IMPACT OF POTASSIUM AND ABA APPLICATION ON VIVIPARY AND SEED QUALITY IN ORIENTAL PICKLING MELON (*Cucumis melo* var. *conomon* Mak.).

By

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(2019-11-206)

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KERALA, INDIA
2021

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DEPARTMENT OF SEED SCIENCE AND TECHNOLOGY
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KERALA, INDIA
2021

DECLARATION

I, hereby declare that this thesis entitled "Impact of potassium and aba application on vivipary and seed quality in oriental pickling melon (*Cucumis melo* var. *conomon* Mak.)." is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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LIST OF ABBREVATIONS

%	-	Per cent
ABA	-	Abscisic acid
μScm^{-1}	-	Micro Siemens per centimetre
^oC	-	Degree Celsius
cm	-	Centimetre
EC	-	Electrical conductivity
g	-	Gram
IMSCS	-	Indian Minimum Seed Certification Standard
K	-	Potassium
KAU	-	Kerala Agricultural University
kg	-	Kilogram
$kg\ ha^{-1}$	-	Kilogram per hectare
mg	-	Milligram
MOP	-	Muriate of potash
MSL	-	Mean Sea Level
POP	-	Package of Practices
RH	-	Relative humidity
t/ha	-	Tonnes per hectare

Introduction

1. INTRODUCTION

Seeds are a major input in any crop production program. The requirement of seeds in our country has increased from 353.54 lakh quintals during 2018-19 to 387.31 lakh quintals during 2019-20 (https://www.indiaagristat.com). Higher requirement demands more production coupled with rapid growth of seed industry. Quality seeds contribute significantly to the crop performance and yield. The quality of seed is influenced by genetic and external factors. One of the factors that deteriorates the quality is vivipary. It is also known as premature or precocious germination, wherein the seeds sprout within the fruit before they are detached from the mother plant. This trait is detrimental as it causes yield and viability losses and inferior nutritional and palatable qualities of fruits and nonviable seeds.

Vivipary is critical from an agrarian viewpoint on the grounds that the absence of seed dormancy in crops is a negative attribute challenging food security with synchronous monetary misfortunes as a result of lower yields. According to Demir and Ellis (1992) postponing harvest can be a reason for vivipary. The high humidity and temperatures during seed development have additionally been accounted for vivipary (Andreoli *et al*., 2006). Vivipary has been attributed to the occurrence of complex innate and ecological elements and the impact of a few genes (Zhang *et al*., 2007).

Vivipary has been observed in about 100 distinct types of blossoming plants, belonging to somewhere around forty genera and twenty-three families (Elmqvist and Cox, 1996). Occurrence of vivipary has been reported in several important agricultural crops like maize (Eyster, 1931), tomato (Yamaguchi *et al*., 1967), chayote (Aung *et al*., 1990), muskmelon (Welbaum *et al*., 1990), bell pepper (Marrush *et al*., 1998), chinese cabbage (Ren and Bewley, 1998), rice (Miyoshi *et al*., 2000), watermelon (Kobayashi *et al*., 2010), sesame (Dubey *et al*., 2011), oriental pickling melon (Nagendra, 2017) and bottle gourd (Aya *et al*., 2019).

Oriental pickling melon or golden melon is a summer vegetable that belongs to the family Cucurbitaceae. It is popularly used for culinary purposes. They are cultivated mainly in East Asia and Japan. The primary oriental pickling melon growing states in India include Kerala, Tamil Nadu, Andhra Pradesh, and Karnataka. Also known as

Sambar Vellari, Vellari or Kani Vellari and it occupies a predominant place in the summer rice fallows in Kerala. Other than culinary purposes, the fruits are revealed as a symbol of prosperity during the festival of 'Vishu' increasing its economic and cultural importance in the state. The smooth and cylindrical fruits have white flesh with watery texture similar to that of a cucumber. Although the slightly bitter seeds are not widely used, the fruits are highly sought after in the beauty and nutrition industries (Swamy, 2017).

Different fertilizer management practices were found to be useful in reducing the precocious germination in melon fruits. According to Ochi and Ito (2012 b), vivipary in melon seeds can be reduced by supplementing the plant with high doses of potassium. Exogenous application of ABA lead to reduced event of vivipary and brought about stamped increment of potassium retention (Ochi *et al*., 2013). According to a study conducted in oriental pickling melon variety Saubhagya, occurrence of vivipary was observed to be highest when the crop was sown during December (6.25%) followed by January (3.60 %) and August (1.47 %) (Nagendra *et al.,* 2017). Further studies by Athulya (2019) revealed that application of extra dose of 25% MOP, 50% MOP and 0.5% foliar spray of potassium reduced the incidence of vivipary in oriental pickling melon.

Considering the above, the present study was formulated to elucidate on the effect of potassium and ABA nutrition on occurrence of vivipary and seed quality in oriental pickling melon with the following objective:

1. To assess the effect of potassium and ABA on vivipary and seed quality in oriental pickling melon
2. To assess the storage potential of treated seeds through accelerated ageing test

Review of literature

2. REVIEW OF LITERATURE

Oriental pickling melon is an important crop of Kerala due to its cultural and economic importance. The seasonal demand and good returns in short period of time makes it a valuable source of income for farmers. One of the constraints faced by seed producers in this crop is vivipary where the seeds sprout within the fruit and thus reduce the seed yield. Welbaum *et al*., (1990) opined that viviparous sprouting might be the result of low levels of ABA in the fruit tissues around the placenta. It was also found to be due to lower potassium level in the fruits (Marrush *et al*., 1998). It has been reported that the occurrence of viviparous sprouting can be reduced by high ABA and potassium fertilizer application.

Considering the above, the present study was formulated to expound on the effect of potassium and ABA nutrition on vivipary and seed quality in oriental pickling melon. Under the headings mentioned below, literature pertaining to various areas of the topic is evaluated and briefly addressed:

2.1 Vivipary
2.2 Impact of potassium application on flowering, seed and fruit yield attributes
2.3 Impact of different levels of foliar application of ABA on flowering, fruit and seed yield attributes
2.4 Impact of accelerated ageing on the quality of seeds
2.5 Seed health during accelerated ageing

2.1 Vivipary

Vivipary is an undesirable trait wherein the seeds germinate before they are detached from the parent plant. Yamaguchi *et al*. (1967) opined that vivipary might be the after-effect of abundance nitrate nitrogen, while Marrush *et al*. (1998) revealed that it may very well be because of potassium exhaustion. An examination on watermelon showed that the fruit accumulates a significant degree of ABA which inhibits precocious germination. This may mirror an endurance technique of watermelon to forestall germination near the parent to keep away from autotoxicity brought about by the parent plants. The investigation was also done on melon (*Cucumis melo* L.) to check

for the presence of the seed germination inhibitory mechanism by ABA. The content of ABA was demonstrated to be low in the tissue of melon, and the concentrates got from the fruit tissue had no germination inhibitory effect on the seeds (Kobayashi *et al*., 2010).

Dubey *et al*. (2011) opined that vivipary occurred in sesame owing to the altering levels of plant hormones induced by certain seed borne fungi. Ochi and Ito (2012 a, b) inferred that a high nitrate nitrogen level or lower potassium may prompt a reduction in the ABA content in the fruit juice present around the placenta, bringing about an increased event of vivipary. Specifically, low potassium fertilization was the main factor leading to an increased event of precocious germination.

A high level of potassium fertilization (12.0mmol·L−1) brought about a decline in vivipary in the susceptible lines of melons accompanied by an increment in the endogenous ABA content. No huge differences were seen in the seed number per fruit, the seed weight, and the level of seed germination at a high level of potassium treatment. Further trials were led to break down the impacts of exogenous ABA treatment at a low potassium treatment level (1.5mmol·L−1) on the occurrence of vivipary. At 25 days after fertilization, application of ABA at different concentrations on the fruit of the crop raised following two distinct potassium treatment levels restrained the event of viviparous growing and increased the ABA content in both seeds and the juice content around the placenta (Ochi *et al*., 2013).

Cota-Sánchez (2018) showed that the tomato fruit with viviparous seedlings failed to grow and when the seedlings were isolated and transplanted, a high death rate (83.3%) was noticed. Enduring seedlings produced fruits with one-third of seeds being abnormal. These outcomes shed light on the likely negative impact of vivipary in crops.

A study was conducted in oriental pickling melon variety Saubhagya at the College of Horticulture, Vellanikkara to assess the optimal date of planting for seed production. Occurrence of vivipary was observed to be the highest during December sowing (6.25%) followed by January (3.60 %) and August (1.47 %) sowing (Nagendra *et al.*, 2017).

Studies showed that seed vivipary was high (97.84%) in some bottle gourd accessions. Non-viviparous accessions produced twice the seed yield compared to the viviparous accessions. The analysis also inspected the impact of fruit development time on seed vivipary in bottle gourd. Trials showed that seeds of viviparous accessions collected from fruits 30 days after flowering had no vivipary but the vivipary rates were fundamentally high in seeds harvested from fruits 35 days after flowering (Aya *et al.*, 2019).

Athulya (2019) reported that application of extra dose of 25% MOP, 50% MOP and 0.5% foliar spray of potassium reduced the incidence of viviparous seeds in oriental pickling melon.

Yao *et al*. (2020) reported that silencing of enzyme *METHYLTRANSFERASE1* (*SlMET1*) promoted precocious seed germination and seedling growth within the tomato fruits. This was associated with decreases in abscisic acid (ABA) concentration and levels of mRNA encoding 9-cis-epoxycarotenoid-dioxygenase (SlNCED) involved in ABA biosynthesis.

Pliszko and Górecki (2021) observed that vivipary was seen in 90% of the bloom heads in *Grindelia squarrosa* and it was assumed that the vivipary was due to prolonged precipitation.

2.2 Impact of potassium application on flowering, seed and fruit yield attributes

Potassium (K^+) is an essential supplement component for higher plants and plays imperative roles in cell functions including opening and closing of stomata, turgor regulation, synthesis of protein and charge balance. The gainful impacts of supplemental K presumably came about because of the increased assimilation of leaf photosynthetic CO_2 and photosynthate movement from leaves on to fruits (Gross, 1991).

Potassium application further increased the yield and grain attributes like boldness, oil and protein contents in groundnut. An increase in pod yield was evident with soil and foliar applied potassium in contrast with the control treatment. Pod yields were fundamentally higher when basal and foliar applications of potassium were

practiced. The outcome affirmed that the foliar potassium nourishment is useful for groundnut crop when applied in addition to soil application and not as a substitute for standard soil application (Umar *et al*., 1999).

2.2.1 Flowering, Fruit quality and yield

According to Maragal (2016), the fertiliser treatments (NPK @ 15:7:16, 20:12:21, 25:17:26 and 30:22:31) did not have any effect on the time taken for the first flower to bloom in cucumber and bitter gourd.

Plants treated with 1% borax + 6% KNO_3 took much less time (42.17) to produce their first staminate bloom and produced significantly more pistillate flowers per plant in muskmelon (Srilatha and Kumar, 2019).

Application of 400 mg/L potassium in the root zone was found adequate for optimum yield of Galia melons grown under greenhouse conditions. However, the results revealed that adding as much as 600 mg/L of extra potassium to the plants increased the quality of fruit by increasing TSS of fruit to 8.6% from 6.3%, without reducing the yield (Demiral and Koseoglu, 2005).

Potassium foliar application boosted the total output and fruit quality of brinjal. The maximum fruit yield of 9.46 t/ha was realised from plants treated with foliar spray of 3% K_2O, in contrast to the yield of 9.12 t/ha in untreated plants (Fawzy *et al*., 2007).

According to Lester *et al*. (2010), supplemental foliar applications of potassium led to early maturity in treated melon fruits compared to control. Soil supply of potassium along with foliar treatment in fruit-bearing plants improved the quality of fruits by increasing ascorbic acid, firmness, beta-carotene and sugar content.

Mono potassium phosphate (MPK) and potassium nitrate (KNO_3) at various levels were applied as foliar spray on olive trees either before or after flowering. Outcomes showed that all treatments caused an increase in leaf mineral status, fruit quality and yield than the trees with no treatment. The best outcomes from the foliar applications were acquired with 3% KNO_3 (Sarrwy *et al*., 2010).

In sweet potato, the impact of soil application of K_2O to soils on translocation of photosynthates were evaluated. The treatment improved the chlorophyll content and

leaf area index. It also increased the sucrose synthase action by 16.47% and ABA content in roots by 18.27%. The dry matter dispersion rate to roots was also higher (69.45%) in the treated plants (Liu *et al*., 2013).

According to Shafeek *et al*. (2013), foliar spraying of greater potassium nitrate (15 mM) concentrations enhanced cucumber fruit set (46.55%) and yield per plant. Application of 15 mM KNO_3 resulted in the highest yield (2.64 Kg) per plant followed by 10 mM of foliar KNO_3 treatment.

Foliar application with different potassium levels were studied on two tomato cultivars, Nagina and Roma and contrasted with control (without K). Exogenous treatment of 0.6% potassium fundamentally increased plant height, lycopene content, fruit diameter and weight. Owing to the positive relationship between potassium sustenance and quality of fruit, exogenous application of potassium can add to increased return and improved the quality of fruits in tomato (Afzal *et al*., 2015).

The improvement of development and yield attributes in rapeseed were related with upgrade of potassium level in plant due to foliar use of potassium (Sarma *et al*., 2015). Ramadan and Shalaby (2016) showed that the foliar treatment of K brought about an increase in development and yield of brinjal developed under states of salt stress. The huge impact of potassium application on the weight of fruit was accounted for by a few specialists in tomato (Woldemariam *et al.*, 2018) and cucumber (Correa *et al*., 2018). They reasoned that sufficient potassium builds fruit weight by expanding movement of assimilates to the fruit.

The yield attributes of bitter gourd increased by the application of potassium because of its significant role in hastening cell division and cell lengthening which upgrades the development of a greater number of female blossoms and fruits per plant. The maximum effect in yield was contributed by the application of a combination of phosphorus at 90 kg/ha and potassium at 80 kg/ha resulted in a yield of 15.01 t/ha compared to control which was only 7.65t/ha. (Naorem and Dakho, 2019).

Singh and Sahare (2019) reported that foliar treatment of potassium manures during fruit development stage improved its quality characters and the biochemical constituents in muskmelon. Foliar spray of potassium sources like KCl, K_2SO_4 and

KNO_3 was tried and found accommodating in improving fruit quality. Among the foliar treatments 2% K_2SO_4 was found to be the best resulting in better quality fruits and higher yield of 23.15 t/ha. Foliar application of 2% KNO_3 with an yield of 22.13 t/ha was found to be the next best.

Foliar application of potassium (0.5% MOP) had increased the fruit quality and yield parameters like length (23.66 cm), diameter (17.38 cm) weight (677.2g) of fruit in oriental pickling melon (Athulya, 2019).

2.2.2 Seed quality and yield

Impact of phosphorus and potassium fertilization to the mother plant on seed quality and yield in pea was accounted for by Amjad *et al*., (2004). Potassium could improve economic character of seed of melon *viz.,* melon fruit weight, total seed yield per melon, hundred seed weight, kernels output ratio, lengthwise and sidewise diameter of melon seeds. Yield of melon seeds increased from 9.2% to 13.5% with potash application compared to that without potash (Lai *et al*., 2007).

Olaniyi and Tella (2011) revealed that seed yield was affected by the increased potassium application rates up to 30 kg K_2O/ha in Egusi melon. Maternal nutrient status also affected the germination and performance of its progenies as reported in broad leaved dock seeds (Hrdlickova *et al*., 2011).

Application of 100 Kg/ha of potassium increased the number of seeds in the *Rumex crispus* plant from. It increased from 1831 seeds in control to 2815 seeds in treated plants (Hejcman *et al*., 2012).

Zhang *et al*. (2017) reported that the enrichment of substrate with potassium enhanced the vigour of seedlings in *Brassica oleracea*.

The supply of nutrients significantly affects seed production. The quantity of seed per pod and the pod number in *Capsella bursa-pastoris* fluctuated with the variety of nutrient supply. The hike in quantity of branches per plant, the quantity of seeds per stem, seed per pod and the pod number also added to the seed yield (Yang, 2018).

Sufficient potassium nourishment should happen from the securing of seeds since nutrient status of mother plant influences not just the yield of harvest yet additionally the nature of seeds created (Cruz *et al*., 2019).

The application of K fertiliser has a considerable positive impact on seed quality and yield in oriental pickled melon. Application of extra dose of potassium by foliar (0.5% MOP) or by basal application (25% K and 50% K) was found to improve the seed quality and yield (Athulya, 2019). Treatments at higher concentrations gave better yield. Treatment of chillies at higher concentrations of nanoparticles gave higher yield that treatment with lower concentrations (Mathew *et al.,* 2021).

2.3 Impact of foliar application of different levels of ABA on flowering, fruit and seed yield attributes

Abscisic acid (ABA) is a plant hormone that is essential for plant growth and development. It regulates stomatal closure, seed dormancy, germination, fruit development, fruit ripening, accumulation of metabolites, root growth, hormonal cross talk and plays a major role in developing tolerance to biotic and abiotic stress in plants. Rodrguez-Gacio *et al*. (2009) found that abscisic acid present in the embryo of seed is important for bringing on and maintaining seed dormancy, as well as inhibiting the transition from embryonic stage to germination stage. Abscisic acid synthesized maternally or applied externally to the plant can prevent seed germination but does not induce dormancy but the ABA synthesized by the seed can induce dormancy (Kucera *et al*., 2005).

Raghavan (2002) observed that excised fruits of *A. thaliana* that have completed their development in culture media showed vivipary without going to dormant stage, and that adding the hormone ABA to the culture media inhibits vivipary in cultured fruits. Higher quantities of ABA prevented vivipary in cultured siliques, while siliques cultivated in a medium containing 100 mmol/L ABA showed no vivipary. Although ABA has no impact on embryogenic development, it is an efficient inhibitor of normal and precocious germination.

ABA also aids in the integration of diverse stress signals and downstream stress responses management. ABA was found to have a deleterious impact on disease resistance by interfering with biotic stress signalling at many levels. One of the

few examples of ABA's favourable impact in disease resistance is its engagement in primed callose formation (Mauch-Mani and Mauch, 2005).

2.3.1 Flowering, fruit quality and yield

ABA treatments (5 and 10 mg/l) resulted in a significant increase in female expression in the gynoecious line of cucumber by inhibiting male flowering while increasing female flowering and ovary development (Rudich and Halevy, 1974). Regardless of light regime, exogenous ABA application increased female tendency in gynoecious lines of cucumber and maleness in monoecious cucumber plants (Friedlander *et al*., 1977).

When abscisic acid (250 mg/l) was sprayed to grape vines at flower bud initiation stage the yield of fruits per bunch (112.2 g) and the total yield per plant (4.19 Kg) increased by two folds the normal yield (Quiroga *et al*., 2009).

Abscisic acid can improve the antioxidant capacity, phenolic content, and shelf life of vegetables and fruits. Exogenous treatment with ABA on tomato increased the ABA content in both flesh and seed, and promoted the synthesis of ethylene leading to fruit ripening (Zhang *et al*., 2009).

Exogenous treatment with ABA was found to improve phenolic content, anthocyanins and the antioxidant capacity of muscadine grapes however these impacts might vary depending on the cultivar (Sandhu *et al*., 2011).

Two varieties of blueberry were treated with ABA at three concentrations (0, 200, and 400 ppm). The results revealed that ABA essentially increased the firmness of berries in both varieties, proposing a delay in ripening. All in all, ABA deferred the aging of blueberries, however it did not influence antioxidant capacity, phenolic content, or any individual phytochemicals in the ripe fruits (Buran *et al*., 2012).

Abscisic acid sprayed to the fruits of cucumber at turning stage sped up the deterioration of chlorophyll and furthermore diminished solvent sugar content. It is assumed that the application of exogenous ABA at the turning stage hastened the course of ripening in cucumber (Wang *et al*., 2013).

ABA applied at the cotyledon stage decreased the height of watermelon transplant but the advantage was restricted due to a general decrease in growth, which is independent of the timing of its application. However, it was found that the development by ABA was transient with no adverse consequence on fruit quality and yield (Agehara and Leskovar, 2014).

In blueberry, application of ABA at 1000 mg/l exercised no discernible effects on diameter, length or weight of fruits (Oh *et al*., 2018).

2.3.2 Seed quality and yield

The application of ABA to plants had a positive impact on the developing seeds in many ways. The involvement of ABA synthesised in embryonic tissues in seed dormancy induction was validated in *Nicotiana plumbaginifolia*. Maternal ABA, generated by vegetative tissues and translocated to the seeds, was definitely important throughout embryo development to increase the growth of embryo and avoid seed abortion (Frey *et al*., 2004).

Application of ABA at 300 mg/L on soybean crop increased the chlorophyll content and leaf area. ABA-treated plants had more dry weight, root density and shoot diameter. ABA application additionally expanded the yield of soybean by upgrading carbon portion and transporting to the seed. The increase in number of seeds per pod (2.13) and seed weight per meter (101.08 g) contributed to higher yield. Exogenous ABA improved the seed quality. It did not influence protein levels but improved oil concentration to 21.88% from 21.45% in control (Travaglia *et al*., 2009).

Foliar application of abscisic acid (1 mM) at shoot enlargement and flowering stage led to an increase in grain yield by increasing the weight of seeds per spike (1.17 g) in wheat. It also increased the number of seeds per spike (31) which contributed to higher yield (Travaglia *et al*., 2010).

Application of ABA at bud or at bloom commencement during dry spell helped in alleviating the hindering impacts of drought by further improving development and seed yield of sunflower. An improvement of drought resistance in sunflower genotypes was better when ABA was applied at bud inception stage compared to application at bloom commencement stage under dry spell (Hussain *et al*., 2014).

Application of abscisic acid (10 ppm) improved dry matter (15.03 g) and yield parameters like seed weight (5.44 g), total number of pods per plant (25.75) and test weight of seeds (250.44 g) in chickpea (Kumar *et al*., 2020).

2.4 Impact of accelerated ageing on the quality of seeds

The idea of accelerated ageing test was at first advocated by Delouche and Baskin (1973) to assess the life span of seeds. It is a popular vigour test done to determine the quality of seeds within a short period of time. Various crop seeds have been subjected to accelerated ageing studies in order to forecast their storability.

According to Pesis and Timothy (1983), two cultivars of musk melon subjected to 12 days of accelerated ageing showed different response. The viability of seeds decreased significantly in both the cultivars but one was more susceptible to ageing than the other.

Accelerated ageing was conducted in French bean, lentil, pea and millets. They were aged at a temperature of 20ºC and a relative humidity of 98.2% for 14 days. It was found that the germination of all the seeds reduced as the ageing progressed (Chhetri *et al.,* 1992).

According to Hampton and TeKrony (1995), 41ºC for 72 h were considered as generally acceptable regimen for accelerated ageing. Despite the fact that different studies on cucurbit seeds have been undertaken, no consistent ageing environment has been provided for predicting cucurbit seed lifetime.

Chiu *et al*. (1995) opined that watermelon seeds subjected to accelerated ageing at 45ºC and 79% relative humidity for six days showed a reduction in germination percent compared to seeds without ageing.

The accelerated ageing conditions for cotton were set at 90 to 95% RH and a temperature of 40 to 44ºC. It was observed that the germination started declining from the third day and total loss of viability occurred after 20 days of ageing (Basra *et al*., 2003)

Accelerated ageing at 41°C temperature caused more prominent decrease of germination in melon seeds than 38°C, particularly for seed lots considered as having

lower physiological potential. The span of the maturing time frames was less extreme than the increment in temperature. In this examination, the 72 and 96 hour time frames, for both temperatures, had a higher affectability in distinguishing seed lots that had various degrees of physiological potential (Torres and Filho, 2003).

The impact of accelerated ageing on germination of cucumber, aubergine and melon to examine the impact of time (24-144 h) and temperature factors (40-45°Cwas observed. When ageing was done at 45°C, the germinations of two cucumber seed lots were essentially unique after 72 hours of ageing. In melon seeds, maturing for up to 196 h didn't give great differentiation between cultivars. There was more prominent differentiation subsequent to ageing at 45°C/120 h and 45°C/144 h. The 45°C/48 h and 45°C/72 h treatments differentiated the germinations of the aubergine cultivars while longer ageing brought about a checked decrease in germination of all seed lots to extremely low qualities (Demir *et al*., 2004).

Seeds of radish cultivars were exposed to ageing at 100% RH and 40ºC for 10 days. It showed reformist loss of viability and vigour in the two cultivars used for the study. The germination declined from complete germination during day one to no germination at day nine. Other than germination the seedling length likewise declined adding to decreased degree of liveliness (Jain *et al*., 2006).

When compared to other small seeded vegetable crops like brassicas and lettuce, cucurbit seeds showed to be more resistant to ageing. As a result, ageing temperatures of 40°C did not substantially inhibit germination and therefore help to distinguish between vigour differences in melon seed lots. (Mavi and Demir, 2007).

Sesame seeds subjected to ageing for five days at 49ºC showed significant reduction in germination from day one to no germination at day five. The study found that the accelerated ageing test is useful for determining the quality of sesame seed and it can be used to assess its physiological potential (Ghaderi-Far *et al*., 2010).

According to Kapoor *et al*. (2010), when five varieties of chickpeas were studied for seed deterioration effects under accelerated ageing at a temperature of 45ºC and relative humidity of 100% for 72 hours, all of them showed deterioration in seed quality

parameters like germination, seedling length and vigour. It was found that different varieties exhibited different response to ageing.

A decline in the germination per cent of chilli seeds was observed when they were exposed to accelerated ageing at 100% RH and 42ºC. No germination was observed when the ageing period reached 30 days (Kaewnare *et al.,* 2011).

Six tomato seeds lots were kept for accelerated ageing at 41ºC for a duration of 48 and 72 hours. The moisture was maintained using water (40 mL), saline water (11g NaCl/100 mL water) and saturated salt solution (40g NaCl/100 mL water). The more effective method of ageing was using saturated salt solution compared to standard water method (de Silva Almeida *et al.,* 2014).

Faba beans were subjected to accelerated ageing for 3 to 5 days at different humidity and temperature conditions. It was concluded that a high relative humidity of 100% and a temperature of 45ºC caused a drastic reduction in the germination which ranged from 47% to 64% (El-Abady *et al*., 2015).

Thirteen widely used rootstocks of cucurbits were selected for different vigour tests. Accelerated ageing and controlled degradation experiments were found to be effective in determining cucurbit rootstock seed vigour which also discriminated seed cultivars well (Ermis *et al*., 2015).

According to Vijayakumar and Vijayakumar (2015), accelerated ageing of soybean seeds for seven days was considered optimum to study the seed longevity and differentiate them based on their performance. The germination was reduced to half of the initial value after seven days of ageing. The ageing also had an effect on seedling length where the shoot length and root length rapidly decreased towards the end of ageing period.

Accelerated ageing test was done on black gram seeds by keeping them for ageing for six days at 45ºC and a relative humidity of 100%. When the aged seeds were compared with naturally aged seeds, it was found that six days of accelerated ageing was equivalent nine months of normal ageing (Gomathi *et al*., 2016).

In maize hybrid seeds, accelerated ageing for one day showed an electrical conductivity value (0.279 dS/m) that was similar to one month of storage (0.253 dS/m) under normal conditions (Gajendra *et al.,* 2016).

Exposure of brinjal seeds to accelerated ageing at 41ºC and 72 h were found to be efficient in differentiating the seed lot based on their physiological potential (Deuner *et al.,* 2018).

Sesame seeds were exposed to accelerated ageing by incubating the seeds at 100 per cent relative humidity and 40° C. It was observed that seed deterioration happened during the treatment where the vigour index, seedling length, germination rate and dry matter decreased after 10 days (Kumar *et al*., 2019).

The germination per cent of tomato seeds kept for accelerated ageing at 40ºC and 100% relative humidity reduced from 93% to 0% by the ninth day. Other seed quality parameters like vigour, fresh weight, dry weight, root and shoot length also showed rapid decline over the ageing period (Nigam *et al.,* 2019).

Accelerated ageing done on chilli seeds at 40$\pm$1º C and 100% relative humidity for one day was found to be sufficient to differentiate between chilli seeds subjected to different treatments with nanoparticles (Gayathri, 2019). Seeds that were given no treatment deteriorated faster. The highest EC and the lowest vigour we observed in untreated chilli seeds compared to seeds treated with $CaOCl_2$ + $CaCO_3$ (2 g each/kg seed) and Iodine crystal + $CaCO_3$ (100mg each /kg seed) (Herbert *et al.,* 2021).

2.5 Seed health under storage conditions

Storage begins from harvest to packing and continues till the marketed seeds are sown. Proper maintenance of quality is an important factor to be considered for a seed to be sold. As indicated by Ellis *et al*. (1985), loss of seed quality, suitability and vigour is either because of ageing or the impact of unfavourable environment. Many investigations have analysed the impact of environment conditions on the storability of seeds. Fertilizer can also influence the quality, including germinability, dormancy, composition and size of seeds (Fenner, 1991). Fungi linked with seed storage are also a

significant factor responsible for quality degradation and germination potential reduction (Chormule *et al*., 2018).

Several studies have revealed the involvement of fungal infections during the storage of seed. Infected seeds break down quicker than uninfected seeds during storage (Christensen and Kaufmann, 1969).

Seed-borne fungi are one of the most significant biotic factor affecting seed production around the world. Of the 16% yearly yield loss caused due to plant diseases, basically 10% loss happens because of seed-borne infections (Fakir, 1983). They cause both pre and post-development damage of grains, and subsequently cause some decrease in germination and vigour. The seedborne microorganisms might bring about reduction in germination, discolouration, change in biochemical properties of seed, advancement of plant diseases, conveyance of microorganism to new regions, presentation of new strains of the microorganism alongside new germplasm from different nations and contaminating seeds with toxins. Fungi compared to other microorganisms that infect plants and cause an intense economic loss on crop production due to their capacity to incite infections on crops that cause significant yield loss.

The microorganisms cause damage to the seeds by production of toxins and enzymes that deteriorates the seed quality. Fungi like *Aspergillus sp*. produce aflatoxins which affects seedling elongation, inhibits enzymes, affects synthesis of chlorophyll and damage the endoplasmic reticulum (Halloin, 1986). They may also cause cell membrane damage leading to leakage of electrolytes.

An investigation was done on 28 accessions of *C. melo* for identification of seed borne fungi with no past treatment. An aggregate of 5600 melon seeds were analysed and assessment of seeds plated on PDA showed the presence of 15 genera of fungi, the fungi that showed higher per cent of infection were *Aspergillus* (11%) trailed by *Alternaria* (7%) and *Rhizopus* (6%) (Cruz-Chouque *et al*., 1997).

According to Telang (2010), storage fungi like *Rhizopus nigricans, Aspergillus flavus, Curvularia lunata, Alternaria alternata, Fusarium moniliforme* and *Rhizopus stolonifer* were observed to be more prevailing in the seeds of a local variety of brinjal.

Further assessment on seed storability of contaminated seeds uncovered that the germination seedling length and vigour was the least when contrasted with uninfected control.

The seed borne fungal pathogens of the family Cucurbitaceae were identified utilizing the deep-freeze technique and standard blotter method. A total of 39 species of fungi were isolated and it was presumed that the blotting surface strategy is the most reasonable procedure for the segregation and recognition of contagious microbe instead of the deep freeze technique (Avinash and Ravishankarrai, 2013).

Seeds of three groundnut varieties (Indori, Chandra and Rajasthani) were analysed to examine the impact of seed microflora on the seed quality. The outcomes uncovered that *Aspergillus flavus* was the predominant organisms and on storing the seeds there was an exceptional decrease in germination and vigour (Naikoo *et al*., 2013).

Seeds of seven different vegetable crops *viz.*, cucumber, red amaranth, amaranth, okra, spinach, eggplant and tomato were examined for the presence of seed borne microorganisms. Presence of eleven fungi were identified and the most significant seed infection was seen in okra (26.75%) with the least germination among the contaminated seeds (49.5%). The least seed infection was seen in cucumber (13.50%) with higher germination percent (87%) (Hamim *et al*., 2014).

Al-Amod (2015) opined that the most predominant fungal pathogen found associated with groundnut seeds are *Aspergillus flavus, Aspergillus niger* and *Macrophomina phaseolina*. The occurrence of *Aspergillus niger* was found to be the highest (37.63%) trailed by *Aspergillus flavus* (26.07%) while the infection caused by *Macrophomina phaseolina* (21.02) was found to be the least.

Plant pathogenic fungi *like Aspergillus sp., Alternaria sp., Cladosporium sp.,* and *Penicillium sp.* were detected in cucumber seed lots by blotter test after subjecting the seeds to accelerated aging for a period of for 48, 72, and 96 h. The incidence of *Pencillium sp*. was very high and it caused a reduction in seed quality (Soares *et al.,* 2019).

Seed microflora infection increased with prolonged storage. High incidence of fungal pathogens like *Aspergillus niger* and *Aspergillus flavus* were observed during

storage (Sandhya, 2016; Navya, 2016; Shobha, 2016 and Antony, 2016). The nutrient medium provides suitable media for the growth of pathogens (Nagendra, 2017; Athulya, 2019; Herbert, 2020 and Mathew, 2020).

Materials and methods

3. MATERIALS AND METHODS

The present investigation 'Impact of potassium and ABA application on vivipary and seed quality in oriental pickling melon (*Cucumis melo var. conomon Mak*.).' was undertaken in the Department of Seed Science and Technology, College of Agriculture, Vellanikkara, Kerala Agricultural University, Thrissur during 2019 - 2021. The study envisaged assessing the effect of different concentrations of potassium and ABA on vivipary and its effect on seed quality of variety Saubhagya. The details of the materials used and work carried out are described below.

3.1 Location and climate

The experimental site is located at an altitude of 40 m above MSL at 10°54' N latitude and 76°28' E longitudes. The area experiences a warm humid tropical climate. The field experiment and storage studies were conducted at the Department of Seed Science and Technology, College of Agriculture, Vellanikkara. The monthly mean maximum temperatures varied from 34.6ºC (February, 2021) to 29.8ºC (July, 2021), while the mean minimum temperatures ranged between 21.6ºC (February, 2021) and 23.5ºC (July, 2021). During the study period the relative humidity ranged between 54 percent (February, 2021) and 87 percent (July, 2021), while rainfall ranged between 0.0 mm/cm/litre (February, 2021) and 626.9 mm/cm/litre (July, 2021). The meteorological data recorded during the research period is presented in Table 1.

Table 1: Monthly meteorological data during the study period

Months	Temperature		Relative humidity (%)	Rainfall (mm)	Rainy days	sunshine hours (hrs/day)
	Mean maximum	Mean minimum				
February 2021	34.6	21.6	54	0.0	0	9.2
March 2021	36.8	23.0	59	31.8	1	8.6
April 2021	34.9	23.6	74	72.4	4	6.3
May 2021	32.7	22.9	84	550.5	16	4.5
June 2021	31.2	23.7	84	473.0	21	4.3
July 2021	29.8	23.5	87	626.9	22	2.4

3.3 Experimental material

Seeds of Oriental Pickling Melon variety Saubhagya obtained from Sales and Information Centre, Kerala Agricultural University, were used to conduct the study.

3.4 Experimental Details

The study consists two experiments

Experiment 1: Effect of potassium and ABA levels on vivipary

Experiment 2: Seed storage studies (Accelerated Ageing Test)

3.4.1 Experiment 1: Effect of potassium and ABA levels on vivipary

3.4.1.1 Layout

Design of experiment: RBD

Treatments : 8

Replications : 3

Plot size : 6m × 1.5m

Spacing : 1m × 0.3m

No. of plants/plot : 30

Variety : Saubhagya

3.4.1.2 Treatments

The treatment consisted of different levels of Potassium and ABA sprays as mentioned below:

T_1: Foliar spray of MOP @ 0.5% (at 50% flowering and two weeks after flowering)

T_2: Foliar spray of MOP @ 1.0% (at 50% flowering and two weeks after flowering)

T_3: Foliar spray of MOP @ 1.5% (at 50% flowering and two weeks after flowering)

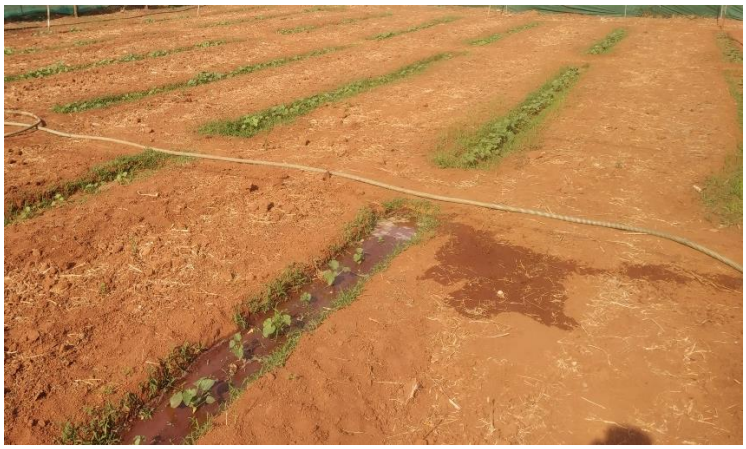
T_4: Foliar spray of ABA @ 100 mg/L (at 50% flowering)

T_5: Foliar spray of ABA @ 200 mg/L (at 50% flowering)

T_6: Foliar spray of ABA @ 300 mg/L (at 50% flowering)

T_7: 70:25:34.75 (50% additional K)

T_8: Control: POP (70:25:25)



15 days after sowing

30 days after sowing

90 days after sowing

Plate 1: General view of the experimental plot

In all the treatments FYM was applied @ 20-25 t/ha as basal dose along with half dose of N (35 kg/ha) and full dose of P_2O_5 (25 kg/ha) and K_2O (25 kg/ha). The remaining full dose of N (35 kg/ha) was applied as two equal splits at the time of vining and at the time of flowering.

3.4.1.3 Treatment details

Seeds of Saubhagya were soaked in water for 24 hours prior to sowing. The seeds were then directly sown in the field and raised as per the Package of Practices (PoP) recommended by Kerala Agricultural University (KAU).

3.4.2 Biometric observations

To ascertain the effect of different levels of potassium nutrition and ABA on crop growth, yield and vivipary, observations on yield and yield attributes were recorded. The observations were recorded on ten randomly selected (tagged) plants in each replication (experimental unit) and the average was calculated. The details of the observations are as under: -

3.4.2.1 Days to appearance of first female flower

The number of days taken from the date of sowing to the emergence of first female flower from the ten tagged plants was recorded.

3.4.2.2 Fruits per vine

The number of fruits per vine was counted from the ten tagged plants in each replication and recorded.

3.4.2.3 Fruit length (cm)

Length of the fruit was assessed as the distance between the proximal and distal end of a fruit. The length of fruits from the ten plants in each replication was measured using a meter scale and the value was expressed in centimetre.

3.4.2.4 Fruit girth (cm)

Fruit girth was measured as the circumference, at the middle of the fruit using a measuring tape from ten tagged plants in each replication and the value was recorded in centimetre.

3.4.2.5 Fruit diameter (cm)

The diameter of all the fruits was measured at the maximum girth with the meter tape and the value was expressed in centimetre.

3.4.2.6 Fruit weight (g)

Weight of the fruits from ten plants in each replication was recorded with the help of a weighing balance and expressed in gram.

3.4.2.7 Fruit yield per vine (kg)

The yield of fruit from the randomly selected ten plants in each replication was recorded and the average value expressed in kilogram.

3.4.2.8 Seeds per fruit

Individual fruits were harvested and the seeds were extracted. With the help of the seed counter (Waver make and model IC-VA) machine the number of seeds per fruit was recorded.

3.4.2.9 Seed yield per plant (g)

Seed yield per plant was recorded by averaging the seed yield of all the fruits per plant in each treatment of each replication separately and expressed in gram.

3.4.2.10 Fresh weight of seed per fruit (g)

The seeds extracted from fruits of each treatment were weighed after using weighing balance and fresh weight was recorded. The fresh weight was expressed in gram.

3.4.2.11 Dry weight of seeds per fruit (g)

After recording the fresh weight, the seeds were dried to a moisture content below eight per cent and the dry weight was recorded. The dry weight was expressed in gram.

3.4.2.12 Chaff seeds (%)

Chaffy seeds were separated from each fruit using seed blower (Dakota type) and the weight was recorded. The value was computed in per cent.

$$\text{Chaffy seeds (\%)} = \frac{\text{Weight of chaffy seeds} \times 100}{\text{Weight of seeds per fruit}}$$

3.4.2.13 100 seed weight (g)

Hundred seeds of four replications randomly drawn from the seed lot was weighed and expressed in gram.

3.4.2.14 Vivipary (%)

Per cent of vivipary was calculated as the ratio of the number of viviparous seeds to the total number of seeds per fruit and was expressed in per cent.

$$\text{Vivipary (\%)} = \frac{\text{Number of viviparous seeds per fruit}}{\text{Number of seeds per fruit}} \times 100$$

3.4.2.15 K content in fruit placenta (%)

The placenta of the fruit was separated from individual fruits collected at the time of the harvest from all the treatments. It was dried, powdered and weighed to 0.2 g. It was then digested using nitric acid and perchloric acid (9:7) until a clear solution was formed. The solution was made upto 100 ml using distilled water in a volumetric flask. It was then filtered and a 5 ml aliquot was taken and the volume made upto 100

ml in a volumetric flask. The K_2O content in the solution was determined in a Systronics flame photometer (Bhargava and Raghupathi, 1993). The potassium content of fruit placenta was estimated and expressed in per cent.

3.4.2.16 K content in flesh of fruits (%)

The flesh of the fruit was removed and its potassium content analysed as per 3.4.2.15 and expressed in per cent (Bhargava and Raghupathi, 1993).

3.4.3 Experiment 2: Seed storage studies

3.4.3.1 Accelerated Ageing Test

Seeds from the eight treatments under Experiment I were collected individually and dried to a moisture content less than 8 percent and packed in butter paper bag. The bag containing seeds were kept on a wire gauge/mesh over water taking care to avoid the seeds coming in contact with the water in the enclosed chamber. It was incubated at a temperature of 40 + 1°C and 98 per cent relative humidity for a period of seven days. Samples were drawn at daily intervals and various seed quality parameters were analysed (Delouche and Baskin, 1973).

3.4.3.2 Experimental details

The details of the experiment are listed below:

Design of experiment: CRD

Treatments : 8

Replications : 3

Variety : Saubhagya

3.4.3.3 Observations

Seed quality parameters such as seed germination (%), root length (cm), shoot length (cm), electrical conductivity (EC) of seed leachate ($\mu S/cm^{-1}$), dry weight of seedling (g), time taken for 50% germination (T_{50}), mean germination time (MGT) and seedling vigour indices were recorded by randomly selecting the seeds from each seed lot of all the treatments. Seed moisture (%) and seed microflora (%) were also noted

during the storage study. The standard procedures for determining the quality parameters of seed are detailed below.

3.4.3.3.1 Germination (%)

Hundred seeds in four replications were randomly drawn from each replication of all treatments. They were sown in plastic trays with properly graded and sterilized sand. The sand was moistened on a daily basis. The germination test was carried out as per the ISTA (1995) rules and maintained for the prescribed time period in a germination room at 25 ± 2°C temperature and 96 ± 2% RH. The number of seeds germinated at first and final count was recorded, i.e., on the 4^{th} and 8^{th} day. The germination per cent was estimated as below.

$$\text{Germination \%} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

3.4.3.3.2 Seedling shoot length (cm)

Ten normal seedlings were chosen randomly from each replication of the respective treatments on the 8^{th} day of germination for quantifying the shoot length. The length between the tip of the shoot and the collar region was measured and expressed in centimetre.

3.4.3.3.2 Seedling root length (cm)

The root length of seedling was measured as the distance from the collar region to the primary root tip from those plants which were used for recording the shoot length and the value was expressed in centimetre.

3.4.3.3.3 Seedling dry weight (g)

The dry weight of seedling was measured by drying the seedlings used for measuring mean seedling length in a hot air oven for 24 hours at 85 ± 1°C. After drying, the seedlings were kept in a desiccator for 45 minutes for cooling. After cooling, the

reading was recorded using a weighing balance. The average dry weight of seedling was taken in gram (Copeland and McDonald, 2001).

3.4.3.3.4 Time taken for 50 % germination

The number of seeds germinated were recorded approximately at the same time of the day and removed until the final day of germination on a daily basis.

Time taken for 50 % (T_{50}) of germination was assessed according to the formula given by Coolbear *et al*. (1984).

$$T_{50} = ti + \left[\frac{\frac{(N+1)}{2} - ni}{nj - ni}\right] \times (tj - ti)$$

Where,

N = Final number of seeds that germinated

ni and nj= Cumulative number of seeds germinated by adjacent counts at times ti and tj while ni< N/2 <nj

3.4.3.3.5 Mean germination time (MGT)

The number of seeds germinated was recorded on a daily basis at approximately the same time of the day and removed until the final day of germination.

Mean germination time (MGT) was calculated as per the equation suggested by Ellis and Robert (1981).

$$\text{Mean germination time (MGT)} = \frac{\sum Dn}{\sum n}$$

Where,

n = number of seeds, which were germinated on day D

Dn = number of days counted from the beginning of germination.

Moist sand method

Roll towel method

Plate 2: Germination test by moist sand and roll towel method

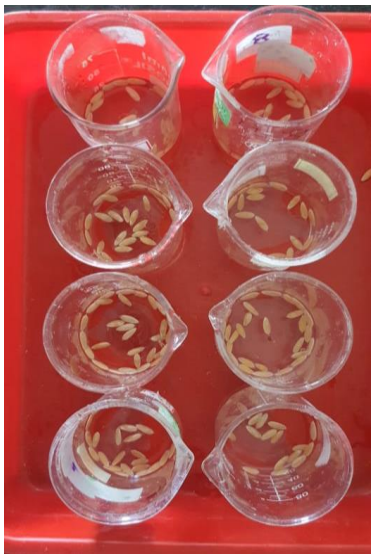


Plate 3: Electrical conductivity study

3.4.3.3.6 Vigour indices

The vigour indices (Vigour index I and Vigour index II) were calculated by employing the formulae suggested by Abdul- Baki and Anderson (1972) and the value expressed as a whole number.

Vigour index I = Germination (%) x Seedling length (cm)

Vigour index II = Germination (%) x Seedling dry weight (mg)

3.4.3.3.7 Electrical conductivity (EC) of seed leachate (μScm^{-1})

Thirty seeds of four replications randomly drawn from each replication of each treatment were used for recording electrical conductivity (EC) of seed leachate. The seeds were surface sterilized with $HgCl_2$ (0.1%) for 5-10 minutes and washed thoroughly with distilled water. The seeds were then soaked in 25 ml distilled water in glass beakers and incubated at 25°C ± 1°C. The glass beakers were left covered to avoid contaminants and to reduce evaporation with occasional stirring of the solution. After 24 hours, the leachate was decanted to another beaker for taking the reading. Electrical conductivity (EC) was estimated using digital conductivity meter with a cell constant of 0.1.

3.4.3.4 Seed moisture content (%)

The moisture content of the seeds was estimated as per the procedure of high constant temperature protocol of ISTA (1985). Two replicates of 5g seeds were weighed and ground to a coarse powder. The powdered seed material was placed in a weighed moisture aluminium cup and after removing the lid, kept in a hot air oven maintained at 103 ± 2°C for 17 ± 1 hour and were allowed to dry. The aluminium cup was closed using the lid on removal from hot air oven and allowed to cool in a desiccator for half an hour. Later, the aluminium cup along with the lid and seed was weighed using an electronic balance. The moisture content was calculated as per the equation below and expressed as per cent (ISTA, 1999).

Moisture content (%) = $(M_2\text{-}M_3 / M_2\text{-}M_1) \times 100$

Where,

M_1 = Weight of the aluminium cup with lid alone

M_2 = Weight of the aluminium cup with lid + Sample before drying

M_3 = Weight of the aluminium cup with lid + Sample after drying

3.4.3.5 Seed infection (%)

Seed micro flora study was carried out using the blotter paper method.

3.4.3.5.1 Blotter method

The presence of storage fungi on seeds was recorded using the blotter method as prescribed by ISTA (1999). Petri plates were lined with three layers of sterilized moistened blotter paper. Twenty-five seeds were placed equidistantly on the moistened blotter paper and incubated for seven days at 20°C for an alternate cycle of 12 hours of light and dark. On the eighth day, the seeds were examined under a stereomicroscope (Leica EZ 4D make) for the presence of any seed-borne fungi. The number of infected seeds were counted and expressed in per cent.

3.4.3.5.2 Agar plate method

In agar plate method, seeds were surface sterilized using 0.1% mercuric chloride and placed on potato dextrose agar medium (PDA) under aseptic conditions. The Petri plates were incubated for seven days and the fungal growth was examined under a stereo binocular microscope.

3.5 Statistical analysis

Statistical analysis of data was performed using General R shiny Based Analysis Platform Empowered by Statistics (GRAPES) developed by KAU and OP stat software. The data obtained from field experiments and storage studies were subjected to statistical analysis by applying Fisher's method of analysis of variance (ANOVA) for randomized block design (RBD) and completely randomized block design (CRD). The significance was tested by Duncan's Multiple Range Test (DMRT) (Snedecor and Cohran, 1967). If the F values were found significant, then critical differences (CD) were calculated.

3.5.1 ANOVA for completely randomized design

The data recorded in each observation were analyzed using ANOVA so as to test the differences between two or more independent groups.

Source of variation	Degree of freedom (df)	Sum of squares (SS)	Mean square (MS) = $\frac{SS}{df}$	Computed F
Treatment	t – 1	SST	MST	MST/MSE
Error	n– t	SSE	MSE	
Total	n – 1	SSTO		

Where,

t = Treatment

n = Total number of observations

SST = Sum of squares of treatment

SSE = Sum of squares of error

SSTO = Sum of squares of total

MST = mean square of treatments

MSE= Mean square of error

3.6.2 Pair wise comparison using DMRT test

Duncan's multiple range test (DMRT) is used for experiments that require the evaluation of all possible pairs of treatment means, especially when the total number of treatments are large.

Computation of numerical boundaries that allow for the classification of difference between any two treatments or means as significant or non-significant is done. However, unlike the LSD test in which only a single value is required for any pair comparison at a prescribed level of significance, the DMRT requires computation of a series of values, each corresponding to a specific series, of pair comparisons. The following steps are followed for ranking the data (Gomez and Gomez, 1984).

Step 1: Rank all the treatment means in decreasing (or increasing) order. It is customary to rank the treatment means according to the order of preference.

Step 2: Compute the s_d value following the appropriate procedure

$$s_d = \sqrt{\frac{2S^2}{r}}$$

Step 3: Compute the (t-1) values of the shortest significant ranges as:

$$R_p = \frac{(rp)\ (sd)}{\sqrt{2}} \text{for } p = 2, 3, \ldots\ldots, t$$

Where, 't' is the total number of treatments, 's' is the standard error of the mean difference computed in step 2, 'r' values are the tabular values of the significant ranges, and 'p' is the distance in rank between the pairs of treatment means to be compared (*i.e.*, p = 2 for the two means with consecutive rankings and p = t for the highest and lowest means).

Step 4: Identify and group together all treatment means that do not differ significantly from each other.

Step 5: Use the alphabet notation according to the ranking to present the test results.

Results

4. RESULTS

The present study entitled 'Impact of potassium and ABA application on vivipary and seed quality in oriental pickling melon (*Cucumis melo* var. *conomon* Mak.)' was conducted at the Department of Seed Science and Technology, College of Agriculture, Vellanikkara, Kerala Agricultural University (KAU), Thrissur during the year 2019-2021. The results obtained from the study are detailed below.

4.1 Experiment I: Effect of potassium and ABA levels on vivipary

4.1.1 Analysis of variance

Analysis of variance revealed significant differences among the treatments for the characters, fruit length, fruit yield per plant, number of seeds per fruit, seed yield per plant, vivipary (%), and potassium content in fruit flesh and placenta (Table 2).

The result pertaining to the effect of potassium and ABA levels on crop growth, fruit and seed yield and vivipary (Table 3) are presented below.

4.1.2 Days to first flowering (Female)

The result on number of days taken for the appearance of the first female flower indicated that the treatments had no significant influence on days taken for the appearance of female flower.

4.1.3 Fruits per vine

The result on number of fruits per vine as influenced by levels of potassium and ABA indicated that there were no significant differences among the treatments for this character.

4.1.4 Fruit length (cm)

Results indicated that fruit length was influenced significantly by levels of potassium and ABA. Considering different levels of potassium and ABA treatments, the fruit length varied from 16.83 cm (T_1; 0.5% MOP) to 20.83 cm (T_5; 200 mg/l ABA). Fruit length was significantly high in T_5 - 200 mg/l ABA (20.83 cm) which was on par

Table 2. Analysis of variance for seed and fruit yield attributes

Trait	Treatments	Error
Days to first flowering (female flower)	1.66^{NS}	2.84
Fruits per vine	0.45^{NS}	0.31
Fruit length (cm)	6.50*	1.64
Fruit girth (cm)	6.75^{NS}	4.89
Fruit diameter (cm)	0.53^{NS}	0.26
Fruit weight (g)	61750.74^{NS}	51572.45
Fruit yield per vine (kg)	0.72*	0.15
Seeds per fruit	11135.43*	2830.27
Seed yield per plant (g)	198.82*	11.04
Fresh weight of seed/fruit (g)	9.18^{NS}	4.29
Dry weight of seeds per fruit (g)	9.17^{NS}	3.48
Chaff seeds (%)	0.04^{NS}	0.02
100 seed weight (g)	0.09^{NS}	0.13
Vivipary (%)	21.97*	0.96
K content in fruit placenta (%)	0.001*	0.00
K content in flesh of fruits (%)	0.001*	0.00

* The value was significant at 5% level of significance

** The value was significant at 1% level of significance

^{NS} The value was non-significant

Plate 4: Oriental pickling melon at harvest stage

Normal fruit **Viviparous fruit**

Plate 5: Vivipary in oriental pickling melon

with T_4 – 100 mg/l ABA (20.67 cm), T_6 – 300 mg/l ABA (20.46 cm), T_2 – 1% MOP (20 cm), T_7 – POP + 50% K (19.8 cm) and T_8 – POP (18.9 cm).

4.1.5 Fruit girth (cm)

The observations on fruit girth indicated that the potassium and ABA treatments did not have any significant influence on fruit girth.

4.1.6 Fruit diameter (cm)

Results indicated that the fruit diameter was not influenced by the different levels of potassium and ABA treatments given.

4.1.7 Fruit weight (g)

The result of fruit weight indicated that the treatments did not have any significant influence on fruit weight.

4.1.8 Fruit yield per vine (kg)

The result on the effect of different levels of potassium and ABA on fruit yield per vine showed that there were significant differences among the treatments. Treatment T_6 (300 mg/l ABA) recorded the highest yield of 3.23 kg which was on par with T_4 (100 mg/l ABA) 2.82 kg, T_5 (200 mg/l ABA) 2.89 kg, T_7 (POP + 50% additional K) 3.01 kg, T_1 (0.5% MOP) 2.63 kg and T_2 (1% MOP) 12.53 kg.

4.1.9 K content in fruit placenta (%)

The results showed that ABA and potassium levels had significant impact on potassium content in fruit placenta. Among the treatments, potassium per cent in the fruit placenta was high in treatment, T_6 – 300 mg/l ABA (0.15%) showing significant difference compared to other treatments followed by T_3 and T_2 which were on par with each other.

4.1.10 K content in flesh of fruits (%)

Abscisic acid and potassium levels had a significant impact on potassium content in the flesh of the fruit. Potassium per cent in the fruit placenta was high in T_6 – 300 mg/l ABA (0.10 %) which differed significantly from the other treatments followed by treatments T_3, T_5 and T_4 which were on par with each other.

Table 3. Effect of potassium and ABA on fruit quality and yield parameters

Treatments	Days to first flowering	Fruits per vine	Fruit length (cm)	Fruit girth (cm)	Fruit diameter (cm)	Fruit weight (g)	Fruit yield per vine (kg)	K content in fruit placenta (%)	K content in fruit flesh (%)
T_1 (0.5% MOP)	33.67	2.67	16.83^{c}	34.67	10.33	1178.00	2.63^{ab}	0.115^{c}	0.062^{c}
T_2 (1% MOP)	34.00	2.33	20.00^{ab}	31.33	9.67	1056.67	2.53^{abc}	0.132^{b}	0.063^{c}
T_3 (1.5% MOP)	33.67	2.33	17.67^{bc}	30.67	9.57	877.00	1.95^{bc}	0.139^{b}	0.083^{b}
T_4 (100 mg/l ABA)	34.67	2.33	20.67^{a}	33.17	10.37	1184.67	2.82^{a}	0.107^{cd}	0.076^{b}
T_5 (200 mg/l ABA)	32.67	2.33	20.83^{a}	34.93	10.80	1325.67	2.89^{a}	0.117^{c}	0.080^{b}
T_6 (300 mg/l ABA)	34.00	3.00	20.46^{a}	33.77	10.50	1209.33	3.23^{a}	0.153^{a}	0.102^{a}
T_7 (POP + 50%K)	34.67	2.67	19.80^{ab}	33.60	10.33	1156.00	3.01^{a}	0.101^{d}	0.064^{c}
T_8 (POP)	35.00	1.67	18.90^{abc}	32.67	10.00	972.00	1.86^{c}	0.099^{d}	0.059^{c}
CD (0.05)	N/S	N/S	2.265	N/S	N/S	N/S	0.689	0.011	0.011
SE	0.973	0.321	0.74	1.277	0.296	131.114	0.227	0.004	0.004

Table 4. Effect of potassium and ABA on seed quality and yield parameters

Treatments	Seeds per fruit	Seed yield per plant (g)	Fresh weight of seed per fruit (g)	Dry weight of seeds per fruit (g)	Chaff seeds (%)	100 seed weight (g)	Vivipary (%)
T_1 (0.5% MOP)	480.00^{c}	30.25^{b}	12.08	11.17	0.38	2.10	6.49^{b}
T_2 (1% MOP)	485.00^{c}	19.72^{c}	11.05	10.30	0.20	2.08	5.36^{bc}
T_3 (1.5% MOP)	497.00^{bc}	26.74^{b}	11.56	10.80	0.13	2.12	3.29^{d}
T_4 (100 mg/l ABA)	586.33^{ab}	31.47^{b}	13.78	13.00	0.28	1.95	6.23^{b}
T_5 (200 mg/l ABA)	553.00^{abc}	29.44^{b}	10.69	9.87	0.37	1.69	3.93^{cd}
T_6 (300 mg/l ABA)	625.33^{a}	43.21^{a}	14.89	14.07	0.10	2.21	1.37^{e}
T_7 (POP + 50%K)	453.33^{c}	30.31^{b}	10.86	9.73	0.24	2.24	8.24^{a}
T_8 (POP)	480.00^{c}	16.19^{c}	9.53	8.87	0.41	2.05	9.73^{a}
CD (0.05)	94.068	5.875	N/S	N/S	N/S	N/S	1.792
SE	43.438	1.918	1.196	1.077	0.071	0.21	0.564

4.1.11 Seeds per fruit

In terms of the number of seeds per fruit, the findings suggested that the impact of ABA and potassium treatments were significant (Table 4). The total quantity of seeds per fruit was highest in T_6 – 300 mg/l ABA (625 seeds) followed by T_4 (586.33) and T_5 (553 seeds).

4.1.12 Seed yield per plant (g)

The results on seed yield as influenced by different potassium and ABA nutrient levels are furnished in Table 4. The amounts of ABA and potassium had a considerable impact on this character. The seed yield per plant ranged from 16.19 g (T_8 – control) to 43.20 g (T_6 – 300 mg/l ABA) and T_6 was significantly higher than all other treatments.

4.1.13 Fresh weight of seed per fruit (g)

Values for fresh weight of seeds per fruit did not vary significantly among the treatments.

4.1.14 Dry weight of seeds per fruit (g)

The dry weight of the seeds per fruit was not influenced by the treatments and showed no significant difference.

4.1.15 Chaff seeds (%)

The result of percent chaff seeds indicated in Table 4 showed that the levels of potassium and ABA treatments did not have any significant impact on the chaffy seeds.

4.1.16 100 seed weight (g)

The findings revealed that test weight was unaffected by the treatments given (Table 4).

4.1.17 Vivipary (%)

The result on vivipary per cent as influenced by ABA and potassium levels are presented in Table 4. The results suggested that potassium levels and ABA treatments

Table 5. Initial seed quality parameters

Treatments	Germination (%)	Shoot length (cm)	Root length (cm)	Seedling dry weight (g)	Electrical conductivity (μScm^{-1})	Mean germination time (days)	Time taken for 50% germination (T_{50})	Vigour index I	Vigour index II	Seed microflora (%)	Seed moisture (%)
T_1	73.33^{bc}	10.96^{f}	10.51^{e}	0.018	17.64^{b}	6.04^{c}	5.22^{bc}	1574^{d}	1295	0.00	6.23
T_2	71.00^{d}	13.17^{a}	9.76^{f}	0.018	14.25^{f}	6.06^{abc}	5.24^{abc}	1627^{d}	1254	0.00	6.20
T_3	73.33^{bc}	10.82^{f}	11.27^{cd}	0.018	15.47^{e}	6.07^{ab}	5.25^{a}	1619^{d}	1295	0.00	6.23
T_4	75.33^{ab}	12.07^{c}	11.89^{a}	0.017	12.26^{g}	6.06^{abc}	5.24^{abc}	1805^{a}	1280	0.00	6.20
T_5	77.00^{a}	11.16^{de}	11.56^{b}	0.017	15.66^{d}	6.07^{a}	5.25^{ab}	1749b	1282	0.00	6.30
T_6	74.67^{b}	12.43^{b}	12.06^{a}	0.019	15.39^{e}	6.04^{bc}	5.22^{c}	1828^{a}	1393	0.00	6.23
T_7	75.00^{ab}	11.04^{def}	11.44^{bc}	0.018	16.24^{c}	6.03^{c}	5.21^{c}	1686^{c}	1324	0.00	6.27
T_8	71.33^{cd}	11.20^{d}	11.07^{d}	0.016	19.60^{a}	6.04^{bc}	5.23^{abc}	1588^{d}	1164	0.00	6.23
CD (0.05)	2.108	0.220	0.236	N/S	0.140	0.025	0.024	54.694	N/S	N/S	N/S
SE	0.697	0.073	0.078	0.001	0.046	0.008	0.008	18.088	40.696	0.00	0.081

had a significant impact on vivipary. The incidence of vivipary was least in treatment, T_6 – 300 mg/l ABA (1.37%) which differed significantly from all other treatments and the highest vivipary was observed in control (T_8 – POP; 9.73%).

4.2 Experiment 2: Seed storage studies (Accelerated Ageing Test)

4.2.1 Analysis of variance

The degree of influence of ABA and potassium nutrition levels on the seed quality indicators investigated before and during the accelerated ageing were revealed using analysis of variance.

4.3.2 Initial Seed quality

The initial seed quality parameters of seeds collected from experiment-I was determined prior to the commencement of accelerated ageing and is presented in Table 5.

Different levels of potassium and ABA nutrition was found to significantly influence the germination per cent (T_5 – 77% to T_2 – 71%), root length (T_6 – 12.06 cm to T_2 – 9.76 cm), shoot length (T_2 – 13.17 cm to T_3 – 10.82 cm), electrical conductivity (T_4 – 12.26 μScm^{-1} to T_8 – 19.60 μScm^{-1}), Mean germination time (T_5 – 6.07 to T_7 – 6.03), Time taken for 50% germination (T_3 – 5.25% to T_7 – 5.21%) and vigour index I (T_6 – 1828 to T_1 - 1574).

4.3.3 Seed quality during storage

4.3.3.1 Germination (%)

The results on germination per cent as influenced by various potassium and ABA levels, and its effects during accelerated ageing are enumerated in Table 6.

The levels of potassium and ABA nutrition influenced the germination (%) significantly during accelerated ageing. At 1 DAA, seeds collected from the treatment T_4 (100 mg/l ABA; 66.33%) registered the highest germination and was on par with treatments T_5 (200 mg/l ABA; 65.67%) and T_6 (300 mg/l ABA; 65.00%). At the end of the ageing period (7 DAA), T_4 (100 mg/l ABA 53%) showed the highest germination and was significantly different from all other treatments. The lowest value was recorded

Table 6. Influence of potassium and ABA nutrient levels on germination % during accelerated ageing

Treatments	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
T_1 (0.5% MOP)	60.67^{b}	52.33^{f}	50.33^{c}	49.33^{e}	46.00^{c}	43.00^{d}	40.67^{d}
T_2 (1% MOP)	58.33^{b}	53.67^{ef}	51.00^{c}	51.00^{de}	46.33^{c}	43.67^{cd}	42.00^{d}
T_3 (1.5% MOP)	61.00^{b}	55.00^{de}	50.00^{c}	45.33^{f}	45.33^{c}	44.00^{cd}	42.00^{d}
T_4 (100 mg/l ABA)	66.33^{a}	64.00^{a}	62.67^{a}	61.67^{a}	56.00^{a}	53.67^{a}	53.00^{a}
T_5 (200 mg/l ABA)	65.67^{a}	65.00^{a}	61.66^{a}	56.67^{b}	51.33^{b}	48.67^{b}	48.00^{b}
T_6 (300 mg/l ABA)	65.00^{a}	61.67^{b}	56.00^{b}	53.33^{cd}	50.00^{b}	49.33^{b}	43.00^{cd}
T_7 (POP + 50%K)	61.00^{b}	58.67^{c}	52.33^{c}	54.67^{bc}	51.00^{b}	47.67^{bc}	46.00^{bc}
T_8 (POP)	59.00^{b}	55.67^{d}	51.67^{c}	51.00^{de}	48.00^{bc}	47.00^{bcd}	47.67^{b}
CD (0.05)	2.714	1.919	2.443	3.147	3.147	4.261	3.127
SE	0.898	0.635	0.808	1.041	1.041	1.409	1.034

Table 7. Influence of potassium and ABA nutrient levels on shoot length (cm) during accelerated ageing

Treatments	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
T_1 (0.5% MOP)	11.14^{d}	10.47^{f}	10.44^{c}	10.14^{d}	10.07^{e}	10.07^{bc}	10.22^{ab}
T_2 (1% MOP)	11.61^{c}	11.33^{c}	11.04^{b}	10.39^{c}	10.26^{cd}	10.25^{b}	10.14^{b}
T_3 (1.5% MOP)	12.44^{a}	10.80^{e}	10.53^{c}	10.30^{cd}	10.43^{b}	10.24^{b}	10.24^{ab}
T_4 (100 mg/l ABA)	11.90^{bc}	10.87^{e}	10.48^{c}	10.29^{cd}	10.31^{c}	10.18^{b}	10.22^{ab}
T_5 (200 mg/l ABA)	11.06^{d}	11.49^{b}	11.21^{a}	11.21^{a}	10.26^{cd}	10.22^{b}	10.33^{a}
T_6 (300 mg/l ABA)	12.18^{ab}	11.80^{a}	11.22^{a}	10.94^{b}	10.55^{a}	10.60^{a}	10.32^{a}
T_7 (POP + 50%K)	12.19^{ab}	11.03^{d}	10.96^{b}	10.14^{d}	10.11^{e}	9.93^{c}	10.17^{b}
T8 (POP)	11.01^{d}	10.98^{d}	10.40^{c}	10.27^{cd}	10.21^{d}	10.14^{b}	10.18^{b}
CD (0.05)	0.353	0.084	0.167	0.193	0.073	0.187	0.117
SE	0.117	0.028	0.055	0.064	0.024	0.062	0.039

Table 8. Influence of potassium and ABA nutrient levels on root length (cm) during accelerated ageing

Treatments	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
T_1 (0.5% MOP)	9.88^{c}	9.66^{d}	9.48^{e}	8.56^{d}	8.49^{d}	8.39^{bc}	8.83^{b}
T_2 (1% MOP)	8.97^{d}	8.79^{e}	8.63^{g}	8.46^{d}	8.44^{d}	8.31^{bcd}	8.52^{c}
T_3 (1.5% MOP)	11.10^{a}	10.34^{c}	9.97^{c}	9.33^{b}	9.59^{a}	9.01^{a}	9.81^{a}
T_4 (100 mg/l ABA)	11.37^{a}	11.46^{a}	10.56^{a}	9.82^{a}	9.34^{b}	8.59^{b}	8.83^{b}
T_5 (200 mg/l ABA)	10.26^{bc}	10.31^{c}	9.78^{d}	8.77^{cd}	8.46^{d}	8.43^{b}	8.90^{b}
T_6 (300 mg/l ABA)	10.94^{ab}	10.68^{b}	10.29^{b}	9.22^{b}	9.07^{c}	8.42^{b}	8.83^{b}
T_7 (POP + 50%K)	10.19^{bc}	9.37^{d}	9.07^{f}	8.39^{d}	8.48^{d}	8.11^{cd}	8.44^{c}
T_8 (POP)	9.87^{c}	9.50^{d}	9.32^{e}	9.11^{bc}	8.40^{d}	8.07^{d}	8.21^{d}
CD (0.05)	0.727	0.290	0.180	0.421	0.181	0.278	0.075
SE	0.240	9.663	0.060	0.139	0.060	0.092	0.025

in T_1 (0.5% MOP; 40.67%) which was on par with T_2 (1% MOP; 42.00%) and T_3 (1.5% MOP; 42.00%).

Germination progressively declined over the ageing period in all the treatments irrespective of the treatments and after 4 days of ageing the germination declined below the standard for seed certification prescribed by IMSCS (60.00% for melon). In general, seeds collected from the treatments, T_4 (100 mg/l ABA) exhibited superior germination as compared to other treatments throughout storage

4.3.3.2 Shoot length (cm)

The results ascertained in seedling shoot length as influenced by various treatments and its effect during the ageing period are enumerated in Table 7.

Seeds collected from treatment T_6 (300 mg/l ABA) showed the highest seedling shoot length throughout the ageing period. Highest value of shoot length was observed in treatment T_5 (200 mg/l ABA; 10.33 cm) at the end of accelerated ageing (7 days) and it was on par with T_6 (200 mg/l ABA; 10.32 cm), T_3 (1.5% MOP; 10.22 cm), T_4 (100 mg/l ABA; 10.22 cm) and T_1 (0.5% MOP; 10.22 cm). The lowest value was seen in treatment T_2 (1% MOP; 10.14 cm) which was on par with T_7 (POP + 50% K) and T_8 (control; 10.18) at the end of storage. Shoot length progressively declined over the ageing period in all the treatments.

4.3.3.3 Root length (cm)

The results recorded on seedling root length was influenced by different potassium and ABA levels and their effects during accelerated ageing are presented in Table 8.

The highest seedling root length was observed in treatment T_4 (100 mg/l ABA) till 4 days of accelerated ageing and then on T_3 (1.5% MOP; 9.81 cm) towards the end of ageing period (7 days). The lowest values towards the end were recorded in control (T_8 – POP; 8.21 cm). A progressive decline in seedling root length was observed over the ageing period.

Table 9. Influence of potassium and ABA nutrient levels on seedling dry weight (g) during accelerated ageing

Treatments	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
T_1 (0.5% MOP)	0.017	0.016^{ab}	0.015^{cd}	0.013^{c}	0.013^{b}	0.013^{c}	0.013^{cd}
T_2 (1% MOP)	0.017	0.016^{abc}	0.015^{d}	0.014^{bc}	0.013^{b}	0.013^{c}	0.013^{d}
T_3 (1.5% MOP)	0.018	0.017^{a}	0.016^{b}	0.014^{bc}	0.014^{ab}	0.014^{b}	0.014^{abc}
T_4 (100 mg/l ABA)	0.016	0.015^{d}	0.015^{d}	0.014^{bc}	0.013^{b}	0.014^{b}	0.014^{bcd}
T_5 (200 mg/l ABA)	0.017	0.015^{cd}	0.016^{b}	0.013^{c}	0.013^{b}	0.013^{c}	0.014^{ab}
T_6 (300 mg/l ABA)	0.017	0.017^{a}	0.017^{a}	0.015^{a}	0.015^{a}	0.015^{a}	0.015^{a}
T_7 (POP + 50%K)	0.017	0.015^{bcd}	0.016^{bc}	0.014^{b}	0.013^{b}	0.014^{b}	0.014^{ab}
T_8 (POP)	0.016	0.016^{abc}	0.015^{d}	0.014^{bc}	0.014^{ab}	0.013^{c}	0.014^{abc}
CD (0.05)	N/S	0.001	0.001	0.001	0.001	0.001	0.001
SE	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 10. Influence of potassium and ABA nutrient levels on electrical conductivity (EC) of seed leachate (μSm^{-1}) during accelerated ageing

Treatments	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
T_1 (0.5% MOP)	22.17^{e}	27.53^{b}	36.17^{bc}	37.60^{ab}	41.43^{ab}	44.13	43.83^{de}
T_2 (1% MOP)	19.29^{f}	23.11^{e}	33.00^{e}	36.47^{c}	39.93^{b}	45.47	44.83^{cde}
T_3 (1.5% MOP)	27.10^{b}	27.33^{b}	35.80^{c}	37.10^{bc}	41.43^{ab}	44.13	49.13^{ab}
T_4 (100 mg/l ABA)	25.17^{c}	27.31^{b}	34.50^{d}	36.57^{c}	37.30^{c}	46.20	47.73^{abc}
T_5 (200 mg/l ABA)	22.80^{d}	24.38^{d}	32.67^{e}	34.50^{d}	39.87^{b}	45.50	45.73^{bcde}
T_6 (300 mg/l ABA)	22.68^{d}	25.47^{c}	33.33^{e}	34.60^{d}	37.20^{c}	46.03	42.43^{e}
T_7 (POP + 50%K)	29.50^{a}	27.27^{b}	36.67^{ab}	37.20^{bc}	40.47^{b}	47.77	46.40^{abcd}
T_8 (POP)	26.73^{b}	28.13^{a}	37.23^{a}	38.17^{a}	43.13^{a}	48.47	49.27^{a}
CD (0.05)	0.390	0.374	0.727	0.695	2.124	N/S	3.208
SE	0.129	0.124	0.240	0.230	0.702	1.081	1.061

Table 11. Influence of potassium and ABA nutrient levels on mean germination time (MGT) during accelerated ageing

Treatments	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
T_1 (0.5% MOP)	6.08^{bc}	6.06^{c}	6.14^{c}	6.21^{c}	6.53^{b}	6.95^{a}	7.05
T_2 (1% MOP)	6.22^{a}	6.14^{ab}	6.31^{b}	6.55^{a}	6.62^{a}	6.71^{b}	7.07
T_3 (1.5% MOP)	6.08^{bcd}	6.08^{c}	6.13^{c}	6.17^{d}	6.36^{d}	6.57^{c}	7.04
T_4 (100 mg/l ABA)	6.06^{cd}	6.07^{c}	6.08^{d}	6.10^{e}	6.18^{f}	6.25^{f}	7.03
T_5 (200 mg/l ABA)	6.09^{b}	6.06^{c}	6.07^{d}	6.11^{e}	6.17^{f}	6.20^{g}	7.04
T_6 (300 mg/l ABA)	6.05^{d}	6.10^{bc}	6.13^{c}	6.24^{c}	6.24^{e}	6.29^{e}	7.03
T_7 (POP + 50%K)	6.10^{b}	6.16^{a}	6.40^{a}	6.44^{c}	6.52^{bc}	6.55^{c}	7.05
T_8 (POP)	6.05^{d}	6.08^{bc}	6.32^{b}	6.47^{b}	6.47^{c}	6.51^{d}	7.05
CD (0.05)	0.030	0.054	0.035	0.043	0.048	0.037	N/S
SE	0.010	0.018	0.012	0.014	0.016	0.012	0.012

Table 12. Influence of potassium and ABA nutrient levels on time taken for 50% germination (T_{50}) during accelerated ageing

Treatments	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
T_1 (0.5% MOP)	5.26^{bcd}	5.25^{c}	5.38^{c}	5.39^{c}	5.70^{b}	6.14^{a}	6.25
T_2 (1% MOP)	5.40^{a}	5.32^{ab}	5.49^{b}	5.73^{a}	5.80^{a}	5.89^{b}	6.26
T_3 (1.5% MOP)	5.26^{bcd}	5.26^{bc}	5.31^{d}	5.35^{d}	5.54^{d}	5.75^{c}	6.23
T_4 (100 mg/l ABA)	5.24^{cd}	5.25^{c}	5.26^{d}	5.29^{e}	5.36^{f}	5.43^{f}	6.22
T_5 (200 mg/l ABA)	5.27^{bc}	5.24^{c}	5.25^{d}	5.30^{e}	5.35^{f}	5.38^{g}	6.25
T_6 (300 mg/l ABA)	5.23^{d}	5.28^{bc}	5.31^{cd}	5.42^{c}	5.42^{e}	5.47^{e}	6.22
T_7 (POP + 50%K)	5.28^{b}	5.34^{a}	5.58^{a}	5.62^{b}	5.71^{b}	5.73^{c}	6.24
T_8 (POP)	5.23^{d}	5.28^{bc}	5.51^{ab}	5.65^{b}	5.65^{c}	5.69^{d}	6.24
CD (0.05)	0.030	0.057	0.068	0.043	0.050	0.037	N/S
SE	0.010	0.019	0.022	0.014	0.016	0.012	0.010

4.3.3.4 Dry weight of seedling (g)

The data ascertained on dry weight of seedling as influenced by various treatments and their effect during the ageing period are detailed in Table 9.

Treatment T6 (300 mg/l ABA) recorded the higher value throughout the treatment days and it declined from 0.017g to 0.015g at the end of ageing.

4.3.3.4 Electrical conductivity (EC) of seed leachate (μSm^{-1})

The results recorded on electrical conductivity of seed leachate as influenced by different potassium and ABA levels and their effects during accelerated ageing are presented in Table 10.

The impact of potassium and ABA treatments on electrical conductivity showed significance with higher values in control (T8 – POP) for most of the days of ageing and towards the end of ageing. The lower values of electrical conductivity did not show a specific trend but the lower value at the end of storage was in treatment T6 (300 mg/l ABA FS; 42.43 μSm^{-1}). The electrical conductivity increased over the ageing period.

4.3.3.5 Mean germination time (MGT)

The data obtained on mean germination time as influenced by various nutrient levels and its effects during the ageing period are enumerated in Table 11.

Seeds collected from T5 (200 mg/l ABA) recorded the low value of mean germination time in most of the days but at the end of storage, the treatments showed no significance. The mean germination time progressively increased over accelerated ageing period.

4.3.3.6 Time taken for 50% germination (T_{50})

The results ascertained on time taken for 50% germination as influenced by different potassium and ABA treatments and their effects during the storage period is presented in Table 12.

The highest time taken for 50% germination did not show a specific trend but the lower values were seen in treatment T5 (200 mg/l ABA) for most of the days and towards

Table 13. Influence of potassium and ABA nutrient levels on vigour index I during accelerated ageing

Treatments	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
T_1 (0.5% MOP)	1275^{d}	1053^{d}	1002^{c}	922^{fg}	853^{e}	793^{d}	774^{e}
T_2 (1% MOP)	1201^{d}	1079^{d}	1002^{c}	961^{ef}	866^{e}	810^{d}	783de
T_3 (1.5% MOP)	1435.733^{bc}	1162^{bc}	1025^{c}	889^{g}	908^{cde}	847^{cd}	841^{cd}
T_4 (100 mg/l ABA)	1543^{a}	1428^{a}	1318^{a}	1238^{a}	1100^{a}	1,007^{a}	1,009^{a}
T_5 (200 mg/l ABA)	1400^{c}	1417^{a}	1294^{a}	1132^{b}	960^{bc}	907^{bc}	923^{b}
T_6 (300 mg/l ABA)	1502^{ab}	1386^{a}	1204^{b}	1074^{c}	981^{b}	937^{ab}	823^{cde}
T_7 (POP + 50%K)	1364^{c}	1196^{b}	1047^{c}	1013^{d}	947^{bcd}	859^{bcd}	856^{c}
T_8 (POP)	1231^{d}	1139^{c}	1018^{c}	988de	893de	856^{bcd}	876^{bc}
CD (0.05)	83.555	48.953	46.281	48.016	60.963	82.472	61.790
SE	27.632	16.189	15.306	15.879	20.161	27.274	20.435

Table 14. Influence of potassium and ABA nutrient levels on vigour index II during accelerated ageing

Treatments	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
T_1 (0.5% MOP)	1031^{bc}	854^{d}	772^{b}	658^{ef}	612^{d}	559^{cd}	542^{d}
T_2 (1% MOP)	1011^{bc}	858^{d}	765^{b}	696^{def}	602^{cd}	553^{d}	546^{d}
T_3 (1.5% MOP)	1078^{ab}	916^{bcd}	800^{b}	634^{f}	634^{bcd}	616^{b}	588^{cd}
T_4 (100 mg/l ABA)	1061^{ab}	938^{bc}	940^{a}	863^{a}	728^{a}	751^{a}	724^{a}
T_5 (200 mg/l ABA)	1094^{ab}	975^{b}	986^{a}	755^{bcd}	684^{ab}	632^{b}	688^{ab}
T_6 (300 mg/l ABA)	1126^{a}	1048^{a}	952^{a}	818^{ab}	733^{a}	722^{a}	630^{bc}
T_7 (POP + 50%K)	1017^{bc}	899^{cd}	820^{b}	783^{bc}	680^{ab}	667^{b}	658^{b}
T_8 (POP)	964^{c}	890^{cd}	775^{b}	714^{cde}	672^{abc}	611^{bc}	667^{ab}
CD (0.05)	87.088	61.730	51.883	68.931	62.261	53.284	57.990
SE	28.801	20.414	17.158	22.796	20.590	17.621	19.178

Table 15. Influence of potassium and ABA nutrient levels on seed microflora (%) during accelerated ageing (Blotter paper method)

Treatments	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
T_1 (0.5% MOP)	2.50	5.00	5.00	7.50	10.00	10.83	14.17
T_2 (1% MOP)	1.67	4.17	5.00	5.83	8.33	8.33	11.67
T_3 (1.5% MOP)	1.67	3.33	5.00	5.83	7.50	8.33	14.17
T_4 (100 mg/l ABA)	0.83	3.33	3.33	7.50	8.33	10.00	14.17
T_5 (200 mg/l ABA)	1.67	4.17	5.83	7.50	10.00	11.67	16.67
T_6 (300 mg/l ABA)	1.67	2.50	5.00	6.67	7.50	10.83	11.67
T_7 (POP + 50%K)	1.67	4.17	5.83	7.50	10.00	10.83	14.17
T_8 (POP)	2.50	5.00	6.66	8.33	10.83	11.67	15.83
CD (0.05)	N/S	N/S	N/S	N/S	N/S	N/S	N/S
SE	0.722	0.659	0.780	1.062	0.884	1.062	1.816

Table 16. Influence of potassium and ABA nutrient levels on seed microflora (%) during accelerated ageing (Agar plate method)

Treatments	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
T_1 (0.5% MOP)	3.33	4.17	10.00	8.33	10.83	11.67	16.67
T_2 (1% MOP)	2.50	5.83	7.50	7.50	10.00	10.00	14.17
T_3 (1.5% MOP)	2.50	3.33	5.00	6.67	10.00	10.83	15.00
T_4 (100 mg/l ABA)	2.50	5.83	5.83	7.50	9.17	10.83	15.83
T_5 (200 mg/l ABA)	3.33	5.00	6.67	6.67	9.17	10.83	16.67
T_6 (300 mg/l ABA)	2.50	4.17	5.00	5.00	8.33	13.33	17.50
T_7 (POP + 50%K)	1.67	5.00	8.33	9.17	10.83	11.67	17.50
T_8 (POP)	2.50	6.67	10.00	9.17	14.17	14.17	16.67
CD (0.05)	N/S	N/S	N/S	N/S	N/S	N/S	N/S
SE	1.021	1.768	1.350	1.318	1.250	1.284	2.205

the end of ageing no significant difference among treatments was observed. The T_{50} increased over accelerated ageing and ranged from 5.23 (T_6 – 300 mg/l ABA) at day 1 to 6.26 (T_2 – 1.5% MOP) at day 7.

4.3.3.7 Vigour index I

The results recorded on vigour index I as influenced by various nutrient treatments and their effects during the storage period are presented in Table 13.

The seedling vigour index I of seeds collected from treatment, T_4 (100 mg/l ABA) was found to be superior throughout the ageing period and it differed significantly from all other treatments. The lowest value was observed in T_1 (0.5% MOP; 774) and the highest value was observed in T_4 (100 mg/l ABA; 1009) towards the end of ageing period.

4.3.3.8 Vigour index II

The data obtained on vigour index I as influenced by various potassium and ABA treatment, and their effects during accelerated ageing period are presented in Table 14.

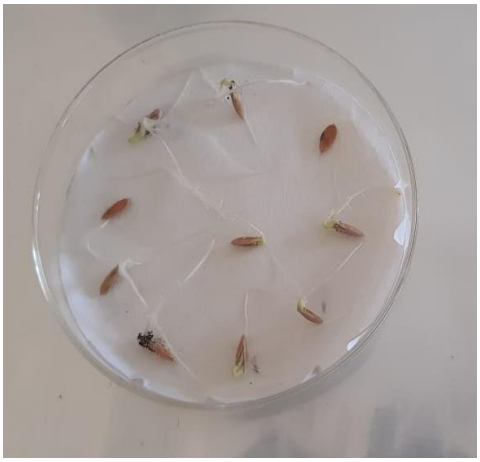
The vigour index II progressively decreased over the accelerated ageing period and ranged from 1126 (T_6 – 300 mg/l ABA) at the start to 524 (T_1 – 0.5% MOP) by end of ageing period. The highest value was observed in treatment T_4 (100 mg/l ABA; 724) towards the end of storage and was significantly different from all other treatments.

4.3.3.9 Seed microflora (%)

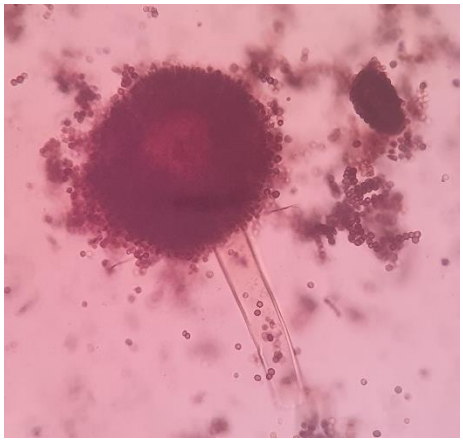
The results recorded on seed microflora as influenced by various nutrient treatments and their effects during the storage period are presented in Table 15 and 16.

In blotter paper method, the seed microflora ranged from 0.83 per cent in T_4 (100 mg/l ABA) at the start to 16.67 per cent in T_5 (200 mg/l ABA) by the end of the storage period. The data did not show any significant difference among the treatments.

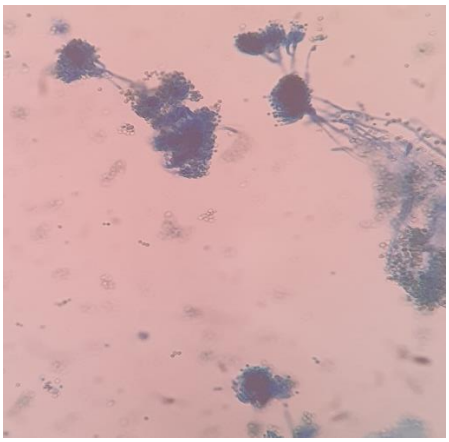
Agar plate method



Blotter paper method



Aspergillus sp.



Pencillium sp.

Plate 6: Seed microflora study

Table 17. Influence of potassium and ABA nutrient levels on seed moisture (%) during accelerated ageing

Treatments	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
T_1 (0.5% MOP)	11.33	12.23	12.83	14.37	14.43	15.20	14.73[b]
T_2 (1% MOP)	11.17	12.23	12.73	14.27	14.37	14.97	15.10[a]
T_3 (1.5% MOP)	11.23	12.13	12.77	14.07	14.23	14.93	13.63[e]
T_4 (100 mg/l ABA)	11.30	12.30	12.67	14.00	13.73	14.83	14.10[cd]
T_5 (200 mg/l ABA)	11.23	12.20	12.57	14.00	14.40	15.30	14.07[d]
T_6 (300 mg/l ABA)	11.23	12.27	12.63	14.37	14.77	15.03	13.97[d]
T_7 (POP + 50%K)	11.30	12.33	12.73	14.13	14.43	15.00	15.00[a]
T_8 (POP)	11.23	12.20	12.70	14.20	14.43	15.17	14.33[c]
CD (0.05)	N/S	N/S	N/S	N/S	N/S	N/S	0.252
SE	0.071	0.081	0.120	0.139	0.304	0.163	0.083

In agar plate method, the data recorded on seed microflora revealed that the treatments were non-significant. The values increased from 1.67 per cent in treatment, T_7 (POP + 50% K) at the start to 17.50 per cent in treatments T_6 (200 mg/l ABA) and T_7 by the end of the storage period. The pathogens detected on the seeds of oriental pickling melon during the study were *Aspergillus niger* and *Pencillium* sp.

4.3.3.10 Seed moisture (%)

The findings demonstrated that the seed moisture as influenced by nutrient levels and their effect on ageing were not found to be significantly different among treatments till day 6 of accelerated ageing (Table 17). The seed moisture per cent ranged from 11.17% (T_2 – 1.5% MOP) in the beginning of ageing to 16.67 (T_5 – 200 mg/l ABA) by the end of study (7 days).

Discussion

5. DISCUSSION

There are several factors that affect the seed production by reducing the quantity of quality seeds and vivipary is one of them. It has been reported in oriental pickling melon by several authors. Factors like environment, genotype and availability of plant nutrients contribute to this trait. The application of potassium and ABA has been found effective in controlling vivipary in several crops.

In light of this, an investigation was made to study the effects of potassium nutrition and ABA on vivipary and seed quality in oriental pickled melon. The findings are presented and discussed below.

5.1 Effect of potassium and ABA nutrient levels on flowering, fruit quality and yield attributes

Among the fruit quality characteristics fruit length varied significantly by different levels of potassium and ABA application. The treatment, 200 mg/l ABA recorded the highest fruit length of 20.83 cm which was on par with 100 mg/l ABA (20.67 cm), 300 mg/l ABA (20.46 cm), 1% MOP (20 cm), POP + 50% K (19.8 cm) and control (18.9 cm). All the ABA treatments were effective in increasing the fruit length. This may be caused by an increase in the level of nutrient and water absorption due to enhanced root hair formation induced by ABA (Bai *et al.,* 2007). The enhanced allocation of nutrients to the fruits may have led to increased growth and development in the melon fruits.

The treatments had an influence on the overall yield of the crop (Fig. 1). Higher yield was noticed in treatments, 300 mg/l ABA (3.23 kg), 100 mg/l ABA (2.82 kg), 200 mg/l ABA (2.89 kg) and POP + 50 per cent additional K (3.01 kg). This may be due to improved allocation of photoassimilates to the fruits. Quiroga *et al*. (2009) reported similar results where, ABA spraying boosted yield per plant in field-grown grapes by promoting berry set due to ABA-promoted allocation of photoassimilates. ABA was found to enhance the yield of wheat by enhancing photoassimilate transfer from source to sink in wheat (Travaglia *et al.,* 2010). Diaz-Perez *et al*. (2014) reported highest yield in ABA (1000 ppm) treated bell pepper plants but had no effect in individual fruit weight. Exogenous ABA application was also found to improve the

output of fresh figs by up to fivefold when applied on of fruit clusters of the desired size (Lama *et al*., 2019). However, the treatments did not have a significant effect on the individual fruit weight. Similar results were observed by Cantin *et al*., (2007) where foliar ABA application did not influence the fruit weight in grapes.

The application of potassium has also led to an increase in yield. This may be due to the effect of potassium supplementation on plants in improving photosynthetic activities and transfer of photosynthates from production sites to sink (Cakmak *et al*., 2005, Abd El-Latif *et al*., 2011 and Patil, 2011). The increase of yield in oriental pickling melon by the application of potassium fertilizer was also reported by Athulya (2019). Similar results were reported by Singh and Sahare (2019) in muskmelon. Their findings showed that foliar potassium application increased the yield and quality of fruits.

The potassium content in fruit flesh and placenta was influenced by the potassium and ABA treatments. The highest level of potassium content in the flesh of fruit (Fig. 2) was seen in treatment with 300 mg/l ABA (0.10 per cent) followed by 1.5 per cent MOP (0.08 per cent), 200 mg/l ABA (0.08 per cent) and 100 mg/l ABA (0.08 per cent). Similarly, the highest content of potassium in fruit placenta (Fig. 3) was observed in 300 mg/l ABA (0.15 per cent) followed by 1.5 per cent MOP (0.14 per cent) and 1 per cent MOP (0.13 per cent). Foliar application of ABA not only increases the level of ABA but also enhances the absorption of potassium in cucumber (Du and Tachibana, 1995). The application of potassium increases the content of potassium in fruit placenta and flesh in oriental pickling melon (Athulya, 2019). Since high potassium fertilisation encourages the transfer of photosynthetic assimilate to fruits, more nutrients are accumulated in the fruits.

The days for emergence of female flower were not significantly influenced by different nutrient levels. These findings are in agreement with those reported by Maragal (2016) in bitter gourd. They found that fertiliser treatment had no effect on the time taken for the first flower to bloom. Fruits per vine also did nor vary significantly with treatments because there was no change in the number of female flowers by the treatments given. ABA was found to increase the number of female flowers in

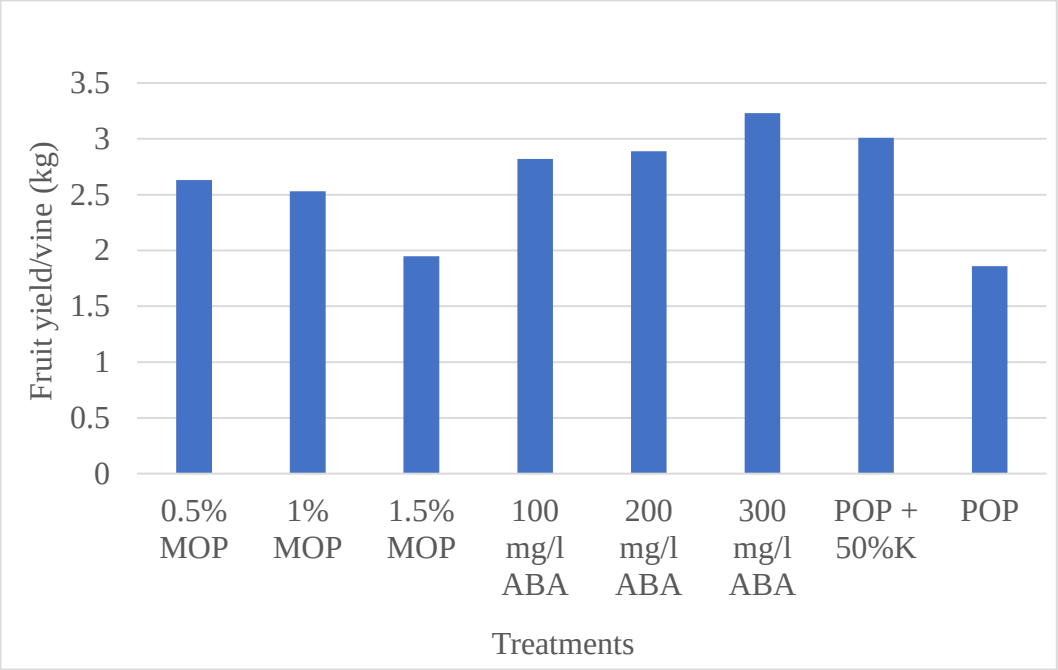


Fig. 1 Effect of potassium and ABA on fruit yield (kg)

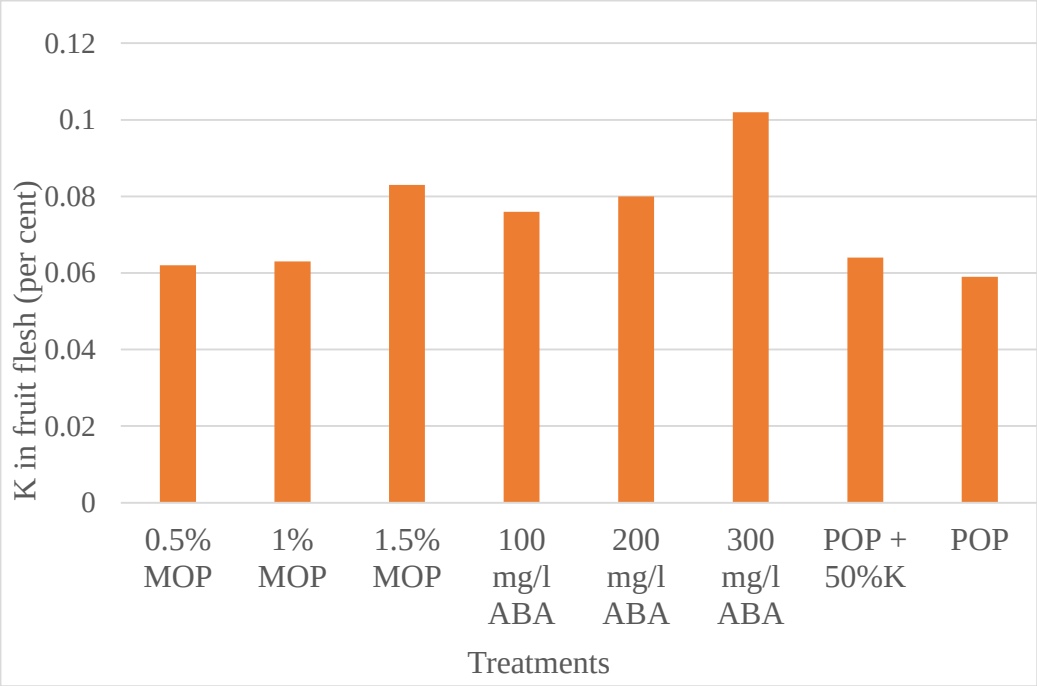


Fig. 2 Effect of potassium and ABA on K content of fruit flesh (per cent)

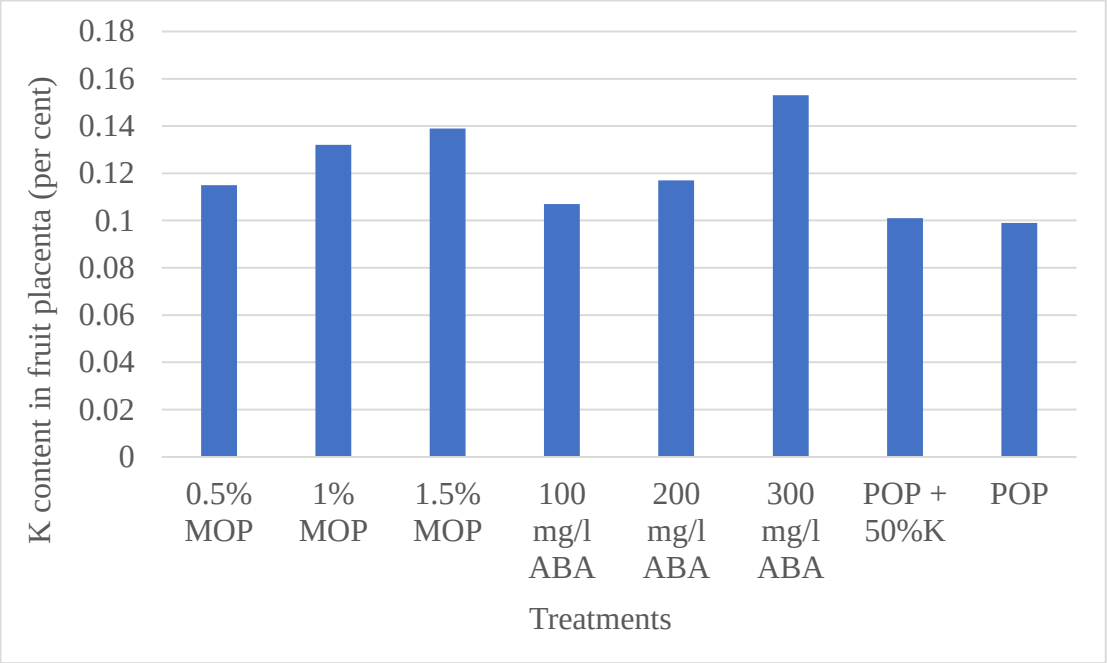


Fig. 3 Effect of potassium and ABA on K content of fruit placenta (per cent)

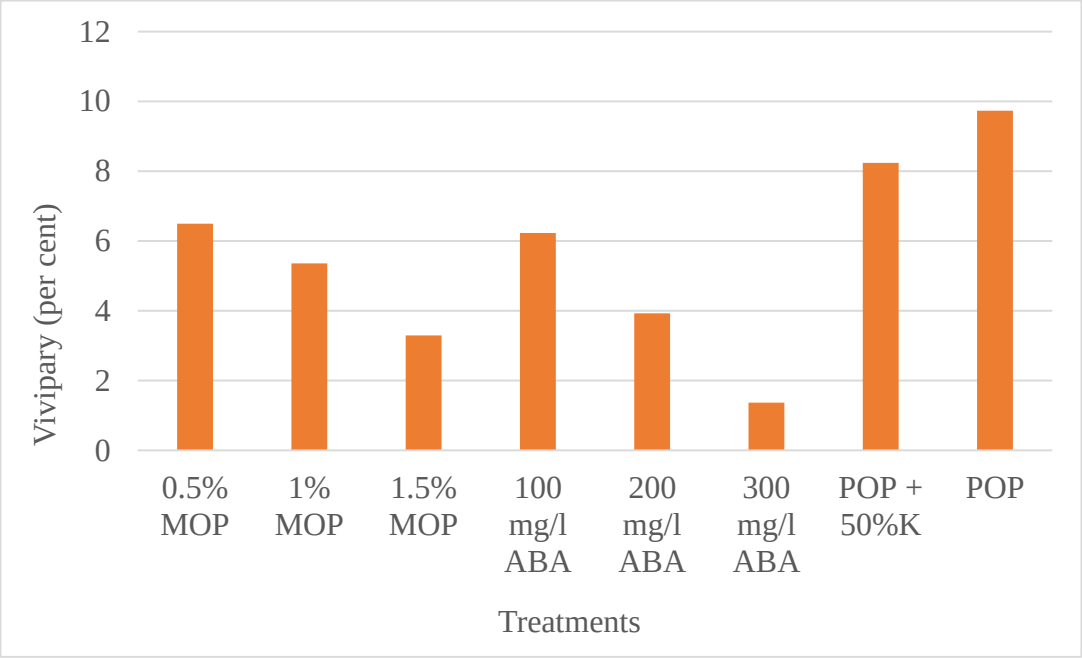


Fig. 4 Effect of potassium and ABA on vivipary (per cent)

gynoecious cucumber lines (Rudich and Halevy, 1974). In monoecious lines of cucumber only male flowers were increased and not female flowers (Friedlander *et al*., 1977). Since the cucurbit crop used in the study is monoecious, the treatments did not increase the number of female flowers leading to no increase in the fruit number.

5.2 Effect of potassium and ABA nutrient levels on seed quality and yield attributes

The seed quality and yield attributes include fresh and dry weight of seeds, chaffy seeds per cent, 100 seed weight, vivipary per cent, number of seeds per fruit and the yield of seeds per plant. The nutrient treatments had significant influence on characters like vivipary, seeds per fruit and seed yield per plant.

According to Welbaum *et al*. (1990) low ABA content in the fruit tissues can lead to vivipary in muskmelon. Abscisic acid prevents vivipary by inducing dormancy in the seeds. The increase in ABA content in fruits by direct application of ABA had a positive impact in the reduction of precocious germination. The increase in ABA content in fruits and seeds was observed in tomato treated with exogenous ABA (Zhang *et al*., 2009). Vivipary was found to be lowest in treatment with 300 mg/l ABA with a value of only 1.37 per cent which was followed by treatment 1.5 per cent MOP showing a vivipary of 3.29 per cent (Fig 4). The effect of ABA application in reducing the viviparous sprouting as observed in the present study is in agreement with the results reported by Ochi *et al*. (2013).

The application of potassium fertilizer was also found to be effective in reducing vivipary in melon seeds (Ochi and Ito, 2012 b). This may be due to the fact that the higher rate of potassium caused an increase in the ABA content in the fruit juice present around the placenta (Ochi *et al*., 2013). Similar results on effect of potassium on reducing vivipary was also reported by Athulya (2019) in oriental pickling melon.

The number of seeds per fruit (Fig. 5) and seed yield (Fig. 6) was higher in ABA treatments with 300 mg/l ABA having the highest values in both the cases. This may be caused due to the role of abscisic acid in enhancing the accumulation of nutrients in the seeds. Similar results were reported in soyabean (Kumar *et al*. 2000), peas (Kumar, 2003) and in wheat (Yang *et al*. 2014) where the application of abscisic acid was found

to improve the seed yield by boosting dry matter redistribution and grain starch accumulation. A higher seed yield was also noted in chickpea by the application of ABA (Kumar *et al*., 2008) to plants. In general, foliar treatments of bioregulators like ABA have been found to be quite successful in increasing grain output, especially under high temperature conditions (Kumar *et al*., 2020).

5.3 Effect of ageing on seed quality and longevity

Seeds extracted from fruits of different treatments were subjected to accelerated ageing for seven days to observe its effect on the quality and longevity of seeds. According to the observations made in the present study it was noted that the quality of seeds regardless of the treatments declined over the ageing period. The seed quality parameters like vigour, germination, shoot and root length decreased along with the increase in electrical conductivity of seed leachate, mean germination time, seed moisture and seed infection per cent indicating the loss of seed quality over ageing. Similar results on loss of seed quality in oriental pickling melon over storage were reported by Nagendra (2017), Reshma (2018) and Athulya (2019).

Seed coat characteristics, age-induced physicochemical degradation, lipid peroxidation resulting in the production of toxic metabolites, denaturation of proteins and enzymes may all be factors in the marked decrease in seed quality parameters as storage time progresses (Roberts, 1972). Deterioration as a result of accelerated aging conditions are comparable to those found in normal situations, with the exception that the pace of degradation is much faster (Delouche and Baskin, 1973).

The seeds under ABA treatments showed better germination throughout the accelerated ageing (Fig. 7). The higher per cent of germination may be due to the impact of ABA in reducing vivipary and increasing the quality of seeds (Ochi *et al*., 2013). The ageing test helped in differentiating the treatments based on its storability and it was found that treatment with 100mg/l ABA was the best among them. According to Clerkx *et al*. (2004), the longevity of seeds are closely related to its sensitivity to ABA.

The seedling length is an important factor in determining the seed quality. The shoot length (Fig. 8) and root length (Fig. 9) gradually declined over accelerated ageing.

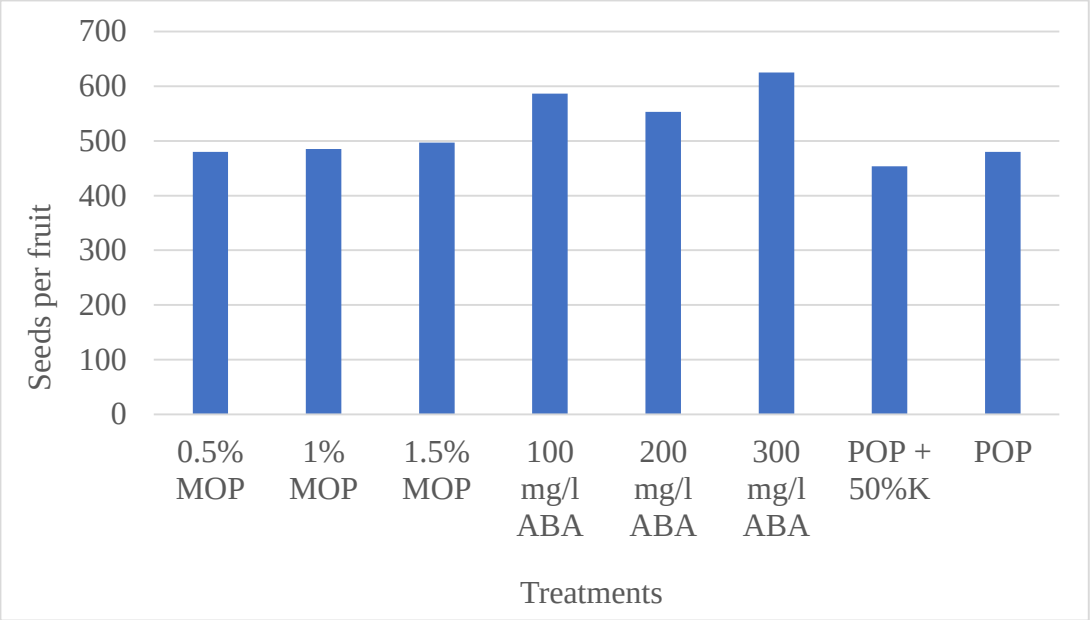


Fig. 5 Effect of potassium and ABA on seeds per fruit

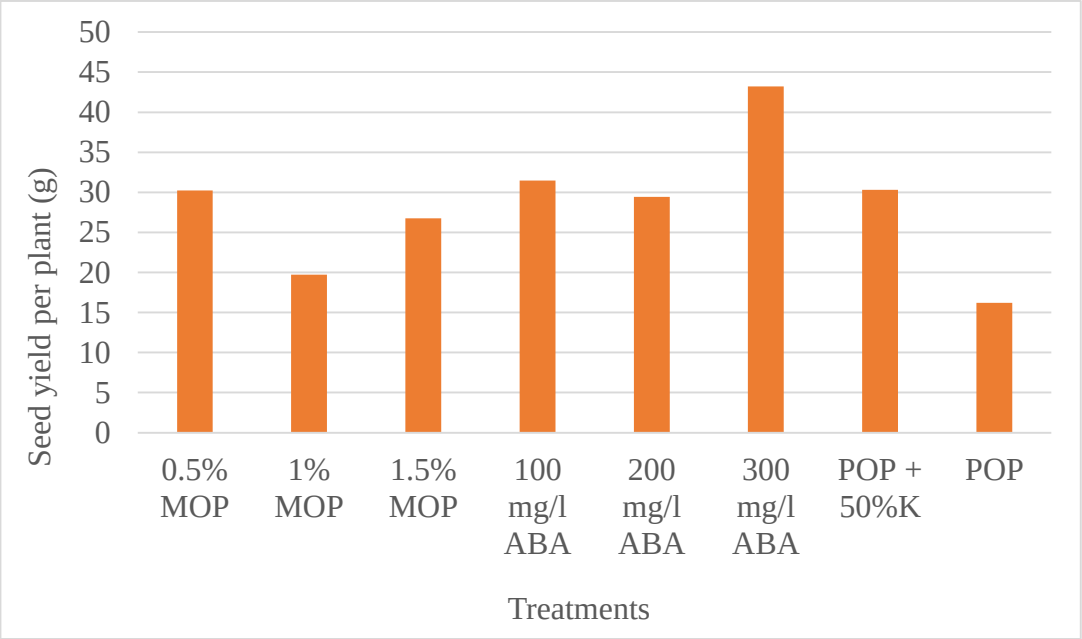


Fig. 6 Effect of potassium and ABA on seed yield per plant (g)

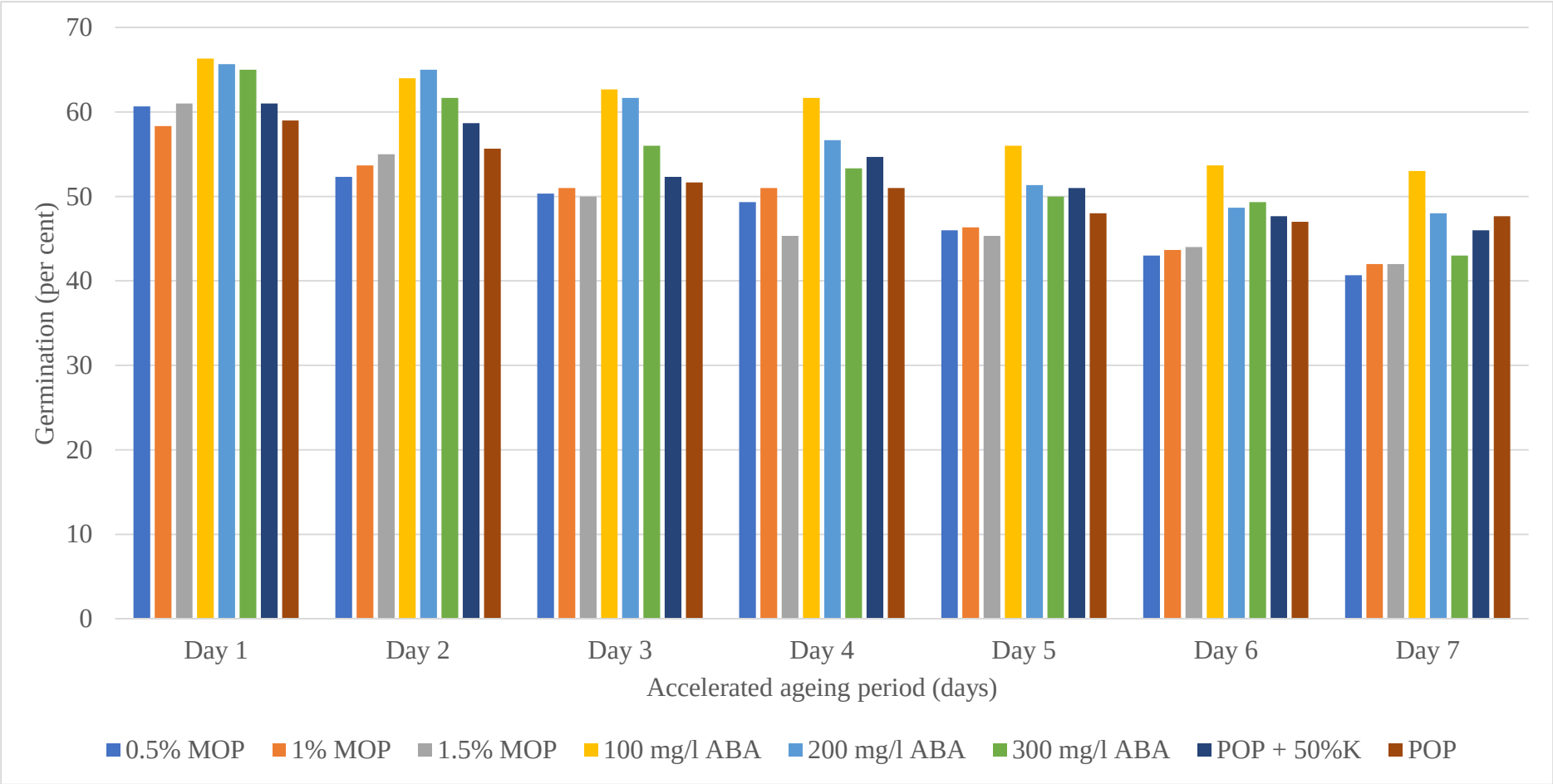


Fig. 7 Influence of potassium and ABA nutrient levels on germination per cent during accelerated ageing

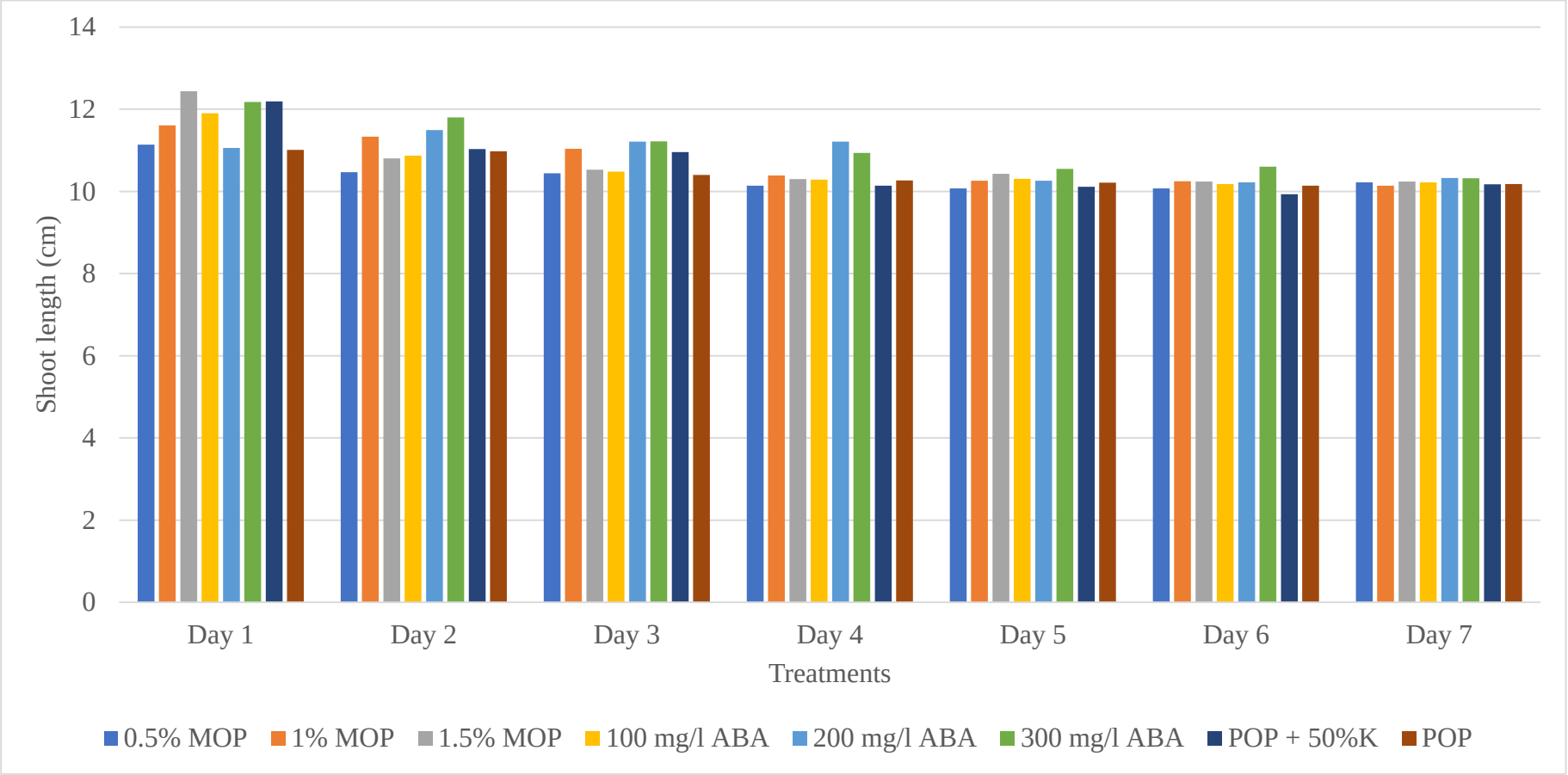


Fig. 8 Influence of potassium and ABA nutrient levels on shoot length during accelerated ageing

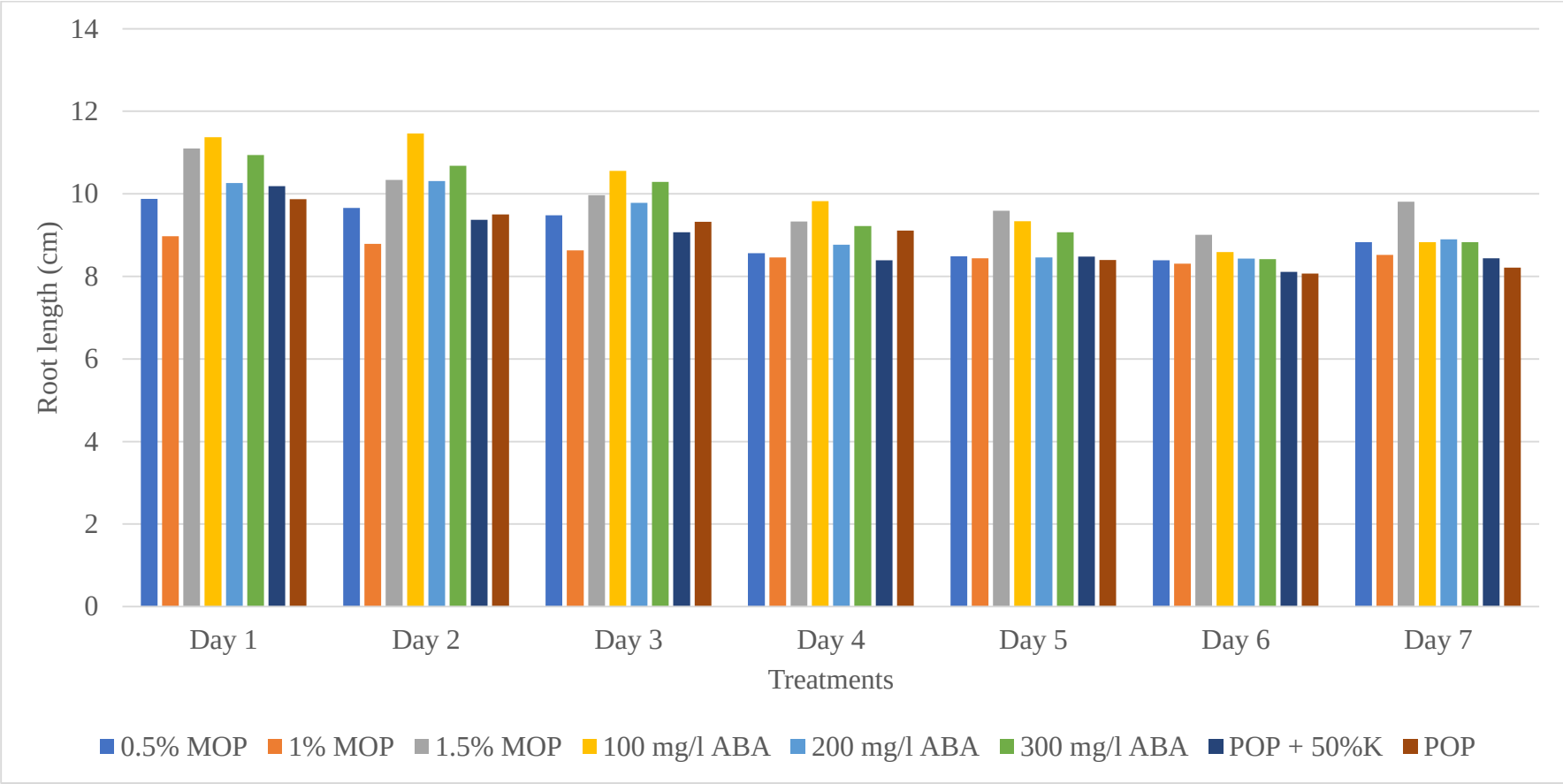


Fig. 9 Influence of potassium and ABA nutrient levels on root length during accelerated ageing

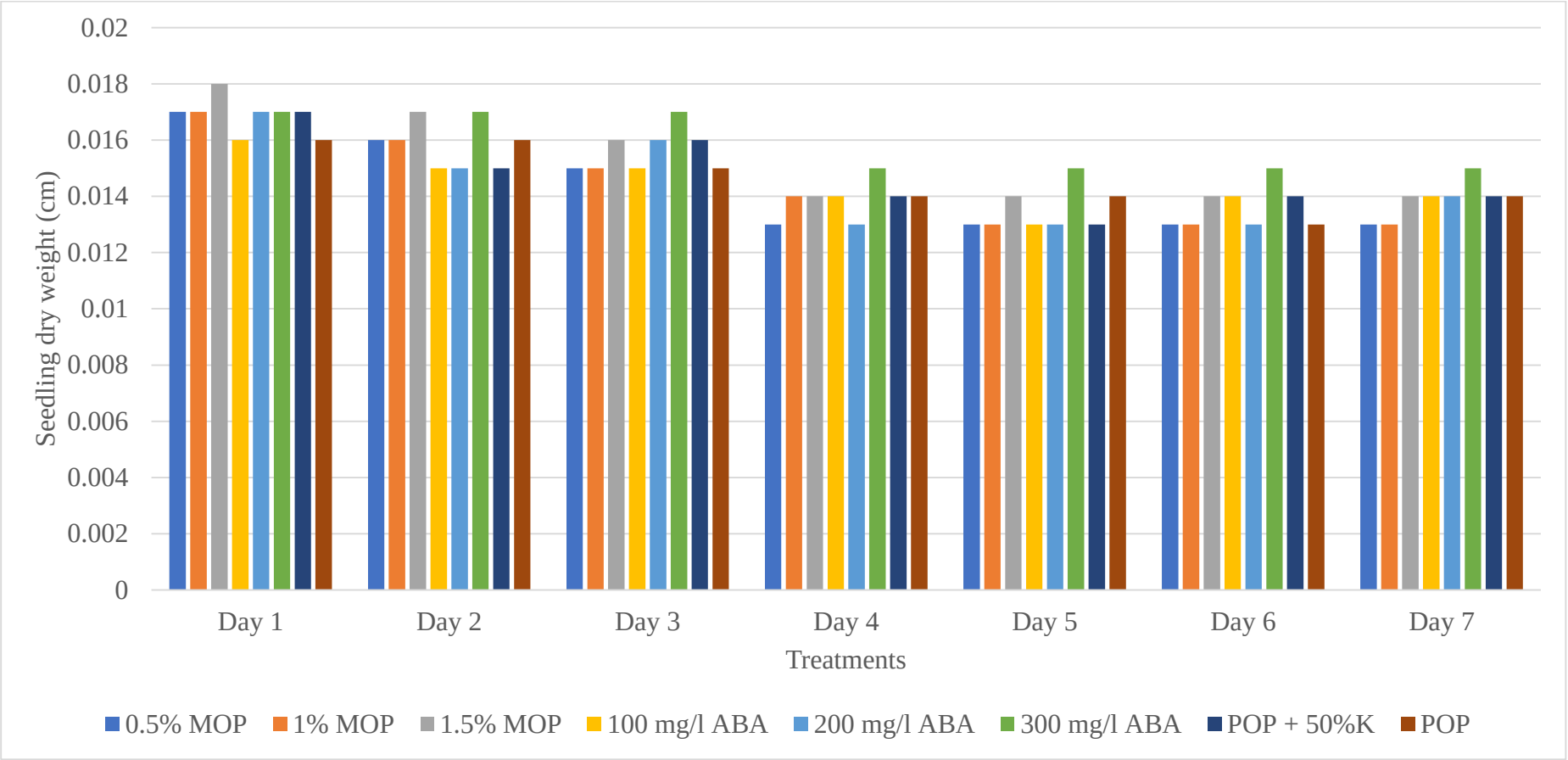


Fig. 10 Influence of potassium and ABA nutrient levels on dry weight of seedling during accelerated ageing

The decrease in seedling length seen with the headway of storage period brings about a decrease in seed vigour. Comparative outcomes to the current investigation were in concurrence with the findings of Aswathi (2015) in cowpea and Athulya (2019) in oriental pickling melon. The decline in seedling length could be related to seed ageing or deterioration, which is a gradual change caused by the accumulation of metabolites that eventually diminishes the seed vigour during storage (Hunje *et al*., 2019).

The seedling dry weight is directly related to its vigour. The result obtained from the present study showed that the highest dry weight of seedling was observed in treatment with 300mg/l ABA throughout the accelerated ageing period (Fig. 10). This may be due to higher nutrient accumulation in seeds during seed set leading to production of more vigourous seeds. The increase in dry weight as a result of ABA application was also reported by Travaglia *et al*. (2010).

The vigour index is an indicator of the potential of a seed lot. Vigour index I and II were used to determine the vigour index (Abdul Baki and Anderson,1973). Vigour index I is a product of germination per cent and seedling length, whereas vigour index II (Bewley and Black, 1994) is a product of dry weight and germination per cent. The result showed a decrease in the vigour over the ageing time. Vigour index I (Fig. 11) and II (Fig. 12) declined in all the treatments over storage but at the end of storage treatment 100mg/l ABA showed highest vigour and was found to be superior to other treatments. The rate of decline in seed vigour may be due to several factors like initial quality of the seed, uniformity of seed lot and storage condition. The loss of vigour can be directly related to the process of ageing. Similar to this, Gomathi *et al.* (2016) reported a decline in vigour of black gram seeds as a result of ageing.

The electrical conductivity (EC) of seed leachate is a measure of the seed's viability and vigour. More chemicals escape into the media as the membrane integrity of seeds deteriorates. The mechanical injury, poor membrane structure, and leaky cells could all be a factor. This causes more electrolytes such as amino acids, sugars and organic acids to be lost from the seeds increasing conductivity in the soaking water. Lower conductivity implies that the seeds are of higher quality and vice versa. Seeds that are less vigourous or more degraded have a slower rate of cell membrane repair

during imbibition for germination, releasing more solutes into the environment (Marcos-Filho, 2015).

According to the results obtained from the study the lowest electrical conductivity of seed leachate towards the end of ageing was observed in treatment, 300mg/l ABA (42.23μSm^{-1}). Electrical conductivity was fundamentally changing with treatments given during crop development. As the time of ageing progressed, the electrical conductivity increased regardless of treatments (Fig. 13). The increase in storage period cause lipid peroxidation and loss of membrane integrity of seeds leading to leakage of cell constituents. This increases the electrical conductivity of seed leachate. Similar results were reported by Nagendra (2017) and Athulya (2019) in oriental pickling melon under normal storage conditions. Accelerated ageing hastened up the process of seed deterioration and the increase in the electrical conductivity happened within few days that would take months to occur under normal storage. The higher rate of increase in EC was also seen in maize hybrid seeds compared to normal storage (Gajendra *et al.,* 2016).

Mean germination time is a factor that can be used to determine the performance and vigour of a seed lot and is calculated using the formula cited by Ellis and Roberts (1980). Mean germination time is a good indicator of how long it takes a lot to germinate. The faster the seeds germinate, the lower will be the value of MGT. The results showed an increase in mean germination time during the ageing process treatments indicating a decline in vigour of seeds and showed no significant difference among the treatments at the end of accelerated ageing.

The time taken for 50 per cent germination is also a vigour indicating factor that increases with the decrease in vigour. In the study, results have shown that the time taken for 50 per cent germination decreased over ageing and at the end of ageing period it showed no significance among the treatments. The shorter time it takes for 50 per cent germination indicates faster germination and greater vigour. This germination metric has the same ageing period pattern as the mean germination time. This is in consonance with Athulya (2019).

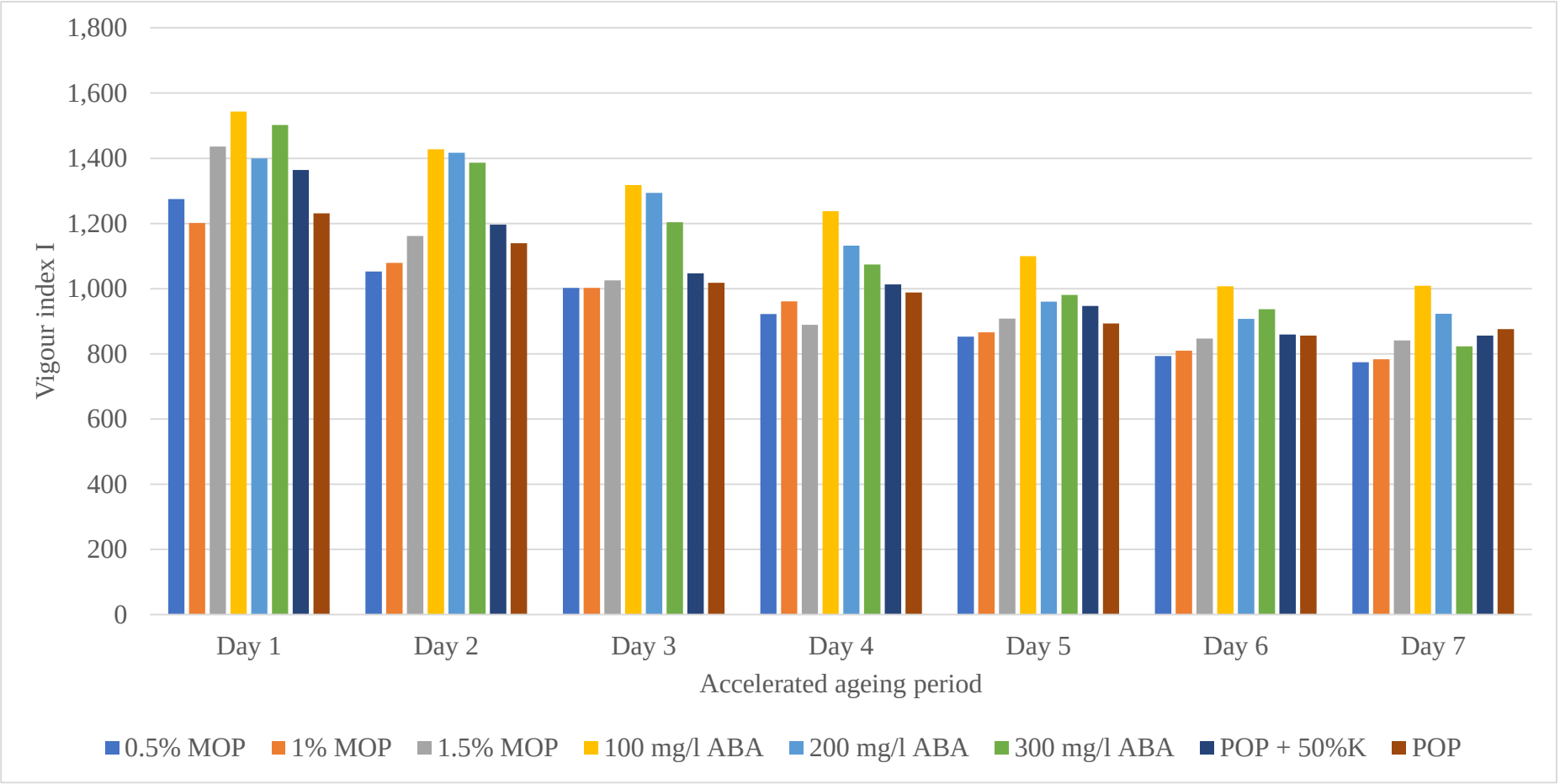


Fig. 11 Influence of potassium and ABA nutrient levels on vigour index I during accelerated ageing

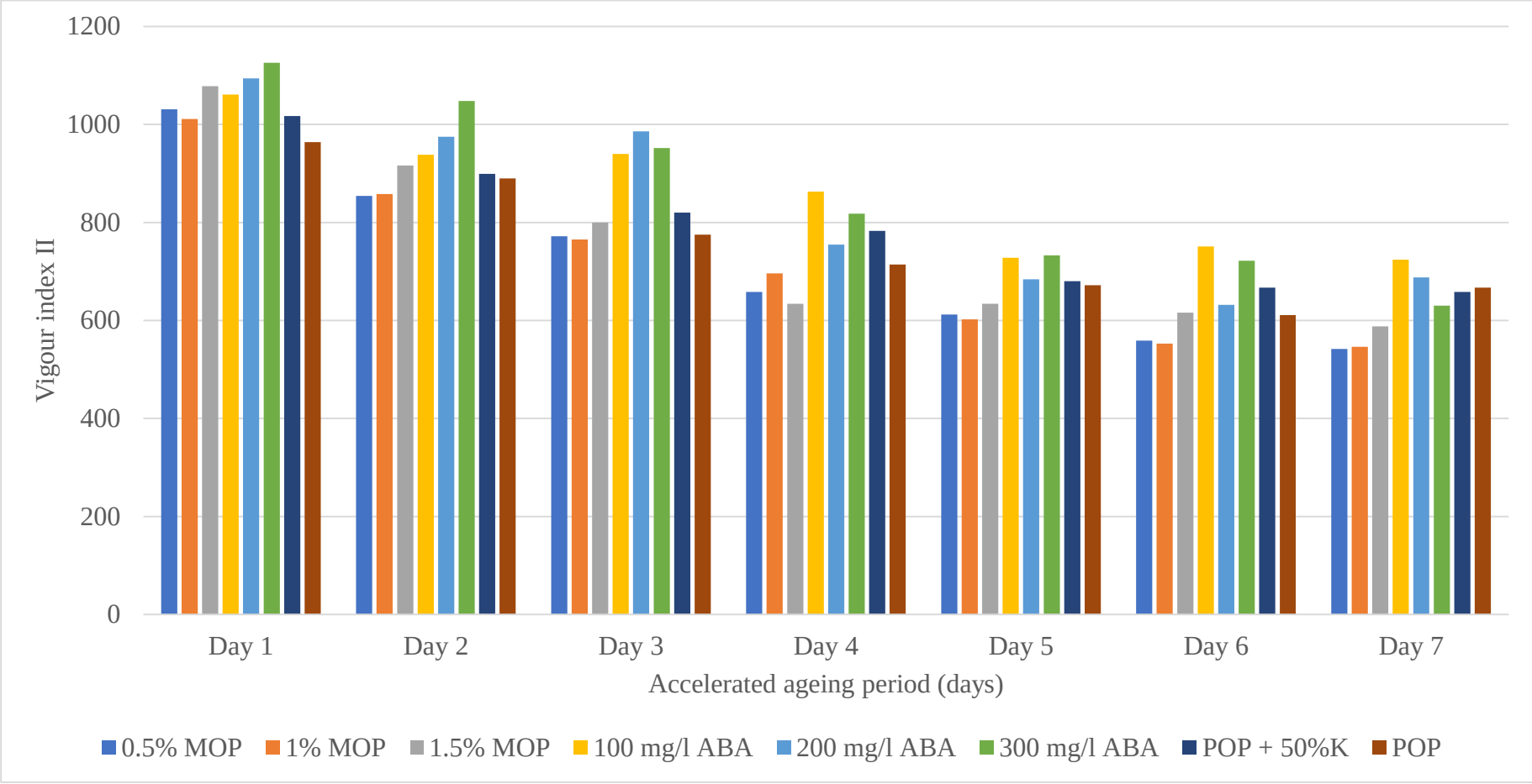


Fig. 12 Influence of potassium and ABA nutrient levels on vigour index II during accelerated ageing

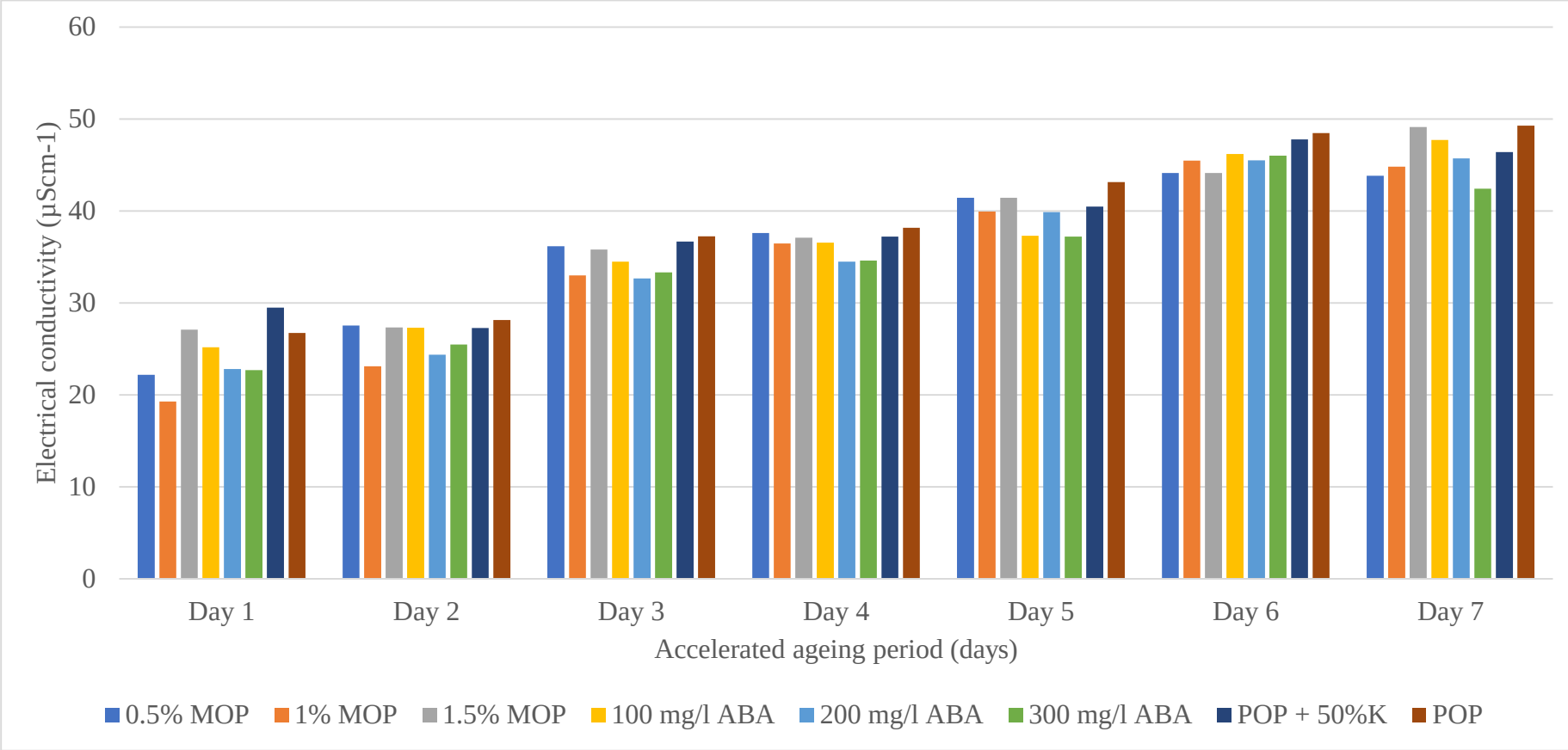


Fig. 13 Influence of potassium and ABA nutrient levels on electrical conductivity (EC) of seed leachate (µScm^{-1}) during accelerated ageing

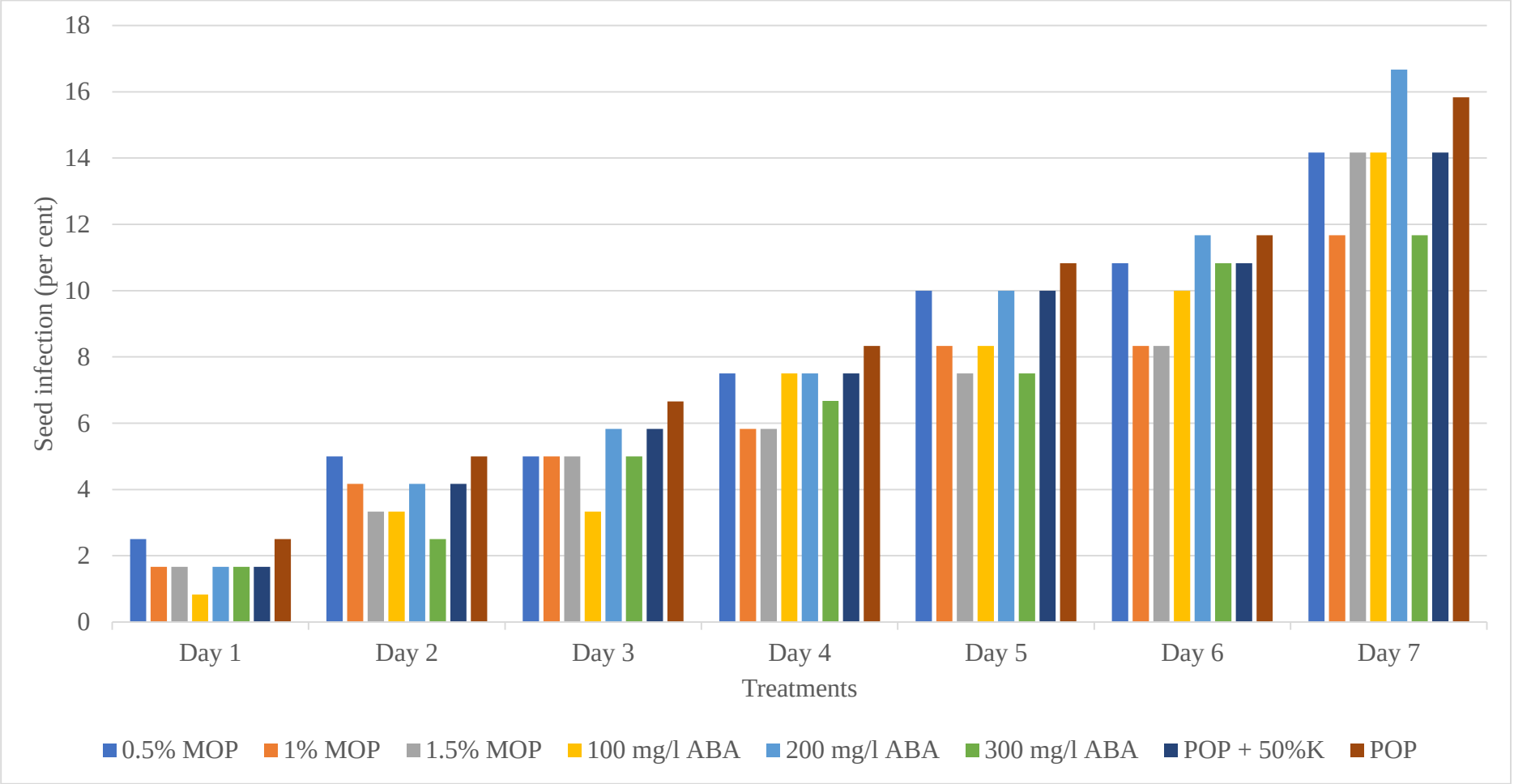


Fig. 14 Influence of potassium and ABA nutrient levels on seed microflora (per cent) during accelerated ageing (Blotter paper method)

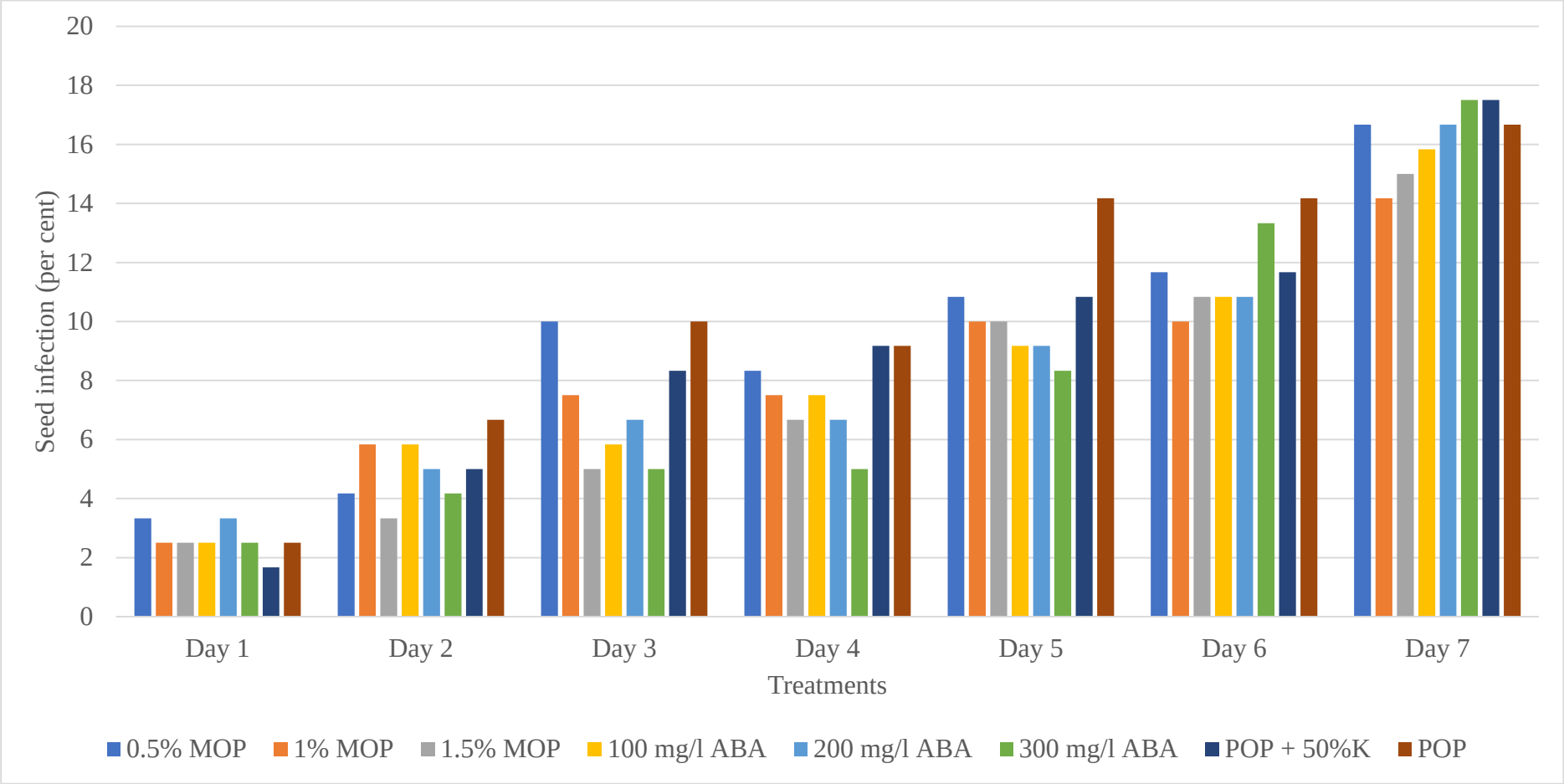


Fig. 15 Influence of potassium and ABA nutrient levels on seed microflora (per cent) during accelerated ageing (Agar plate method)

The infection per cent of seed was initially nil but as the seeds were stored under high humid conditions, it favoured the growth of pathogens on the seeds. The infection percentage increased over storage but did not vary significantly among the treatments.

Blotter paper (Fig. 14) and agar plate method using potato dextrose agar as medium were used to determine the fungal infection. The fungal infection varied from 0.83 per cent to 16.67 per cent in blotter paper method. The agar method showed higher percent of infection (Fig. 15). This may be due to the nutrient rich condition provided by the medium for proper growth of the pathogens. *Aspergillus niger* and *Pencillium* sp. were the organisms isolated from the seeds. Similar findings were reported by Aswathy (2015) in cowpea, Shobha (2016) in ash gourd, Nagendra (2017) and Athulya (2019) in oriental pickling melon.

The seed quality boundaries like seedling vigour, germination, shoot and root length diminished with delayed storage. Comparative examinations were shown in chilli by Navya (2016) and Sandhya (2016), in ash gourd by Shobha (2016) and Athmaja *et al*. (2018) and in oriental pickling melon by Nagendra *et al*. (2017) and Reshma (2018).

In the present study treatments with abscisic acid (300 mg/l ABA) and potassium (1.5 per cent MOP) were found effective in reducing the vivipary and the ABA treatments were found to be the more effective in reducing the vivipary and enhancing the seed quality compared to potassium treatments but the high price of the hormone ABA remains a problem. The cost of pure abscisic acid is high that it gives less profit to the seed growers compared to the use of potassium which is cheap and easily available. The benefit cost ratio when using potassium was found to be 5.5 which shows a very high return when compared to the use of abscisic acid where the benefit cost ratio is only 0.55. This shows that the foliar spray of potassium (1.5 per cent) is more beneficial to farmers compared to ABA unless a cheaper grade of the hormone is used. Several types of ABA-mimicking agents have also been developed to circumvent the limitations of ABA for use in diverse agricultural applications which can be tested for its efficacy (Gupta *et al*., 2020). Such chemicals may be used as an alternative to yield the benefits of ABA in seed production after its efficacy for the study is examined.

Among the treatments given, the treatment with 300 mg/l ABA was found to be the best in improving seed quality characters like seed yield and reducing the vivipary. This was followed by treatments, 200 mg/l ABA and 300 mg/l ABA. All the ABA treatments was found to be superior to the potassium treatments in the study. Among the potassium treatments given, foliar spray with 1.5 per cent potassium was the best followed by POP + 50 per cent additional K.

FUTURE LINE OF WORK

1. The present study confirms the impact of ABA and potassium on vivipary in oriental pickling melon variety Saubhagya. The study may be conducted on different varieties showing vivipary.
2. The hormone ABA used in the study is of pure grade and costly. The efficacy of different grades of ABA and ABA mimicking agents may be studied which may be cost effective.
3. Seed longevity tests were done by accelerated ageing method only. It may be done along with natural ageing under normal storage conditions and compared with accelerated ageing till the loss of viability.

Summary

6. SUMMARY

The present study on 'Impact of potassium and ABA application on vivipary and seed quality in oriental pickling melon (*Cucumis melo* var. *conomon* Mak.)' was conducted at the Department of Seed Science and Technology, College of Agriculture, Kerala Agricultural University, Vellanikkara, Thrissur during the year 2019-2021.

The impact of application of foliar sprays of potassium (0.5% MOP, 1% MOP, 1.5% MOP and POP + 50% K) and plant hormone abscisic acid (100 mg/l ABA, 200 mg/l ABA and 300 mg/l ABA) on vivipary, seed quality and seed longevity were assessed. Oriental pickling melon variety Saubhagya was raised in the field during the month of February 2021. The findings of the study are summarized below.

1. Effect of potassium and ABA levels on vivipary

- The best treatment for reducing vivipary was foliar spary of 300 mg/l ABA followed by foliar spray of MOP at 1.5 per cent.
- The seed quality parameters like seeds per fruit and seed yield per plant varied significantly. The best treatment that enhanced the number of seeds per fruit and seed yield was 300 mg/l ABA.
- Fruit quality characters like fruit length and yield varied significantly. All the abscisic acid treatments gave better results in improving both fruit length and fruit yield per plant. The potassium treatment, POP + 50% K also gave significantly higher fruit yield which was on par with the ABA treatments.
- The potassium content in the flesh and placenta of fruit was highest in the treatment with 300 mg/l ABA.

2. Seed longevity studies

- The seed quality parameters like vigour, germination, shoot and root length decreased with the increase in accelerated ageing period. An increase in electrical conductivity of seed leachate, mean germination time, seed moisture and seed infection per cent observed were also showing the decline in seed quality over accelerated ageing.

- The seeds collected from treatment 100 mg/l ABA showed the highest germination and vigour throughout the accelerated ageing and maintained minimum germination for seed certification prescribed by IMSCS (60.00% for melon) till day 4 of accelerated ageing.
- The highest dry weight of seedling and lowest electrical conductivity of seed leachate was seen in seeds extracted from treatment 300 mg/l ABA which indicates that it is the best among all other treatments.
- The seed infection was initially nil but it gradually increased over ageing period regardless of the treatments. The agar plate method showed higher infection per cent compared to blotter method. The pathogens detected were *Aspergillus niger* and *Pencillium* sp.
- The treatment with 300 mg/l of ABA was found to be the best among all the treatments for improving the overall quality and yield of seed.

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IMPACT OF POTASSIUM AND ABA APPLICATION ON VIVIPARY AND SEED QUALITY IN ORIENTAL PICKLING MELON (*Cucumis melo* var. *conomon* Mak.).

By

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ABSTRACT OF THE THESIS

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Abstract

Oriental pickling melon is a crop with cultural and economic significance in Kerala. Vivipary has been observed in this crop which reduces the seed yield and quality. Adjusting the planting time and application of some chemicals were found effective in controlling vivipary.

The study on 'Impact of potassium and ABA application on vivipary and seed quality in oriental pickling melon (*Cucumis melo* var. *conomon* Mak.)' was conducted at the Department of Seed Science and Technology, College of Agriculture, Kerala Agricultural University, Vellanikkara, Thrissur during the year 2019-2021 using the variety 'Saubhagya' to understand the effect of different levels of potassium and ABA on vivipary and the quality of seeds.

The crop was sown during the month of February (2021) following randomised block design with eight treatments and three replications. The treatments consisted two foliar sprays of potassium (0.5% MOP, 1% MOP, 1.5% MOP) at 50 per cent flowering and at an interval of two weeks after flowering, one foliar spray of abscisic acid (100 mg/l ABA, 200 mg/l ABA and 300 mg/l ABA) at 50 per cent flowering and a basal application of recommended fertilizers with 50 percent additional potassium (POP + 50% K). The treatments had significant impact on fruit and seed quality parameters. The fruit length and yield were enhanced in the ABA treatments. The potassium treatment, POP + 50% K also gave significantly higher fruit yield which was on par with the ABA treatments. Higher content of potassium in fruit flesh and placenta was observed in 300 mg/l ABA treatment.

The treatments were effective in controlling the vivipary. The abscisic acid treatment (300 mg/l ABA) was the most effective which reduced the vivipary up to 1.37 per cent followed by the treatment with potassium (1.5 per cent MOP) where the vivipary was 3.29 per cent. The number of seeds per fruit and the total seed yield was the highest in the treatment with 300 mg/l abscisic acid.

The seeds extracted from fruits harvested from the field experiment were used for the seed longevity studies. The storage potential was assessed with the help of accelerated ageing test. The seeds were tested for different quality parameters after each

day of accelerated ageing and the results showed that the seed quality deteriorated during the 7-days of ageing in all treatments. The seed quality parameters like vigour, germination, shoot and root length decreased whereas the electrical conductivity of seed leachate, mean germination time, seed moisture and seed infection per cent increased indicating a decline in seed quality over accelerated ageing.

The highest germination and vigour throughout the accelerated ageing was observed in seeds collected from treatment 100 mg/l ABA and it maintained minimum germination for seed certification prescribed by IMSCS (60.00% for melon) till day 4 of accelerated ageing. The highest dry weight of seedling and lowest electrical conductivity of seed leachate were observed in seeds extracted from treatment 300 mg/l ABA.

The seed infection did not vary among the treatments. Initially there was no incidence of any pathogens but as the ageing period advanced the seed infection per cent increased. The pathogens like *Aspergillus* sp. and *Pencillium* sp. were identified. The agar plate method showed higher infection per cent compared to blotter method.

From the study it can be concluded that the overall performance of the seed was found to be higher in abscisic acid treatment (300 mg/l ABA) indicating that it is the best treatment among all the treatments given.