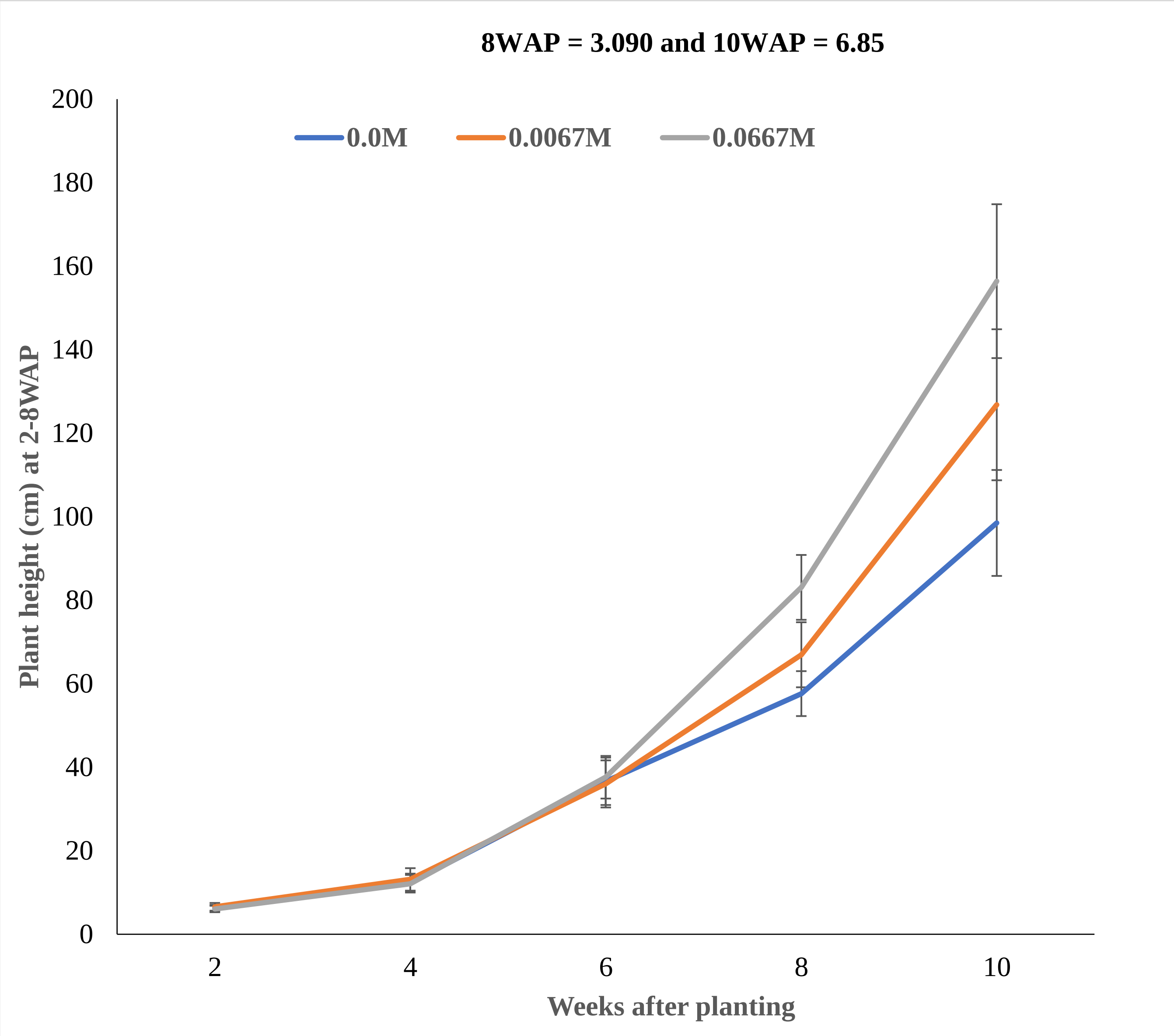

Figure 12:Effect of phenylmercuric acetate as antitranspirant on plant height of millet.

4.2.2 Leaf Number

Genotypes significantly ($P < 0.05$) influenced leaf number at 6WAP. The genotype with the highest mean leaf number of 25.72 was 200 Gy. This was followed by 300 Gy with 24.17 as mean leaf number. Genotype 100 Gy recorded the least mean leaf number with 20.94. There was no significant ($P > 0.05$) difference between 100 Gy, 200 Gy, 300 Gy and 'Zah' genotypes (Figure 13). It was observed that, there was no significant ($P > 0.05$) difference between genotypes 'Zah' and 'Naara'.

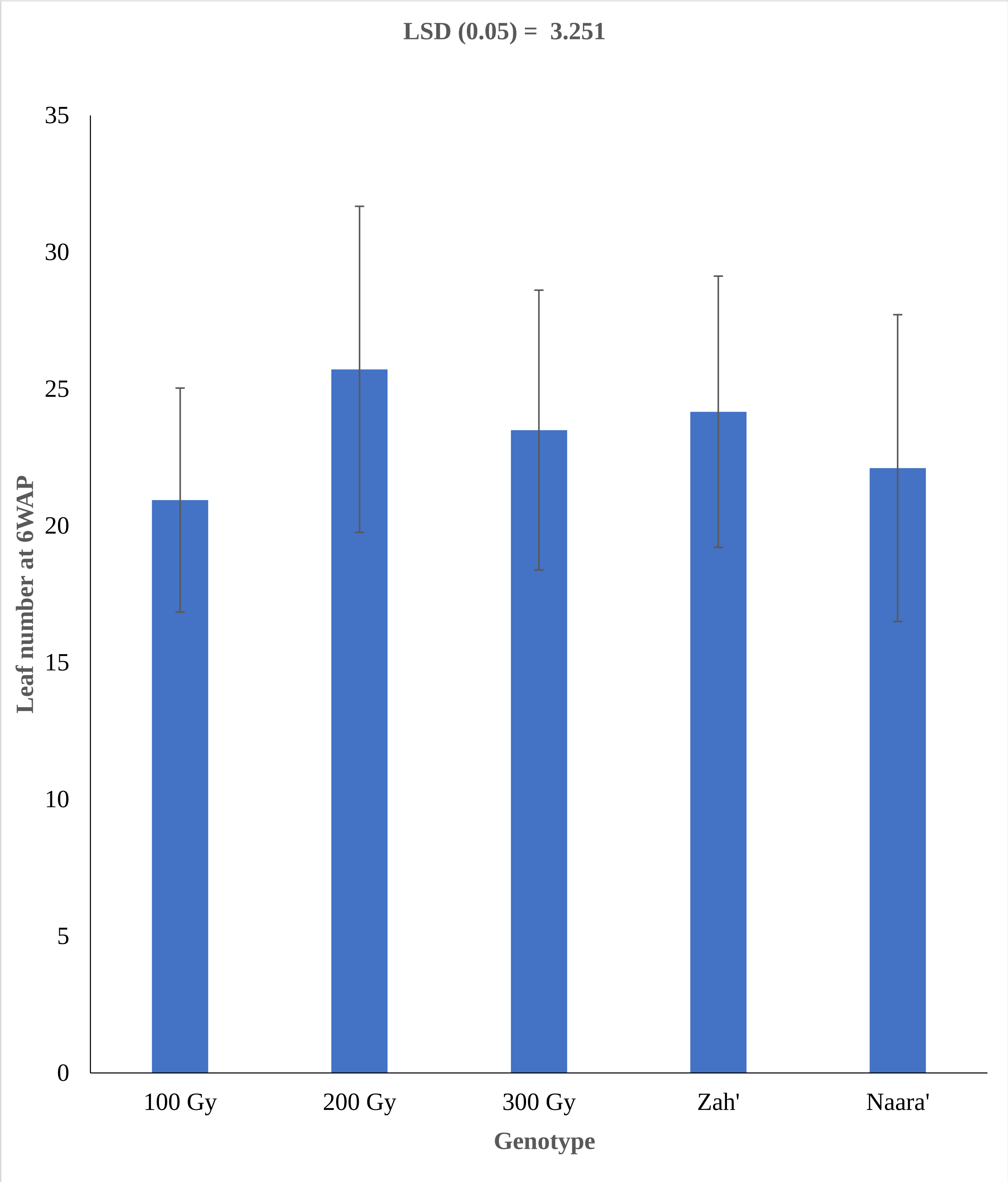

Figure 13: Effect of Genotype on leaf number 6WAP.

Genotype, phenylmercuric acetate and water application had significant ($P < 0.05$) influence on leaf number. The highest mean leaf number of 29.67 and the least mean leaf number of 23.00 was recorded from the interaction at 6WAP.

At 8WAP the interaction produced a highest mean leaf number of 74.33 and a least mean leaf number of 61.

At 10WAP the interaction produced a highest mean leaf number of 135.7 and a least mean leaf number of 106.7.

The highest mean leaf number of 29.67 produced when Naara genotype was treated with phenylmercuric acetate antitranspirant at 0.0667 and water application at 100% requirement. This was followed by leaf number of 29.33 when the same treatment was applied on 300 Gy genotype. The least leaf number of 23.00 was observed when 100 Gy genotype was applied with the same antitranspirant treatment of 0.0667 (Table 6)

Table 6: Interaction of phenylmercuric acetate antitranspirant, genotype and water application on number of leaves of millet.

		Phenylmercuric acetate Antitranspirant					
		0.0M		**0.0067M**		**0.0667M**	
		Water application %(WUE)		Water application %(WUE)		Water application %(WUE)	
Weeks After Planting	**Genotype**	**50**	**100**	**50**	**100**	**50**	**100**
6	100 Gy	19.67	23	17.33	21	22.33	23
	200 Gy	22.33	24	29.67	30.67	26.33	29.33
	300 Gy	21.67	22.33	26.33	28.67	27.67	28.33
	'Naara'	19.67	23.67	19.33	25.67	24.67	29.67
	'Zah'	23.67	25.33	20	21.33	30	25.67
8	100 Gy	52.67	58.67	57.67	59.67	59	74.33
	200 Gy	56.67	71.67	54.67	48.33	63.67	64.33
	300 Gy	61	65.33	55.67	59.67	60.33	61.67
	'Naara'	50.33	63.33	53.33	55	61	61
	'Zah'	52.67	58.67	44	46.67	57.33	60.67
10	100 Gy	89	107.7	104	115.3	112	130
	200 Gy	94.7	135	102	103	115	129.3
	300 Gy	95	125	98	118.3	106.3	135.7
	'Naara'	82.7	118	102	107.7	110.3	134.3
	'Zah'	83.7	98	84	86.3	96.3	106.7

LSD (0.05): Genotype x Kaolin x Water application; 6WAP = 7.964, 8WAP = 14.813, 10WAP = 22.23

4.2.3 Tiller number

Phenylmercuric acetate significantly ($P < 0.01$) influenced tiller number at 10WAP. Phenylmercuric acetate application at 0.0667 M recorded the highest mean tiller number with 13.17, followed by at 0.0067 M with the mean tiller number at 10.73. The antitranspirant concentration at 0.0 M recorded the least mean tiller number of 9.47 (Figure 14). However, water application did not significantly ($P > 0.05$) influence tiller number at 10WAP.

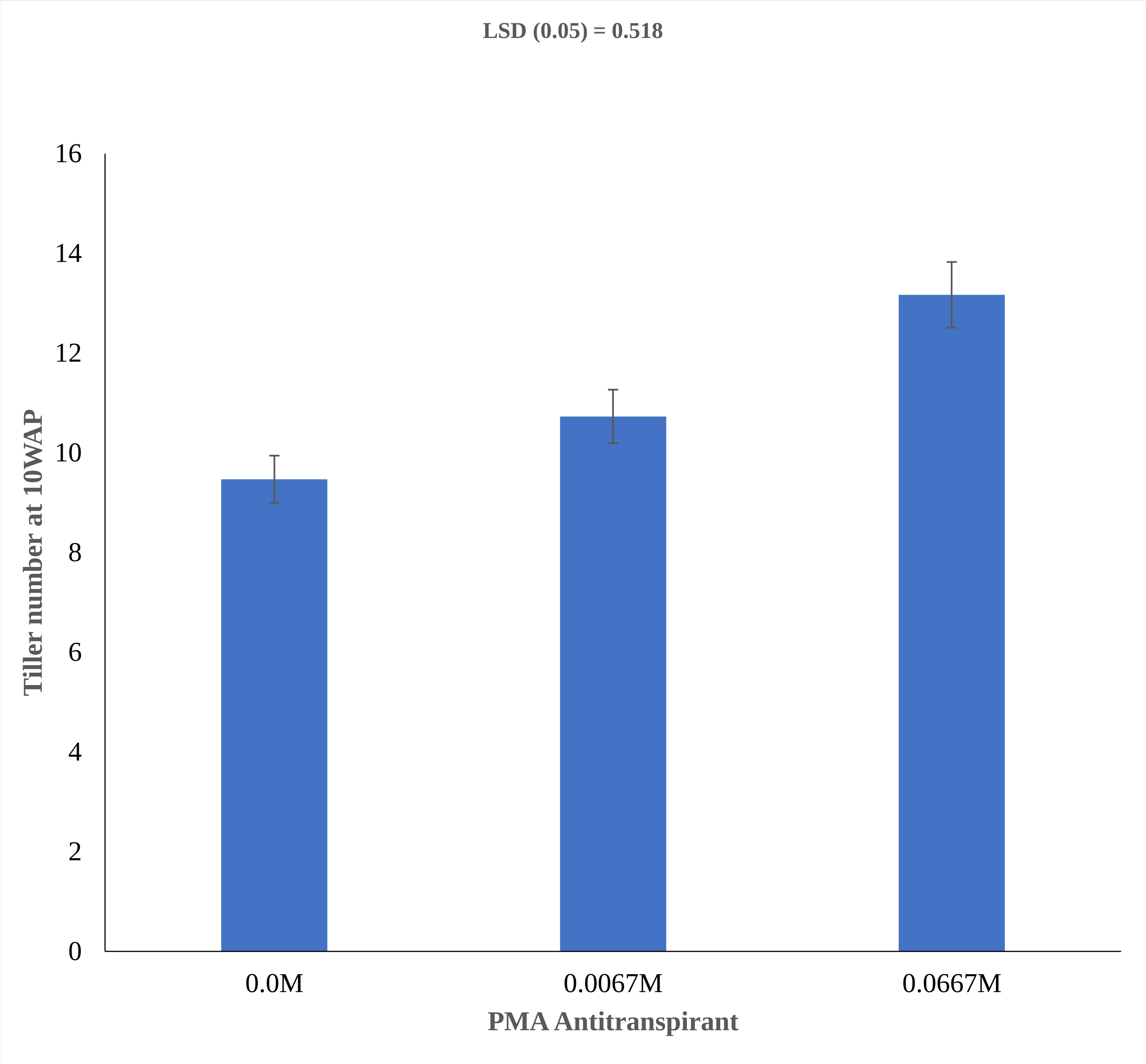

Figure 14:Effect of Phenylmercuric acetate on tiller number of millet plant.

4.2.4 Leaf Area Index (LAI)

The interaction of genotype x phenylmercuric acetate significantly ($P < 0.05$) influenced leaf area index at 6WAP. The interaction resulted in a highest mean leaf area index of 2.08 and a least mean area index of 1.31. When 'Zah' genotype was applied with phenylmercuric acetate at 0.0667M concentration, the highest leaf area index of 2.08 was recorded, followed by leaf area index of 1.850 when the same level of phenylmercuric acetate was applied to 200 Gy plants. The 100 Gy recorded the least mean leaf area index of 1.583 with same antitranspirant concentration (Figure 14).

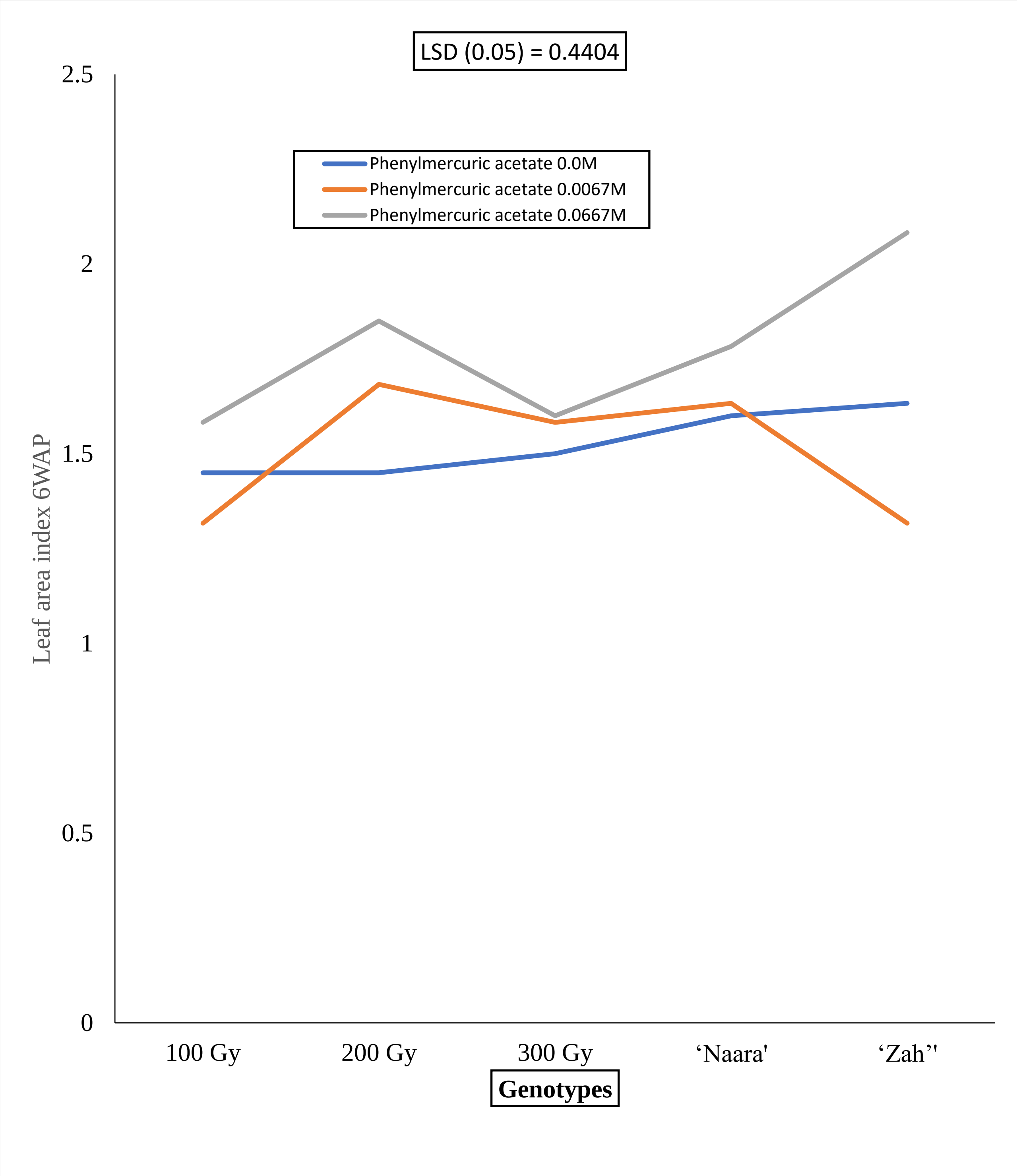

Figure 15:Effect of the Interaction of Phenylmercuric acetate antitranspirant and Genotype on Leaf Area Index 6WAP.

4.2.5 Chlorophyll Content

The interaction of genotype and water application significantly ($P < 0.05$) affected chlorophyll content. The highest chlorophyll content of 47.16 spad unit was recorded by 300 Gy genotype at water application rate of 100% water requirement, followed by 200 Gy genotype by water application rate of 100% with leaf area index of 46.77. The least leaf area index of 43.11 was recorded by 'Zah' with the same water application rate (Table 7).

Table 7: Effect of the Interaction between Genotype and water stress on chlorophyll content.

Genotype	Water Application	
	50% WUE	**100% WUE**
100 Gy	45.06	45.80
200 Gy	44.96	46.77
300 Gy	45.96	47.16
'Naara'	44.92	45.79
'Zah'	45.53	43.11

LSD (0.05): Genotype x Water application; = 3.379

4.3.0 Results from experiment three

4.3.1 Plant height

Kaolin significantly ($P < 0.05$) influenced plant height at 8WAP. Kaolin as antitranspirant application at 0.3g/l concentration recorded the highest plant height of 129.9 cm followed by 112.9cm when kaolin was applied at a concentration of 0.15g/l. Plants treated with kaolin at a concentration of 0.0g/l recorded the least plant height of 98.1 cm (Figure 16).

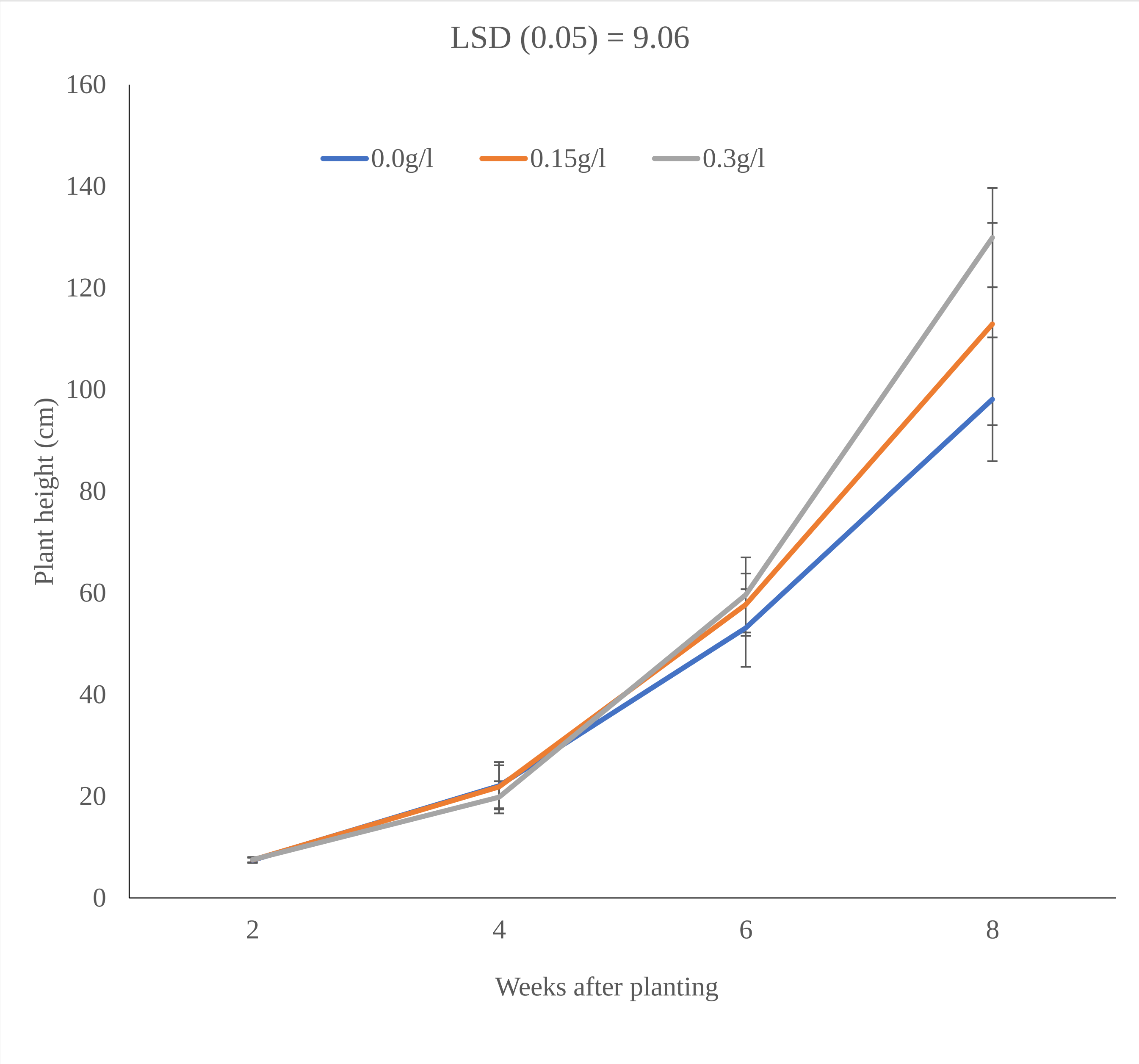

Figure 16:Effect of Kaolin antitranspirant on plant height of millet

4.3.2 Leaf number

leaf number increased with increased levels of kaolin. At 2 and 4WAP, Kaolin as antitranspirant did not significantly ($P > 0.05$) influence leaf number. However, at 6 and 8WAP, leaf number was significantly ($P < 0.05$) affected by levels of kaolin application. Kaolin applied at 0.3g/l recorded the highest leaf number of 122, followed by mean leaf number of 107 when kaolin was applied at 0.15g/l. The Lowest mean leaf number of 85 was recorded when no kaolin was applied. (Figure 17).

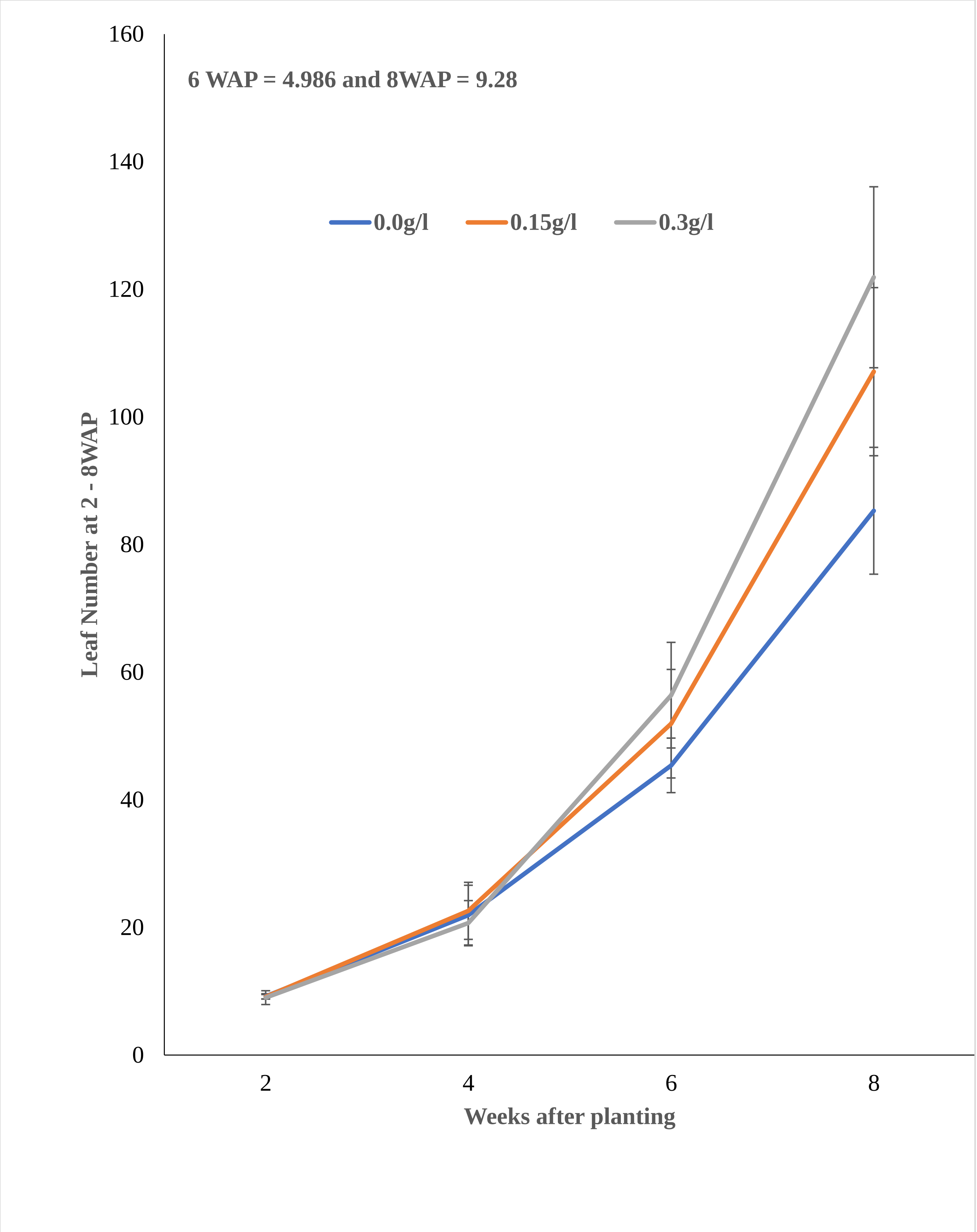

Figure 17: Effect of Kaolin antitranspirant on leaf number.

4.3.3 Leaf Area Index

Kaolin as antitranspirant highly significantly ($P < 0.001$) influenced leaf area index at 8WAP. Kaolin application of 0.3g/l to plants recorded the highest mean leaf area index of 1.991. This was followed by the concentration of 0.15g/l which recorded mean leaf area index of 1.632. At a concentration of 0.0g/l recorded the least mean leaf area index of 1.346. (Figure 18).

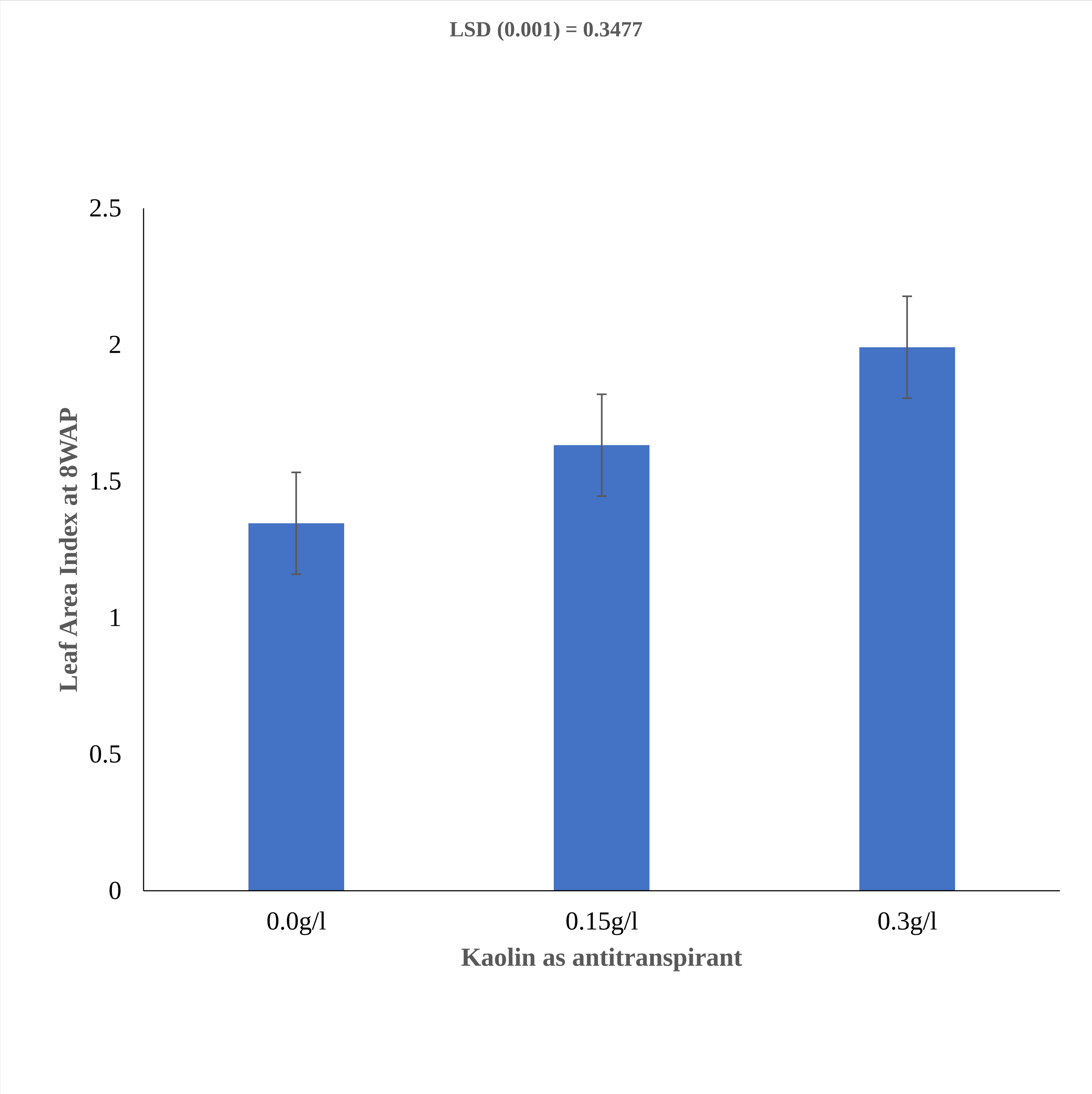

Figure 18:Effect of Kaolin as antitranspirant on leaf area index.

Genotypes were significantly different at 5% level on probability at 6WAP on leaf area index. However, there was no significant ($P > 0.05$) difference among 100 Gy, 200 Gy, 300 Gy and ‘Zah’ genotypes. There was no significant ($P > 0.05$) difference between ‘Naara’ and ‘Zah’ genotypes. (Figure 19).

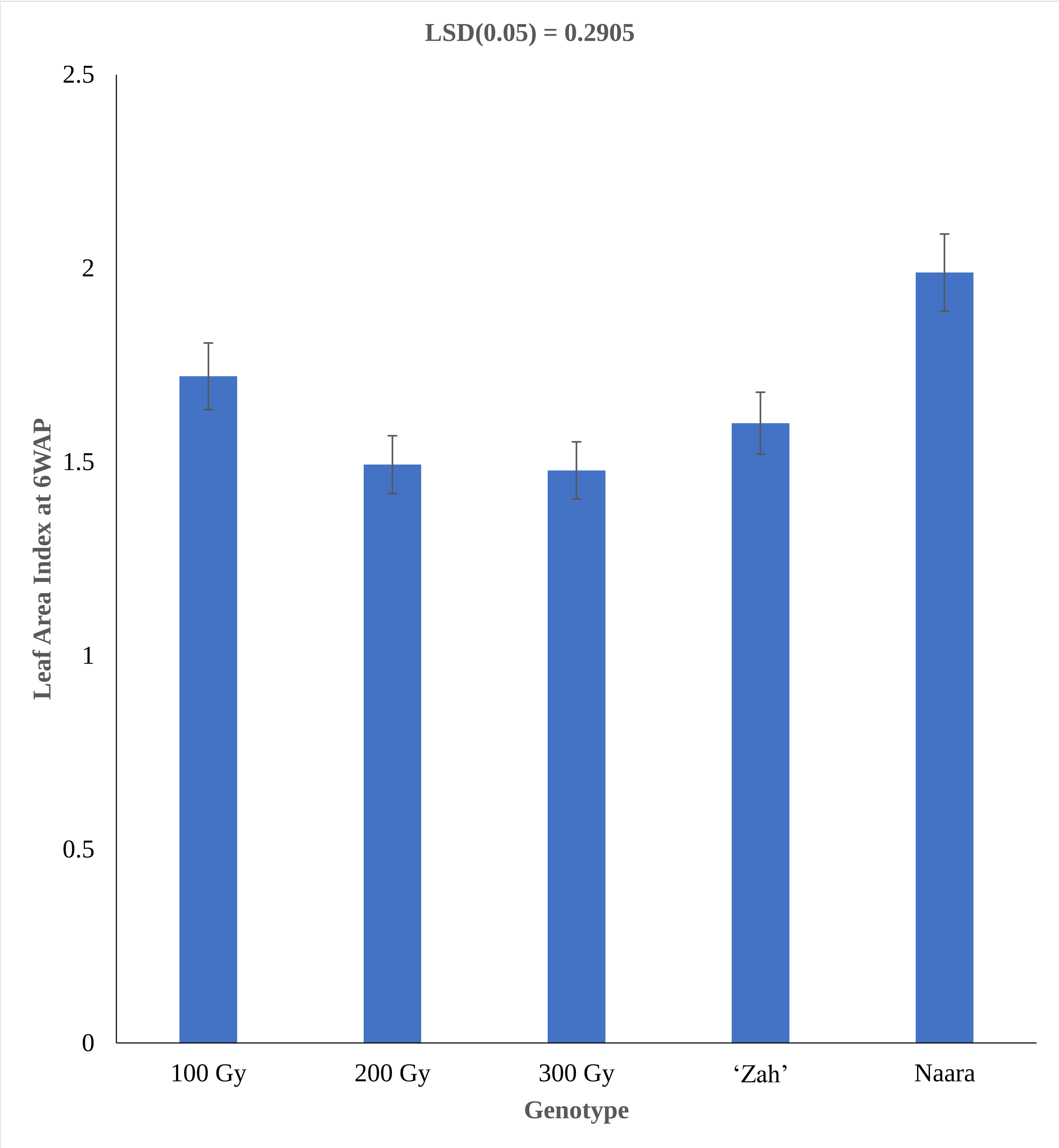

Figure 19:Effect of Genotypes on leaf area index.

4.3.4 Panicle Weight/ plant

Kaolin as antitranspirant significantly ($P < 0.05$) influenced panicle weight per plant. Genotype did not show significant ($P > 0.05$) difference on panicle weight. Kaolin as antitranspirant application levels recorded different panicle weights. A concentration of 0.3g/l applied to plants recorded the highest mean panicle weight of 34.27 grams, followed by plants treated with 0.15g/l concentration with mean value of 28.59 grams. The least panicle weight of 22.35 grams was recorded by plants treated with kaolin at concentration of 0.0g/l (Figure 20).

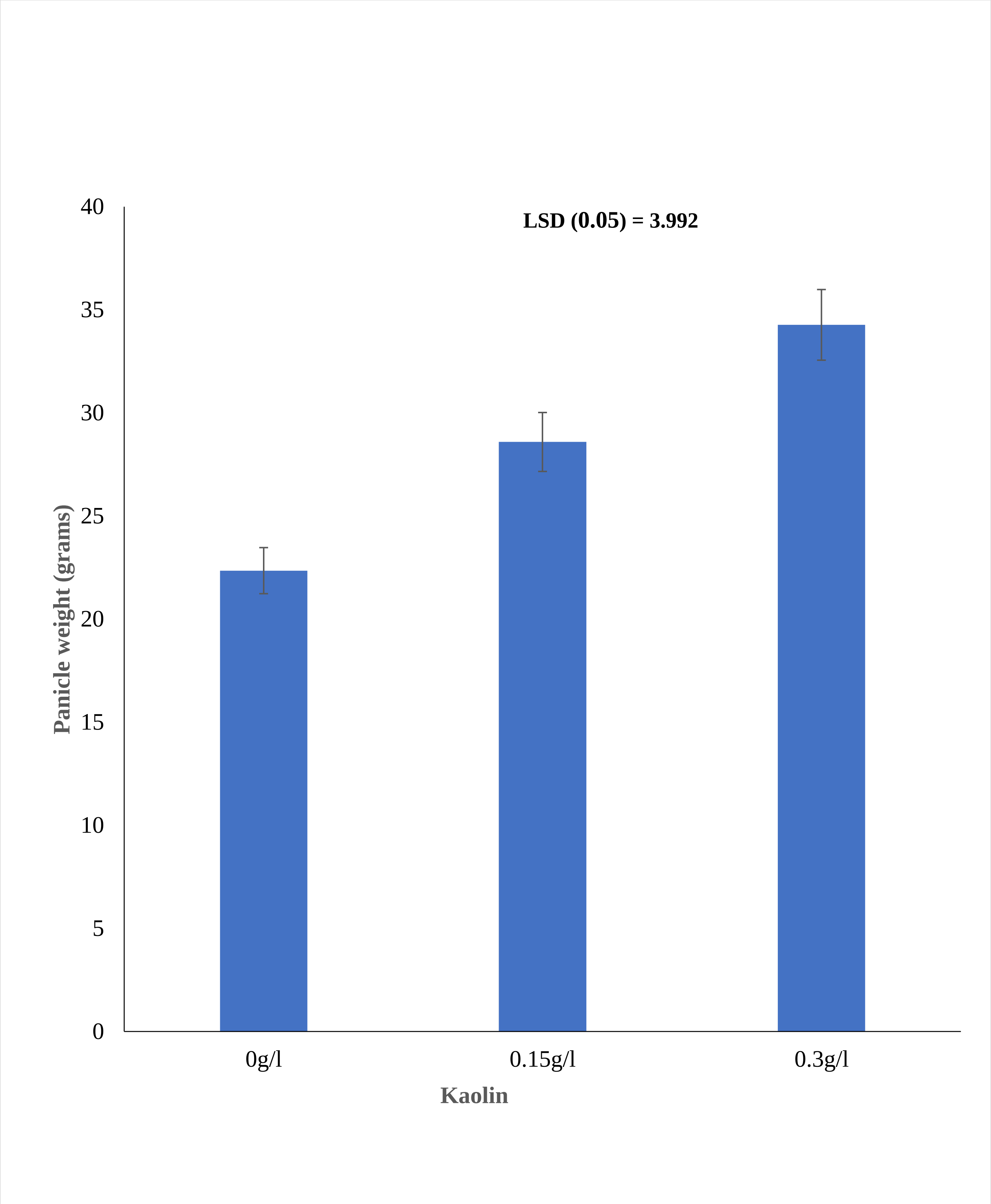

Figure 20:Effect of Kaolin antitranspirant on average panicle weight.

4.3.5 Total crop yield

Kaolin as antitranspirants significantly ($P < 0.05$) influenced total crop yield. Kaolin application of concentration at 0.3g/l recorded the highest mean total crop yield of 2.13 ton/ha, followed by the concentration at 0.15g/l which recorded mean total crop yield of 1.26 t/ha. No Kaolin recorded the least total crop yield of 1.19t/ha (Figure 21). Genotype did not significantly ($P > 0.05$) influence total crop yield. The interaction of genotype and kaolin did not influence ($P > 0.05$) significantly total crop yield.

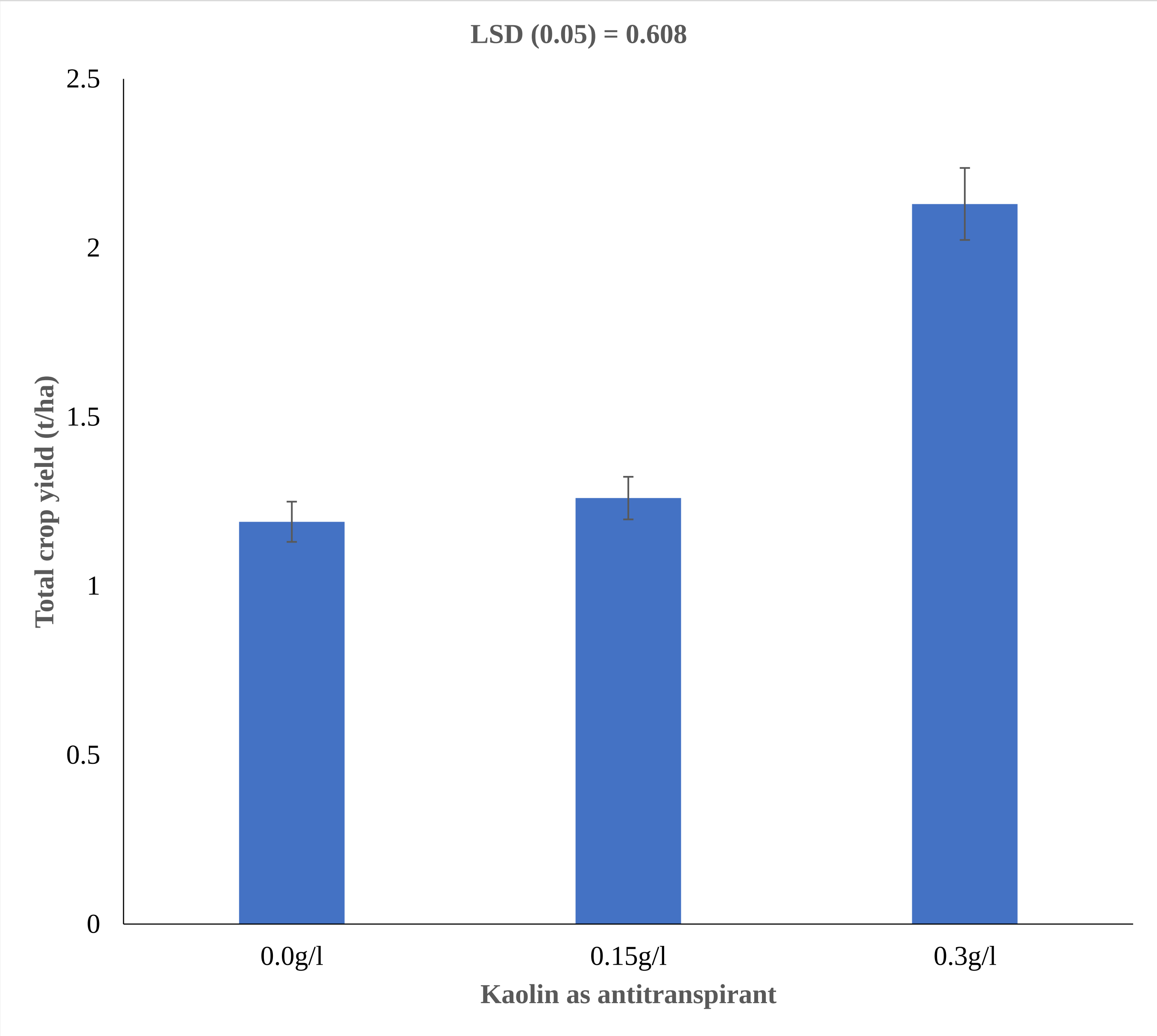

Figure 21: Effect of Kaolin antitranspirant on total crop yield.

4.3.6 Water Use Efficiency (WUE)

Kaolin significantly ($P < 0.5$) influenced water use efficiency. Kaolin as antitranspirant applied at a concentration of 0.3g/l to plants recorded the highest water use efficiency of 18.6, followed by water use efficiency of 11 when kaolin at a concentration of 0.15g/l was applied to plants. The least mean water use efficiency of 10 was recorded when plants treated with kaolin at concentration of 0.0g/l. Genotype did not significantly ($P > 0.5$) influence water use efficiency. Interaction between genotype and Kaolin did not significantly affect ($P > 0.5$) water use efficiency (Figure 22).

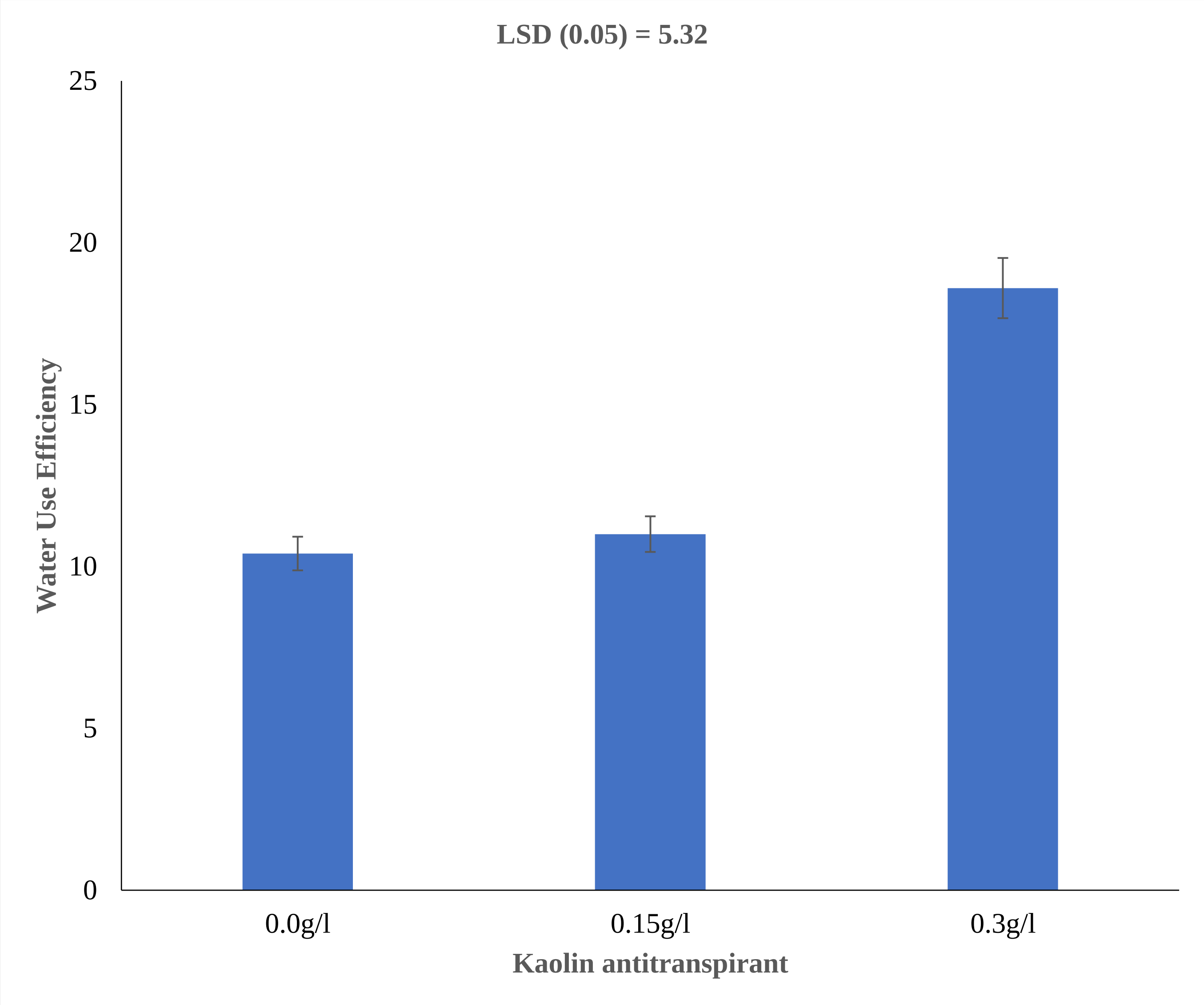

Figure 22: Effect of Kaolin antitranspirant on WUE.

4.4.0 Results from experiment four

4.4.1 Leaf number

Genotypes were significantly different at 5% level of significant at 6WAP on number of leaves. However, The 100 Gy genotype recorded the highest mean leaf number of 88.44, followed by the 200 Gy with mean leaf number of 81.00. while 'Naara' gave the least mean leaf number with 77.44.). There was no significant ($P > 0.05$) difference with interaction between genotype and phenylmercuric acetate at 2 and 4WAP (Figure 23).

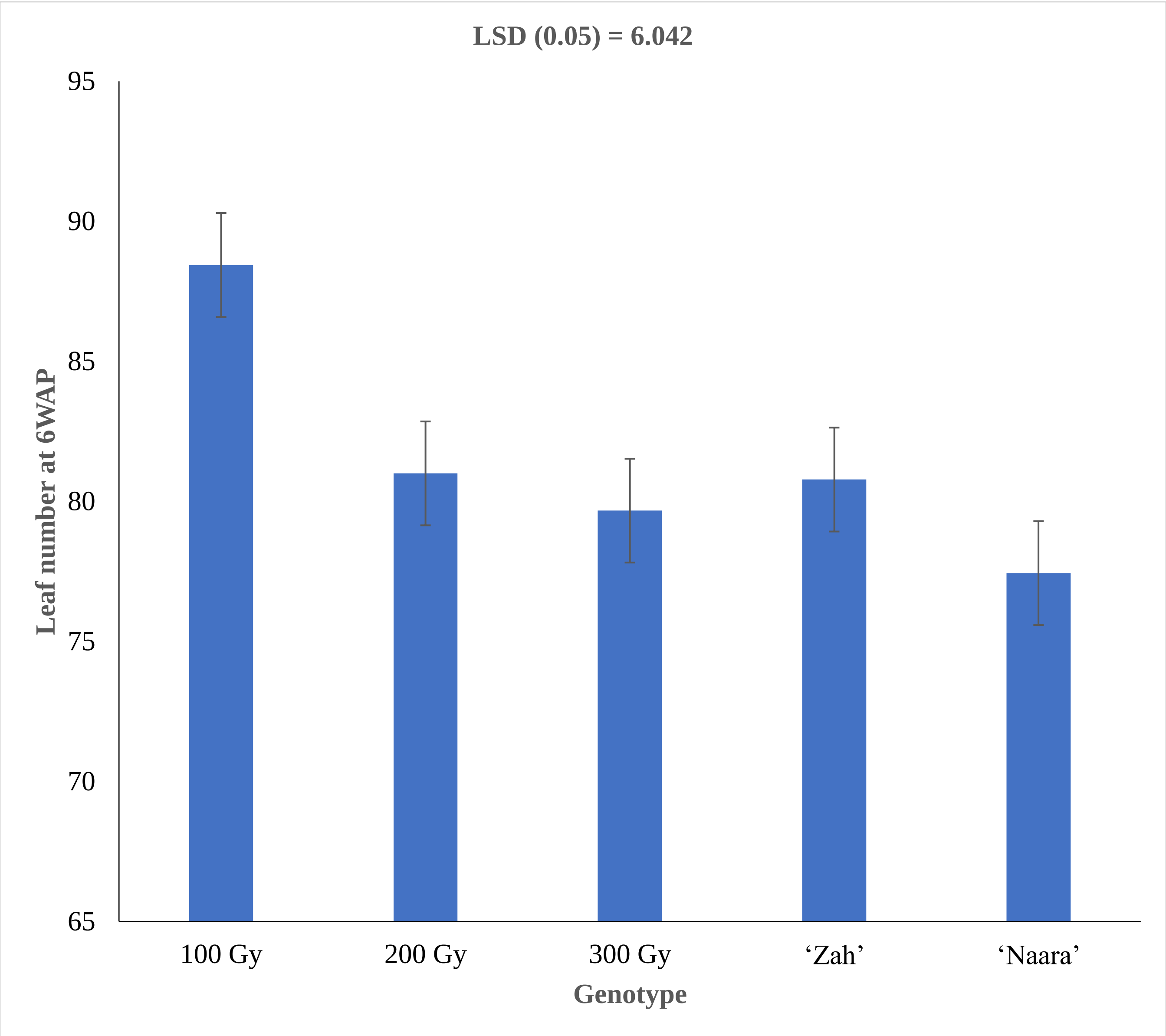

Figure 23: Effect of genotype on number of leaves 6WAP.

4.4.2 Panicle weight per plant

The interaction of genotype and phenylmercuric acetate antitranspirants significantly ($P < 0.05$) influenced mean panicle weight. The interaction produced a highest mean panicle weight of 45.57. the least mean panicle weight of 33.27. The highest panicle weight per plant of 45.57 was observed when phenylmercuric acetate at 0.0667 M concentration was applied to 300 Gy plants, followed by panicle weight of 43.07 when antitranspirant was applied on 200 Gy plants. The least panicle weight of 33.57 was realized when 100 Gy plants were treated with the same concentration of phenylmercuric antitranspirant. Genotype did not significantly ($P > 0.05$) influence mean panicle weight. Phenylmercuric acetate antitranspirant did not significantly ($P > 0.05$) influence mean panicle weight (Table 8).

Table 8: Effect of genotype x phenylmercuric acetate interaction on average panicle weight.

Genotypes	Phenylmercuric acetate		
	0.0M	**0.0067M**	**0.0667M**
100 Gy	33.00	33.27	33.57
200 Gy	31.33	39.30	43.07
300 Gy	33.77	39.63	45.57
'Zah'	34.73	36.07	40.57
'Naara'	33.10	36.03	37.93

LSD (0.05): Genotypes x Phenylmercuric acetate = 6.407

4.4.3 Total crop yield

Phenylmercuric acetate as antitranspirant significantly ($P < 0.05$) influenced total crop yield. The antitranspirant application level of 0.0667 M recorded the highest crop yield of 2.723 t/ha followed by 0.0067 oncentration with the mean crop yield of 2.544 t/ha while plants which were not treated with the antitranspirants recorded the least mean crop yield of 2.208t/ha (Figure 24).

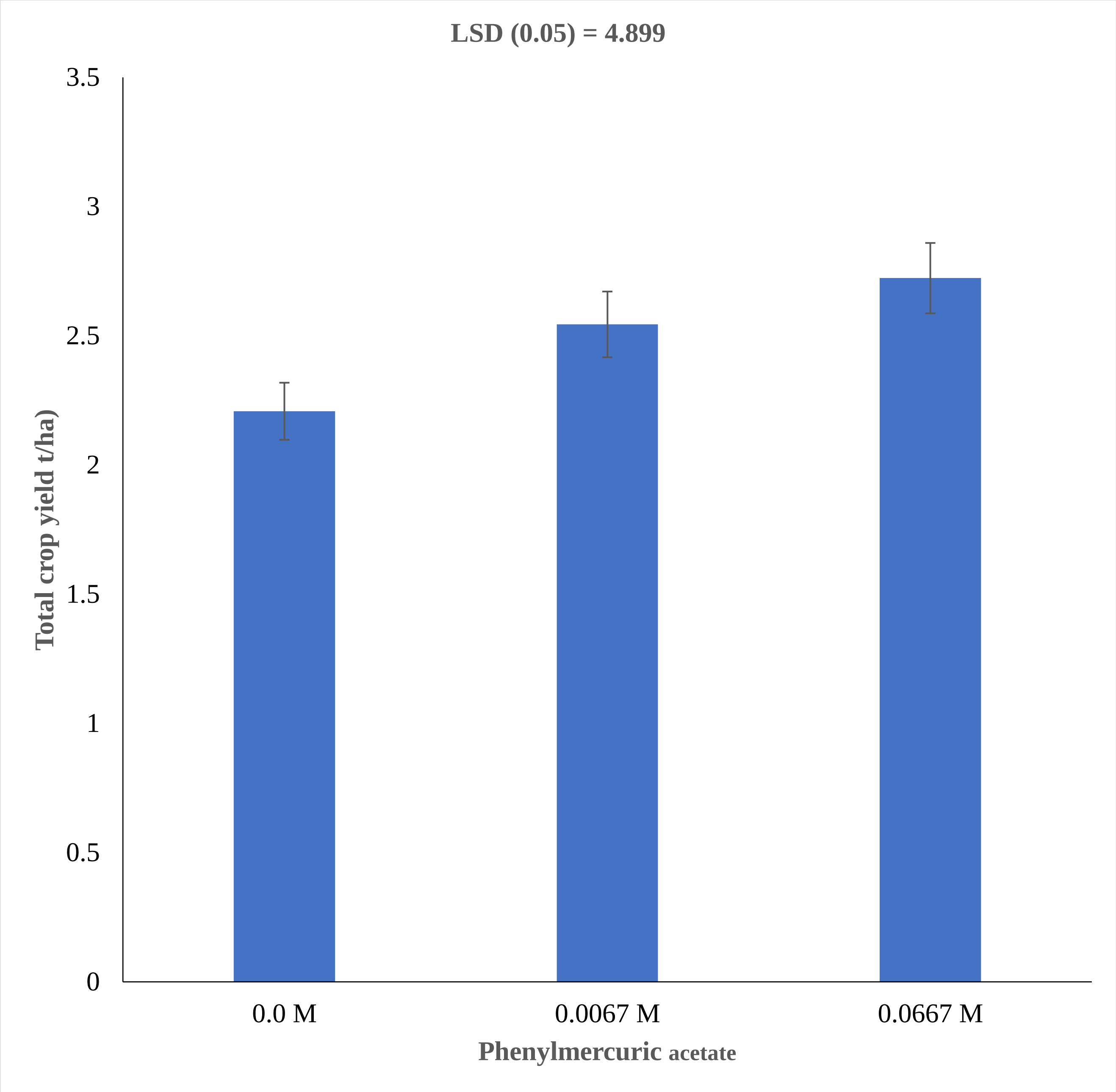

Figure 24: Effect of Phenylmercuric acetate antitranspirant on total grain yield.

The interaction between phenylmercuric acetate antitranspirant and genotype significantly ($P < 0.05$) influenced total crop yield. The highest crop yield of 3.27 t/ha was recorded with the interaction. The least crop yield of 1.79 t/ha was obtained with the interaction iof genotypes and phenylmercuric acetate. when 200 Gy plants were applied with 0.0667 M of phenylmercuric acetate, followed by 3.26 t/ha when 300 Gy plants were applied with the antitranspirant at the rate of 0.0667 M. The least total crop yield of 0.91t/ha was observed when 100 Gy plants were applied with antitranspirants at a rate of 0.0067 M (figure 25).

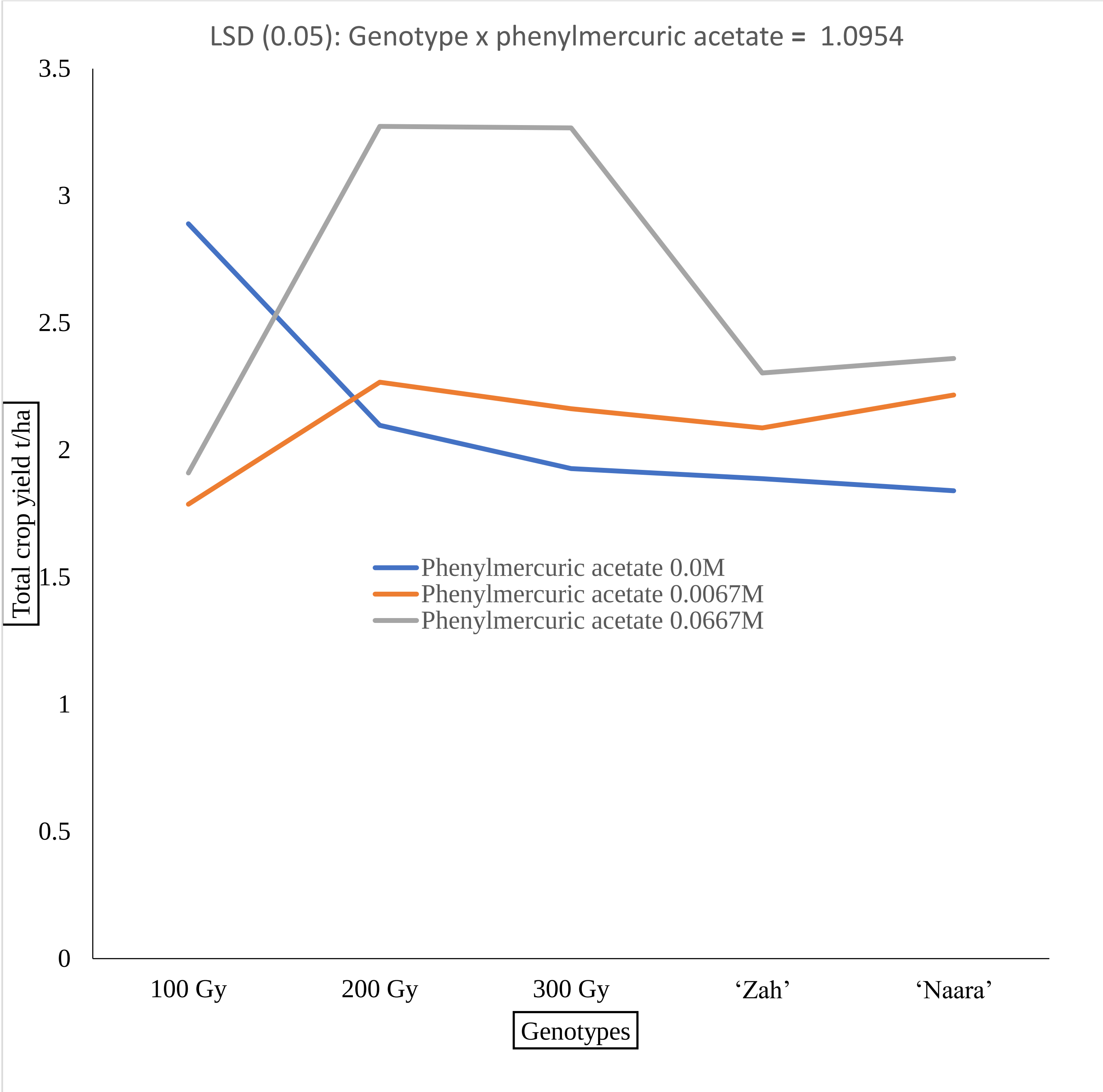

Figure 25: Interaction between genotype and phenylmercuric acetate antitranspirant effect on total crop yield of millet.

4.4.4 Water Use Efficiency (WUE)

Genotypes were significantly different at 5% level on probability. The genotype that recorded the highest mean water use efficiency was 300 Gy with the mean water use efficiency of 24.38. This was followed by 200 Gy genotype with the mean value of 22.29. 'Zah' genotype recorded the least water use efficiency of 17.14.. There was no significant ($P > 0.05$) difference between 'Zah' and 'Naara' genotypes (Figure 26) However, phenylmercuric acetate antitranspirant did not significantly ($P > 0.05$) influence water use efficiency.

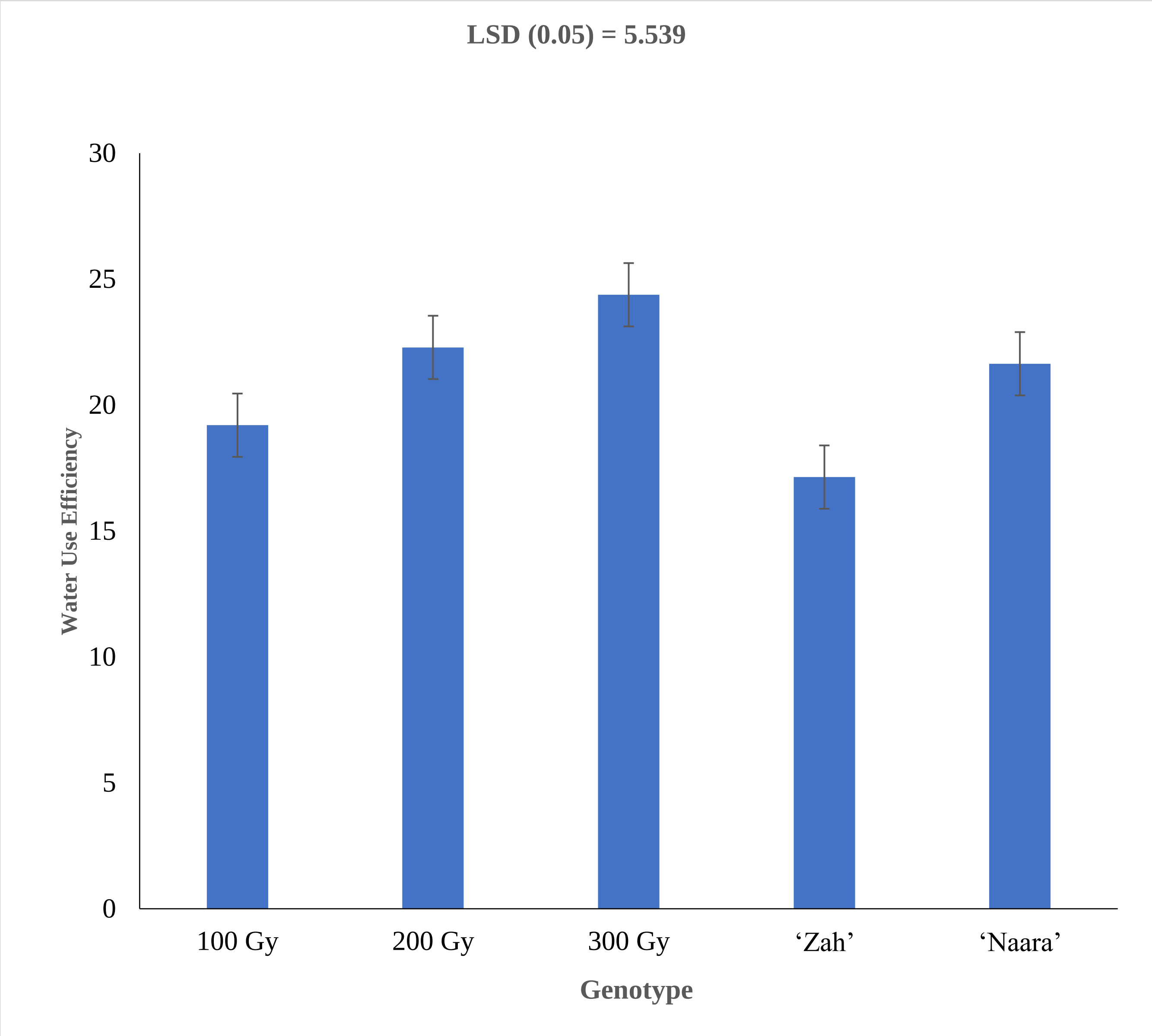

Figure 26: Effect of Genotype on Water use efficiency.

CHAPTER FIVE

DISCUSSION

5.1 Growth parameter

.Water loss from crop plants can be minimized by employing an antitranspirant like Phenylmercuric acetate (stomata closure type) or plant coating materials such as kaolin as antitranspirant. From this study, it is obvious that, antitranspirants can play a role in combating the negative impacts of extremely hot conditions on crops. This falls in line with the findings of Ahmed *et al* (2012) and Ebrahiem-Asmaa (2012), who found out that, antitranspirants can improve crop growth by limiting the negative impact on crop plants from extreme hot weather conditions. The obtained results might be as a result of antitranspirant coatings which increased stomatal resistance by increasing the resistance to water vapor diffusion from the pores of the coated plants. This reduces transpiration and conserve moisture in plant for growth and development.

Segura-Monroy1 *et al* (2015), said kaolin improves plant height. Plant height was found to be lower with lower amount of antitranspirants applied and plant height was increased when higher kaolin concentration was applied.

Plant are able to absorb more nutrients from the soil following the application of kaolin, promoting physiological processes like cell division and expansion, the number of tillers and number of leaves. This is in line with the findings of Silva (2012), that number of leaves, leaf area, leaf area index, plant dry matter, and crop growth rate increased with application of kaolin antitranspirant.

The increased in vegetative growth was linked to reduced evaporation loss and sufficient soil moisture near the root zone following the antitranspirant application. This is further supported by Nezhadahmadi *et al* (2013), who found out that drought can reduce leaf area which can consequently decrease photosynthesis. The application of Kaolin to reduce transpiration owing to the reflection of incident radiation from the leaf surface or the partial shutting of stomata could explain the improvement in these growth metrics with Kaolin spray. As a result of Kaolin spray, the plants' superior stratification may have resulted in decreased leaf withering and increased photosynthates, ultimately resulting in higher vegetative growth. Kaolin served as transpiration suppressant, lowering the heat from leaf and diminishing stomata (Rosati *et al*., 2007).

The combination of genotypes and water regimes resulted in a significant increase in leaf numbers. Both the sole impacts of phenylmercuric acetate and the interaction of phenylmercuric acetate and water application regime had a substantial influence on leaf number. The observed increases in leaves might have been caused by antitranspirants that have the potential effect to help plants develop root system for vegetative growth and thus revealed that the effect of water stress on number of leaves may be due to the negative effect of shortage of available water on internodes elongation and thus led to a decrease in the rate of leaf emergence.

The number of leaves grew as the concentration of kaolin used increased. Variation in number of leaves of genotypes is due to their defferences in response to the kaolin antitranspirant. The study revealed that 100 Gy was the genotype that produced the highest number of leaves, followed by 300 Gy. Similar results were observed by Yadav *et al* (2006) that lower doses of gamma rays are known to have stimulatory effect on plant growth than higher doses of gamma rays through modification in the pattern of hormonal functioning in plant cell.

The leaf area index was higher when Kaolin was applied at a concentration of 0.15g/l compared to Kaolin application at 0.3g/l. These findings were similar to those of Ulameer and Ahmed

(2018) and Peng *et al* (2018) who found that application of antitranspirants affected this leaf area index positively.. According to Ulameer and Ahmed (2018), the interaction between irrigation and antitranspirant resulted in a significant leaf area index .

The effect of kaolin antitranspirant and water application on genotypes influenced chlorophyll content. Water application at 100% and 50% plant water requirements did not vary much with respect to the application of kaolin as antitranspirant because the antitranspirant might have conserved enough plant water for photosynthesis to take place. This agrees with Ulameer and Ahmed (2018), who found that kaolin improved photosynthetic rate under water-deficit conditions in maize plants. Silva (2012), also observed a positive effect of Kaolin on plant water conservation. The increased chlorophyll content and vegetative growth could also be attributed to an increase in leaf number as a result of kaolin application, which reduced leaf temperature via increased leaf reflectance and decreased transpiration rate (Cantore et al., 2009) .

5.2 Water Use Efficiency

The growing adverse seasonal rainfall and other abiotic conditions, as well as limited water resources affecting millet production, is garnering greater attention from researchers and users (Ceccon *et al.*, 2006). Water use efficiency is the amount of carbon assimilated per biomass/grain produced per unit of water used by the crop (Hatfield and Dold, 2019). It can be observed that number of leaves increased with increasing levels of kaolin antitranspirant due to the effect of antitranspirants ability to reduce drought effect on plants. According to Hanson and Hitz (1982) stomatal management is the first and most critical step in responding to drought, since it decreases water loss, slows the development of water stress, and lessens the severity of the condition. Stomatal closure permits plants to reduce transpiration while also limiting carbon dioxide uptake, resulting in a decrease in photosynthetic rate (Nayyar and Gupta 2006).

Kaolin applied to the plants formed a coat on plant leaves,closed stomata which prevented or reduced transpiration as well prevented sun burns (Abdallah 2019; Passerini and Hill 1993). It was observed that water use efficiency was increased with kaolin application at 0.3g/l but very little difference was observed between 0.0g/l and 0.15g/l levels of kaolin antitranspirant applied. This proves that, millet is a drought tolerant crop, making it exhibit higher water use efficiency values.

Reduced transpiration can help in limiting excessive water loss from plants with the application of antitranspirants which help to increase drought tolerance by causing xeromorphy and/or stabilizing cell structure (Silva, 2012).

Despite the fact that millet is drought tolerant, it was observed that plant moisture was necessary at the initial stages, of growth. Hassan *et al* (2014) reported that moisture stress causes poor plant stand and a reduction in leaf area index, resulting in lower grain and feed yields.

5.3 Yield component

In this study, leaf number was significantly influenced by the application of antitranspirants which reduced plant stress and ensured plant growth, development and yield. Research has shown that antitranspirant can help alleviate drought and enhance crop output (Mphande *et al*., 2021). High yields were achieved under full irrigation, with the application of kaolin which was confirming the findings of Djurović *et al* (2016). Antitranspirants increased plant water conservation leading to production of more tillers and higher number of leaves which increased leaf area index, This finding is supported by Oosterom *et al* (2001) who made a similar observation. Antitranspirants application significantly influenced average panicle weight leading to more filling of the millet grains.

Average grain weight was significantly influenced by the application of antitranspirants. This implies, the antitranspirants helped crop plants conserve moisture which facilitated grain filling of the panicles. Genotype as a factor significantly influenced average grain weight. The 300 Gy, 200 Gy and 100 Gy mutant gynotypes had higher well filled gains than Zah and Naara genotypes. This could be attributed to the exposure to gamma rays which demonstrated changes in genetic make up seed and resulted in the production of higher average grain weight. The number of tillers increased when the dose of gamma radiation was increased. This agrees with the findings of Abdul *et al* (2009), who reported that most parameters increased with increased gamma irradiation. And this is attributable to increased mitotic activity in meristematic cells.

5.4 Total grain yield

All cultivated cereals are drought resilient, yet pearl millet is the most drought tolerant of them all (Govindaraj *et al.,* 2010). Induced mutation resulting from seeds exposed to gamma irradiation followed by selection as seen in this study produced significantly increased total grain yield. It was observed that mutant genotypes showed much response with higher grain yield than unirradiated genotypes. This agrees with the findings of (Sudarmonowati *et al*., 2021). This also confirms a study on yield parameters by Singh *et al*. (2013) and Fadia *et al*. (2011) that higher irradiation doses resulted in increases in yield. Interaction between genotype and phenylmercuric acetate antitranspirant had a substantial impact on total grain yield. These increases in yield could be attributed to the fact that antitranspirant conserve soil moisture by reducing evapotranspiration.

Application of antitranspirant favored plant metabolism, physiological processes, photosynthetic rate, carbohydrate metabolism, and many other important functions that directly affected greatly total grain yield. In this respect, studies conducted on tomato and potato also showed that kaolin application gradually decreased plant stress, which is vital for plant growth and development (Cantore et al., 2009).

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

It can be concluded from experiment one that kaolin antitranspirant applied on millet plants has impacted on plant growth as it has increased in plant height, leaf number, tiller number and leaf area index. Further more, the application of both kaolin and water on millet showed much effect on plant height and chlorophyll content which reveals the importance of kaolin in plant growth and development. The genotype which showed outstanding traits was 200 Gy followed by 300 Gy.

From experiment two we can conclude that phenylemercuric acetate application on millet plants resulted in good plant growth with increased plant, leaf number and tiller number. The application of phenylemercuric acetate with watering regimes has further proven positive with increased in leaf number, leaf area index and chlorophyll content. The genotype which showed outstanding characteristics was 200 Gy followed by 300 Gy.

In experiment three kaolin antitranspirant application on millet plants on field experiment resulted in increased plant height, leaf number and leaf area index. This proves to be a good material to support plant growth. It has further been observed to have increased total crop yield and water use efficiency. The genotype which showed outstanding traits was 300 Gy followed by 100 Gy.

In experiment four it can be concluded that phenylmercuric acetate application on millet plants on field experiment resulted in increased leaf number, total crop yield and water use efficiency. The interaction of phenylmecuric acetate and millet genotypes has further showed an increase in leaf number and total crop yield. The genotype with outstanding traits is 200 Gy followed by 300 Gy.

The application of kaolin and phenylmercuric acetate antitranspirants soly or in combination with water regimes has been proven to have impacted enoumous change on plant growth and development in this study.

6.2 Recommendations

Based on the findings from this study, it has been observed that 200 Gy and 300 Gy genotypes have been outstanding with growth and yield traits be recommended to farmers as varieties to be used in the northern part of Ghana.

The application of antitranspirants have played much role to have exposed the traits of millet genotypes, to improve millet yields in terms of severe drought, introduce application of antitranspirants on crops to conserve moisture,

The application of water on millet gynotypes proves beneficial to growth and yield, Water regime of 100% be applied on millet plants in times of drought for enhanced plant growth and yields

I recommend further studies be carried out with Kaolin and Phenylmercuric acetate on other crops in drought prone areas.

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