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Effect of Different Rates of Gibberellin Hormones on Yield and Quality of White Kishmish Grape (*Vitis Vinifera* L)

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ABSTRACT

A field experiment was conducted at Saripul University, Afghanistan, to evaluate the effect of exogenous Gibberellin application at 8 and 16 days after flowering on yield and yield components of kishmish grape. The study employed an RCBD design with three replications, testing gibberellin at concentrations of 20 ppm, 60 ppm, and 100 ppm. The hormone was applied at the early fruit-formation stage to assess its effects on fruit set, size, weight, number of clusters per plant, number of berries per cluster, and yield per plant. and sugar accumulation. The statistical analysis revealed that most measured yield and yield-related parameters showed significant differences ($P \le 0.05$) in response to gibberellin treatment compared with the control. Specifically, fruit fresh and dry weight, number of clusters per plant, number of berries per cluster, berry length and width, and total yield per plant increased significantly (maximum at 20ppm rate), indicating the positive influence of GA_3 in enhancing economic productivity and quality of seedless kishmish grape. However, parameters like cluster length and width did not show a significant response to the applied treatment. In other words, the 20 ppm dosage consistently produced the maximum value across all measured yield parameters. Although higher concentrations (60 and 100 ppm) showed better performance than the control, their performance diminished as the doses increased, suggesting a potential hormonal imbalance at higher concentrations. Therefore, the current study revealed that a precise application of gibberellin at 20 ppm during the early fruit-formation stage can enhance kishmish grape yield and quality.

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INTRODUCTION

Grapes (*Vitis vinifera* L), a deciduous fruit of sub-tropical and temperate regions, belong to the *Vitaceae* family (Vincent et al., 2019). Recently, several grape varieties have been successfully released worldwide (Alston and Sambucci, 2019). Among them, the Kishmish grape variety is one of the most widely cultivated and economically important grape varieties in Afghanistan. It has seedless, oval-shaped fruit with a sweet taste. Physiologically, it's more resistant to water shortage and drought due to its deep root system. Berries of Kishmish grapes can be consumed in many forms, such as fresh juices, beverages, and raisins (Poudel et al., 2022).

In today's grape production, several methods are used to improve grape yield and quality (Khan et al., 2020a). So far, farmers have been using canopy management, appropriate spacing, thinning, nutrient application, and different regulatory hormones to improve yield and quality throughout the year (Howell, 2001; Khan et al., 2020b). Growth regulators such as Gibberellins have a positive effect on cluster compactness and berry quality (Castro-Camba et al., 2022a; Ranpise & Patil, 2022). The external application of gibberellin is essential for regulating several physiological functions, even though it is naturally produced in plants. The hormone affects flowering, fruit development, and ripening in grapes (Sawant et al., 2024). It encourages the growth of clusters, leading to increased yield and improved quality, inducing cell division and elongation (Afshari-Jafarbigloo et al., 2020a).

Previously, different studies reported that gibberellins influence key aspects of fruit set, seed development, and seed germination (Castro-Camba et al., 2022b). In commercial grape production, gibberellin application is popular for enhancing cluster weight, berry length, diameter, and sugar content (Beasley, 2020). The increase in berry size and quality is due to the effects of gibberellins on cell development and changes in photosynthetic product accumulation (Gupta et al., 2022). Application of gibberellin on Cardinal and Michele Palieri varieties showed a positive impact on both varieties. Total sugar concentration and polyphenol oxidase activity were higher during maturation, whereas organic acid concentration decreased in both varieties (Rusjan, 2010). Similarly, Different concentrations of gibberellin hormone (10-20ppm) sprayed on Sultani grape at 5- 10 cm cluster length showed improvement in cluster and berry size, sugar content, antioxidant and total phenolics (İşçi, 2019). Gibberellin played a significant role in increasing berry size, cluster weight, and yield of the Recel Uzum variety when applied at a concentration of 40ppm at the early berry-size stage (Afshari-Jafarbigloo et al., 2020b).

Averages of cluster and berry weight with applications of 15 ppm, 20 ppm, and 25 ppm were significantly higher thanhe control (Khan et al., 2009). In recent years, the use of growth hormones for grape production has been promoted in Afghanistan, but the role of these hormones in white Kishmish grapes has not been properly investigated. Therefore, the aim and objective of this study are;

- To investigate the effects of gibberellin hormone on grape yield and quality as well as to evaluate the effects of different gibberellin concentrations on yield components and quality attributes of kishmish grapes.

METHODS AND MATERIALS

This study was conducted in Jorghan Abad village, Saripul province, Afghanistan, on an eight-year-old grape cultivar (Kishmish seedless) planted under system (I) at a spacing of 4/6 meters in 2024. The area is located at 36°13'905" N, 65°54'819" E, at 600 m a.s.l. The study area is characterized by scarce and irregular rainfall distribution. The region received an average annual rainfall of 27.36mm, indicating its hyper-arid environment (Mather, 2007). The data obtained from the Afghanistan Ministry of Agriculture indicated that the average annual maximum and minimum daily temperatures of the Saripul province during the study period was 34°C and -3 °C respectively.

Experimental Procedure

The experiment was arranged in a randomized complete block design with three replications. Each replication had eight plants, ensuring statistical reliability and accuracy. Before gibberellin application, the vines of experimental plants were pruned at similar growth stages to ensure uniformity across treatments. Other agricultural operations such as fertilization, irrigation (furrow and ridge irrigation), weed control, green pruning, and pest management were performed based on recommended guidelines for grape plants.

Gibberellin hormone obtained from an agricultural input supplier in Mazar-e-Sharif, Balkh Province, was applied to the fruit twice after flowering. Similar concentrations were applied twice to each treated vine. The first application was made 8 days after flowering, followed by the second application at 16 days after flowering. Thus, each treated vine received two sequential applications of the same doses, and the timing was part of the treatment protocols rather than an experimental factor. The hormone was tested at four doses: 0 ppm (control), 20 ppm, 60 ppm, and 100 ppm. Following hormone application, the plant was monitored until full ripening.

Sampling and Data Collections

Once the fruit reached its physiological maturity, the treated clusters were harvested separately, and 5 berries were randomly selected from each cluster for evaluation. The number of clusters per vine and the number of berries per cluster were counted at the time of harvest. The cluster fresh weight was immediately determined after harvest, and the dry weight was recorded after drying using a digital balance. The length and width of the cluster were measured with a graduated ruler. A Vernier caliper determined the length and width of the berry. The total soluble solids (Brix) were measured using a digital refractometer (ATC, 0-40%). The fruits were weighed after collection by a digital balance, and their yield was measured per plant. The panel members, including 10 academic staff members from the Faculty of Agriculture, Saripul University, evaluated the mesocarp, skin, and flavor of the fruit, as well as color and hardness.

Data analysis

All collected data were subjected to analysis of variance (ANOVA) using SAS statistical software program version 9.2. The least significant difference test (LSD) was used to separate means at the 5% significance level. Additionally, a correlation analysis was conducted to examine the relationships among variables.

FINDINGS

The analysis of variance showed a significant difference in gibberellin rates among yield components and quality attributes of kishmish grapefruit (Table 1). Fruit cluster weight was significantly ($P \leq 0.05$) affected by gibberellin doses. The Heaviest cluster (440g) was recorded at 20 ppm, which was not significantly different from 60 ppm, whereas the minimum weight was recorded in the control (360g) units. Similarly, cluster dry weight was significantly affected ($P \leq 0.05$) by gibberellin doses; the maximum weight (153g) was recorded at 20 ppm, and the minimum (128g) in the control group (Table 1). Cluster width and cluster length did not show a significant difference ($P \leq 0.05$) between gibberellin doses (Table 1). Better values (26.3cm length and 15.1cm width) were recorded for the treatment with a 20 ppm gibberellin concentration.

The number of clusters/plant showed significant differences among treatments ($P \leq 0.05$). The maximum number of clusters/plant (59) was observed in plants treated with 20 ppm, and there was no statistical difference between 60 ppm and 100 ppm; the minimum (31) was observed in the control group. The number of berries per cluster also showed a significant difference($P \leq 0.05$). The maximum count (376) was recorded from the plant treated with 20ppm gibberellin, and the minimum count (265) was recorded from the control units, which showed statistical similarity with the plants treated with 60ppm and 100ppm gibberellin (Table 1).

Berry length and berry width also varied significantly ($P \leq 0.05$) among treatments. The maximum berry length and width were 16.9 mm and 14.3 mm, respectively, observed at 20 ppm doses (Table 1). In comparison, the minimum value was in the control units. These showed that the applied gibberellin doses had a considerable influence on fruit development, indicating dose-dependent responses. Similarly, total soluble solid (TSS) content was significantly affected ($P \leq 0.05$) by gibberellin doses. The highest TSS value was recorded for the treatment with 20 ppm doses, while the lowest value was observed in the control unit (Table 1).

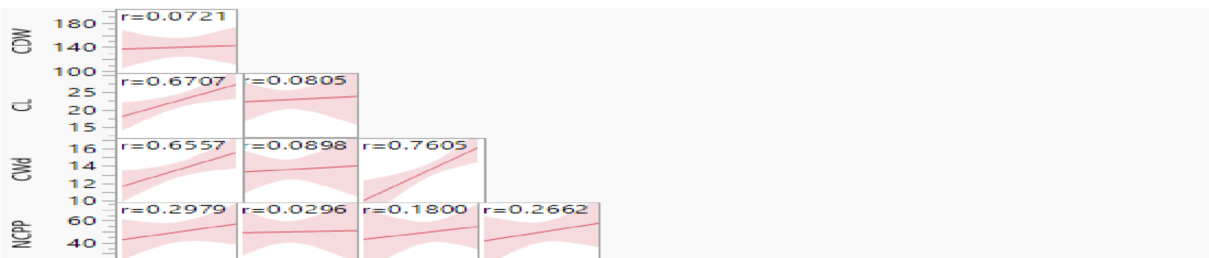
Additionally, yield per plant was significantly affected by the treatments ($P \leq 0.05$). The maximum yield per plant was obtained with 20 ppm gibberellin, which was not significantly different from the 60 ppm and 100 ppm gibberellin treatments. In contrast, the lowest yield was obtained from untreated (control) plants (Table 1).

Table1: *Growth and yield components of grape as affected by gibberellin rates*

Doses	Cluster fresh weight (g)	Cluster dry weight (g)	Cluster length (cm)	Cluster width (cm)	Number of clusters /plants	Number of berries/clusters	Berry length (mm)	Berry width (mm)	TSS (Brix)	Yield per plant (kg)
20ppm	440^{a}	153^{a}	26.3	15.1	59^{a}	376^{a}	16.9^{a}	14.3^{a}	27^{a}	13^{a}
60ppm	420^{ab}	139^{b}	22.5	13.6	57^{a}	293^{b}	16.9^{a}	14.0^{a}	26^{b}	12^{a}
100ppm	383^{bc}	138^{b}	22.2	13	52^{a}	288^{b}	15.1^{b}	12.0^{b}	25^{c}	11^{a}
Control	360^{c}	128^{c}	20.4	12.6	31.3^{b}	265^{b}	14.7^{b}	12.0^{b}	24^{d}	9^{b}
F-test	*	**	NS	NS	*	**	*	**	**	**
LSD 0.05	55.0	7.8	5.7	2.2	18.4	36.5	1.7	0.57	0.40	1.56
CV (%)	6.87	2.81	12.43	8.11	18.5	5.98	5.41	2.18	0.78	6.55

Means followed by the same letter within the same column are not significantly different. LSD=least significant difference, CV=coefficient of variation, *, **, significant and highly significant, respectively.

The correlation graph (Graph 1) indicated that cluster weight (CW) showed a positive, highly significant correlation ($P \le 0.01$) with CL ($r=0.67$) and YPP ($r=0.70$). This indicates that cluster weight contributes substantially to cluster length and yield improvement (Graph 1). Similarly, cluster length (CL) showed a positive, highly significant correlation ($P \le 0.01$) with CW ($r=0.67$) and CWd ($r=0.76$). This revealed that longer clusters are commonly associated with more cluster diameter and cluster weight. In addition, clustering the cluster length relation with both variables showed the positive effects of gibberellin hormones on total productivity. On other way number of clusters per plant showed a positive and highly significant correlation ($r=0.68$**) with yield per plant (Graph 1). This indicates that an increasing number of clusters per plant directly enhances total productivity. Moreover, Berry length (BL) and berry width (BW) showed strong positive and very highly significant correlations ($P \le 0.01$) ($r=0.98$), which may relate to the proportional effects of gibberellin hormone treatments on both traits. In other ways, cluster length (CL) and number of berries per plant (NBPC) showed significant negative correlations ($P \le 0.05$) ($r=-0.56$) and ($r=-0.64$) with TSS, respectively (Graph 1). This may indicate a possible trade-off between fruit size and sugar concentration, where larger fruit size dilutes soluble solids due to an increase in water ccumulation.



Graph1: *Correlation graph. Where CW=cluster weight, CDW=cluster dry weight, CL=cluster length, CWd=cluster width, NCPP=number of clusters per plant, NBPC=number of berries per cluster, BL =berry length, BW=berry weight, TSS=total soluble solid, YPP=yield per plant*

DISCUSSION

The study investigated the effect of exogenous gibberellin (GA3) application at different concentrations (0, 20, 40, 60ppm) on yields and yield components of kishmish grape. The result revealed a significant improvement in yield, yield components, and grape quality in response to gibberellin treatment, with 20 ppm doses showing optimal effectiveness across most traits. Cluster fresh weight, cluster dry weight, number of clusters/plants, number of berries/clusters, berry length, berry width, TSS (Brix), and yield per plant were markedly improved in the GA3 treatment, compared to the control. This improvement in the yield component of Kishmish grape is due to enhanced cell elongation and cell division induced by the gibberellin hormone (Acharya et al., 2023; Pahi et al., 2020). This is in agreement with previous reports by Franciosini et al. (2017) and Li et al. (2024) on the development of plant organs, cell number, and cell size, which are determined by cell division and cell expansion and are mainly controlled by genetic networks, hormonal signals, and environmental responses. In agreement with Zhou et al.(2024a), the cluster weight, number of clusters per plant and number of berries per cluster were enhanced by gibberellin hormone treatment at the very early fruit formation stage. Similarly, a previous study found that GA3 treatment 12 days after full bloom resulted in the greatest cluster weight, berry weight, and berry diameter (Choi et al., 2023). In addition, several studies reported that gibberellin applications increased fruit weight (kg/vine), indicating its superior efficiency in stimulating fruit development compared with the untreated control(Choi et al., 2023; Mohamed et al., 2019; Prakash et al., 2022).

Plants treated with GA3 exhibited significantly larger clusters and berry length and width compared to untreated plants. The observed increase in cluster and berry sizes is consistent with the previous report by Poudel et al. (2022). The yield attributes, such as berry sizeClick or tap here to enter text., berry weight, and cluster weight, were significantly increased in response to gibberellin treatment in the Thompson seedless variety of grapes (Li et al., 2024; Marzouk & Kassem, 2011a). Similarly, in seedless cultivars like Thomson and Crimson, application of gibberellin (10 to 50ppm) at the early fruit formation stage caused a significant increase in berry physical characteristics like width, weight, and volume (Dokoozlian & Peacock, 2001; Marzouk & Kassem, 2011).

The TSS(brix) concentration of kishmish grapes was significantly increased in response to gibberellin hormone treatment. This aligns with the report by Marzouk & Kassem (2011), who indicated that GA3 application enhances fruit sugar content, prevents fruit drop, and accelerates ripening. In addition, other scholars reported that gibberellin-treated fruits increased fruit weight, total soluble solids, aroma, and the expression of genes involved in anthocyanin metabolism, while inhibiting the expression of acid-related genes (Poudel et al., 2022; Zhou et al., 2024b). Gibberellin, especially at higher concentrations, increased seedlessness, elongated berries, increased berry weight at the base, and increased skin hardness, ultimately leading to improved fruit quality for fresh consumption (Zhou et al., 2024b). In other ways, the total soluble solids of fruits were not affected by the application of GA3 (Prakash et al., 2022).

The application of gibberellin significantly enhances fruit development and increases fruit set (Anwar et al., 2023). This is due to the effects of Gibberellin on fruit drop before harvest when compared with the untreated control groups (Hussain et al., 2025). The effect of GA3 on berry diameter significantly affected berry weight, volume, and yield (Poudel et al., 2022). In addition, Prakash et al. (2022) stated that fruiting, fruit growth rate, and yield were significantly increased in GA3 - and sucrose-treated plants compared to the control treatment. Yield per plant per vine showed a significant positive association with cluster width, weight, and cluster number. The number of clusters per vine had the greatest direct effect on fruit yield per vine, followed by bunch weight; a similar pattern was reported by Gupta et al. (2015). According to McAtee et al. (2013), the application of a plant growth hormone complex has been shown to increase fruit set by up to 1.2% in citrus crops, demonstrating the hormone's effectiveness in increasing productivity. The application of gibberellin hormone provided significant differences in kishmish grape yield, fruit sizes, and total soluble solids contents. This may indicate that the hormone directly interacts with the plants' physiological functions to produce this positive output. The interaction of hormones with plant physiological functionis a complex process that significantly influences growth, fruit development, and adaptation to unfavorable environmental conditions (Castro-Camba et al., 2022c; Ross et al., 2011).

The positive correlation between cluster weight (g) and cluster dry weight, as well as cluster length, was due to the physical as well as physiological influences of GA3 on grapefruits. Gibberellins promote cell elongation, cell division, and cell enlargement in the berry tissue, which induces the positive correlation between fresh and dry weights of the fruits (Chen et al., 2025; Feng et al., 2025). Another finding on grape genetic variability indicated the importance of berry weight as a character influenced by hormone activity, which is also related to berry size, including berry length and width (Houel et al., 2013). Accordingly, the positive correlation between berry width and berry length is due to the genetic makeup of the fruit and the exogenous applied hormone, which enhances the expression of those important traits. The finding revealed that yield per plant and the number of clusters per plant were directly correlated, consistent with previous findings (VanderWeide et al., 2024). In other words, the negative correlation between cluster size and number of berries per plant with total soluble solids indicates source-sink dynamics, where an increase in fruit number and size reduces sugar accumulation. This is consistent with previous studies reported by Akšić et al. (2019), De Oliveira et al. (2007), Nestby et al. (2005), and Sabbatini et al. (2019): more berries compete for the limited carbohydrates and nutrients produced by the plants.

CONCLUSION

The findings of the study demonstrate that the application of gibberellin at the early fruit formation and development stage influences key growth, yield, and quality parameters of kishmish grape. Among the tested concentrations, 20ppm, 60ppm, 100ppm, and the control group, 20ppm, consistently produced superior results. This indicated that gibberellin at optimally low doses acts as an effective plant growth regulator through improving physiological efficiency and endogenous hormone levels. Conversely, higher concentrations (60 ppm and 100 ppm) yielded lower results, indicating a dose-dependent response, where excessive hormonal use may disrupt normal plant metabolic processes. Therefore, application of 20 ppm gerbilline doses twice, at 8 and 16 days after flowering, is recommended as an economical treatment to enhance Kishmish grape yield and quality under similar agroecological conditions. Further research should explore the physiological mechanisms underlying these effects, the consistency of these effects across diverse grape varieties, and other environmental factors.

Authors Contributions

- Mohammad A.A. conceptualized and supervised the study.
- Mohammad.A.A; Kumesa.W.G;Ismail.Q; Rohitashw.K. designed the methodology.
- Mohammad.A.A; Ismail.Q; Collected the data.
- Mohammad. A.A; Kumesa. W.G., Rohitashw.K. analysis and interpretation of the data.
- Mohammad.A.A; Kumesa.W.G; Ismail.Q; Rohitashw.K. writing and editing the manuscript.
- All authors reviewed and approved the final version.

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Conflict of Interest Statement

The authors declare that they have no conflict of interest regarding the publication of this paper.

Data Availability Statement

Data supporting the findings can be accessed upon request from the corresponding author.

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