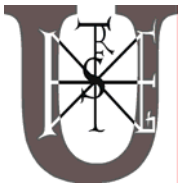

SZENT ISTVÁN UNIVERSITY

EFFECT OF PRE-SOWING SEED TREATMENTS FOR QUALITY OF CUCUMBER, PEPPER, TOMATO AND PEA SEED

PhD Dissertation

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CONTENTS

1. INTRODUCTION

Vegetable crops are the important component in the daily human diet all over the world. Well understanding of the vegetable food value and the increasing world population lead to increasing the area devoted to vegetable production. The population of the world is increasing at the rate of about 2 % per year. The world land is limited and the land that is best for agricultural purposes rather declines. Therefore, such a way to increase the vegetable production capacity is essential to meet the market demands. The basic of the high yield and the good quality of the vegetable is the good propagation material, the top quality, germinative seed.

Seed is the primary and essential starting point of a wide range of horticultural crops, including the majority of vegetables except those vegetatively propagated (i.e. Irish potato and sweet potato).

Seedling emergence and field stand establishment is one of the problems facing the growers, especially in early planting where adverse conditions are prevailed (low temperature and high soil moisture)

Seed germination and seedling emergence are affected by many factors such as: seed genotype, seed quality (seed viability and seed vigor) and the environmental conditions (moisture and temperature) prevailing during seed germination and subsequent seedling emergence, assuming that the seed is not dormant.

The demand for vegetable varieties of high seed quality lots that exhibit early, uniform, vigorous seedlings, early and high fruiting of good quality from each seed sown at optimum or adverse conditions has been increased greatly in recent years.

Delayed, erratic germination and emergence, poor stand, slow early seedling growth rate and non-uniform maturity are often limit crop production even under optimum environmental conditions **(Gerson and Hanma, 1978; McGrady and Cotter, 1984; Cavero et al., 1995)**. Sowing of low seed quality (low seed vigor) even at optimum conditions or sowing of high seed quality (high seed vigor) at adverse conditions, both of them usually germinate and emerge over a longer period of time. This slowed and reduced seed germination and subsequent seedling emergence in the soil was found to be the most important source of variation among plants in crop size or weight, maturity and producing of fewer normal healthy seedlings. The initial variation in plant size will increase as the crop mature **(Pill, 1995**). Also this wide spread of seed germination and seedling emergence increases the incidence of pre-damping off mortality caused by soil born fungi **(Ferris and Baker, 1990**), allows the weeds to be well established before the seedlings crop are large enough to be cultivated, compete with the main crop and moreover, they interrupt the cultural practices such as fertilization, chemical application and mechanical harvesting.

Planting of high seed quality at favorable conditions not only allows early and high quality products of high price, but also extend the harvesting period. Even stands also are important especially, in once-over harvesting operation, because the yield is related to the plant uniformity **(Nienhuis et al., 1983)**.

Early and uniform germination, adequate seedling emergence and establishment is critical stage for the commercial growth of many horticultural crops, particularly for direct-seeded crops because of reduced germination and subsequent seedling emergence at low soil temperatures. Crops indigenous to the tropical and subtropical are especially sensitive to chilling (i.e., physiological injury caused by exposure to non-freezing temperatures below 10 °C) that often occur under early season temperate conditions **(Bennett et al., 1992).**

Early planting favored the growers because it increases the yield per plant and price per unit of product. Planting during early spring, where cold and wet soils are common. Therefore, poor stand or stand failure would be expected because these conditions (low soil temperatures and wet soil) are favorable for the pathogen, but not for the plant in concern, a high incidence of disease is predicted. In the other word, under these conditions mentioned above, the pathogen is faster than plant, then the pathogen will win the race and the damping-off occurs especially in case of seed lots whose seeds take longer time to emerge (low vigor seed lot) (figure 1) (**Ferris and Baker, 1990**).

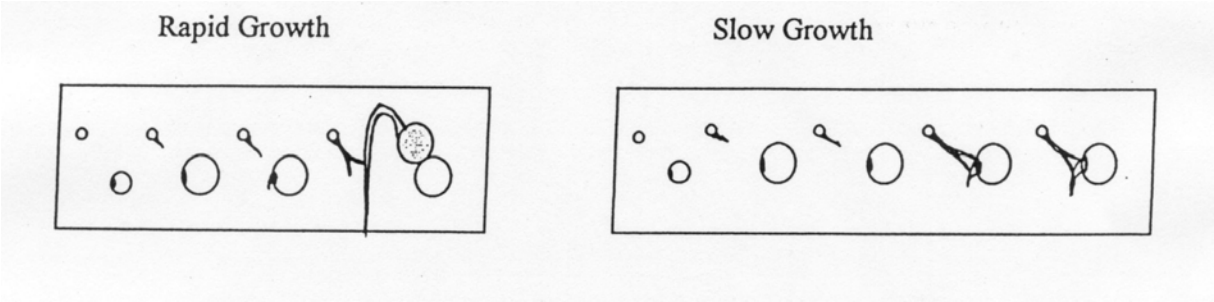


Figure 1. Illustration of a hypothesis explaining the effect of germination and emergence speed on the probability of damping-off due to Pythium ultinum. Left: rapidly germinating seed, which emerges and becomes resistant before being killed. Right: slowly germinating seed, which is killed before emergence. In each drawing, the small circle to the upper left of the left-most seed represents a sporangium of the pathogen (**Ferris and Baker, 1990**).

In cold, wet soils (unfavorable for seed germination and seedling emergence and growth, but favorable for germination and growth of the microorganisms in the soil, including plant pathogenic propagules) the interval between seeding, germination and seedling emergence is crucial to stand establishment and eventual yield. If this period is long, seeds and seedlings may be killed by soil pathogens.

Cold soil, prolongs the length of time elapsing of rapid leakage before the repairmen of the seed membranes, increases the rate of the exudates released by germinating seed **(Simon and Weibe, 1975**). In cold soils, the germinating seeds and the developing seedlings remain in the court of exudation for a greater period of time and reduced the development of the host plant. Therefore, the actual concentration of the exudates available for microorganisms at the infection vicinity could be greater than at higher temperatures **(Schroth et al., 1966)** and then, more damping-off should take place for seed lots whose seeds take longer period to emerge **(Ferrris and Baker, 1990)**. Furthermore, long-term exposure to low temperatures reduces seedling growth after emergence. **Leach (1947**) stated that many soil pathogens had lower optimum growth temperatures than the minimum temperature for seed germination. Thus, while seed germination was inhibited by low soil temperature, soil microorganisms could readily grow multiply and attack the seed.

Wet soils increase the quantity of exudation released by germinating seeds, more energy substrate be available to the pathogenic propagules in the soil, allow the motility of zoospores and increase their activities **(Flentje, 1964a, 1964b; Kerr, 1964)**. The effects of cold and wet soils are even more detrimental to germination and emergence when low quality or low moisture seed lots are planted **(Powell** and **Matthews, 1977; Woodstock, 1988)**. Several previous investigations indicated that germination speed of deteriorated seeds (low-quality seed lots) was lower due to copious amount of sub-cellular damage (great leakage), which must be repaired before germination could progress **(Powell** and **Matthews, 1977; Simon, 1984; Woodstock, 1988)**, then the incidence of the damping-off is increased.

Planting at low soil temperatures can be avoided in commercial productions by delaying planting time, but the economic incentives of early planting to achieve early season harvest or extend the growing season by planting under less than ideal conditions early in the season effectively eliminate the option of later planting as the sole method of improving crop emergence. The delay in planting to wait more favorable temperature conditions can be compensated for by using transplants, but transplants of chilling sensitive species are also susceptible to injury when exposed to chilling temperatures during production or after transplanting (Jennings and Saltveit, 1994). Sensitivity of the germinating seed to chilling decreases as the moisture content of the seed is increased before planting.

Various techniques may be taken to alleviate soaking and low temperature injury and then, reduce the amount of exudates available to the pathogen in the soil. These techniques include selection, breeding and manipulation of the environmental conditions.

Breeding for such varieties of high seed quality that germinate and emerge under less-than-optimum soil conditions is money and time expenses add to the production costs. In most production situation, control of environment condition (soil conditions) is

impossible. However, it is possible to control the vigor of the seed in order to improve germination, seedling emergence and finally successful stand establishment and economically yield.

Thus, any pre-sowing seed treatment capable of improving seed germination, seedling emergence and stand uniformity at optimal or suboptimal soil conditions by minimizing the period needed for emergence and stand establishment, reducing the exposure time to soil crusting, unfavorable temperatures, soil-born diseases and reducing the amount of seed leachates available to the pathogens or deprivation of the pathogens from energy substrates in the vicinity of the seed **(Alvarado et al., 1987**), would be of great value to insure successful stand establishment as practical alternatives to breeding or selection.

The effectiveness of any seed treatment depends on kind and concentration of used material, duration and condition of the treatment, kind of the crop, variety, seed quality and seed moisture at the time of treatment.

The responses of seeds to these pre-sowing seed treatments mentioned above were different. The objectives of this study are: 1) To improve the germination and seedling vigor, 2) to determine which of these treatments is most effective procedure in improving seed performance and 3) to observe variety and seed types differences and response to pre-sowing seed treatments.

In my thesis I studied the seed quality of the four important vegetable species, the followings cucumber, pepper, tomato, pea.

1.1. CUCUMBER

Cucumber (***Cucumis sativus*** L.) is one of warm season crops, indigenous to the tropical and subtropical. Cucumber plants required a warm climate for rapid and satisfactory production. Cucumbers are planted in early spring in the regions of the Mediterranean Basin, where climate conditions are favorable for early market. Whereas, the fresh cucumber may be limited to the late spring and late summer months in the northern production regions of the Europe and the United States respectively.

Cucumber, one of the most popular vegetable cops is used all over the world in different ways. Immature cucumber fruits are consumed as salad vegetables or pickled and also used as cooked vegetables. In South East Asia, cucumber foliage is also eaten as a salad and cooked as vegetables. In West India, immature gherkin fruits are used pickled, in some curry preparations and as cooked vegetables. In Japan, female blossoms are used as garnish.

The world cucumber and gherkin production in 1989-91, 1997, 1998 and 1999 was 17161, 26521, 26641 and 26662 thousand metric tons respectively and the cultivated area was 1171, 1545, 1565 and 1566 thousand hectares respectively. In Libya, the average cucumber production in 1989-91, 1997, 1998 and 1999 was 20, 8, 10

and 10 thousand metric tons respectively, while the cultivated land was 1, 1, 1 and 1 thousand hectares for the years 1989-91, 1997, 1998 and 1999 respectively. In Hungary, the cultivated area in 1989-91, 1997, 1998 and 1999 was 9, 7, 7 and 7 thousand hectares respectively, while the average production was 93, 119, 119 and 119 thousand metric tons for the years 1989-91, 1997, 1998 and 1999 respectively **(FAO, 1999)**.

Seed germination and seedling emergence of cucumber is affected by numerous factors, some related to the seed itself such as: inheritance factors, seed development and maturation conditions, fruit age (days from anthesis to harvesting), seed fermentation, seed drying, seed storage and handling. While the other factors are related to the environmental factors including temperatures, moisture (water quality and quantity) soil diseases, seedbed condition and seed pre-germination treatments.

Under optimum conditions, soil temperature is the limiting factor playing a major role influencing the rate and the percentage of seed germination and seedling emergence.

Generally, cucumber seeds will germinate at temperature range between 15°C and 35°C and the number of days of seedling to emerge ranges from 13 days at 15°C to 4 days at 35°C **(Nienhuis et al., 1983)**. For rapid germination, soil temperature should be 20°C or higher. The optimum temperature is 25-35°C. At 25°C, emergence occur within 2-4 days. At 20°C, it takes 6-7 days for seedlings to emerge. Temperature below 15°C, (13.9, 13, 12°C), depending on the cultivar, reduced or slowed seed germination and seedling emergence **(Nelson** and **Sharples, 1980; Nienhuis et al., 1983; Russo** and **Biles, 1996)**. While at 10°C no germination occurs **(Harrington** and **Kihara, 1960; Jennings** and **sltviet, 1994)**.

The minimum temperature requirement for cucumber seed germination and emergence are not the same for cucumber cultivars. However, the difference among cucumber cultivars in the ability to germinate and emerge at low temperatures have been observed **(Nienhuis et al., 1983; Reeggan, 1987; Kapitsimadi et al., 1990)**. Differences in germination performance also were observed among seed lots within cultivar. These within cultivar differences may be due to seed quality and pre-germination seed treatments.

Cucumber cultivars that exhibit early and uniform seedling establishment at low soil temperatures are needed from each seed sown not only because it could allow early production, but also extend the harvesting season. The even stands are also important in once-over harvesting operation, because the yield is related to the plant uniformity. Breeding for such cultivars are money and time expenses add to the production costs. Thus, the use of chemicals pre-germination seed treatments capable of improving germination and seedling emergence at optimal and suboptimal temperatures may be a useful tool to ensure successful stand establishment

1.2. TOMATO

Among the most widely grown vegetable crops in the world tomato (***Lycopersicon lycopersicum*** /L/ kars.ex Farw/Mill.), second after potato.Tomato is a warm seson crop , show a wide range of climatic tolerance, can be grown in the field wherever there are more than 3 months of frost- free weather. Tomatoes are more successful where the sunny period is long with light and evenly distributed rainfall and the daily temperature between 21-27°C and night temperature bentween 10-12°C. Night temperature should not exceed 18°C. Temperatures that are too high or too low will have bad effect on fruit setting and development. Ripe tomatoes are nutritionally valuable for carotene as pro-vitamin of vitamin A and vitamin C content. Both increase as the fruit ripens on the vine, but decrease when mature green fruits develop color off the vine. Low light intensity limits the fruit ascorbic acid content. The acid and sweet taste and unique flavors account for its popularity and diverse usage.

Tomato plant is a warm season crop. The minimum soil temperature is 10°C. The optimum is 30 °C and the maximum is 35 °C. Between 25 °C and 30 °C, seedling emergence can occur within 6-9 days.

Soil temperature has a great effect on seed germination speed. Although seedling emergence can occur within about 6 days at 25°C to 30°C, it takes about 2 weeks at 14°C. The minimum soil temperature 10°C, at which seed germination and seedling emergence takes 43 days. Maximum temperature is 35°C. **Resh (1980)** suggested temperature range of 18-21°C day/night for tomato seed germination and seedling emergence.

Ripe tomato fruits are eaten fresh, cooked, or processed. The processed forms include, juice, sauce, paste, dehydrated and puree. Green tomato fruits are pickled, candied and made into preserves.

The world tomato production in 1989-91, 1997, 1998 and 1999 was 75321, 86663, 90468 and 90360 thousand metric tons respectively, while the area cultivated was 2900, 3198, 3246 and 3254 thousand hectares for the years 1989-91, 1997, 1998 and 1999 respectively. In Hungary, the cultivated area was 2, 2, 2 and 2 thousand hectares for the years 1989-91, 1997, 1998 and 1999 respectively and the average yield was 21, 36, 36 and 36 metric tons for the years 1989-91, 1997, 1998 and 1999 respectively. In Libya, the average yield was 152, 155, 158 and 158 thousand metric tons for the years 1989-91, 1997, 1998 and 1999 respectively, while the area cultivated was 11, 8, 9 and 9 for the years 1989-91, 1997, 1998 and 1999 respectively **(FAO, 1999)**.

1.3. PEPPER

Pepper (***Capsicum annuum*** L.) is second most wildly cultivated crop among solanaceous fruits. It is widely spread vegetable all over the world. Pepper is a warm

season crop. It can tolerate extreme hot weather better than tomato and eggplant. Pepper plants are sensitive to cool wet weather.

The most notable character of pepper is flavor and whether sweet, mild or strongly pungent. Most European pepper is mildly pungent while those Hungarian are somewhat strongly pungent. The Capsaicin (C_{18} H_{22} ON_3) is the pungent principle in pepper contained in the septa and in the placenta tissue of the fruit but not in fruit wall. The seeds also contain small amount of pungent compound. Although, a single dominant gene controls fruit pungency, the growth environment and gene modification can affect pungency. In many countries, pepper fruits are considered an indispensable food. Pepper fruits are highly rated vegetables for human nutrition. Peppers are an excellent source of vitamins A and C. Red pepper fruits contain several more times pro-vitamin A (B-carotene) than green fruits and about twice as much as vitamin C (ascorbic acid). Pepper fruits are superior to tomatoes and eggplants in vitamin A and C content.

Pepper fruits are used in many different ways. They are eaten raw in salad, cooked preservations include salsa and processed by canning, freezing, pickling and as hydrated and powder condiment products. Pepper is used daily in every Libyan kitchen for preparation of different food items due to its pungency, spicy taste and beside the appealing color it adds to the food. Sweet pepper is more common in Hungary.

The world pepper production in 1989-91, 1997, 1998 and 1999 was 10788, 16353, 16712 and 17226 thousand metric tons respectively and the cultivated area in 1989-91, 1997, 1998 and 1999 was 1087, 1238, 1212 and 1210 thousand hectares respectively. The average Libyan yield was 17, 13, 14 and 14 thousand metric tons for the years 1989-91, 1997, 1998 and 1999 respectively, while the cultivated land in 1989-91, 1997, 1998 and 1999 was 1, 1, 1and 1 thousand hectares respectively. The average Hungarian production in 1989-91, 1997, 1998 and 1999 was 146, 141, 140 and 140 thousand metric tons for the years 1989-91, 1997, 1998 and 1999 respectively **(FAO, 1999)**.

Seed germination and seedling emergence is often slow and nonuniform even under optimum environmental conditions (**Gerson** and **Honma, 1978; Randle** and **Honma, 1981)**.

Seeds germinate very slowly in cool soils (15°C), the optimum temperature is 30°C and the maximum is 35°C. At optimum soil temperature (30°C), seeds germinate in 6-10 days. **Kotowski (1927)** reported that the rate of germination increased with temperature and no germination took place at less than 11°C. Genetic differences in the ability to germinate at suboptimal temperatures have been reported **(Gerson** and **Honma, 1978)**.

1.4. PEA

Pea (***Pisum sativum*** L.) is a cool season crop. Pea seed germination can occur over a wide range of soil temperatures. The optimum temperature is 20°C. The germination rate increases with increasing temperature. At temperature greater than 25°C, germination percentage decreases. Seeds germinate slowly at 16°C, for good healthy seedlings, the soil temperature should be at least 18°C. The optimum mean temperatures for pea growth are between 13°C and 18°C. Growth stops above 29°C.

Pea seeds are good source for proteins. The crop is grown for their succulent or dry seeds. Peas are used as fresh or processed. The processed forms include, freezing, canning and hydrated.

The world green pea production in 1998-91, 1997, 1998 and 1999 was 6701, 6876, 6898 and 6892 thousand metric tons respectively and the cultivated area was 857, 828, 831 and 821 thousand hectares for the years 1989-91, 1997, 1998 and 1999 respectively. In Libya, the cultivated land in 1989-91, 1997, 1998 and 1999 was 3, 2, 2 and 2 thousand hectares respectively, while the average yield in 1989-91, 1997, 1998 and 1999 was 6, 11, 11 and 11 thousand metric tons respectively. In Hungary, the average production was 300, 176, 170 and 170 thousand metric tons for the years 1989-91, 1997, 1998 and 1999 respectively and the cultivated area in 1989-1991, 1997, 1998 and 1999 was 32, 18, 11 and 11 thousand hectares respectively **(FAO, 1999)**.

Gumilevaskaya et al. (1997) suggested that a temperature of 28°C was best for pea radicle emergence and further growth of axes, these processes were retarded at 34 and 36°C and substantially or completely inhibited at 38 and 40°. Gumilevskaya et al. (1993) explained the negative effect of high temperature (38 and 40°) on pea seed germination was as the result of inhibition of protein mobilization in the axes. **Gumilevaskaya et al. (1997** stated that radicle emergence was less sensitive than the subsequent growth of axes. Initial imbibition at 40° retarded subsequent germination at 28°C.

2. LITERATURE REVIEW

2.1. Seed quality

Seed quality is a limiting factor affecting, not only germination capacity but also emergence potential, field stand and uniformity, seedling growth and finally crop productivity. The significance of seed quality is more pronounced under adverse seed sowing conditions.

Seed quality (seed viability and vigor) has a profound effect on seed performance, stand establishment and ultimately economical yield.

Seed vigor refers to the ability and strength of a seed to germinate successfully and produce normal seedling and optimum field stand under both optimum and suboptimal soil conditions and therefore, to maximize yield.

Seed vigor is gradually acquired as the seed develops on the parent plant reaches a maximum at the physiological maturity stage. Conditions inhibiting normal plant growth and seed development and maturation can reduce the maximum attainable vigor. Following physiological maturity, seed vigor is readily declined till being seeded in the following growing season or as seed deterioration progress by means of physical, physiological and pathogenic deteriorative processes. These deteriorative processes could be reduced or delayed to some extent, but can not be avoided. Seed deterioration is an irreversible process **(Copeland** and **McDonald, 1985)**.

The rate and the degree of vigor declining depends upon the environmental factors prevailing following the physiological maturity stage and throughout field maturity, harvesting, processing and storage conditions.

Abdul Baki (1980) suggested that the individuals in any lot might fall into 1 to 3 categories with respect to their vigor potential as follows; 1) seed that never reached high vigor, in this case the seed was harvested at an immature stage and never attained optimum physiological maturity. 2) Seed that attained and maintained high vigor, seed was developed from a healthy plant under optimum environmental conditions of seed development and maturity, was properly harvested at physiological maturity, carefully conditioned and stored under optimum conditions; 3) seed that attained vigor and then lost it partly or totally, the seed reached maximum vigor as in case 2, but lost its vigor through damage from delayed harvest, method of harvest, conditioning and storage under unsuitable conditions: this seed is called deteriorated. He suggested also that the more vigorous the seed lot, the fewer seeds it contains of categories 1 and 3 and the seed lot with no seed of categories of 1 and 3 would be high in germinability, field emergence, seedling growth and ultimately profitable yield.

Seed vigor definition as adopted by **AOSA (1983)** "Seed vigor comprises those seed properties, which determine the potential for rapid, uniform emergence and development of normal seedling under a wide range of field conditions".

Although seed quality is acquired during the growing season as each seed grows and develops, seed quality is influenced throughout the seed life starting from the quality and the genotype of the initial seed and the environmental conditions prevailing during the time of fertilization on the parent plant, pre-harvest, harvest and subsequent processing and postharvest conditions, including storage conditions, application of pesticides either at the field or at the store to the moment of seed sowing by numerous factors

Perry (1980) listed the major factors which may induce variation in seed quality, as: genetic constitution, environment and nutrition of the mother plant, stage of the maturity at harvest, seed size and weight, seed position on the mother plant, mechanical integrity, deterioration and aging and pathogen.

Brocklehurst (1985) listed the principal factors ,which influence seed quality throughout the life of the seed, from the time of fertilization on the mother plant until the moment of seeding, as: seed genotype, environmental conditions during seed development, seed position on the mother plant, harvesting timing and techniques, storage conditions and pre-sowing treatments.

Basu (1995) reported the factors influencing seed quality, as: preharvest conditions include, quality of the initial seed, soil fertility, temperature and photoperiod, moisture status of soil and pesticide or herbicide application; harvesting and processing conditions and postharvest storage conditions including: seed moisture and drying, storage temperature and oxygen pressure. Also plant density has an affect **(Mahajan et al., 1998; Aray et al., 1999)** and time of sowing and harvest **(Castillo et al., 1994; Mahajan et al., 1998)**.

The effect of any stress on seed yield and quality depends on many factors, including the stage of plant development during at which it occurs, its severity, duration and the crop kind.

Quality of the initial seed

Field stand is the essential first step in the growing of vegetables. The worst possibility, emergence failure that necessitate resowing, could mean a delay in harvest that leads to a drastic fail in market price. Uneven emergence reduces overall yield in wide-spaced crops leading to variability in harvest date. Lack of uniformity in the rate of emergence can also adversely affect the ability to harvest at one time.

Perry (1969) found that pea seed lots of low vigor level, germinated slowly in the laboratory, emerged poorly in the field and produced relatively small seedlings.

Low-vigor seed lots have a low oxygen uptake during early stages of germination, slow germination rate and seedling growth. They also exhibit poor retention of solutes when placed in water, either because of areas of dead cells on their cotyledons or because of presence of damaged cell membrane **(Matthews et al., 1980)**.

It has been found that the volatile substances (aldehydes) released from aged pea seed during germination stimulated spore germination of several common soil fungi. **(Harman et al., 1978, 1980)**.

Iqbal and **Smith (1996)** stated that pea seed germination percentage, field emergence percentage, root and shoot length and dry matter content were reduced and abnormal seedlings and electrical conductivity become higher with increasing severity of aging.

Sowing of dry deteriorated pea seed lots (low vigor seed lots), highly sensitive to environmental conditions during germination, had significantly highly imbibition injury, prolonged germination and poor germination uniformity **(Hosendi** and **Horakova, 1998)**.

Larson et al. (1998) demonstrated that seedlings produced from the older pea seed lots emerged more slowly than seedlings from the younger seed lots, the differences in the growth attributes diminished through out the growing season.

Taweekul et al. (1998) recorded that high vigor pea seed lots emerged well under wet and cold soil conditions (more than 90 %). In contrast, low vigor seed lots, depending on cultivar and vigor status, was emerged poorly (43-62%) and slowly resulting in lower plant establishment, low leaf area index, and leaf area duration. The number of plants / m^2 at final harvest for low vigor seed lots was reduced by 33-50%. This resulted in reduction of total dry matter and seed yield by 54-60% and 57-68% respectively.

Maternal plant development is vegetative in nature initially, eventually shifting to reproductive stage. Vegetative growth cycle presumably has little or no effect on seed vigor because the cell structures of the seed are not yet built or are the storage materials deposited **Dornbos (1995)** stated that drought and high temperature stress during vegetative development had little effect on the quality of harvested seed but affect yield.

Fougereux et al. (1997) found that water stress during the flowering period of pea plant did not reduce seed quality compared to treatment of irrigation as needed and reduced seed yield only slightly.

Reproductive stage comprises flowering, pollination, seedfill and seed maturation. Environmental stress can impact seed quality as a function of its severity, reproductive stage during which stress occurs and genetic constitution of the mother plant grown. Good

plant health during reproductive stages particularly, seed development, extremely important to insure maximum level of attainable vigor. It isUnlikely that early reproductive stage (flowering and pollination) would affect subsequent seed quality, as the primary structures of the seed are not yet being built nor are the storage materials being accumulated for later reproductive development.

Dornbos (1995) reported that environmental conditions during early seed development, after pollination, perhaps induce abnormal development and contribute to vigor loss.

Drought during seed development period usually interrupts seeds development and results in light and shriveled seeds. **Fougereux et al. (1997)** demonstrated that water stress during pea seed-filling decreased seed yield but the effect on seed quality was not significant. Irrigation during seed filling yielded higher individual seed weight and fewer variables than irrigation as needed treatment.

Mineral nutrients play an important role in plant growth, development, yield and eventually quality of harvested seeds. Adequate and proper balances supply of these nutrients to the parent plants are necessary for optimal growth; yield and vigor of produced seeds. Application of excessive or insufficient amounts of nutrients to the mother plants can cause toxicity, poor and/or abnormal plant growth, which in turn confer to inferior seed quality. While mineral deficiencies in seed are rare, they do occur and can influence the yield of the crop produced by seed under certain condition.

Nitrogen

Harrington (1960) reported that severe nitrogen deficiency in pepper resulted in very low seed yield and a major proportion of the seed was abnormal.

Austin (1972) suggested that the reduction in sugarbeet germinability of high-nitrogen fruits could be due to copious accumulation of germination inhibitors in the fruits of high nitrogen-plants. On the other hand, significantly better pre- and post germination of okra seeds was observed from plants grown under high nitrogen level in the field than seeds from plants not supplied with additional nitrogen fertilizer (Basu, 1995)

George et al. (1980) concluded that the combination of higher nitrogen and phosphorus (.56 g n / pot and .24 g p / pot) applied to tomato mother plant increased the germination and seedling emergence rates of the progeny. In their second experiment, they found that increasing of mineral nutrition of (N .28 g, P .36 g and K .93 g per pot) produced a significant improvement in seed quality.

Padrit et al. (1996) reported that application of nitrogen significantly improved pea seed vigor as conductivity value and hollow heart percentage were reduced and post accelerated aging germination was increased.

Phosphorus

Phosphorus reserves (phytic acid) in the seed have very significant roles in the metabolism of germinating seeds. In addition to its nutritional role, it might act as a natural antioxidant.

Austin (1966) found that the pea seeds harvested from plants grown under sever phosphorus deficiency, were phosphorus-deficient, produced smaller plants and yielded lower yields than seeds produced from corresponding non-deficient-phosphorus pea parent plants.

George et al. (1980) concluded that higher levels of phosphorus supplied to tomato parent plants increased the total seed yield.

Padrit et al. (1996) revealed that phosphorous application improved pea seed vigor through reducing hallow heart and increasing post accelerated aging germination. Absence of nitrogen or phosphorous significantly increased hallow heart levels in seeds from the top pods than those from the bottom pods. Hallow heart level did not differ with pod position when an adequate amount of nitrogen and phosphorous were applied (200 kg nitrogen plus 22.5 kg phosphorous / hectare).

Potassium

Extreme potassium deficiency in pepper resulted in a higher percentage of abnormal seed and lower pre- and poststorage germinability than seeds from corresponding nondeficient-potassium mother plants **(Basu, 1995**).

Calcium

Calcium plays an important role in membrane integrity. Calcium-deficient seeds exhibited increased electrical conductivity value, indicating that membrane integrity was impaired **(Dornbos, 1995)).**

Leggatt (1948) stated that pea seed produced from a boron deficient land produced abnormal seedlings when planted in sand.

2.2. Temperature

Extreme temperatures are not preferable to growth and development of the seeds. **Halligam (1986)** observed that at high temperature and seed moisture of 70-80 %, the incidence of hollow heart was the highest and it increased with the length of exposure to high temperature. At pod wrinkle stage (70-80% moisture content), exposure for 5 days resulted in 20 % of the seeds had hollow heart. Over 80 % of the seeds had hollow heart symptom after 5 days exposure to daily mean temperature of 32.5°C.

Damage from excessive heat during seedfill can dramatically decrease seed quality **(Dornbos, 1995**).

2.3. Photoperiod

The timing and the duration and the quality of light experienced by the mother plant can have a marked influence on the dormancy and the quality of harvested seed.

Photoperiod and temperature treatments given to fruits detached from cucumber and tomato mother plants, influenced the germination of the seeds. This modification in germination within these fruits was partly due to changes in phytochrome content and alternation of the hormone status of the fruits and seeds (Gutterman and Porath, 1975; Gutterman, 1978; as quoted by **Thomas** and **OToole, 1980)**.

2.4. Soil moisture and herbicides

Adequate soil moisture and regulated water supply is essential and depends, depending on the requirement of the crop and stage of development, provides seed of good quality growth. Rainfall and irrigation are the two major sources of soil water for field crops. Both of them are main determinants of seed quality. While irrigation can be controlled, rainfall, although vitally important for successful farming, is often responsible for poor seed quality.

For good seed quality, a relatively dry climate during the ripening stage is desirable for most crops, except for rice. Too wet soil may conduce to production of poor seed quality, especially in combination with a high relative air humidity. Even with rice, a dry climate during ripening stage produces seeds of good vigor.

Extreme drought stimulates premature desiccation and reduces the seed quality in terms of pre- and poststorage germinability **(Basu, 1995**).

Preharvest rains can cause very serious injury to seed quality in terms of stimulation of pathogen infection, possibility of sprouting or partial germination of nondormant seeds, which were not compatible with subsequent drying and reducing of storability. As such, seeds badly affected by preharvest rains should not be stored for seeding purposes **(Basu, 1995**).

Pesticide and herbicide applied to the soil or to the growing plants may impact the development of the seed and affect its quality, especially if the concerned herbicide or pesticide is not easily biodegradable. Some fungicide may interfere with electrical conductivity readings of the soak water **(Basu, 1995**).

2.5. Maturation process and harvest maturity

Maximum seed quality is attained by physiological maturity. While, it is desirable to harvest the seed as possible at the physiological maturity, but, practically, one must wait till harvest maturity, when seed moisture content is sufficient low to permit mechanical harvest with no damage to the seed.

Seed moisture loss is a physical process controlled by air relative humidity and temperature, wind blow and impedance of pod or husk.

Exposure of seed in the field during seed maturation process to a wide range of temperature and moisture fluctuation and pathogen infection make seeds more vulnerable to rapid vigor loss. Warm and humid weather conditions can stimulate the activity of plant pathogen, reducing seed quality **(Dornbos, 1995**).

Horcika and **Hosnedi (1997**) recorded that the lowest value of electrical conductivity test was coincided with maximum laboratory germination of pea seeds.

Khattra et al. (1997) reported that in pea, the maximum physiological maturity acquired depends on the cultivar. They also found that maximum dry weight, germination potential and seed vigor as measured by root and shoot length and seedling dry weight were attained in the 35 and 46 days after anthesis. The contents of starch, proteins, DNA and RNA in the seed were comparable at physiological and harvest maturity. Harvesting at physiological maturity appeared to be feasible.

Seed may never achieve its maximum vigor if it is harvested prematurely. Seed maturity at harvest is important to subsequent germination in many crops **(Biddle** and **King, 1978**; **Edwards** and **Sundstrom (1987**); **Cavero et al., 1995)**.

Matthews et al (1980) reported that harvesting immature pea seeds containing high moisture level is a cause of the production of low-vigor seeds and more physical and mechanical damage will be occurred to their soft testae in terms of coat cracks during harvest and process operations, facilitating rapid imbibition and leakage. Under storage these seeds deteriorated rapidly.

Biddle (1980) pointed out that the damage from mechanical threshing was significantly greater in pea seeds harvested at very immature stage.

Drying pea seeds at an immature stage of their development is a reason of low-vigor seed produced **(Matthews et al., 1980)**. Such a case occurred in countries like New Zealand, Hungary and Canada, where many of the pea seeds are grown, because the dry summer favor the production of seed free of seed-born diseases. This could be due to the effects of the very dry climate early in seed development.

Fruit ripening at the time of seed extraction has been recorded as a factor that can affect pepper seed quality and germinability behavior.

Randle and **Honma (1981**) pointed out that the riper the pepper fruit that provided the seed, the earlier germination occurred. Similarly **Quagliotti et al. (1981)** found that fruit postripening of pepper could be interesting, especially when fruits were harvested not fully ripe. **Edwards** and **Sundstrom (1987**) observed that seeds obtained from fully ripe pepper fruits had greater germination rates than those taken from orange-colored fruits.

Cavero et al. (1995) stated that seeds extracted from pepper fruits harvested at full ripeness and allowed to overridden had a better germination behavior than seeds extracted from fruits picked at half ripeness even when allowed to ripen or overripe. Therefore, picking half-ripe pepper fruits for seed extraction should be avoided, even when the fruits are allowed to overripe.

Edwards et al (1986) recorded that cucumber seed germination may exceed 90 % in seeds collected from 28, 35, 42 day-old fruits (days after pollination). Greater fruit maturity generally was associated with significantly more rapid rates of germination. Keeping fruits on mother plants till complete ripening resulted in accumulation of germinating inhibitors. Fermentation duration and storage period had significant affect on the ability of seeds to germinate at certain temperatures. For example fresh seed (1-week) showed no germination at 15°C and only a low percentage at 20°C, but achieved up to 90% germination at higher temperature (25°C). After 6 months storage, seeds exhibited substantially improved germination at 15°C and 20°C, but diminished at 25°C, particularly for those seed lots that had received no or short fermentation period (0 and 1 day). After six months storage, germination rate at 20°C was accelerated from all fruit maturates. Seeds from 4 and 6-week fruit maturity exhibited significantly more rapid rates of germination for fresh seeds and after 6 months of seed storage.

Nerson and **Paris (1988**) found that cucumber seeds cv. Bet Alfa from the youngest fruits (21 days past anthesis) did not germinate probably related to the seeds being collected while their embryos were still developing. While 35 day-old fruits were sufficiently mature for maximal germination percentage and rate. Fermentation did not affect the germination percentage of seeds from the most mature cucumber fruits, but did increase and accelerate germination in seeds from immature (28 dpa) fruits and significantly decreased the electrical conductivity in leachates from 28 dpa seeds. The electrical conductivity and leakage of potassium, sodium, proteins, nucleic acids and soluble sugars were decreased with increasing fruit age and fermentation.

Nerson (1991) concluded that cucumber, NK 2002, a pickling-type cultivar seed reaches full germinability by 35 dpa. Fermentation and drying was important for improving germinability of immature seeds. Washing of cucumber seeds increased the rate of germination but not the percentage. They also reported that the seed coat in the cucurbits

completed its growth earlier than did the embryo and this probably played an important role in inhibiting germination of immature seeds. Removal of the seed coat increased germinability of immature seeds. Germination rate was a more sensitive indicator of seed quality (germinability) than germination percentage.

Nandeesh et al. (1996) reported the highest seed quality in cucumber cv. Green Long fruit harvest 40 days after anthesis or harvested 20, 30 days after anthesis followed by post-harvest ripening for 15 days. Seed harvest 40 or 50 days after anthesis did not benefit from post-harvest ripening.

Demir et al. (1999) concluded that cucumber cv. Beta Alpha seeds can be harvested between 39 and 43 days after anthesis with high germinability and vigor. **Kwon** and **Brandford (1987**) reported that tomato seed germination increased gradually as the age of the seed increased inside the fruits till typical red mature color (60 days after anthesis) then its germination declined

Position of the seed on the mother plant plays an important role in the quality of the harvested seed. Considerable differences in germination and dormancy characteristics can occur between seeds harvested from different plants in the same environment and from different flowers on the same plant.

The effect of position of the seed on the mother plant on seed and seedling performance has been reported in many crops. In most cases depending on the species, the heaviest seeds were produced from the first-formed flowers, and generally, such seeds germinated faster and produced larger seedlings than seeds produced from later flowers, but with pepper this was not true.

Castillo et al. (1993) observed that the hollow heart was greatest in seeds collected from pea pods at the bottom of the plants grown at the highest density (200 plant / m2). Electrical conductivity was highest in seeds harvested from pods at the top of the plants regardless plant population.

Seed is harvested as soon as possible after physiological maturity. Care must be taken to harvest the seeds as feasible because environmental conditions that promote slow drying and growth of pathogens frequently occur during the fall.

Whether harvesting and processing operations are performed manually or mechanically, they may affect the quality of produced seed in terms of physical or mechanical damages.

Physical or mechanical damages to the seed can be occurred during harvest, and post-harvest conditioning (threshing, cleaning and packaging), and movement of seed from bin to bin, improper storage and careless handling of seed bags. Damages may be obvious, in case of cracked and split or covert, as physiological bruises to the embryo or seed testae

fractures. Large–seeded legumes were found practically prone to damage **(McDoland, 1999)**.

Seed moisture levels are very important factor determining the degree of the damage during any operation. Seed moisture levels that are too low cause extensive cracking and splitting. Seed moisture that is too high cause less obvious bruises. The major visible injuries are immediately reflected on germinability, the effects of minor invisible damages become apparent upon storage, resulting in a significant reduction in the vigor of stored seeds.

Damaged seed coat promotes rapid exudation of cellular contents upon imbibition. The exudates not only represents a loss of energy and building-block resources necessary to drive vigorous emergence, but these exudates may further promote the germination and sustain the growth of soil microorganisms, capable of pathogenic infection, resulting in pre–emergence seedling mortality.

Hand-harvested pea seeds leached less solute than seeds collected, and handled mechanically **(Flentje** and **Saksena, 1964; Bedford, 1974)**. Although manually harvesting and processing operations are safer, it is more expensive. Therefore, mechanical operations are taking place, especially for large-scale seed production. Mechanical operations include; harvesting, threshing, cleaning, packaging, etc. could be a major cause of poor pre–and poststorage germinability.

Moore (1972) listed the mechanical damages detected in standard growth tests as: detached seed structures, breaks within structures, abnormally shaped structures, scar tissues, infections, restricted growth, uneven placement of cotyledons, unnatural shrinkage of cotyledons, abnormally developed hypocotyls and primary roots and dwarfed, and twisted roots with blunt tips of dull appearance.

It has been cited that no high vigor but low vigor seed lot was obtained following heavy rain during the harvest period. Rainfall shortly before harvest was reported to raise seed moisture content, reduce germination of harvested pea seed **(Flintje, 1964a)** and increase the predisposition of pre-emergence mortality.

Biddle and King (1978) reported a poor pea seed quality as indicated by electrical conductivity tests, when harvested at too low moisture levels, resulting in seed coat damage. **Biddle (1980)** found a high number of cracked seeds when harvested at both high and low moisture content 70% or 18-19%, compared with seeds harvested at 30–40 % moisture content. The electrical conductivity of the both high and low seed moisture content, was high, while for the intermediate seed moisture content (30-40%), it was low. The seeds at high moisture content (70%) are at very immature and their seed coats are very soft and easily damaged during harvesting and threshing operations. At very low seed

moisture content (18-19), seed coats are brittle and easily injured too. Mechanical operations increase the incidence of the injury.

Biddle (1980) indicated that the number of seeds with cracked seed coat increased during threshing as seed moisture content increased or decreased at harvest operations. This might be due to that at high or low seed moisture content, the testae are very soft or very brittle respectively. In both cases, the seeds are easily damaged. **Matthews et al. (1980**) reported that the high incidence of testa cracks caused by the mechanical harvesting and handling operations of the seeds at too low seed moisture content, is the most likely cause of low vigor in pea seeds.

Castillo et al. (1994) found that delaying harvest until 25-15% seed moisture content resulted in higher hollow heart incidence and higher electrical conductivity in seeds harvested from the early sowing as compared with the late crop. They also reported that seeds handling with 24 % moisture content at harvest showed 89-100 % of their cotyledons was completely stained, mean conductivity of 10.8-14.4 μ mho cm^{-1} g^{-1} and lowest percentage of seeds with cracks as compared with seeds with 67.3 or 6.1 % moisture level. They emphasized that the main cause of damage was due to rapid imbibition through cracks.

2.6. Date of sowing and plant density

Castillo et al (1993) pointed out that the incidence of hollow heart was increased as the population density increased (200 plants/m^2). Depending on cultivar, electrical conductivity also increased with increasing plant population.

Castillo et al (1994) reported that date of sowing and harvest might influence pea seed quality. They found that seed vigor was reduced as both conductivity and hollow heart were greater and expected field emergence was significantly lower in seeds from the early sown crop (November sowing). When harvest was delayed until 25-15 % moisture content, hollow heart incidence and conductivity were higher in seeds from the early sown crop compared with the late crop. November sowing seeds encountered greater climatic extremes such as: temperature, rainfall and relative humidity, during their maturation in January than those from the December planting which matured in February.

Mahajan et al. (1998) found that the highest pea seed vigor index was produced at 45×10-cm spacing in monsoon growing season. **Aray et al. (1999**) recorded the highest pea seed germination percentage (96.33%) and greatest seed quality index (772.75) for the 45 × 5 cm spacing, while greatest seed yield was obtained with closer spacing (30 x 5 or 45 x 15 cm).

2.7. Post harvest conditions

Post harvest operations include threshing, drying, and cleaning, packaging pre-storage seed treatments and storage. Care must be taken to avoid any damage to the seed during seed handling operations as feasible.

The longevity of dry-stored orthodox seeds depends on seed moisture contents, storage temperature and relative humidity, oxygen presser and to some extent on the integrity of the seed coat at the time of harvest and subsequent operations. Lowering of seed moisture and temperature generally extend seed longevity. Replacing oxygen by inert gases in hermetically sealed containers give better post storage seed quality than seeds sealed in air. Seed storage reduces vigor more rapidly than viability.

Seed moisture level is a decisive factor affecting seed quality. The proper seed moisture level for harvest is not that for safe seed storage. Thus, seed drying to a certain level is very crucial operation, should be performed very well in terms of drying rate and level, depending on the seed kind in concern. Seed moisture level plays an important role in maintaining seed quality during storage period. Seeds are harvested as soon as possible following physiological maturity with a moisture level neither too high nor too low to avoid any damage to the seed coat.

Storage of orthodox seeds at high moisture level is detrimental because it increases the activity of hydrolyzing enzymes and germination may occur in the store. At high moisture content, seeds are subjected to attack by fungi. High moisture is more detrimental, when oxygen is not readily available, as the products of anaerobic respiration such as: ethanol and acetaldehyde are toxic to the seed. At high moisture, the respiration rate of the seeds and the associated organisms increases, and then the temperature around the seeds increases too. **Wilson (1995**) reported that storage at high moisture level, dropped suddenly both vigor and viability drop off suddenly.

Seed drying to a certain level is a major decisive factor determining its quality, especially if the seed is going to be stored for a period of time. Too rapid drying reduces the seed quality. Optimum rate and level of drying differ with seed kind.

Excessive seed drying is undesirable because it causes physiological deterioration. **Schultz et al., (1962**) found that at 5% seed moisture content, the monomolecular water layer surrounding the macromolecular in seeds ceases to be continuous, and that may enhance lipid peroxidation activity.

Excessive pea seed drying damaged also the embryo itself **(Matthews et al., 1980**). On the other hand, **Shen et al. (1998)** reported that drying to a low moisture levels (5-1%

before storage had no imbibitional damage to pepper seeds. **Zeng et al. (1998**) stated that drying seeds to water content as low as 2.4% could slow the aging damage in cucumber seeds. **Thuy et al. (2000**) reported that neither germination nor electrical conductivity were differ significantly among the selected drying methods to 10 % seed moisture level in pea seeds.

As seed matures, the organelles start to lose their structural organization in various degrees and become less active metabolically **(Abdul-Baki, 1980**). By the time the seed moisture level reaches below 20 % (14-12% or below), characteristic of dry seed, the cell and organelles show signs of shrinkage and alternation of membrane permeability, becoming unable to function as selective permeability barriers, then the influx and efflux of solutes are more rapidly to a certain period of time **(Simon** and **Raja Harun, 1972; Simon, 1974, 1978; Thomson** and **Blott-Aloia, 1982; Wilson** and **McDoland, 1986)**. Data from reviewed literatures so fare did not support the hypothesis suggested by **Simon** and **Raja Harun (1972)** and **Simon (1974**) that membrane lipid in dry seeds are presented in the hexagonal state instead of bilayered conformation at hydrated phase. But the membranes are intact, but the membrane bilayer components are not in proper orientation and arrangement **(Thomson and Blott-Aloia, 1982). Larson (1986)** and **Perry and Harrison (1970**) theorized that in dehydrated seeds the membrane is intact, but that it is boarched by rapid inflow of water. **Simon** and **Raja Harun (1972)** and **Simon (1974**) did not support the boarching of the cell membranes of dry seed by the inrush of water. Dry seed, prepared for storage, is metabolically active, in which enzymes-catalyzed metabolic reactions should be at very low ebb. Various pre-storage seed treatments were found to prolong and maintain seed quality and life or to render the seed immune to accelerated aging, either by dry treatments which do not use water or by wet treatments in which seeds are periodically hydrated-dehydrated cycles during storage. Dry pre-storage treatment techniques, employing organic solvents such as: dichlorometane and acetone have been successfully applied for introducing antiaging chemicals. These chemicals include natural and synthetic antioxidants and free radical controlling agents. The chemicals introduced into the seed, in order to reduce the rate of aging process has been successfully used in pepper **(Woodstock et al., 1983)** and in pea **(Gorecki and Harman, 1987).**.

Yang and Yu (1982) avoided the problems of toxicity of antioxidants by using antioxidants that could be removed after storage. They found that inclusion of the volatile antioxidant (di-teri-butyl sulfide) into the accelerated system resulted in an increase of 30 % germination over untreated aged pea seeds.

Treatment of seeds with very low concentration of alcohol, methanol, ethanol and isopropanal resulted in increased storability of pea **(Bhattacharya and Basu, 1990)**.

Calcium oxycholride (slow releases chlorine) can be applied for treating high-vigor seeds of pea seeds for extending vigor and viability in storage.

Meng et al. (1996) found that coating of cucumber cv. Ting 4-3-1 seeds with Ca Cl_2 significantly improved the germination of aged seeds at 42°C and 100 % RH and tended to promote germination in aged seeds.

Periodic hydration-dehydration cycles treatments of orthodox seeds during storage such as dipping, moisture equilibration, moisture sand conditioning, soaking, spraying, uptake from osmotic media and by vapor-phase hydration, all followed by drying-back, significantly ameliorate the effect of seed aging. This technique resulting in higher post-aging germinability, greater resistance to future accelerated aging and extending the life of the seed **(Basu, 1995**). The significance of the treatment depends on both, the kind and the vigor of the seed at the time of treatment and period of soaking. Harvest-fresh seed with a very high vigor is not responsive to the hydration-dehydration treatment.

Immediately after hydration-dehydration seed treatment, there is no improvement of germinability, but after aging, there are a large improvements, suggesting that the efficacy of the hydration-dehydration is the removal of toxic metabolites, counteraction of free radical and lipid peroxidation or prevention rather than a curative action.

The hydration-dehydration has significantly temporary reduction in the leakage of metabolites (before drying-back). This is may be due to the proper orientation and arrangement of the membrane bilayer components. But after drying-back, the leakage would be similar to the untreated control seeds, indicating the temporary nature of the beneficial hydration effect whereby the membrane reverts back to the original phase upon drying. **(Wilson and McDoland, 1986).**

Study by **Savino et al. (1979**) demonstrated that soaking of tomato, carrot and pea for 18 hours followed by drying-back introduced resistance to subsequent accelerated aging damage. They attributed that to the possibility that substances such as some free radical producing mechanisms were removed by the hydration treatment.

Post-aging germination percentage, seedling growth and crop performance in the field of hydrated-dehydrated treatment seeds have been found to be superior to the untreated seeds **(Basu, 1995)**. Beneficial effects of hydration-dehydration treatments on storability were reported to associated with better membrane integrity**)**, improvement of survival in the field, reduction in lipid peroxide products, greater enzymatic activities of dehydrogenase and amylase enzymes and emanation of lower volatile aldehydes during the early germination phase**.** Hydration in the presence of chemicals such as potassium and sodium salts and several other antioxidant or radioprotective chemicals produced promotive effects on post-aging seed performance. **Wilson and McDonald (1986**)

suggested that the chemicals that protected seeds from radiation damages also extend the life of seeds under natural and accelerated aging conditions.

Pandy (1996) demonstrated that immersion of pea seed cv. Hup and pepper cvs. Arka Gauraw and Arka Lohit in CAGALY liquid consisting of 25 % (w/w) Ca Cl2 in glycerol improved their longevity over seeds with similar water content in hermetic storage at ambient temperature. Immersing seeds in CAGALY liquid is a simple, cost-effective method for enhancing medium or long-term longevity of orthodox seeds at ambient temperature.

Powell and Matthews (1977) reported that storage at 45% RH, 10°C and 10% seed moisture content for 8 weeks maintained a high level of pea seed viability and showed no increase in the electrical conductivity of steep water.

Matthews et al (1980) found that storage pea seeds with 20% seed moisture level in 93 % RH and at 25°C showed a decline in viability and an increase in leaching during storage period.

Gorecki et al. (1992) reported that storage of pea seeds at ambient humidity and 6°C did not reduce seed viability while accelerated aging at 33°C and high humidity or storage at 23-33°C and high humidity both, reduced germination and quality.

Alsadon et al. (1995) noted a slow germination in aged seeds with 24% moisture content at 45°C of tomato and cucumber for 48 and 72 hours respectively. These aged seeds showed a decrease in emergence rate as aging period increased and a significant reduction in seedling length and seedling fresh and dry weight. Tomato seeds were more sensitive to this aging than cucumber seeds.

Kumar et al. (1997) stated that pea seed longevity is genotypically controlled. Seed germination and seedling vigor, depending on cultivar, decreased in all cultivars with increasing storage period at 80% RH and 40°C. They found that seed size within genotype (cultivar) had an affect on seed longevity in some cultivars.

Aladjadjian et al. (1997) measured that the electrical conductivity and optical extinction of tomato, pepper, carrot, dry bean and pea seeds. They found that the electrical conductivity was generally increased as the seed aged. They attribute that this is due to a decrease in the free water content of cells during seed storage. The optical extinction rate of seeds generally decreased as storage time increased. They concluded that as electrical and optical properties of vegetable seeds are related to environmental conditions, measuring and controlling these properties could be used to manipulate seed quality.

Edwards et al. (1986) revealed that six months of storage significantly reduced germination of immature cucumber seed lots. On the other hand, after six months storage,

mature seed lots exhibited germination improvement at suboptimal temperatures (15 or 20°C) but germination at 25°C was reduced.

Nerson and Paris (1988) stated that seeds from immature fruits of cucumber tended to lose their ability to germinate after storage. Germination rate of immature fermented cucumber seeds was improved after storage. The rapid decline of germinability of these seed lots after storage for several months are probably related to the seeds being harvested while their embryos were still developing.

Nerson (1991) stored cucumber seeds of different stages of maturity at 10+-2°C and 45-55% RH in the dark. He found that pre-extraction storage of immature cucumber fruits improved seed germinability. Germination of immature seeds was increased by storage but the longevity of such seeds is limited. Immature seeds of cucumber (25dpa) lost their maximal germinability within one year of storage. The germinability after 4 years of storage started to decline and this effect was first noticeable in germination rate rather than in germination percentage. The germination rate of mature cucumber seeds after 4 years of storage was decreased compared with 3 years storage; germination percentage did not affected.

Assuming a good storage conditions, the most practical way to extend the storage life of seeds is to begin with seed of the highest possible quality (vigor). Deterioration of seeds in storage is a cumulative phenomenon, and harvest before operation maturity, poor weather near harvest sever drying conditions or temporary storage at high moisture can take years off the storage life of seeds.

Seed deterioration in the storage was found to be due to lipid peroxidation in the presence of oxygen, oxidative enzymes such as lipoxygenase and seed moisture beyond adequate level or due to lipid autoxidation as a result of very high temperature beyond the usual physiological range. Both generated free radical. These free radicals assault on cellular membranes, resulting in decreased membrane fluidity, which lead to an increase in cell membrane permeability as well as mitochondrial membrane permeability, decreasing the respiratory competence **(Wilson and McDonald, 1986; McDonald, 1999)**. When such seeds imbibe water early in germination, the reaction of lipids with oxygen decreased as the membranes hydrate and reform. Hydroperoxide lyase becomes active and breaks down the oxygenated fatty acids. This process may cause damage to the seed further by forming an increase in free radicals and by producing toxic secondary products which inhibit respiration, protein synthesis, DNA synthesis and denature protein **(Wilson and McDonald, 1986; McDonald, 1999)**, resulting in non germinated seed or unemerged seedling or weak seedling.

Infection of plants or seeds in the field or in storage by various plant pathogens, fungal, bacterial or viral can reduce seed vigor directly through such mechanisms as enzymatic degradation, toxic production and growth regulation. Seed vigor loss because of infection by pathogens can also occur indirectly to the extent that pathogenic infection limits the ability of the seed to develop normally on that plant.

Moussart et al. (1998) stated that infected seeds caused significantly losses due to poor and high disease transmission to parts of the plant under soil level. Losses were moor serious by low temperatures during the early stages of the crop development.

Pushpa et al. (1999) reported a reduction in seed germination by more than 50% and in radicle and plumule length by more than 25% in all four cucurbita crops including cucumber cv. Punekhire due to Fusarium spp., M. phaseolina and A. niger. Bavistin fungicide was the most effective in inhibiting the growth of seed born fungi of these cucurbita crops.

Before seed can germinate a certain amount of water must be imbibed by the hydrophilic components of the seed. Water is essential for cellular metabolism for at least three reasons: (1) for enzymatic activity, (2) for solubblization and transport of reactants, and (3) as a reactant, especially in hydrolytic digestion of stored reserves of proteins, carbohydrates and fats. How much water depends largely upon the seed composition **(Vertucci and Leopold, 1987)**, seed kind **(Duke and Kakefuda, 1981)**, seed moisture content just before imbibition **(Ellis et al., 1982, 1990; Sivritepe and Dourado, 1995)**, seed coat condition **(Duke and Kakefuda, 1981; Powell and Matthews, 1979)** and to some extent upon environmental factors surrounding the seed as temperatures and water status **(Murphy and Noland, 1982)**. Water entry to the seed is a physical process depends on both properties of water as well as on the seed **(Murphy and Noland, 1982**). Water entry is not limited by the reforming of the membranes of pea **(Waggoner and Parlange, 1976).** In contrary, **Murphy and Noland, (1982)** suggested an involvement of membranes in water uptake in sugar pine and radish.

The imbibition period offers opportunity to insert certain chemicals such as hormones into seed tissues as well as hazard. Imbibition rate is the first effect of seed quality on seed performance in the initial phase of water absorption subsequent to sowing. This phase was described as a period of peril. **Powell and Matthews (1979**) showed that the condition of the embryo before imbibition appeared to influence the response to imbibition and difference in the rate of water uptake between seed lots of pea was related to the incidence of imbibition damage. The ability of the seed to traverse this period successfully and to emerge depends upon the soundness of vigor of the seeds **(Woodstock, 1988**).

As dry seeds or their embryos imbibed water, they leaked materials into the surrounding media or soil. The rate of both processes (imbibition and leakage) showed initial rapid phases, then become less as seed imbibition proceeded **(Simon, 1974**). These initial rapid phases of both processes were because of period of high membrane permeability, which may be more related to the order within the bilayered membrane than to the reorganization of the membrane in the dry state **(Thomson** and **Plott-Aloia, 1982, 1982)**.

The exudates leached out from the seed during imbibition depending on seed kind, condition and cultivar and include a wide variety of substances, e.g., sugars, amino acids, enzymes, proteins, fatty acids and nucleotides **(Woodstock, 1988**). These materials lost from the seed during imbibition period are related to the state of the seed membranes, reflecting the seed vigor. One symptom of imbibition damage was high levels of leakage from the seed or the embryo into soak water.

Potassium (K^+) is the main inorganic ion leached by seed during imbibition **(Wood, 1990)**, accounted for 25 to 50% of the total electrolytes leakage in pea **(Woodstock, 1988)**, followed by sodium and calcium **(Custodio** and **Marcos-Filho, 1997, Barry ,1977)**. There is a strong relationship between the release of these ions during seed imbibition and seed membranes integrity **(Custodio** and **Marcos-Filho, 1997)**. Studies in pea by **Simon** and **Raja Harun (1972), Matthews** and **Rogerson (1976),** in bean **Pandey (1988**) and in soybean **(Custodio** and **Marcos-Filho, 1997)** showed that the evaluation of potassium leakage produced comparable results to those of the electrical conductivity test.

The leakage rate is not the same for each substance **(Simon, 1984)**. The amount leaked out depends upon many factors such as: seed vigor, cultivars **(Powell et al., 1997**), seed kinds **(Duke** and **Kakefuda, 1981**), seed moisture content just before sowing (**Ellis et al., 1990; Ellis** and **Roberts, 1982; Sivritepe** and **Dourado, 1995)**, seed coat condition **(Duke** and **Kakefuda, 1981; Powell** and **Matthews, 1979)** and temperatures and water status of imbibition **(Bramlage et al., 1978; Murphy** and **Noland, 1982).**

The imbibition damage may reduce field emergence either by causing seed death as suggested by **Perry** and **Harrison (1970**), or increasing the predisposition of surviving seeds to infection by soil pathogen.

Results of **Powell** and **Matthews (1980**) indicated that both physiological death, particularly in low vigor seed lots, and increased predisposition can occur. The increased predisposition may be resulted from the cell rupture or the dead tissues on the cotyledons acting as an initial infection site by soil pathogens or from leakage of exudates into the soil causing an increase in the pathogen effect and thus an increase in inoculum potential. The

seed predisposition to the infection is the more significant cause of field emergence failure as indicated by the fact that fungicidal chemical nearly always improve field emergence.

The leakage of intracellular substances from the imbibing seeds is negatively correlated with seed vigor **(Larson, 1968; Matthews** and **Bradnock, 1968; Perry** and **Harrison, 1970)** and with field emergence.

Matthews and Bradnock (1968) found exudation of electrolytes from seed soaked in distilled water for 24 h is negatively correlated to the seed vigor and field emergence: Also electrical conductivity is associated with the percent of non-viable seeds in the pea samples as well as with the predisposition to pr-emergence injury of seeds that are viable **(Matthews and Whitbread, 1968)**. **Simon (1974)** demonstrated that the exudates from seed into water reflected the state of cell membranes.

The electrolytes leaked from the seed in water for 24 hours was correlated with seed vigor and that steeping for longer than 24 hours as long as 72 hours in some cases had little effect on the differences in exudation found between samples **(Matthews** and **Bradnock, 1968**).

The exudation released by germinating seeds, provides the nutrients which are necessary for the germination and growth of the microorganisms, including plant pathogenic propagules in the soil especially in the seed vicinity, rot the germinating seed, causing pre-emergence mortality, so that no shoot ever emerge above the soil. Thus, it would be expected to be correlated with damping-off **(Ferris** and **Baker, 1990; Flentje, 1964a, 1964b; Kerr, 1964; Matthews** and **Whitbread, 1968; Schroth et al., 1966; Shorth** and **Lacy, 1976)**.

Since the susceptibility of a particular seed lot to per-emergence mortality is related to the extent of leakage from the seed, it is very important to know that factors control leakage. These factors include seed size, seed coat integrity, seed age, seed storage conditions, seed quality, rate of imbibition, initial seed moisture content, imbibition temperatures and seed kind, cultivar and lot. Seed development may influence the quantity of each solute present in the mature seed and its availability for leakage **(Simon, 1974**).

Seed testa is affected by different factors during harvesting, threshing, sorting, packaging and handling. All these factors, depending on seed maturity and seed moisture level at harvest and subsequent operations, can cause bruises or fractures to the testa. Proper seed moisture level at harvest and care during harvest and subsequent operation could insure the production of undamaged seed coats seeds.

The functional significance of seed coat lies in its protective roles for dry embryo. These include: mechanical protection from injury due to striking or abrasion, physical holding seed parts together and shielding the embryo, retention of water and protection

against desiccation following imbibition, avoidance of imbibition injury from excessively rapid water uptake. Furthermore it reduce leakage of solutes, delays the response to chilling injury, protection from biotic stresses such as fungal invasion and insect attack and may release chemicals into the surrounding which inhibit or restrict the germination of competing plant seed (**Larson, 1968; Simon, 1974; Bramlage et al., 1978; Powell** and **Matthews, 1978; Woodstock, 1988)**.

Presence of seed coat delays water entry and reduces the leakage of solutes **(Larson, 1968). Simon (1974**) reported that the presence of the seed coat does more than just act as a protective function from the external adverse condition and as a barrier slowing down the exudates to the external medium but it actually reduces the extent of leakage from the embryo itself. He measured the electrical conductivity of 50 Meteor pea embryos in 50 ml water for 1 hour it was 1400 μmho/cm^2. With the intact peas, the conductivity was only 410 μmho/cm^2. When he dissected testa and embryo apart in a fresh 50 ml of water. The conductivity was less than 300 μmho/cm^2 in place of the expected 990 mho/cm Indicating that in the intact seed, substances leaking out of the embryo were largely remain trapped in the small space between embryo and testa, accumulating there to a high concentration. Thus, it appears that the leakage was diminished by the presence of much solute in the water around the embryo.

Powell and **Matthews (1978**) found that the testa reduced water uptake and exudation and protected the dry embryo from the damaging effect of rapid water uptake during imbibition. No damage occurred on the surface of cotyledons when the seeds were imbibed intact, or beneath the seed coat when only half of the testa was removed. The removal of the seed coat resulted in a rapid water uptake, lead to death of the outer layers of cells on the abaxial surface of the cotyledons within the first 2 minutes of imbibition. They suggested that the imbibition damage resulted in reduced respiration and germination, a decline in the rate of food reserve transfer from the cotyledons to the growing points and a lower rate of growth.

Powell and **Matthews (1979**) suggested that the significant of cracks, which need not to be microscopic, lies in the increased rate of water entry which occur, resulting in cell death and solute leakage due to the imbibition damage to the embryo. They also reported that many low vigor lots contain a large proportion of seeds with inconspicuous cracks in their coats, which allow rapid water uptake to occur when the seeds are soaked in water. This phenomenon results in extensive areas of dead cells on the abaxial surface of the cotyledons. This situation is the result of initial condition of the embryo and/or imbibitional damage to the cotyledons during imbibition and subsequently leads to a high leakage. The sensitivity to this damage is greater in some pea lots than others.

Bramlage et al. (1978) demonstrated that presence of the seed coat delays the response to chilling injury. **Powell** and **Matthews (1978**) reported a similar conclusion that the presence of the testa protected or ameliorate injury to the embryo from imbibition damage at low temperatures.

Matthews et al. (1980) found the most important cause of low vigor in commercial seed lots is due to the condition of the testa. They also noted a slowing down water uptake and absence of dead tissues by leaving the seed coat on. (Imbibition damage may reduce field emergence either by causing the death of the seed as reported by **Perry** and **Harrison (1970**) or increasing the predisposition of surviving seed to infection by soil fungi. Evidence from **Powell** and **Matthews (1978**) results indicated that both physiological death, particularly in weak lots and increased predisposition can occur.

Biddle (1980) reported a highly significant correlation between the percentage of seeds with one or more cracks and electrical conductivity of vining pea seeds cv. Sprite.

Powell and **Matthews (1980**) related that the differences in the field emergence of seed lots of vining pea were due to differences in the sensitivity of seeds to imbibition damage caused by the faster water uptake. The reduced emergence in wet soil resulted from a rapid rate of water entry and a consequent increase in imbibition damage. They also stated that the extent of imbibition damage in the different seed lots used appeared to be related to their sensitivity to damage from a particular rate of water entry rather than differences in the rate of water uptake into the seed as they observed previously **(Powell** and **Matthews, 1979**). Absence of seed coat or cracked seed coat resulted in killing areas of tissue on the abaxial surfaces of the cotyledons due to rapid uptake of water **(Larson, 1968; Powell** and **Matthews, 1978, 1979; Matthews et al., 1980)**.

Perry (1967) found that the incidence of visible seed coat damages in peas was not directly related to field emergence. However, in a comparison of two different seed lots he associated poor emergence with microscopic cracks in the seed coat, which he thought allowed the entrance of the fungus into the seed.

Flentije and **Saksena (1964**) and **Schroth** and **Cook (1964**) found that if the seed coats were damaged deliberately the seeds would leak more than those would, which were free of damage and their field emergence was reduced as compared with non-damaged seed coats.

Larson (1968) compared the leakage from Alaska seeds with testa completely removed leaving only the embryo and from intact seeds and from the testa alone. He stated that the presence of seed coat delayed water penetration and reduced the leakage of exudates of pea seeds. On the other hand he noted that the isolated embryos leaked more rapidly during the first few hours and produced twice the weight of solute after 24 hours

than intact seeds. Isolated seed coats leaked little to the steep water. He noted also shorter stems, lesser stem and root dry weight and greater dry weight of cotyledons in the absence of the teata (18 days old seedlings). When the seed coats were removed from pea seeds, the embryos imbibed more rapidly than the intact seed and leak more profusely and over a longer period, while presence of the testa protected the seed against leakage of intercellular substances during imbibition **(Simon, 1978**). **Powell** and **Matthews (1978**) demonstrated that when pea seeds were imbibed in water without their seed coats, vital staining indicated that cells on the abaxial surface of the cotyledons were dead while no damage was observed on the surface of the cotyledons when the seeds were imbibed intact. The differences in the rate of water uptake between seed lots of pea were due to the soundness of the seed coat. **Powell** and **Matthews (1980)** suggested that the rapid water imbibition in pea associated with seed coat damage led to poor field emergence. **Duke** and **Kakefuda (1981**) found that the outermost layers of embryo cells of pea seeds without testa suffer massive rupture during rapid imbibition and the testa inhibit the leakage of high molecular weight intercellular substances during imbibition.

In contrary, **Pesis** and **Ng (1986)** studied the effect of muskmelon seed coat removal on germination, aerobic and anaerobic respiration in seed lots of varying quality. They found that seedling emergence of decoated muskmelon seeds was more rapid and occurred at a higher percentage. The respiration activity was greatly affected by seed coat removal; anaerobic respiration as measured by ethanol production was higher in intact seeds than in decoated ones. **Nerson (1991)** demonstrated that removal of the seed coat increased the germination percentage of not fully developed embryos of cucumber (immature seed). This case may be due to inhibitory role of the seed coat in germinating of immature seed (not fully developed embryos).

Leviatov et al (1993) stated that the removal of the seed coat and the endosperm layer in front of the embryo's radicle tip eliminated the differences in germination rate under low temperature conditions between tomato lines. They indicated that the endosperm layer imposed the main barrier to germination of tomato seeds at low temperatures**. Leviatov** and **his college (1995)** attributed the differences in germination ability at low temperatures of 12.5°C between tomato lines to the endomannanase activity. A significant increase in endomannanase activity was found in a cold-tolerant tomato line prior to germination at 12.5°C.

Based upon the above investigators, it is concluded that dry intact seed (pea seed) do not leak so copiously into the surrounding medium during imbibition as do dry embryos. This is either because the uptake of water is restricted by the enclosing structure (i.e. testa), or because the testa acts as a barrier to the efflux of solutes, or both.

These observations are of significant to the seed producers because any treatment at harvesting and subsequent processes of the crop, which leads to increase in cracks in the testa will decline the seed vigor through the effect of imbibition injury on the embryo. So care should be taken to avoid any seed coat damage to insure production of high quality seed and then guarantee satisfactory field stand and profitable yield.

Genetic differences in ability to germinate at suboptimal temperatures in peas **(Torfason** and **Nonnecke, 1959**) tomato **(EL Sayed** and **John, 1973)** cucumber **(Lower, 1974**) and pepper **(Gerson** and **Honma, 1978)** have been reported. Although imbibition at lower temperatures reduced the rate of water entry to the imbibing seed or embryo, it resulted in more seeds were killed and more electrolytes were leaked than at 20°C **(Perry** and **Harrison, 1970, Powell** and **Matthews, 1978)**. Solute exudation from imbibing seeds was found to be greater at temperatures below 20°C **(Simon, 1974; Simon** and **Wiebe, 1975)**. **Perry** and **Harrison (1970)** found that at lower temperatures more pea seeds were killed, more electrolytes were leaked and less water was absorbed than at 20°C. The detrimental effect of soaking at low temperatures was more pronounced in the low-vigor seed lot than in the high-vigor lot.

Simon (1974) proposed that when dry pea seeds imbibe at low temperatures (chilling temperature), the membranes (phospholipids) are unable to change rapidly from dehydrate to hydrated state because they are gelled in a rigid molecular shape resulting in more leakage.

Bramlage (1975) as quoted by **Bramlage et al. (1978**) proposed that the leakage may be due to tubular channels in membrane phospholipids, which open under condition of low water seed content.

Bramlage et al. (1978) stated that low temperature impeded and delayed membrane reorganization and producing injury to the imbibing soybean embryo as indicated by prolonged the rapid leakage.

Powell and **Matthews (1978**) reported that as the temperature of the imbibing water was declined the imbibition of intact seed or embryo became lower. Sensitivity of pea embryos to imbibition damage at low temperatures, resulting in more extensive damage to the cotyledons, greater leakage and possibly death of the seed.

Tao and **Zou (1993**) inferred that the damage to the reconstructive process of the membrane structures and functions in seed cells during low temperature imbibition may be an important cause of respiratory metabolic disorder in pea and soybean.

Simon et al. (1976) reported that there was little leakage from cucumber seeds at temperature of 20 down to 3°C. Leakage from cucumber embryos was no faster in cold than at 20°C over a 6-hour period. They concluded that the failure of cucumber seed

germination in cold not due to imbibition of cold water or loss of membrane integrity but most likely result from a denaturation of proteins. Denaturation of proteins may cause inactivation of enzymes or it could perhaps prevent the orderly association of proteins into organelles such as mitochondria or ribosomes.

Jennings and **Saltveit (1994**) demonstrated that cucumber seeds may be imbibed for at least 6 days at 2.5°C and still retain their ability to germinate normally at adequate temperature. They did not observe any germination at 10°C. Rate and extent of imbibition at 25°C was much greater than at 2.5°C for all lots.

Yang and **Sung (1994**) demonstrated that although triploid watermelon seeds leakage was significantly less at suboptimal temperature (15°C) than at optimal temperature (25°C) in both heavy and light seeds, the average germination percentage of the two seed weight classes was lower at the lower temperature (15°C). Light seeds leaked more electrolytes and imbibe more water (per gram or seed) than heavy seeds.

Russo and **Biles (1996**) found that incubation of cucumber cv. Arkansas little leaf seeds at various temperatures (13.9, 15.6 and 20°C) did not affect mineral content. However this was not the case for the cv Earlipik 14, where high level of mineral were found at 20°C than other incubation temperatures, indicating that mineral had leaked from seeds incubated at the lower temperatures. In cultivar Arkansas Little Leaf, germination at 13.9 and 15.6°C was well below 50%. They suggested that leakage of mineral from seed is not only one factor involved in initiating and sustaining germination but other factors are also involved in germination such as: the lack of formation or denaturation of proteins of specific weights.

Abdur Rab and **Saltveit (1996**) demonstrated that cucumber seeds are insensitive to chilling imbibition and chilling at non-sensitive stage (seed) will not only be less damaging but will also effectively delay the growth of the radicle to the sensitive stage. Thus ensuring the survival of the seedling radicle.

Jennings (1999) stated that cucumber seed is one of plant species, which is resistant to chilling injury during imbibition but become increasingly susceptible at the time of radicle emergence.

The damaging effects, which resulted during imbibition of intact seed or embryo at low temperatures, were in fact not because of low temperature itself but as the result of imbibition damage. These deleterious effects could be largely avoided or reduced by raising seed moisture content (by giving the seed only limited access to water), seed priming (by placing seeds or embryos in a solution of very low water potential instead of free water), high vigor seed lot, undamaged seed coat and sealing the cracked testa by chemicals.

Seed moisture content is a decisive factor affecting seed damaging during imbibition especially at low temperatures. Pervious investigators **(Larson, 1968, Perry** and **Harrison, 1970, Powell** and **Matthews, 1977, 1978, Rowland** and **Gusta, 1977, Ellis** and **Roberts, 1982, Ellis et al., 1990, Sivritepe** and **Dourado, 1995)** showed that a dramatic loss of viability occurred when low moisture content pea seeds were soaked in water.

Rowland and **Gusta (1977**) reported a reduction from 90% to 69% normal germination following rapid imbibition of intact pea seeds dried from 13.5% to 7.5% moisture content. **Powell** and **Matthews (1977**) dried intact pea seeds from 10% to 5% moisture contents, they noted an increase in mean electrical conductivity of the steep water.

Ellis and **Roberts (1982**) showed that desiccation from 16.8% initial seed moisture content to low seed moisture contents, at least down to 7% was not harmful to pea seed germination, which was initially 98%. Soaking the dry, intact, pea seeds in water for 24 h reduced germination significantly by an average 7%, irrespective of initial seed moisture content with exception of seed at the lowest moisture content, 7.2% where, the damage was twice. The proportion of seeds damaged by soaking in water for 24 h at 20°C was constant between 7.9% and 16.8% moisture content, but that this proportion doubled following desiccation from 7.9% to 3.7% moisture content. They concluded that the proportion of pea seeds, which were susceptible to damage by soaking injury was increased at moisture contents of 7.2% or below was the result of increased sensitivity to the (stressful) rehydration environment as a result of desiccation, but not a consequence of desiccation alone. Subsequently, **Ellis et al, (1990**) showed that desiccation of pea cultivar 'Feltham First' from 14.8% initial seed moisture content to 9.6% moisture content resulted in a decrease in normal germination from 92% to 79%. Moreover, drying from 14.8% moisture content to 4.8% moisture content resulted in reduction from 92% to 65% normal germination. Desiccation to 3.7% resulted in only 50% of the seeds produced normal seedlings. As seed moisture content was declined below 8.8% the proportion of seeds capable of any germination following soaking decreased progressively from just above 90% at 8.8% moisture content to just below 40% at 3.75 seed moisture content.

Sivritepe and **Dourado (1995**) found that pea seeds of high lot lost viability more rapidly during soaking in water as seed moisture content decreased, while low vigor seed lot lost viability more rapidly at both high and low seed moisture content. Soaking of high vigor seeds with 15.1% moisture content at 20°C for 12 h reduced normal germination from 96.5% for non-soaked to 94%, the slight reduction in the proportion of seeds germinating normally was highly significant. Normal germination of the high viability and low moisture content seed lot (4.8%) declined from 94% to 56% after 12 h soaking, while the reduction within the first hour of soaking was from 94% to 86.5%. On the other hand, in low vigor

seed lot and high moisture content 15.1%, the percentage of normal germination decreased from 79.5% to 3% after 12 h soaking. Also in low viability with low moisture content (4.8%), the percentage of normal germination decreased from 73.5% to 16.8%. All the differences were highly significant. The discrepancy in the results of the above mentioned investigations might be because of the vigor of pea seeds used **(Sivritepe** And **Dourado, 1995)** or possibly that their germination test results confounded survival with hardseededness induced by desiccation such as reported by **Powell** and **Matthews (1977**) and **Ellis** and **Roberts (1982**).

Seed lots with low seed moisture contents are more sensitive to imbibition injury during imbibition at low temperature. **Prusinski et al. (1996)** reported that pea seeds with 6-8% moisture content were most sensitive to low temperature as indicated by high conductivity and low germination.

2.8. Cultivars

Differences in water sensitivity at low temperature damage, electrical conductivity and field emergence between crops, cultivars and seed lots were reported by many investigators.

Cucumber seeds were reported to be non-sensitive to imbibition damage at low temperature over longer period of time. For example **Jennings (1999**) stated that cucumber is one of the crops, which its seeds are non-sensitive to chilling injury during imbibition, becoming susceptible to chilling injury beyond certain radicke length.

Gerson and **Honma (1978**) reported varietal differences among pepper cultivar ability to germinate at optimal and suboptimal temperatures. **Milotay et al. (1991**) found differences in the germination ability among various cucumber cultivars and lines at temperature of 22°C and less. **Flentje** and **Saksena (1964**) showed differences in exudation and field emergence between round and wrinkled-seeded cultivars of pea. **Matthews** and **Bradnock (1968**) found marked differences in mean exudation and mean emergence between wrinkled-seeded pea cultivars and between the seed sample of the same cultivar. Varietal differences in the minimum germination temperature of four cucumber cultivars were recorded by **Kapitsimadi et al. (1990)**. Differences in the ability of tomato lines to germinate at low temperatures were demonstrated by **Leviatov et al. (1993, 1995**). **Shukla et al. (1994**) reported variation in seed vigor (seedling dry weight) after 8 days and germination percentage among garden pea cultivars. **Horcicka (1996**) demonstrated differences in water sensitivity and electrical conductivity between seed lots.

Russo and **Biles (1996**) reported differences in the ability of cucumber cultivars to germinate at less than the optimum temperature. They inferred that the mineral leaked from

cucumber seeds incubated at lower temperatures was dependent on the cultivar. Cucumber cv. Earlipik 14 seeds leaked mineral at lower temperatures compared with temperature at 20°C. However, this was not the case for the cv. 'Arkansas Little Leaf ' where incubation at different temperatures did not affect mineral content.

The amount of exudates and the incidence of the disease will be greater if low vigor seed lots are planted under cold and wet soil (early planting in the spring). Low temperatures increased the rate of leakage and prolonged the period before leaching was diminished **(William** and **Herner, 1982)**

Numerous reports indicated a positive relationship between seed exudates and susceptibility to the pathogen attack **(Flentje** and **Saksena, 1964; Rajagopalan** and **Bhuvaneswari, 1964; Shorth** and **Lacy, 1976; Simon, 1974;Powell** and **Matthews, 1980)**.

The electrical conductivity test of seed steep water was used satisfactory to evaluate seed vigor and field performance in pea **(Matthews** and **Bradnock, 1968; Bradnock, 1968; Bradnock** and **Matthews, 1970; Powell et al., 1997; Horcika** and **Hosnedi, 1997)**, in soybean **(Vieira et al., 1999)** and in field bean seeds **(Barros et al, 1999)**.

2.9. Pre-germination seed treatment

Chemical and water pre-germination treatments were found to be effective in improving and accelerating seed performance of certain crops at a wide range of environmental conditions.

Among seed treatments studied so far: Wittwer and Bukovac (1957), as quoted by **Nelson** and **Sharples (1980**) reported that gibberellic acid promoted low temperature germination of pea and bean seeds.

Ellis (1963) acclaimed that treating tomato seeds with nutrient solutions (3 ml of 1.5 % $K3PO_4$ and 1.0 % KNO_3 per 1.0 gm of seeds) for 6 days at 24^{o}C has advanced seedling emergence up to 5 days at night temperature of 10^{o}C.

Fieldhause and **Sasser (1975**) reported that seeds of pepper (cv. California Wonder) receiving sodium hypochlorite treatment germinated faster and showed more rapid early growth than untreated or treated seeds followed by acid washing.

Irwin et al. (1981) stated that dry pepper seed took double as long as to emerge as fresh pregerminated seed at 15/10°C.

Harrington and Kihara (1960) demonstrated that chilling injury was not significantly increased in unrgermenated seeds of pepper and muskmelon by temperatures below15°C. The possibility of poor stand or stand failure of warm-season crops was due to

chilling injury of the germinating seed in addition to the better adaptation of soil pathogen to cold conditions.

Lower (1974) found significant differences among 11 cucumber cultivars for germination rate and uniformity at different temperature regimes ranging from 14 to 24°C. He further observed differences in germination performance among seed lots within cultivars. These within cultivar differences may by due to the effects of numerous pregermination treatments such as seed production environment, seed maturity, processing method, seed age and storage conditions.

Simon et al. (1976) deduced that at 20°C, cucumber seeds germinate rapidly and the time required for 50% of the seeds to germinate increased rapidly at temperatures below about 14°C. Incubation of seeds at 8-10°C on filter pepper moistened with water or solutions ranging from 10-5M to 10-2M of the following substances: histidine, methionine, lysine, leucine, arginine, thaiamine, ascorbic acid; or solution of indoleacitic acid, gibberellic acid or kinetin at 10-6 to 10-4. After 19 days, the germination was no more than 4% in any treatment. He concluded that there was no evidence that imbibed cucumber seeds suffered any harm if they were held at 10°C for 10 days or more. However, there was no evidence of loss of membrane integrity and the leakage was little at any temperature from 20°C down to 3°C. Further more, the seeds, which were held at 10°C or less germinated sooner than if they had been incubated at 20°C from the start. The failure of cucumber seeds to germinate in cold conditions could not be attributed to damage resulting from imbibition in cold water but it may be resulted from a denaturation of proteins.

Jennings (1999) demonstrated that cucumber seeds were resistant to chilling injury during imbibition but gradually became more sensitive as their radicles emerged. He attributed the failure of cucumber cultivars to germinate at low temperatures to the effects of chilling on an enzyme (alpha-glactosidase) involved in the metabolism of raffinose and stachyose which may be involved in chilling tolerances differences.

Sachs (1977) said that watermelon (cv. Sugar Baby) seed priming by 2 % or 3% KNO_3 for 24 hr at temperature of 30^oC was effective for seed germination at suboptimal temperature of 10^oC.

Kapitsimadi et al. (1990) reported that depending on cucumber cultivar, the mean number of days to emerge decreased with increasing temperature from 12°C to 20°C. Differences in the number of days from sowing to seedling emergence was observed among cultivars at all temperatures.

Nelson and **Sharples (1980)** declared that the rate and the total germination of cucumber seeds (cv. Explorer) incubated at suboptimal temperature of 12^oC was increased

by soaking the seeds in Fusicoccin (0.5mM) for 16 hr and then air dried for 24 hr at 25^{o}C and Fusicoccin was more effective than GA_4/ 7+Kinetin or GA_4/ 7 + Kinetin + Ethyphon.

Nerson et al., (1985) noted that soaking watermelon seeds (cv. Alen) in H_2O, GA_4/ 7, AB for 24 hr or in 3% KNO_3 for 5 days followed by drying were successful in increasing germination at suboptimal temperature of 17°C.

Edwards et al. (1986) reported that the ability of cucumber germination improvement by seed fermentation is, in part, cultivar dependent. Further, they found that germination of mature or immature cucumber seeds was increased by fermentation at 25°C for 4 days, but longer fermentation duration had deleterious effects under some condition.

Alvarado et al. (1987) found that the KNO3-primed tomato seed emerged most rapidly than PEG-primed seed. Reduction in the time required for emergence by priming with either KNO3 or PEG at 20°C for 7 days was observed. Seedlings from primed seeds emerged earlier and more uniformly and maintained greater mean plant dry weight, leaf areas, and ground cover percentage than seedling from untreated seeds throughout the pre-flowering period. Early maturity, total yield and soluble solids content of fruits was not improved by seed priming.

Nerson and **Paris (1988**) declared that germination rate and percentage of cucumber seeds from immature (28 days after enthuses) fruits were improved by seed fermentation at 25^{o}C for 3 days.

Fernandez et al. (1992) stated that hydration-dehydration pepper seed treatment reduced electrolyte leakage. In aged seeds, the longest pretreatment increased the final germination percentage and shortened germination time. Pretreatment did not affect the final germination percentage at 25.5°C, but shortened germination time and resulted in more uniform germination. At 15.5°C, seed treatment increased germination percentage and velocity and reduced root emergence time compared with untreated seeds. Final emergence percentage and seedling growth in the greenhouse was not affected by any pre-treatments.

Milotay et al. (1991) reported that the temperature of 17°C affected decisively the length of time required till germination and initial development. At 15°C differences between cucumber cultivars and lines germination were more pronounced. They concluded that the acceptable germination rate could only be expected above 17°C. Early planting in cold soils should be avoided.

Nerson (1991) increased germination rate and percentage of cucumber seed from immature (25 daa) fruits by either pre-extraction storage for 10-20 days or fermentation at 25°C for 3 days or by both together.

Smith and **Cobb (1991**) demonstrated that the priming of pepper seeds was dependent on both the osmotic potential of the solution and the duration of the treatment rather than a specific salt. Seeds soaked in double distilled water and then dried germinated faster than unsoaked, but not as fast as primed in salt solutions for 17 days at 23°C. Priming with KNO3 (-1.25 Mpa), K2SO4 (-1.08 Mpa) or Na2SO4 (-1.13 Mpa) yielded the best results as indicated the time to 50% germination and final germination percentage as compared with thee other seed treatments or the control.

Bennett et al. (1992) stated that the use of vacuum osmopriming as a tool to improve sweet corn (cv. How Sweet it is) seed germination and seedling emergence did not appear to be beneficial tool at this experiment.

Jennings and **Saltveit (1994**) found no seed germination for the two cucumber cultivars at 5 and 10°C., and mean germination rate of 1992 seed lots of the two cultivars were indistinguishable at temperatures from 15 to 30°C. The older seed lot (1989) of Poinsett 76 was significantly different from the tow 1992 seed lots at 15 and 30°C. At low temperature. Imbibition rate was lower. They further noted that cucumber seeds might by imbibed at 2.5°C for at least 6 days and still retain their ability to germinate normally upon transfer to suitable temperature.

Passam and **Kakouriots (1994**) deduced that osmoconditioning in 0.7 M mannitol solution in darkness at 25°C for 3 days improved the rate of cucumber seed germination at temperatures of 15 and 25^{o}C in water and NaCl solution up to 200 mM (16.5dS m-1). The total germination percentage was also improved at 15^{o}C. They also found that seedling emergence, radical length and the expansion of cotyledon and the first leaf were promoted, but the benefits of the treatment did not persist beyond the seedling stage.

Yang and **Sung (1994)** mentioned that the germination percentage of triploid watermelon seeds was lower at 15°C, while mean germination time was increased by about 5 days compared with temperature at 25°C. Seeds also leached less electrolytes at 15°C than those at 25°C. Water imbibition at 15°C was less than at 25°C. Reduction in water imbibition might by due to the change in the permeability of deed tissue and the fluidity of water with decreased temperature. They suggested that the inhibition of germination at suboptimal temperature should not be attributed to the decreased metabolic activities, however, both ICL and MDH activities of seed eventually increased to same level at 15 and 25°C. The only difference was in the time taken to reach the maximal level. They concluded that suboptimal temperature could retard the germination of triploid watermelon seeds, which might by attributed to the lagged development of enzymes associated with seed germination.

Meng et al. (1996) reported that calcium chloride treatment of cucumber seeds significantly improved the germination of aged seeds.

Russo and Biles (1996) observed that at 20°C, approximately 90% of seeds of both cultivars germinated, with at least 80% of germination occurred between 36 and 48 hours. While for seed incubated at 15.6°C germination began by 48 hours, but no more than 50% of seed germinated by 168 hours. At 13.9°C, no more than 2% of incubated seed germinated.

Mauromical and Cavallaro (1996) claimed that osmopriming of herbage grasses seeds for 6 days in aerated solution of polyethylene glycol (PEG 6000) at -1.2 or KNO_3 at -0.7 or K_2HPO_4 at - 0.7 Mpa in the dark at 18 ± 1^oC and then dried at 30°C until approximately original moisture content was reached, improved the rate and the total seed germination at suboptimal temperatures of 2 and 3^oC.

Carter (1997) reported that the differences in germination rate in response to temperature was common in pepper and mean daily germination depending on cultivar was decreased as the temperature increased from 15°C to 25°C. Pepper seed priming with NaCl plus Pro-Gibb T improved the emergence rate of all cultivars at less than optimum temperature (15°C) as well as at optimum temperature of 25°C in case of some cultivars.

Cholakov et al. (1997) reported that cucumber cv Pobeda seeds treated with laser and gamma irradiation 14 days before planting gave higher yield of seeds than the control treatment, especially the combined gamma and laser treatment which gave 21.6 and 28% increase in yield of seeds and seed fruit over control. Irradiation also increased field germinability and weight of 1000 air-dried seeds compared with the control treatment. The increase was greater with combined treatment.

Zeng et al. (1998) indicated that cucumber seeds dried to 2-4% water were significantly susceptible to imbibitional damage. This injury could be avoided by pre-humidification or by slow imbibition in polyethylene glycol solution.

Dilip et al. (2000) revealed that non dormant cucumber seeds germinated well (65-95%) in temperature range of 15-35°C. If dormancy was induced by soaking them in -1.8 Mpa PEG and plusing with far red light for 15 minutes, seed germination declined (60%) in temperature range of 25-30°C. They found that exposure of such dormant seeds to 30°Cfor 6 hours changed seeds from dormant to germinable state with no increase in membrane fluidity. Intracellular protein did not change during either transition state.

Sreenivasulu et al. (1998, 1999, 2000) reported that application of various chemicals (acetaldehyde, acetone, alcohols and ethanol) to secondary dormant, unimbibed cucumber cv. Poinsett 76 seeds broke their dormancy quite effectively. The treated water

imbibed seeds showed significantly greater cellular membrane fluidity than untreated water imbibed control seeds. Acetaldehyde seed treatment evoked germination in shorter time.

Gibberellins and Naphthalene acetic acid (NAA) were utilized to improve seed germination seedling emergence and seedling height in some ornamental plants **(Renard and Cler, 1978; Abdulla** and **McKelvie, 1980; Grzesik** and **Chognowuski, 1992)**.

Mohsen and **Kulkuttawi (1990**) reported that soaking tomato seeds in indolacetic acid of naphthalenacetic acid at 10-3M enhanced nitrogen accumulation in tomato seedlings during the first 10 days of seedling growth.

Mozarkar et al. (1991) observed increasing in fruit yield in tomato by 12, 8, 6 and 5% over control by seed treatments with naphthalene acetic acid, gibberellic acid or indolacetic acid and indolepropionic acid, respectively.

Tomato cv UC 97 seed germination was enhanced by 10 ppm IAA and 40 ppm Nicotinamide seed treatments **(Sheteawi, 1993**).

Soaking of the seeds followed by seedling sprayings of tomato cv Pusa Early Dwarf by IAA, GA3 and NAA, gave the best fruit retention and yield **(Kar et al., 1993**).

Suryawanshi et al. (1997) found that drying of fresh harvested cucumber seeds in an oven at 45°C for 72 hours or soaking in 1000 ppm GA3 for 24 hours released the dormancy and increased seed germination.

Applying exogenous mannanaase from soil-born bacteria increased tomato seed germination rates under both low and moderate temperature environments **(Leviatov et al., 1995**).

Priming with potassium nitrate accelerated tomato seed germination and emergence of seedlings. Also plant dry weight, leaf area and ground cover percentage were greater during the pre-flowering period, but it did not improve earliness of maturity, total yield and fruit soluble solids **(Alvarado et al., 1987**).

Gibberellins enhanced seed germination of Matthiola incana, Brillant Barbara, also soaking seeds in GA3, GA3-7 and ANN produced taller plants with earliness flowering, but plant height at harvest, yield and seed quality were not affected by soaking seeds or spraying the plants with plant growth regulators **(Grzesik, 1995**).

Hou and **Romo (1998**) reported that Ethanol, GA3 and citric promoted germination, while sodium nitrate inhibited germination. Soaking in citric acid damaged the radicles of the seedling. They also reported that the promotion of germination by GA_3 or citric acid was weak during the test period.

Atonik, Aromatic Nitro compounds, brown liquid of peculiar odder was reported as a plant growth stimulant without any phytotoxicity or any harm effects to man or environment. The Producer Company stated that Atonik could be applied on plants in all

stages of plant development. It stimulates roots, improves germination, growth and yield. It is revealed that soaking of tomato seeds in Atonik solution at 0.5 % (0.5 ml/l) for eight hours makes germination quicker and more uniform **(Asahi Chemical, MFG. Co., LTD)**.

Vitavax (carboxin), a fungicide seed treatment has been utilised by several investigators not only to control fungal pathogens but also to improve percentage and rate of seed germination, to increase seedling growth and yielding, in raugh lemon seeds **(Sharma, 1989**), rice seeds **(Misra et al., 1990, Buffa et al., 1991**), wheat **(Svetov, 1991**), chickpeas **(Zaidi et al., 1991)**, cotton **(Poswel et al., 1992**) and ground nut **(Emmimath, 1994**).

Also **Dhyani et al. (1991**) reported that seed treatment of red and bell pepper (Capsicum annum and Capsicum frutescens) with Vitavax at 0.3 % conc. of seed weight, improved seed germination and seedling growth. On the other hand, **(Raj et al., 1990**) and (**Salazar, 1993**) stated that vitavax seed treatments controlled the fungal pathogens, but did not affect seed germination in phaseolus (Vigna) tungo and wheat respectively.

It has been shown **(Buffa et al., 1995**) that double doses of Vitavax seed treatment had a phytotoxic effect on rice cultivars; Roma and Ariete.

The reported effects of soaking in water on germination and subsequent seedling growth varied from improving to reduction or no effect, depending on kind of seed, condition of soaking, duration of soaking and seed moisture content.

Soaking injury could be resulted from a lack of free oxygen during imbibition, harmful effect of pure water on imbibing tissues, suboptimal temperature during soaking, cellular disorganisation (membrane integrity) because of dry seed, leaching out of essential compounds and bacterial action or any combination of these **(Larson,1968)**

To insure rapid and uniform germination it might be thought desirable to soak seeds in water before sowing them, but for many species the opposite is true **(Simon, 1984**).

Soaking in water was used to promote germination **(Alvarez-Racelie** and **Bagaloyos, 1977; Singh** and **Tomar, 1972)** and to increase seed vigor **(Basu** and **Dhar, 1979**).

On the other hand, reduction in germination following rapid imbibition has been observed in both peas **(Perry** and **Harrison, 1970; Rowland** and **Gusta, 1977; Ellis** and **Roberts, 1982)**..

In their studies, Kidd and West soaked seeds in water for 8-72 hours at 17°C and then set them in sand or soil **(Simon, 1984**). Pea, sunflower and common bean seeds germinated less rapidly if soaked for longer than 24 hours. On the other hand, seeds of broad beans germinated more rapidly and produced taller seedlings if they were first soaked for up to 72 hours.

Flentje (1964a) demonstrated that the attack of pea seeds by Pythium is usually occurred from 48–96 hours after planting and if no attack by Pythium that occurred within the first 96 hours then no attack took place at all. He also reported that the attack by the fungi may preceded by the leakage of materials from the germinated pea seed into the soil in the vicinity of the seed, leading to stimulation and prolific growth of Pythium around the seed, causing rotting. He found that the percentage of seeds attacked increased with increased of soil moisture level from wilting point to field capacity and soil moisture may affect the leakage of materials from the seed rather than have a direct effect on Pythium activity.

Flentje and **Saksena (1964**) concluded that pea cultivars differ in the amount of sugar diffused and then in their susceptibility to be attacked by Pythium species during germination. The sugar lost from the germinating seeds occurs during the first 24 hours of germination (imbibition) that stimulates the growth of soil fungi. They also reported that germination of seeds in water for 24 hours or in sterile moist sand for 4-5 days before planting in Pythium-infested soil should obviate the stimulation of Pythium and reduce the percentage of seed rotting. High soil moisture levels increase pre-emergence rotting through its effect both on increasing the amount of sugar lost and on the activity of Pythium in soil will attack the epicotyl or plumule even without the stimulus of substances leaking from the seed.

Damaged seed coat markedly increased both sugar loss and pre-emergence rotting. Hand-harvested seed with negligible cracking of the seed coat leaks much less substances during germination and is less affected by pre-emergence rotting than machine–harvested seed. Deliberate seed cracked away from the micropyle increased the amount of sugar but showed significantly less rotting at the 16 % soil moisture level than did seed cracked near the micropyle. They also observed that the amount of exudates from both hand-harvested seeds cracked opposite the micropyle (100% with cracked testa) and machine-harvested seeds (64 % with cracked testa) was approximately the same but machine-harvested seeds had significantly higher percentage rotting at all moisture levels (12.6-18 %) than did the hand-harvested seeds cracked away from the micropyle. They indicated that not only sugar loss and cracking of the testa influence pre-emergence rotting but other factors must also be considered.

Kerr (1964) stated that soil moisture do not affect disease incidence directly, but the importance of high soil moisture is to allow motility of zoospores and / or to increase the amount of sugar leaked from pea seeds to promote infection, or both may be involved. He also mentioned that both soil type and soil bulk density affect sugar loss (more sugar being exuded from pea seeds in non-aggregated sand than from those in aggregated soil).

He also reported that the pathogen causing diseases favored by low soil moisture too, infection might be reduced in wetter soils by plant leachates stimulating the soil microflora, which in turn inhibits growth of the pathogen.

Rajagopalan and **Bhuvaneswari (1964)** revealed that sowing of ungerminated seeds of rice resulted in rapid progression of the foot-rot disease and high mortality, and the infection was occurred within the first 72 hours after seeding, the period of bulk exudation of amino acids and sugars.

As quoted by **Rajagopalan** and **Bhuvaneswari (1964**), Rajagopalan, (1960) revealed that sowing of germinated seeds of rice resulted in delayed and slowed progression of the disease and lowered the mortality of the plants as compared with those ungerminated seeds. He also found that inoculation of ungerminated seed five days after planting (post-germination) brought down the mortality percentage from 90 to 22 %.

Certain cultivars of peas were susceptible to attack by Pythium species in the first 72 hours after planting in the soil and that during the period of rapid swelling over the first 24 hours, the seeds leaked copious amounts of sucrose which favored the growth of Pythium (Rajagopalan, 1960, as quoted by **Rajagopalan** and **Bhuvaneswari, 1964)**.

Schroth and **Cook (1964**) mentioned that the amount of exudates was increased with damage to the testa of bean seed.

Schroth, et al. (1966) stated that most of solutes leaked are sugars and amino acids, which can probably be replenished during later hydrolysis.

Larson (1968) proposed that the high leakage and reduced seedling growth of imbibed embryos was due to damage occurring during early imbibition, as a result of the disruption of cell membranes caused by the rapid inrush of water, allowing the leakage of cell materials leading to reduction of seeding growth. **Larson (1968**) found that the amount of material lost during 24 hours soaking from intact seeds was less than did embryos. The losses represent an insignificant amount compared to the dry weight changes of root, shoot and cotyledon of the seedling during their 18 days of growth. The intact seeds lost 1.76 mg per seed, which represents 1.05 % of its dry weight.

Matthews and **Bradnock (1968**) found exudation of electrolytes from seed soaked in distilled water for 24 h is negatively correlated to the seed vigor and field emergence: Also electrical conductivity is associated with the percent of non-viable seeds in the pea samples as well as with the predisposition to pre-emergence injury of seeds that are viable **(Matthews** and **Whitbread, 1968)**.

Simon and **Raja Harun (1972**) proposed that as seeds dry out cell membranes lose their integrity when such dry seeds imbibe water there is a short period before membrane integrity is reformed, during which solutes can leak out the cell. It was proposed that in the

dry peas seed, membranes phospholipids adopt the porous hexagonal organisation, so that leakage occurred rapidly when the dry seeds first placed in water but further leakage is depressed by reforming the normal bilayer structure of the membranes following rehydration, also solutes from inner cells may be limited by the increased length of diffusion path **(Simon, 1974**).

Harrison (1973) noted a decline in germination of intact peas following rapid imbibition in water at 1°C. This decrease in germination was associated with the death of the meristematic areas of the radicle and plumule (tissues in the axes).

Simon and **Wiebe (1975**) reported that the extent of leakage from imbibing pea embryo depends on the initial water content: At water content 35% or more, leakage in reduced to a relatively trivial rate. Seeds with this degree of hydration are killed by 2-min exposure to liquid nitrogen.

Bramlage et al. (1978) suggested that leakage period is a time of membrane reorganization, and imposing low temperature during this period prolongs the period leakage resulting in delayed membrane reorganization. They also concluded that a greater solute leakage during imbibition may deplete the tissues of soluble food reserves resulting in delaying germination or retarding growth of soybean seedling but it should not cause embryo failure. Moreover, solute leakage may stimulate growth of microorganisms.

Powell and **Matthews (1978**) reported no damage occurred to the surface of cotyledons when seeds were imbibed intact. Germination of intact seeds after soaking for 30 hours at 20°C was 100 %. Germination after imbibition minus the testa in water was 70% and the rate of germination slower than the intact seed. They also noted that the reduced germination from injured embryos may be resulted from the death of meristematic areas of the radicle and plumule, the same explanation was made by **Harrison (1973**) that the depression in seed germination was associated with the death of the meristematic tissues in the axes.

Lewis et al. (1979) found no problems with soaking several cultivars of peas and soybeans for 24 hours, whereas, snapbean seeds were injured by soaking for 24 hours in acetone.

Murphy and **Noland (1982**) stated that membranes are involved both in water up take and solute leakage. The effect of temperature on initial imbibition and leakage rates of radish and sugar pine can be accounted for primarily by changing in water viscosity. The imbibition should be dependent both on properties of water as well as the seed. It is indicated that viscosity is one of the temperature-dependent properties of water strongly involved in rates of absorption of seed. They also, found increasing in leakage rates at

chilling temperatures below 15°C and at temperatures above 28 to 30°C. These changes in leakage rates were associated with membrane properties.

Spaeth (1987) noted that during 6 hours, excised pea cotyledons leaked from 1 to 11 micrograms protein per milligram of seed dry weight and the quantities of protein diffused primarily depended on cultivar.

Norton (1988) noted that soaking seeds of pea for 21 hours at 25 °C reduced emergence percentage of both cultivars and even more for 72 hours, however, the response of the cultivars were different. Addition of oxygen to the soak water decreased subsequent emergence in peas.

Ledeunff (1989) reported that immersion of peas allowed a rapid water uptake which rate was strongly linked to temperature. At 10°C and 40°C, soaking, although during a brief period, inhibited the germination, increased abnormal seedling number and stimulated pathogen development and finally he concluded that hydration with folded paper with two contact areas was more advantageous than immersion.

Ellis et al (1990) noted that soaking the seeds in water for 24 hours at 20°C resulted in reducing of total germination, but only substantially for those seeds dried to 8.8% moisture content or below. When seed moisture content was reduced below 8.8% the proportion of seeds capable of any germination following soaking declined dramatically from just above 90% at 8.8% to just below 40% at 3.7%. The proportion of seeds injured by soaking increasing from no more than 5 % when the seeds before submerging were at 9-15 % moisture content to all of the seeds at around 4 % moisture content. They also found that the proportion of seeds capable of producing morphologically normal seedlings was much more sensitive than total germination to soaking

Petruzzelli et al. (1994) found that when peas were germinated at 5°C for the initial 8 h of imbibition and then removed to 20°C, germination and growth were significantly delayed and, at the same time, the burst of ethylene was delayed and much less intense.

Sivritepe and **Dourado (1995)** observed a reduction in normal germination of high viability pea seeds with 15.1% moisture content from 96.5% to 94% following 12 h soaking. Normal germination of the high viability and low moisture content decreased from 94% to 86% within the first hour of soaking and to 56% after 12 h soaking. In low vigor, and high moisture content seed lot, the normal germination declined from 79.5% to 3% after 12 h soaking. All differences were highly significant.

Petruzzelli et al. (1997) stated that exposing pea cv. Frijaune seeds to 5°C at the beginning of imbibition greatly delayed germination and ethylene production. The presence of ethephon improved tolerance to chilling injury. The greatest beneficial effect on

germination, ethylene production and $k^{+.}$ efflux reduction was obtained in the presence of zinc.

Sivritepe and Eris (2000) recorded that post-storage priming treatments increased germination percentage and decreased mean germination time (MGT) of pea seeds. The maximum benefit was occurred with 4 days treatment with water. They suggested that the critical seed moisture content, which facilitated repair of chromosomal damage, were between 34 and 38%.

3. MATERIALS AND METHODS

3.1. Pepper seed treatment by VITAVAX

The experiment was carried out in the glasshouse at the University of Horticulture and Food Industry, Budapest, Hungary. The work was started on 15th May 1995. The seed samples of three different type of pepper varieties (Capsicum annuum L.) hot long forcing variety Csipke, sweet open field variety Fehérözön and Kalocsai-622 sweet spicy pepper were treated with 0.2 % Carboxin 17 % + thiram 17 % (as Vitavax 200) or distilled water control. Each 100-pepper seed were placed on filter paper funnel inside a glass funnel. 25 ml of Vitavax or distilled water was poured into the glass funnel.

Immediately, following filtration of the solution, each 25 seeds were planted into each polyethylene containers, filled with Florasca soil-mix, and then irrigation was applied. Containers were then covered with moist paper towels and kept moist to ensure good condition for germination and emergence. Covers were removed as soon as the cotyledons cleared the soil. Watering was made as needed for all containers. Glass house temperatures were maintained at 27/22°C day/night ± 2 ^{o}C.

Seedlings were considered emerged when the cotyledons were free from the soil. In instances where, the cotyledons emerged with seed coat still attached, seedlings were considered emerged when the seed coat cleared the soil surface. Emergency was recorded daily.

At the termination of the experiment, 35 days after planting, total survival seedlings, normal and abnormal seedlings according to the ISTA regulation were recorded. Random samples of 12 seedlings per treatment (3 seedlings per container) from the total survival seedlings (normal and abnormal) were cut off at the soil surface and taken to the laboratory. Number of normal and abnormal seedlings of the 48 seedlings of 4 replication per treatment is represented in table (1). The following traits were determined.

1-Fresh weight of 12 seedlings (in grams): The 12 seedlings were weighted immediately to record fresh weight.

2-Stem-leaf area in cm^2 of 12 seedlings: The area of 12 seedlings was measured by. TIP LVM-2 instrument.

3-Dry weight in grams of 12 seedlings: The 12 seedlings were oven-dried at 105^{o} for 72 hours to determine dry weight.

4-Nitrogen, phosphorus and potassium seedling contents in mg/g seedling dry weight. Dried materials were grounded and then weighted for N, P and K assessment by Kyeldahl method.

The 2 seed treatments and 3 different type of pepper variety were arranged in a factorial, using completely randomized design. Each treatment 100 seeds were replicated 4 times. The analysis of variance and LSD were calculated according to the used design.

Table 1: Number of normal (NS) and abnormal (ABS) seedling taking randomly to the laboratory assessment

Type of variety Treatment	hot long forcing (Csipke)		sweet, open field (Fehérözön)		sweet spicy (Kalocsai-622)	
Seedling character	NS	ABS	NS	ABS	NS	ABS
Control	47	1	41	7	43	5
Treated	31	17	38	10	31	17

3.2. ATONIK seed treatments

Atonik, plant growth stimulant, products of ASAHI Chemical MFG., CO., LTD (4-15-1 Kitatanabe Higashisumiyshi ku Osaka, Japan), was obtained from Nichimen Cooperation, Budapest, Hungary. Atonik is a plant regulator eliminating the unfavorable environmental factors, which would impede plant development. It is neither phytotoxic nor dangerous for humans and environment. Atonik is no hormone, no pesticide but a special stimulant of biochemical and physical processes in the plants. Making use of Atonik, high yield of good quality may be obtained. Atonik can be applied in every phase of plant development. It is cheap, easy to apply and it increases yield and profit.

Action mechanism

Atonik can be easily taken up and translocated by the plants. It vitalized all the cells of the plant by accelerating plasma flow. It stimulates root formation, improves germination, and helps growth and fruit formation. It has a unique promoting effect on pollen germination, on the elongation of stamen filaments, on fertilization, and consequently, on better fruit setting.

Atonik is beneficial to the propagation of soil microorganisms, accelerates the decomposition of organic materials, and indirectly improves the fertility of the soil. Repeated treatments may result in higher effectiveness.

An adequate nutrient level in the soil and proper plant protection are preconditions of the successful application of Atonik.

Application in vegetable crops

Seed dressing: Vegetable seeds should be soaked in 0.05 % solution of Atonik (5 ml Atonik in 10-liter water) for 8 hours. The treatment makes germination quicker and more uniform.

Composition of Atonik, It is composed of the following:

0.1% 5-nitroguayacol Na-salt

0.2% o-nitrophenol Na-salt

0.3% p-nitrophenol Na-salt

3.2.1. ATONIK tomato seed treatment

National Institute for Agricultural Quality Control, Budapest, Hungary provided two different germinability seed samples of tomato (Lycopersicon esculentun L.) one was low 57% germination (cultivar K-Jubileum) the second 77% pursuant to the standard (cultivar Delta).

Seeds were soaked at room temperature for a period of 8 hours in 25 ml of fresh prepared aqueous solutions of Atonik at 0.25, 0.5 and 1.0 ml/l or in deionized water as a control. Then seeds were removed from the solution and deionized water and were air dried at room temperature. On the next day, March 8th, 1996 50 seeds of each treatment were seeded between paper towels, and germinated according to the ISTA rules (1995) regulations in the growth chamber with day/night temperatures of 30/20 °C and relative humidity of 75 %. Each 100 seeds represent one treatment. Each treatment was replicated 4 times. The treatments were arranged in a factorial experiment using a completely randomized design. First evaluation was made after 5 days, on March 13th for seed germination percentage. Final evaluation was made after 10 days, on March 18th and normal seedling percentage was recorded. Length of root and hypocotyl were assessed from 20 seedling taken randomly from each treatment. The analysis of variance and LSD were calculated according to the used design.

3.2.2. ATONIK cucumber seed treatments

Effect of Atonik treatment on high germination cucumber seed

National Institute for Agricultural Quality Control, Budapest, Hungary provided sample of cucumber seed with high germination % (above 95) (Cucumis sativus L) (cultivar Dolge Zelene from Slovenia)

Seeds were soaked for periods of 8 and 24 hours in 25 ml of fresh prepared aqueous solutions of Atonik at 0.25, 0.5 and 1.0 ml/l or in deionized water as a control. Seeds with Atonik solution were placed in the growth chamber with day/night temperatures of 30/20 °C and relative humidity of 75 %.

Seeds of previously treated with Atonik solutions or deionized water were seeded between papers and germinated according to the ISTA rules (1995) regulations in the same growth chamber with the same conditions. Seeds were incubated in the end

of May for 8 hours soaking period and in the first of June 1996 for 24 hours soaking period, at National Institute for Agricultural Quality Control, Budapest. First germination percentage count was made 96 hours after sowing.

At the termination of the experiment 186 ± 2 hours of the sowing, final germination percentage, normal seedling percentage, seedlings hypocotyl, length of 3 cm and more percentage and seedlings hypocotyl length of 5 cm and more percentage were recorded.

The 4 seed treatments and the 2 soaking periods were arranged in a factorial in a complete randomized design. Each treatment 50 seeds and was replicated 4 times. The analysis of variance and LSD were calculated according to the used design.

Effect of Atonik treatment on two different cucumber varieties (Budai félhosszú) F_1 vigorous and (Nati F_1) medium plant growth

Cucumber cultivars, Budai félhosszú seed lot of 1990 and Nati F_1 seed lot of 1991 were soaked for 8 hours at room temperature in fresh aqueous solution of Atonik at the rate of 0.25 ml/l or in distilled water or no soaked seeds, dry control seeds. The experiment was carried out in glass house on February 1997 at University of Horticultural and Food Industry, Budapest, Hungary

After soaking, surface moisture was quickly removed with absorbent paper. Seeds were then planted in directly after treatment without drying in transplanting trays filled with vermiculite. After seeding, trays were irrigated then covered with moist paper to maintain good moisture condition. Once emergence started, the cover was removed immediately. The criterion used for emergence was the freeing of the cotyledons from the vermiculite. Irrigation was applied as needed. Seedlings were fertilized. Seedlings were transplanted on March 25 and 26th1997. The experiment was terminated on April 29-30th. Emergence percentage, mean emergence time (MET) and length per seedling were calculated and recorded. Assessment of plant photochemical efficiency was performed with portable Plant Efficiency Analyser (PEA).

Data were subjected to statistical analysis, in case of significance; LSD separated means was applied. The experimental design used was completely randomized factorial design with four replicates each 25 seeds.

Seeds of cucumber cvs. Budai félhosszú and Nati F_1 were acquired from National Institute for Agricultural Quality Control Budapest, Hungary. The experiment was carried out in the greenhouse at the University of Horticultural and Food Industry, Budapest, Hungary. Seeds of both cultivars were treated as in experiment 2. Dry seeds were not included. Seeds were then planted in pots of size number 10 filled with vermiculite. Emergence percentage, mean emergence time were recorded. Seedling

length was measured as the average of 24 seedlings, on June, 15-16th, 1997. The experiment was designed in completely factorial design with four replicates. Each treatment consisted of 25 seeds. Data were statistically analyzed and LSD was used to compare means.

Seeds of cucumber varieties named, Budai félhosszú F_1 and Nati F_1 were soaked in fresh prepared aqueous solution of Atonik at 0.25 ml/l and distilled water for 8 hours (Zaghdani et al., 1996) at room temperature. After surface drying, each 50 seeds were placed in plastic trays on folded towel paper moistened with tap water. Trays were covered with their covers and incubated at 10, 15, 20 and 25°C. in light except for 10°C, was in dark. Incubation period ranged from one week for 20 and 30/25°C and 30 days for 10 and 15°C. Seeds were inspected daily and germinated seeds with radical length of 5 mm or more were recorded and removed out. Nongerminated seeds, which were incubated at 10 and 15°C for 30 days, were transferred to 25°C to determine the effect of incubation at low temperatures (10 and 15°C for one month) on seed germinability. Water was added to the trays as needed during incubation period for all treatments.

The experiment was conducted during June 1997, at National Institute for Agricultural Quality Control, Budapest, Hungary. The experiment was designed as completely randomized factorial design with 4 replicates per treatment. Each replicate consists of 50 seeds per tray.

Final germination percentage and mean germination time were calculated and subjected to statistical analysis. LSD was used to compare between means.

3.3. Water soaking pea seed treatments

For study of the effect of water soaking on germination we used different smooth- seeded and wrinkle-seeded pea seed samples.

3.3.1. Smooth-seeded variety

Seed samples of two different varieties, wrinkle-seeded variety (Jubileum) and variety (Rajnai törpe) were used in this study during March 1998 at The National Institute for Agricultural Quality Control Laboratories, Budapest Hungary to determine the effect of soaking periods and temperatures on pea seed quality. Seeds of Jubileum were used in a preliminary experiment at a wide range of temperatures from 0°C to 30°C. The results indicated that the temperature of 0°C gave the lowest result and the 30°C reduced the germination percentage as compared with 15°C.

Based upon this results, 50 seeds of variety Rajnai törpe were soaked in deionized water at 5, 10, 15 and 20°C for periods of 0.5, 1, 4, 8, 24, 48 and 72 hours and non-soaked seeds, as a control. After each soaking period, seeds surface moisture were removed by

absorbent paper and seeded between rolled paper. The rolled papers were placed in polyethylene bages for moisture conservation and then incubated at 20°C for 8 days according to the **ISTA** (1995) rules (Figure 32).

At the end of the experiment (8 days), the total germination percentage, normal germination percentage, normal seedlings percentage, vigorous seedling percentage (epicotyl length longer than 5 cm) and non-vigorous seedling percentage (epicotyl length shorter than 5 cm).

Data were statistically analysed based on a completely randomized factorial design with four replicates. Each treatment contained 100 seeds. Means comparison was performed using LSD.

3.3.2. Wrinkle-seeded pea variety

Samples of 50 wrinkle-seeded pea variety Farida were used in this study during July 1998 to determine the influences of water soaking times and temperatures on pea seed quality.

The study was conducted at the Laborites of National Institute for Agricultural Quality Control, Budapest Hungary. Each 50 seeds were weighed and soaked in 250 ml of deionized water in 400 ml beakers for 0.5, 1, 41, 118, 24, 48 and 72 hours at 5, 10, 15 and 20°C in four replicates. Following each seed treatment, seeds were removed from water, surface dried and reweigh to determine the amount of water absorbed (expressed as percentage of a fresh weight gain during each imbibitional period). Unsoaked, dry seeds were used as a control. Germination tests were carried out between wet papers and incubated at 20°C for 8 days.

After 8 days, seedlings were classified as vigorous (epicotyl longer than 5 cm) or non-vigorous (epicotyl shorter than 5 cm). Fresh and dry weights of normal seedlings were measured. Respiration of short and long seedlings were checked by IRGA, LI-COR 6200 photosynthesis system. Normal germination %, vigorous seedling % and the dry weigh percentage of the normal seedlings were calculated.

Data were analysed as a completely randomized factorial design with two factors and 4 replicates. Statistical analysis was performed by a two-way analysis of variance followed by LSD mean separation test.

3.3.3. Electrical conductivity measurements of wrinkle-seeded pea seed

Samples of wrinkle-seeded pea variety Lambado used in this study were obtained from the laboratory of The National Institute of Agricultural Quality Control, Budapest, Hungary. The study was conducted at the laboratory of the National Institute of Agricultural Quality Control. During Seed moisture content at the time of the study was determined by the high constant temperature oven method prescribed by the

International Seed Testing Association (**ISTA, 1995**). Seed moisture content was 10.4 % (fresh weight basis). Seeds with visible damage were discarded as feasible.

Four replicate patches of 50 seeds (with same size) were weighed and soaked in 250 ml of deionized water in 400 ml beakers at 20 °C for various periods (15, 30, 60 min., 4, 8, 12, 24, 48 and 72 hours). The beakers were then covered for protection. At predetermined intervals, the seeds were removed, blotted dry and re-weighed. Changes in weight due to imbibition were expressed in terms of an increase in the percentage moisture content (expressed as a percentage of seed wet weight).

The electrical conductivity of the soak water was determined at the start and at the end of each soaking period after gently swirling the solution and seeds. The electrical conductivity was measured with a portable measuring bridge (cell constant 0.71) and the results expressed in $\mu S\ cm^{-1}\ g^{-1}$. To assess the imbibition and electrical conductivity of the steep water during the 72 h, seeds were removed from the soak water after 0.5, .75, 1, 4, 8, 24, 48 and 72 h of the beginning of soaking. At each interval, electrical conductivity of steep water was measured and seeds were blotted dry and re-weighed, and then returned to the same water in their beakers.

The seed viability and seedling vigor was determined after imbibition treatments. Each 50 seeds (replicate) were planted in one white plastic tray of sand. The trays were closed with their own covers and placed in the growth chamber at 20°C. Soil moisture level in the trays was adjusted by adding one volume of water per three volumes of sand. Trays were inspected daily to count and record the emerged seedlings. Mean emergence time (MET) was calculated (**Powell et al., 1997**). At the end of the experiment (12 days after planting), trays were taken out of the growth chamber. Final counts for emerged seedlings were recorded. Emerged seedlings were carefully removed from the sand and then immersed in water to remove all adhering soil. Abnormal seedlings (as prescribed by **ISTA 1996**) were separated, counted and discarded. The length of normal seedlings (epicotyl) was measured by digital sliding caliper. Fresh weights of the plumula, root system and cotyledon of the normal seedlings were determined and recorded. Dry weights of cotyledons, plumules and roots were determined by drying in an oven at 90 C for 5 days.

Another four replicate patches of 50 seeds (with same size) were weighed and soaked in 250 ml of deionized water in 400 ml beakers at 20 °C for various periods (15, 30, 60 min., 4, 8, 12, 24, 48 and 72 hours). The beakers were then covered for protection. At predetermined intervals, the seeds were removed, blotted dry and re-weighed. Changes in weight due to imbibition were expressed in terms of an increase in the percentage moisture content (expressed as a percentage of seed wet weight). The electrical conductivity of the soak water was determined at the start and at the end of each soaking period after gently swirling the solution and seeds. The electrical

conductivity was measured with a portable measuring bridge (cell constant 0.71) and the results expressed in μS cm^{-1} g^{-1}. Minerals leaching in the steep water were determined at the end of each soaking period by INDUCTIVELY COUPLED PLASM (ICP). The results were expressed as part per million (ppm).

Data were analysed as a completely randomised design with 4 replicates. Statistical analysis was performed by a one-way analysis of variance followed by LSD mean separation test when the F-test was significant at least at 0.05 level.

4. RESULTS

4. 1. Effect of VITAVAX on seed performance

The calculations of pepper seedling emergence and seedling growth were finally presented in Tables 2, 3 and 4 and Figures 2-6.

4.1.1. Seedling emergence 16 day after planting

Tables 2, 3 and 4 show the effect of Vitavax seed treatment of three pepper types on seedling emergence in terms of percentage. The statistical analysis showed that the effect of pepper type, seed treatment and the inter-action type x seed treatment were significant. Seedling emergence percentage was higher in Fehérözön (sweet open field) and Kalocsai-622 (sweet spicy) varieties with no significant difference between them. The averages were 84.25, 82 % and 60.75 % for Fehérözön, Kalocsai-622 and Csipke (hot long forcing pepper), respectively (Table 4). As to the effect of seed treatment, seedling emergence was affected by seed treatment (Figure 2). Vitavax seed treatment significantly decreased the percentage of seedling emergence at 5 % level. The averages were 78.5 % and 73.23 % for control and treated seeds, respectively (Table 3).

As to the variety x seed treatment interaction, seedling emergence of the three pepper types and the two seed treatments can be compared using the given LSD (Table 2).

It can be said here that Vitavax seed treatment can not be recommended to be used at 0.2 % conc. with Fehérözön (sweet open field) or Csipke (hot long forcing pepper) variety, because it decreased emerged seedlings significantly at 1 % level as compared with control. Where as, Vitavax seed treatment of Kalocsai-622 increased the emerged seedlings, but this increase just failed to be significant (Table 2).

4.1.2. Seedling survival percentage

Tables 2, 3 and 4 show the influence of Vitavax seed treatment of three pepper types on the survival seedling percentage 35 days after planting. The effect of pepper types and inter-action were significant, the effect of seed treatment was not significant. Due to the effect of pepper types, the difference between Fehérözön and Kalocsai-622 was not significant, but both of them produced significantly higher percentage of survival seedling than Csipke the averages being 88.00, 86.375 % and 70.25 % for Kalocsai-622, Fehérözön

and Csipke, respectively (Table 4). As to the pepper types x seed treatment interaction, Vitavax highly significantly decreased the survival seedling percentage for Fehérözön variety as compared with untreated seeds, while the increasing effect of Vitavax on survival seedling percentage with Kalocsai-622 and Csipke was not significant compared with control (Table 2). As to the effect of seed treatment, the effect of Vitavax was comparable to the control; they produced 81.33 % and 81.75 %, respectively (Table 3).

4.1.3. Normal seedling percentage

Tables 2, 3 and 4 show the effect of Vitavax seed treatment of pepper types on normal seedling percentage.

The analysis of variance indicated that all two main effects and interaction were significant. Kalocsai-622 variety was highly significantly superior over the other two varieties followed by Fehérözön, which produce higher normal seedling percentage than Csipke at the 5 % level of significant. The average means were 78.125, 69.625 % and 59.750 % for Kalocsai-622, Fehérözön and Csipke, respectively (Table 4).

As to the effect of seed treatment, Vitavax seed treatment appeared to have a deleterious effect on the normal seedling percentage however; Vitavax highly significantly reduced the normal seedling percentage as compared with control. The averages were 73.667 % and 64.667 % for control and treated seeds, respectively (Table 3, Figure 3).

As to the variety types x seed treatment inter-action, Vitavax seed treatment resulted in a reduction of normal seedling percentage of Fehérözön variety at the 1.0 % level of significant. The reduction with Csipke variety was not significant. Although, Vitavax increased the normal seedling percentage for Kalocsai-622 variety, but the increase just failed to be significant. At the seed treatment with Vitavax, Kalocsai-622 variety was highly significantly above both Fehérözön and Csipke varieties. But with untreated seeds, Csipke variety was significantly below both Fehérözön and Kalocsai-622 at 1 % and 5 % level, respectively (Table 2).

4.1.4. Abnormal seedling percentage

Tables 2, 3 and 4 show the influence of Vitavax seed treatment of the three pepper variety types on seedling abnormality percentage. The analysis of variance revealed that the two main effects and the interaction were significant. Kalocsai-622 and Csipke variety produced almost the same abnormal seedling percentage and both were significantly

superior to Fehérözön at the 5 % level. The averages were 10.5, 16.75 % and 9.875 % for Csipke, Fehérözön and Kalocsai-622, respectively (Table 4).

As to the seed treatment, untreated seeds resulted in highly significantly lower abnormal seedling percentage. The averages being 7.667 % and 17.083 % for untreated and Vitavax seed treatment, respectively (Table 3).

As to variety types x seed treatment interaction effect, at the Vitavax seed treatment, Fehérözön variety produced highly significantly percentage of abnormal seedling than both Kalocsai-622 and Csipke varieties at the 1 % level. The difference between Kalocsai-622 and Csipke was not significant. Vitavax seed treatment increased the seedling abnormality percentage as compared with control at the 1 % and 5 % level for Fehérözön and Csipke, respectively. But with Kalocsai-622 the increase was not significant as compared with control (Table 2).

4.1.5. Seedling fresh weight

The effect of Vitavax seed treatment of 3 pepper variety types on fresh weight is presented in Tables 2, 3, 4 and Figure 4. The statistical analysis revealed that the effect of seed treatment was significant, but the effects of variety types and variety x seed treatment interaction were not significant.

As to the seed treatment, application of Vitavax decreased the seedling fresh weight highly significantly by 2.76 g as compared with control. The averages being 9.66 g for control and 6.9 g for Vitavax treatment (Table 3).

The differences among varieties at any seed treatment were not significant. Also reduction of fresh weight due to Vitavax seed treatment in any variety was not significant too (Table 2).

The three varieties produced comparable fresh weight. Their averages were 8.50, 8.22 g and 8.12 g for Csipke, Fehérözön and Kalocsai-622, respectively (Table 4).

4.1.6. Stem-leaf area in cm^2 of seedlings of pepper

The effect of Vitavax seed treatment of pepper variety types on stem-leaf area is shown in Tables 2, 3, 4 and Figure 4. The analysis of variance revealed that the effects of seed treatment and variety x seed treatment inter-action were significant, but the effect of variety was not significant. The seedling stem-leaf area was not affected by variety, the averages being 23.250, 22.250 cm^2 and 21.125 cm^2 for Fehérözön, Kalocsai-622 and Csipke, respectively (Table 4).

Vitavax application had a highly significant effect on seedling stem-leaf area. The reduction was 8.083 cm^2 as compared with control. The mean averages were 26.250 cm^2 and 18.167 cm^2 for control and Vitavax treatment, respectively (Table 3).

As to the seed treatment x variety interaction, the Vitavax significantly reduced the seedling steam-leaf area of Csipke variety by 14.75 cm^2. But the reduction of seedling stem-leaf area of both Kalocsai-622 and Fehérözön as compared with control did not reach significant level. At the control seed treatment, the three varieties did not show significant difference among them. But at the Vitavax seed treatment, the seedling stem-leaf area for Csipke was significantly lower than that for the other varieties. The difference between Fehérözön and Kalocsai-622 was not significant (Table 2).

4.1.7. Seedlings dry weight

The effect of Vitavax seed treatment of three pepper variety types on seedling dry weight is presented in Tables 2, 3, 4 and Figure 4, 5. The statistical analysis indicated that the effect of seed treatment was significant but there was no sign of effects due to variety or interaction.

Vitavax seed treatment produced highly significant reduction in seedling dry weight by 0.209 g as compared with untreated seed control. The averages being 0.696 g and 0.487 g for control and Vitavax treatment, respectively (Table 3)

As to the variety x seed treatment interaction effects, the reduction in dry weight as affected with seed treatment in response to any variety or the difference in dry weight among varieties in response to seed treatment, both had no significant effect (Table 2).

The differences among the three varieties were not significant. The averages being 0.576, 0.612 g and 0.588 g for Csipke, Fehérözön and Kalocsai-622, respectively (Table 4)

4.1.8. Seedling NPK content mg/g seedling dry weight

Nitrogen content

Tables 2, 3, 4 and Figure 6 show the effect of Vitavax seed treatments of three pepper variety types on seedling nitrogen contents. The analysis of variance indicated that the two main effects and inter action were significant. The Csipke seedlings nitrogen content was superior over the other varieties at the 1 % level, followed lay Fehérözön compared with Kalocsai-622 at the 5 % level. The averages being 43.696, 40.600 mg/g and 38.966 mg/g seedling dry weight for Csipke, Fehérözön and Kalocsai-622, respectively (Table 4).

As to the seed treatment effects, Vitavax seed treatment highly significantly increased seedling nitrogen content by 3.331-mg/g dry weight as compared with control. The averages were 42.753 mg/g and 39.422-mg/g dry weight for Vitavax seed treatment and control, respectively (Table 3).

Where as, the variety x seed treatment interaction, the Vitavax seed treatment was superior over control at each of the three varieties by 1.492, 4.9 mg/g and 3.602 mg/g dry weight with Kalocsai-622, Fehérözön and Csipke, respectively. All these differences were significant, except with Kalocsai-622, the difference was not significant. On the other hand, Csipke variety showed superiority over the other varieties at any one of seed treatments followed by Fehérözön at Vitavax seed treatment only. All differences were significant at the .01 level (Table 2).

Phosphorus content

The effect of Vitavax seed treatment of the three pepper variety types on seedling phosphorus content is represented in Tables 2, 3, 4 and Figure 6. The statistical analysis revealed that the effect of variety was significant, but seed treatments and interaction effects were not significant.

Neither the increases nor the decrease in phosphorus content due to Vitavax in both Csipke and Kalocsai-622 or with Fehérözön were significant due to. Also the differences among varieties at each seed treatment were not significant (Table 2).

The reduction effect of Vitavax was not significant as compared with control. The averages being 2.156 mg/g and 2.115 mg/g dry weight for control and Vitavax, respectively (Table 3)

As to the effect of variety types, Fehérözön variety was significantly lower than Kalocsai-622 and Csipke at the 5 % and 1 % level, respectively. The difference between Kalocsai-622 and Csipke was not significant. The averages being 1.869, 2.201 mg/g and 2.336 mg/g dry weight for Fehérözön, Kalocsai-620 and Csipke, respectively (Table 4).

Potassium content

Tables 2, 3, 4 and Figure 6 show the effect of Vitavax seed treatments of three pepper variety types on seedling potassium content. The analysis of variance indicated that the two main effects and interaction were significant. As to the effect of variety, Csipke was highly significantly higher than Fehérözön and Kalocsai-622. But the differences

between Kalocsai-622 and Fehérözön were not significant. Their averages were 125.25, 106.55 and 112.25 mg/g dry weight for Csipke, Fehérözön and Kalocsai-622, respectively (Table 4).

As to the seed treatment effect, Vitavax seed treatment highly significantly increased K content as compared with control. The average being 107.267 mg/g and 122.1 mg/g dry weight for control and treated seed, respectively (Table 3).

As to the variety types x seed treatment interaction effect, the differences among varieties at the control were not significant, while at Vitavax, the differences between Kalocsai-622 and Fehérözön was significant at the 5 % level and the difference between Csipke and the other two varieties was highly significant. The averages due to the Vitavax were 143. 116.9 mg/g and 106.4 mg/g dry weight for Csipke, Kalocsai-622 and Fehérözön, respectively (Table 2).

Table 2: Effects of Vitavax seed treatment and pepper variety types on seedling emergence % 16 days after sowing (SE%), survival seedlings % (SS%), normal seedlings % (NS%), abnormal seedlings % (ABS%), 12 seedlings fresh weight g (SFW), stem-leaf area cm^2 of 12 seedlings (SLA cm^2), 12 seedlings dry weight g (SDW) and seedling nutrients contents mg/g dry weight of N, P and K 35 days after sowing.

Variety types	Treat.	SE%	SS%	NS%	ABS%	SFW	SLA	SDW	N	P	K
Forcing pepper (Csipke)	Control	66.50	69.250	63.000	6.250	10.640	28.500	0.746	41.895	2.313	107.500
	Vitavax	55.000	71.250	56.500	14.750	6.360	13.750	0.406	45.497	2.360	143.000
White pepper (Fehérözön)	Control	90.000	90.500	83.250	7.250	9.250	25.500	0.687	38.150	1.955	106.700
	Vitavax	78.500	82.250	56.000	26.250	7.190	21.000	0.537	43.050	1.783	106.400
Spice pepper (Kalocsai-622)	Control	79.000	84.250	74.750	9.500	9.090	24.750	0.657	38.220	2.200	107.600
	Vitavax	86.200	91.750	81.500	10.250	7.150	19.750	0.519	39.712	2.202	116.900
LSD P= 0.05		7.280	7.900	8.070	6,980	NS	5.800	NS	1.692	NS	8.840
LSD P= 0.01		9.980	NS	11.060	9.550	NS	NS	NS	NS	NS	12.120

NS= non-significant.

Table 3: Effects of Vitavax seed treatment on pepper seedling emergence 16 days after sowing (SE%), survival seedlings (SS%), normal seedlings (NS%), abnormal seedlings (ABS%), 12 seedlings fresh weight g (SFW), stem-leaf area cm^2 of 12 seedlings (SLA cm^2), 12 seedlings dry weight g (SDW) and seedling nutrients contents mg/g dry weight of N, P and K 35 days after sowing.

Treatments	SE%	SS%	NS%	ABS%	SFW	SLA	SDW	N	P	K
Control	78,500	81,330	73,667	7,667	9,66	26,250	0,696	39,422	2,156	107,267
Vitavax	73,230	81,750	64,667	17,083	6,900	18,167	0,487	42,753	2,115	122,100
LSD P= 0.05	4,206	NS	4,662	4,027	1,200	3,348	0,092	0,977	NS	5,107
LSD P= 0.01	NS	NS	6,387	5,516	1,655	4,586	0,126	1,338	NS	6,997

NS= non-significant.

Table 4: Effects of pepper variety types on seedling emergence 16 days after sowing (SE%), survival seedlings (SS%), normal seedlings (NS%), abnormal seedlings (ABS%). 12 seedlings fresh weight g (SFW), stem-leaf area cm^2 of 12 seedlings (SLA cm^2), 12 seedlings dry weight g (SDW) and seedling nutrients contents mg/g dry weight of N, P and K 35 days after sowing.

Variety types	SE%	SS%	NS%	ABS%	SFW	SLA	SDW	N	P	K
Forcing pepper (Csipke)	60,750	70,250	59,750	10,500	8,500	21,125	0,576	43,696	2,336	125.250
White pepper (Fehérözön)	84,250	86,.375	69.625	16,750	8,220	23,250	0,612	40.600	1.869	106.550
Spice pepper (Kalocsai-622)	82,600	88,000	78.125	9.875	8,120	22,250	0,588	38.966	2.201	112.250
LSD P= 0.05	5,151	5,584	5,710	4,932	NS	NS	NS	1,197	0,360	6,255
LSD P= 0.01	7,056	7,650	7,822	NS	NS	NS	NS	1,639	0,630	8,570

NS= non-significant.

Figure 2. Effects of Vitavax seed treatment and variety types on seedling emergence % (SE%), survival seedlings % (SS%), normal seedlings % (NS%) and abnormal seedlings % (ABS%) 16 days after sowing

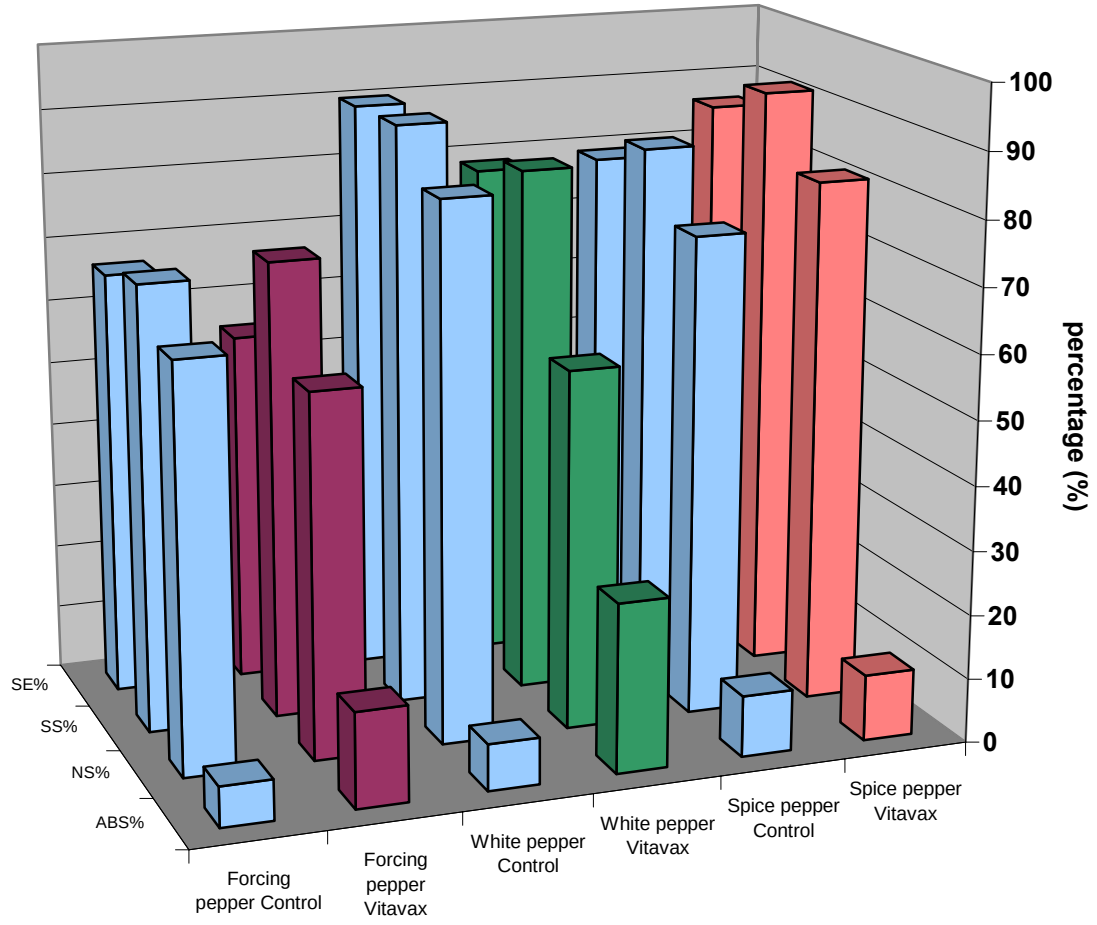


Figure 3. Effects of Vitavax seed treatment on seedling emergence (SE%), survival seedlings (SS%), normal seedlings (NS%), abnormal seedlings (ABS%) 16 days after sowing

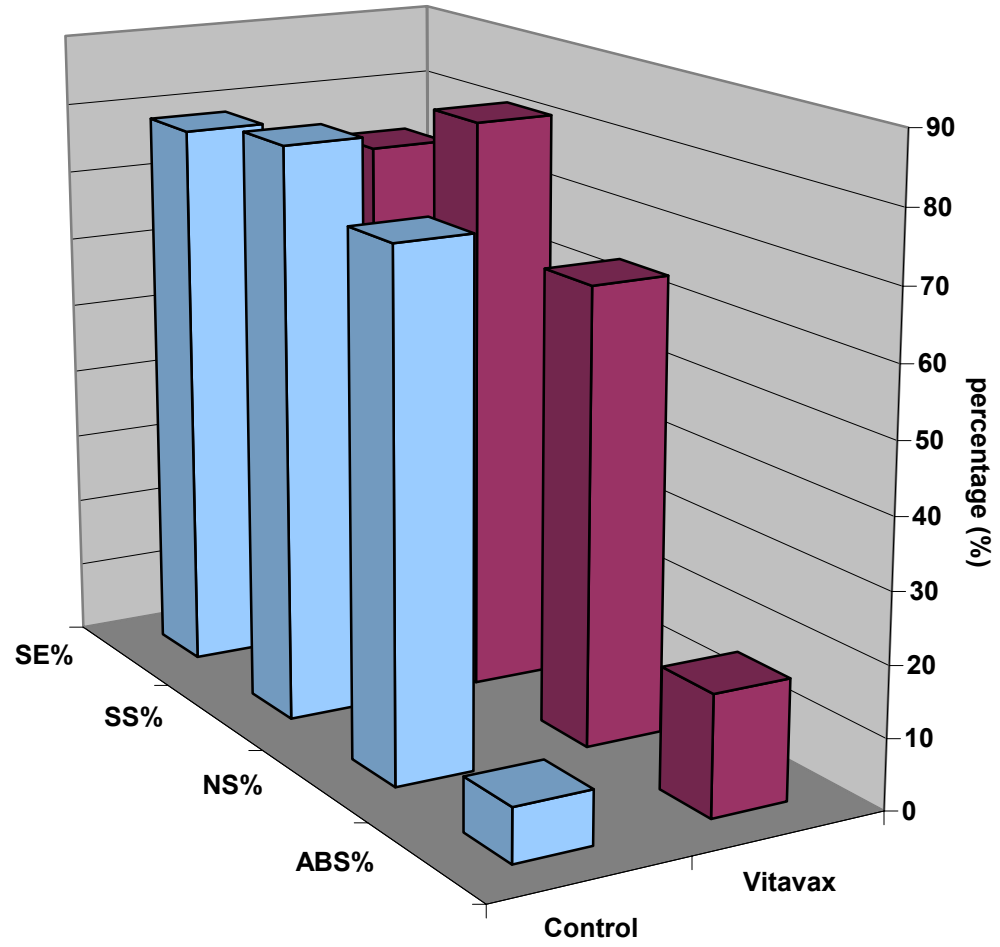


Figure 4. Effects of Vitavax seed treatment and variety types on fresh weight (SFW, g), stem-leaf area (SLA, cm^2) and dry weight (SDW, g) of 12 seedlings 16 days after sowing

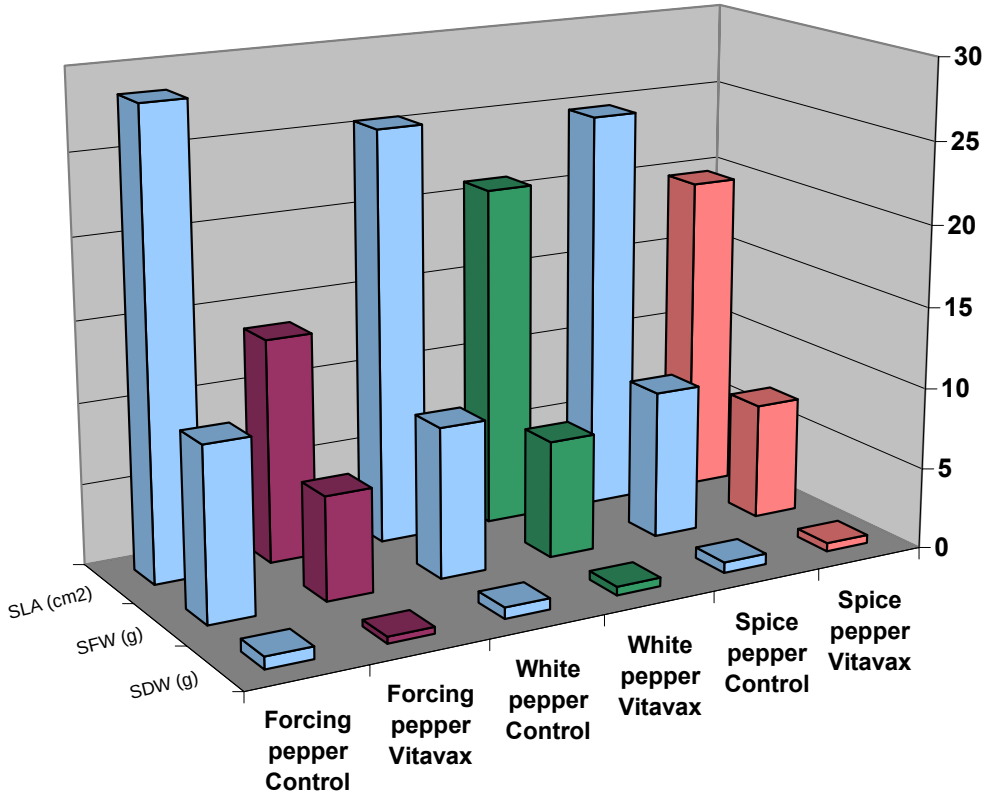


Figure 5. Effects of cultivars on fresh weight (SFW, g), stem-leaf area (SLA, cm^2) and dry weight (SDW, g) of 12 seedlings 16 days after sowing

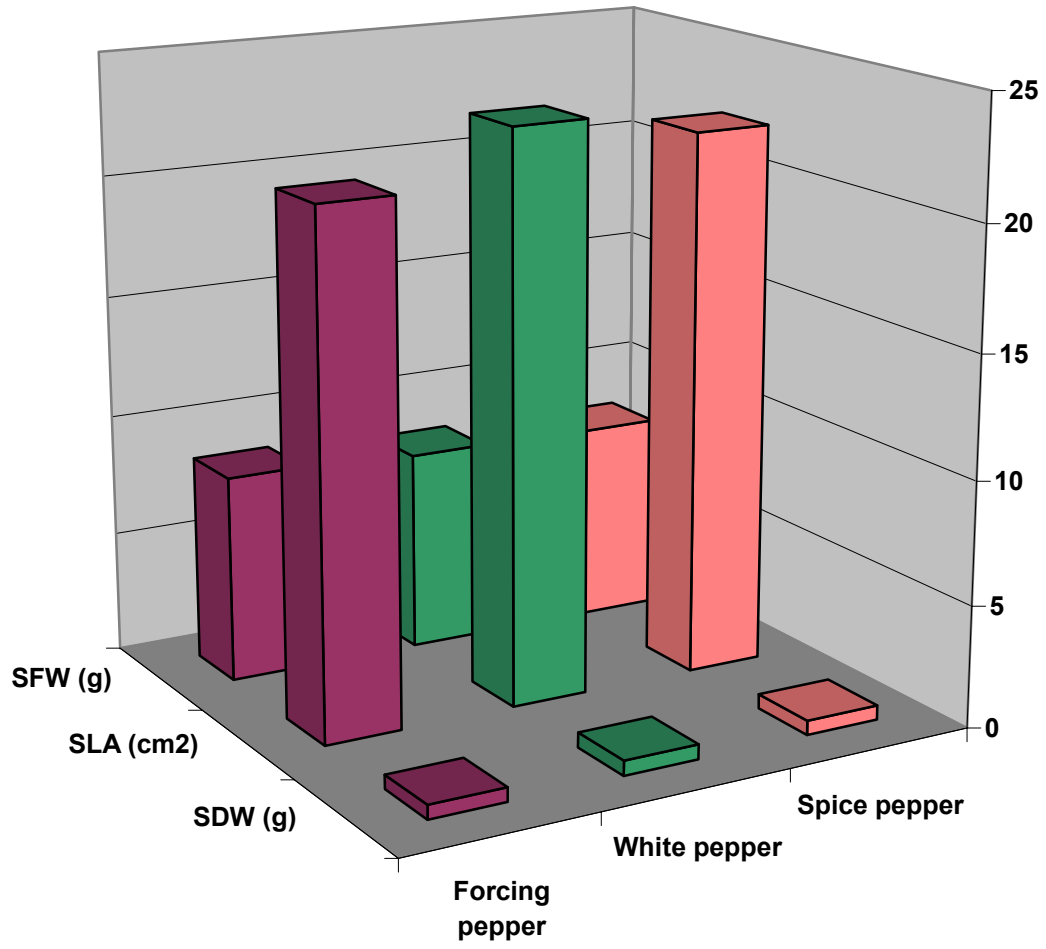
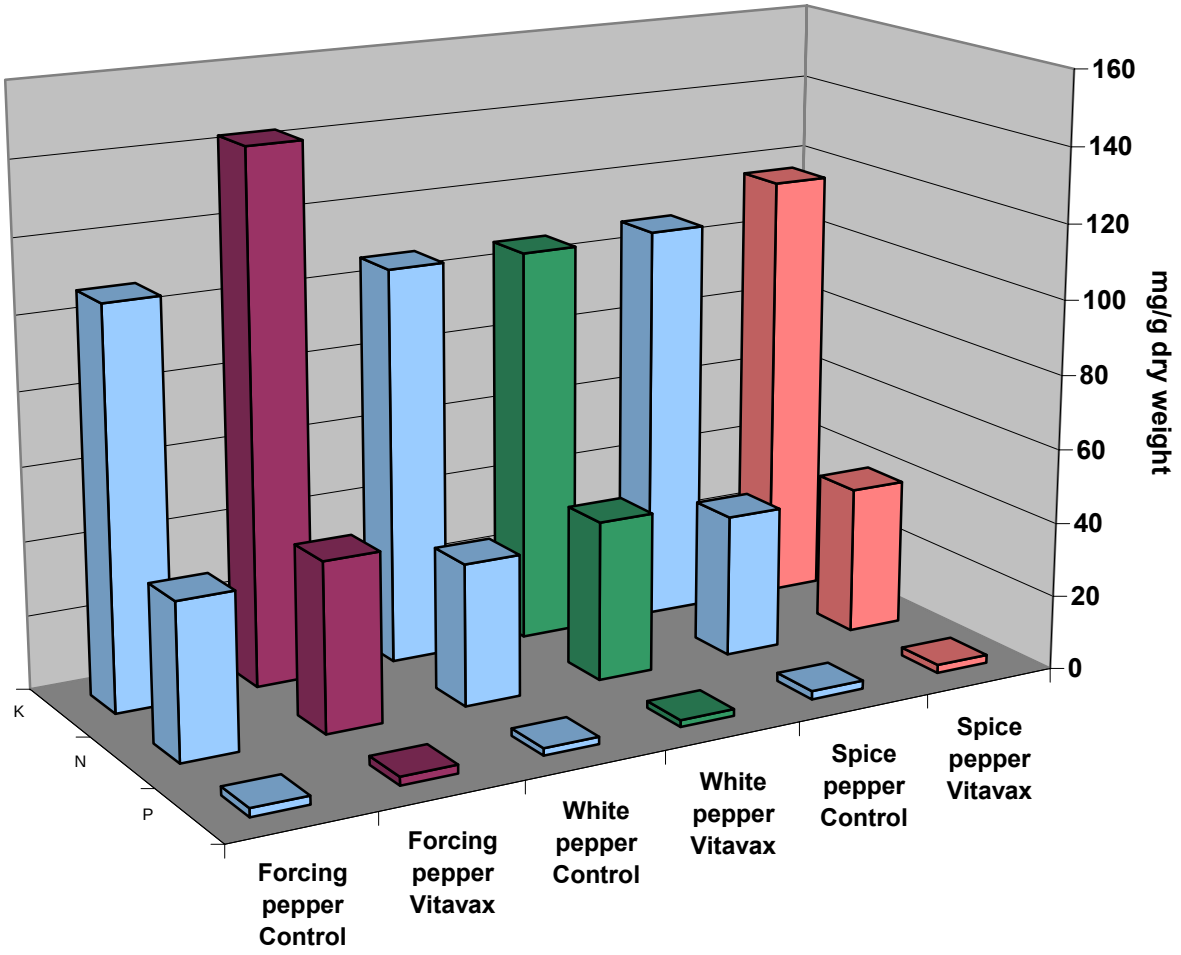


Figure 6. Effects of Vitavax seed treatment and variety types on seedling nutrients contents of N, P and K (mg/g dry weight) 35 days after sowing



4.2. EFFECTS OF ATONIK SOLUTION ON TOMATO SEED PERFORMANCE

Results of Atonik effects on tomato seed are presented in Tables 5, 6, 7 and Figures 7 and 8.

4.2.1. Seed germination

Statistical analysis revealed that the effects of the treatment and the interaction were not significant, but the effect of the germinability of seed samples was highly significant. Seed germination percentage of Delta variety was higher (77 %). K-Jubileum variety 57 % (Table 5). Due to the effect of treatment cross the average germination percentage ranged from 64.63 to 68.88 % for Atonik (1.0 ml/l) and (0.5 ml/l), respectively (Table 6).

4.2.2. Normal seedling percentage

Neither seed treatment nor the interaction had significant effect. The mean average normal percentage ranged from 89 to 87.63 % for Atonik at 0.25 ml/l and the control, respectively (Table 6). Cross seed treatments, variety K-Jubileum produced 89.3 %, while Delta gave 84.19 % (Table 5). The difference was highly significant.

4.2.3. Radicle length per seedling (cm)

Radicle seedling length did not affected by Atonik treatment or by the interaction. Radicle length ranged from 6.81 to 6.59 cm for Atonik at 0.25 ml/l and at 0.5 ml/l, respectively (Table 2). Delta variety had highly significantly longer radicle (7.2 cm) than K-Jubileum (6.14 cm) (Table 5).

4.2.4. Hypocotyl length per seedling (cm)

The results indicated that K-Jubileum variety produced longer seedling during this period (5.76 cm) than Delta (5.31 cm). The difference between them was highly significant (Table 5). Effect of seed treatment across variety was not significant, the range was from 5.56 to 5.52 cm for control and Atonik at .05 or at 1.0 ml/l (Table 6).

Table 5: Effect of tomato varieties on seed germination % (G %), normal seedling % (NS %), radicle length (RL cm) and hypocotyl length (HL cm) after 8 days

Varieties	G %	NS %	RL cm	HL cm
Delta	77,00	84,19	7,20	5,31
K-Jubileum	57,13	89,63	6,14	5,76
LSD 0.01	**	**	**	**

** = Highly significant differences.

Table 6: Effect of seed treatment on seed germination % (G %), normal seedling % (NS %) and length of radicle (RL cm) and hypocotyl (HL cm) after 8 days.

Seed Treatment	G %	NS %	R L Cm	H L Cm
Control	68,00	87,63	6,62	5,56
Atonik at 0.25	66,75	89,00	6,81	5,53
Atonik at 0.5	68,88	86,50	6,59	5,52
Atonik at 1.0	64,63	85,25	6,65	5,52
LSD 0.05	NS	NS	NS	NS

NS = ***non-significant differences.***

Table 7: Effect of seed treatment and germinability of the seed samples of varieties on seed germination % (G %), normal seedling % (NS %) and length of radicle (RL cm) and hypocotyl (HL cm) after 8 days.

Cultivar	Seed treatment	G %	NS %	RL Cm	HL Cm
Delta	Control	75,25	85,00	7,01	5,26
	Atonik at 0,25	77,25	87,50	7,30	5,25
	Atonik at 0,5	78,25	82,75	6,03	5,56
	Atonik at 1,0	77,25	81,50	7,45	5,16
K-Jubileum	Control	60,75	88,50	6,23	5,85
	Atonik at 0,25	56,25	90,50	6,33	5,82
	Atonik at 0,5	59,50	90,25	6,14	5,49
	Atonik at 1,0	52,00	89,00	5,85	5,87
LSD 0.05	NS	NS	NS	NS	NS

NS = ***non-significant differences.***

Figure 7: Effect of tomato cultivars on seed germination % (G %), normal seedling % (NS %), radicle length (RL cm) and hypocotyl length (HL cm) 8 days after seeding

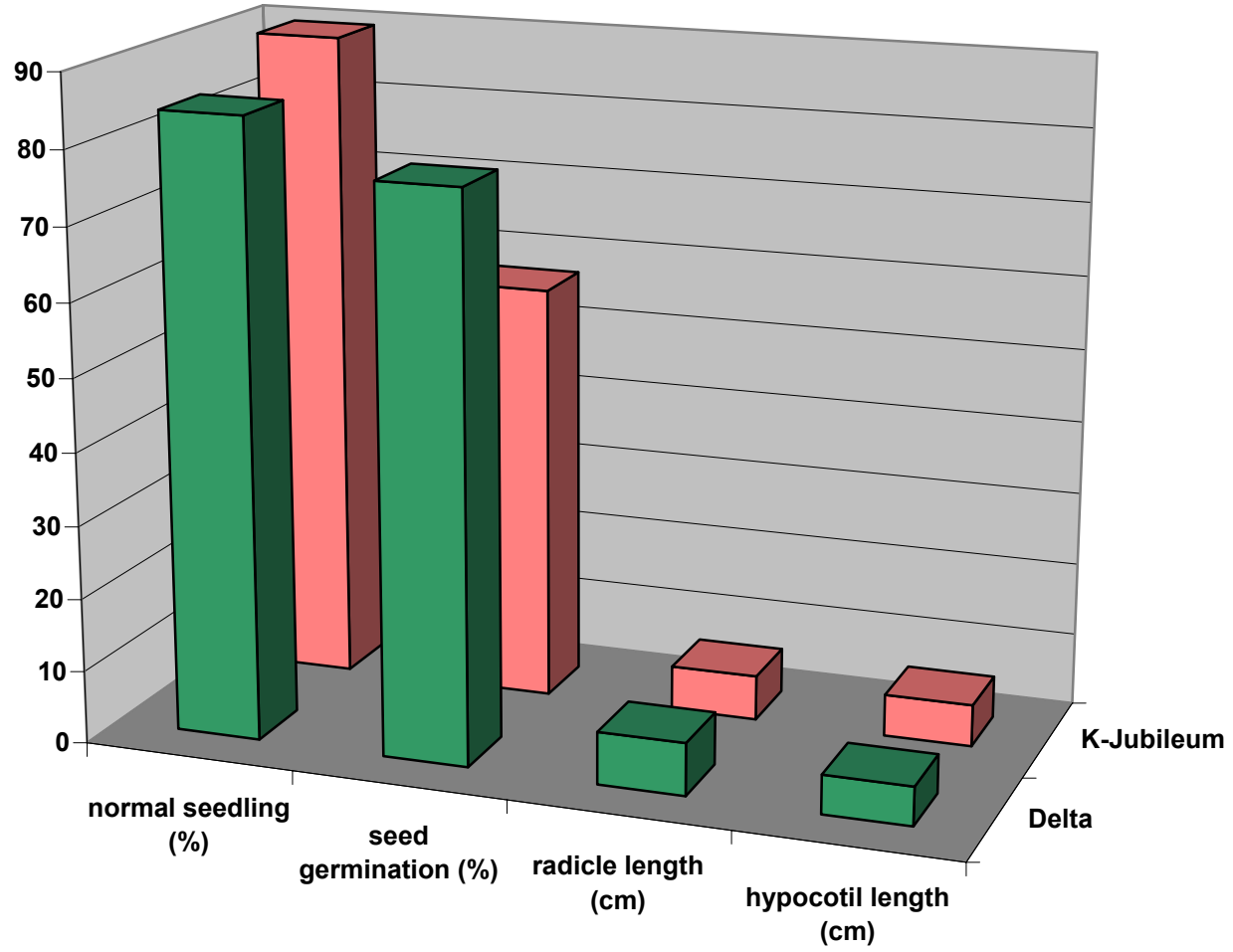
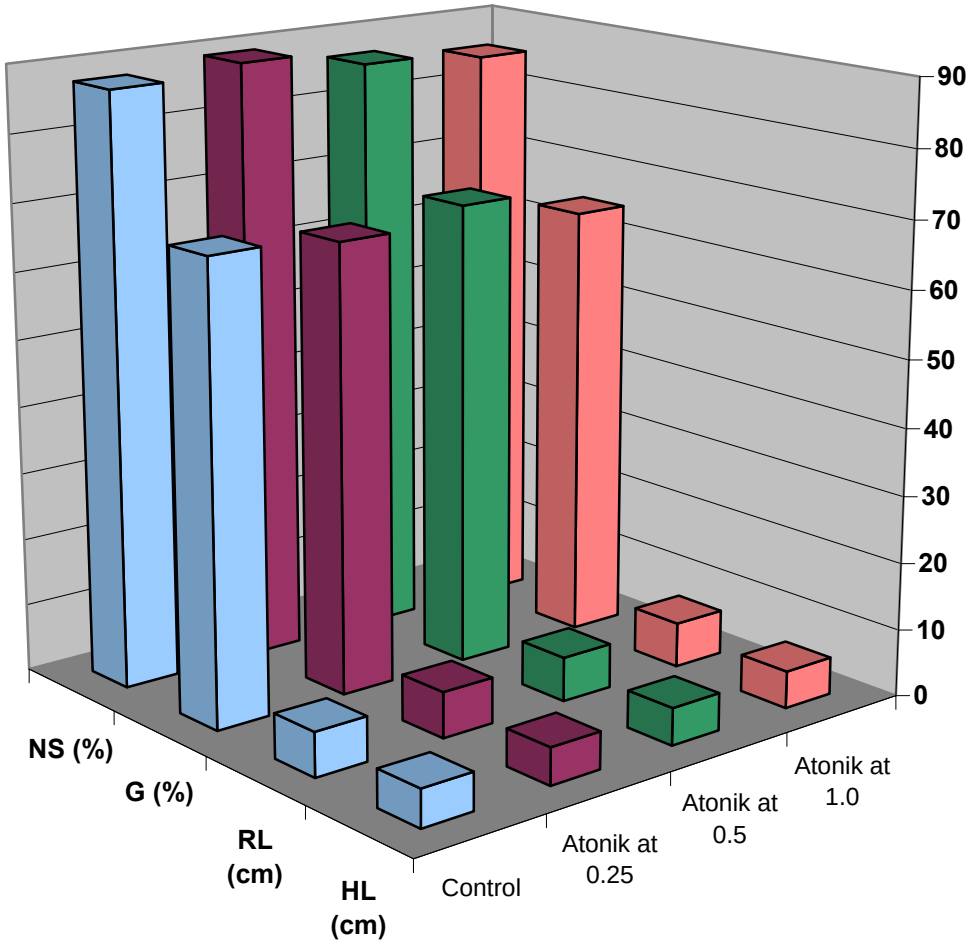


Figure 8: Effect of seed ATONIK treatment on seed germination % (G %), normal seedling % (NS %) and length of radicle (RL cm) and hypocotyl (HL cm) 8 days after seeding



4.3. EFFECT OF ATONIK SOLUTION ON CUCUMBER SEED PERFORMANCE

4.3.1. High germination cucumber seed performance

The calculations of seed germination and seedling growth of cucumber (variety **Dolge Zelene)** were finally presented in Tables from 8-12 and Figures 9-12.

Table 8 shows the effect of Atonik seed treatments and soaking periods on cucumber seed germination percentage 96 hours after seeding. The statistical analysis of variance revealed that the two main effects and their interaction were non-significant. As to the soaking periods over all seed treatments, the germination percentage was reduced from 80. % to 77 % by increasing soaking period from 8 to 24 hours, with no significant effect. As to the Atonik seed treatments for 8 hours, Atonik seed treatment non-significantly reduced the germination percentage as compared with control. The average means being 84.5, 79.0, 79.5 and 77.5 % for control, 0.25, 0.5 and 1.0 ml/l Atonik respectively. On the other hand, Atonik seed treatments for 24 hours, increased seed germination percentage as compared with control, but the increases were non-significant. The average were 73.5, 76.5, 78.5 and 78.0 % for control, 0.25, 0.5 and 1.0 ml/l Atonik, respectively. Also the Atonik seed treatments over the two soaking periods had no significant effect, the average were 79.0, 78, 79.0 and 78 % for control, 0.25, 0.5 and 1.0 ml/l Atonik, respectively

Table 8: Effect of Atonik seed treatments and soaking periods on First count seed germination % (69 hours after seeding) of cucumber (Dolge Zelene variety)

Soaking periods h (A)	Atonik seed treatment ml/L (B)				Soaking periods mean
	Control	0.25	0.5	1.0	
8	84,50	79,00	79,50	77,50	80,13
24	73,50	76,50	78,50	78,00	76,63
Seed treat, mean	79,00	77,75	79,00	77,75	

Source of variance	Calculated F		Required F for significant	
			5 %	1%
Soaking periods (A)	1,92	**NS**	4,26	7,82
Seed treatments (B)	< 1,00	**NS**	3,01	4,72
Soaking period x seed treat.	1,06	**NS**	3,01	4,72

*NS = **non-significant differences.***

Table 9 shows the effect of Atonik seed treatments and soaking periods on cucumber seed germination 186 ± 2 hours after seeding. The analysis of variance indicated that there are no significant effects due to the main effects and their interaction. Soaking periods of 8 hours and 24 hours produced seed germination of 95 and 96 %, respectively, while seed germination due to seed treatments overall the soaking periods were ranged from 93.75 for control to 96.5 for 1.0 ml/l Atonik with no statistical effect. The average germination percentages of seed treatments for 8 hours were 94.0, 96.0, 93.0 and 96 % for control, 0.25, 0.5 and 1.0 ml/l Atonik. For 24 h, the average were 93.5 with control, 95.5 with 0.25, 97.0 for 0.5 and 97 % for 1.0 ml/l. Whereas, seed treatments germination percentage means in response to soaking periods were for untreated seeds, 94.0 and 93.5 with 8 and 24 h respectively. Atonik at 0.25 ml/l gave 96 % with 8 h and 95.5 with 24 h, 0.5 ml/l yielded seed germination of 93.5 and 97 % for 8 and 24 h, respectively. The highest Atonik rate 1.0 ml/l gave seed germination percentage of 96.0 and 79 % with 8 and 24 h, respectively.

Table 9: Effect of Atonik seed treatments and soaking periods on final count seed germination % (normal + abnormal seedlings) of cucumber (Dolge Zelene variety)

Soaking periods h (A)	Atonik seed treatment ml/L (B)				Soaking periods mean
	Control	0.25	0.5	1.0	
8	94,00	96,00	93,50	96,00	94,88
24	93,50	95,50	97,00	97,00	95,75
Seed treat. mean	93,75	95,75	95,25	96,50	

Source of variance	Calculated F	Required F for significant	
		5%	1%
Soaking periods (A)	< 1,00 NS	4,26	7.82
Seed treatments (B)	< 1,00 NS	3,01	4.72
Soaking period x seed treat.	< 1,00 NS	3,01	4.72

*NS = **non-significant differences.***

Table 10 shows the effect of Atonik seed treatments and soaking periods on normal seedlings percentage. The analysis of variance indicated that neither soaking period over all Atonik seed treatment levels nor Atonik seed treatments over all soaking periods had any effects on normal seedling percentage. The average means of normal seedling percentage of soaking periods were 91.63 and 89.750 % for 8 and 24 h, respectively. The averages of seed treatment means were 90.75, 91, 91.25. and 89.750 % for control, 0.25, 0.5 and 1.0 ml/l Atonik respectively.

Atonik seed treatments for 8 or 24 h did not affect normal seedling percentage. The normal seedling percentage ranged from 94% to 89 % with 8 h and from 88 to 92.5 % with 24 h

As to the interaction, increasing soaking period from 8 to 24 hs significantly reduced the normal seedling percentage with both control and 0.25 ml/l Atonik by 5.88 and 6.36 %, respectively. While increasing soaking period with higher Atonik rates 0.5 or 1.0 ml/l did not affect normal seedlings percentage significantly. It is appeared that longer soaking period of 24 hours had bad affect with both control or o.25 ml/l Atonik. The higher levels of Atonik 0.5 or 1.0 ml/l may overcome the disadvantages of the longer soaking period of 24 hours.

Table 10: Effect of Atonik seed treatments and soaking periods on normal seedling percentage 186 ± 2 h after seeding of cucumber (Dolge Zelene variety).

Soaking periods h (A)	**Atonik seed treatments ml/L (B)**				**Soaking periods mean**
	Control	**0.25**	**0.5**	**1.0**	
8	93,50	94,00	90,00	89,00	91,63
24	88,00	88,00	92,50	90,50	89,75
Seed treat. mean	90,75	91,00	91,25	89,75	

Source of variance	Calculated F	**Required F for significant**	
		5%	1%
Soaking periods (A)	2,30 **NS**	4,26	7.82
Seed treatments (B)	<1,00 **NS**	3,01	4.72
Soaking period x seed treat.	3,31 *	3,01	4.72

***LSD 0.05** for differences among soaking period x seed treatment means = 5.099.

NS = non-significant differences.

Table 11 shows the effect of Atonik seed treatments and soaking periods on the percentage of cucumber seedlings hypocotyl length of ≥3 cm 186± 2 h after seeding. The analysis of variance revealed that the two main effects and their interaction were not significant. Seed treatments, soaking periods and seed treatments × soaking period interaction had no affect on seedling vigor (hypocotyl length of 3 cm and more). The seedling hypocotyl length of 3 cm and more ranged from 92.5 % to 86 %.

Table 11: Effect of Atonik seed treatments and soaking periods on seedling hypocotyl ≥ 3 cm % (186 ± 2 h) of cucumber (Dolge Zelene variety).

Soaking periods h (A)	Atonik seed treatments ml/L (B)				Soaking periods mean
	Control	0.25	0.5	1.0	
8	90,00	91,50	90,50	86,00	89,50
24	87,00	87,00	92,50	91,00	89,38
Seed treat. mean	88,50	89,25	91,50	88,50	

Source of variance	Calculated F	Required F for significant	
		5%	1%
Soaking periods (A)	< 1,00 NS	4,26	7.82
Seed treatments (B)	< 1,00 NS	3,01	4.72
Soaking period x seed treat.	< 1,00 NS	3,01	4.72

*NS = **non-significant differences***

Table 12 shows the effects of Atonik seed treatments and soaking periods on the percentage of seedlings hypocotyl length of 5 cm and more 186 ± 2 hours after seeding. The analysis of variance indicated that the soaking periods and seed treatments × soaking periods interaction were not significant but Atonik seed treatment was significant at the .01 level. Seedling hypocotyl length of 5 cm and more percentage highly significantly increased with Atonik seed treatment at 0.25 and 0.5 ml/l by 24.11 % and 22.32 %, respectively as compared with the control. Higher rate of Atonik seed treatment of 1.0 ml/l significantly decreased the percentage of seedling hypocotyl length of ≥ 5 cm at the .01 level as compared with the two lower rates used (0.25 and 0.5 ml/l Atonik). But it (1.0 ml/l Atonik) slightly increased the percentage of seedling hypocotyl length of 5 cm and more as compared with control; the difference just failed to be significant at the 5 % level. The averages of seedlings hypocotyl length of 5 cm and more % were 56, 69.5, 68.5 and 60 % for control, 0.25, 0.5 and 1.0 ml/l Atonik, respectively

Table 12: Effect of Atonik seed treatments and soaking periods on seedling hypocotyl length ≥ than 5 cm % (186 ± 2 h) of cucumber Dolge Zelene variety.

Soaking periods h (A)	Atonik seed treatments ml/L (B)				Soaking periods mean
	Control	0.25	0.5	1.0	
8	55,50	72,50	67,50	60,50	64,00
24	56,50	66,50	69,50	60,00	63,13
Seed treat. mean	56,00	69,50	68,50	60,25	

Source of variance	Calculated F	Required F for significant	
		5%	1%
Soaking periods (A)	< 1,00 NS	4,26	7.82
Seed treatments (B)	13,98 * *	3,01	4.72
Soaking period x seed treat.	2,23 NS	3,01	4.72

LDS 0.05 for differences among seed treatment means = 5.095.

LDS 0.01 for differences among seed treatment means = 6.9045.

NS = ***non-significant differences.***

4.3.2. Vigorous (Budai félhosszú F1) and medium plant growth (Nati F1) cucumber varieties. Seed performance)

The experiments were conducted in February in the glasshouse.

Data of seedling emergence, mean emergence time, seedling hypocotyl length and Photochemical Efficiency as affected by variety types, seed treatments and their interaction are represented in Tables 13, 14a, 14b, 15a and 15b.

Tables 13, 14a, 15a show seedling emergence percentage. Statistical studies indicates that the effect of variety types is highly significant while effects of seed treatments and the interaction between variety types and seed treatment are not significant.

Medium plant growth variety Nati F_1 seedling emergence percentage is very significantly superior to vigorous variety Budai félhosszú F_1, which its seedling emergence is less than 50 %. The averages are 93.17 and 48.67 % for Nati F_1 and Budai félhosszú F_1, respectively (Table 13).

Neither Atonik nor water seed treatments show any significant influence on seedling emergence percentage compared to dry seeds The seedling emergence means are 72.25, 71.75 and 68.75 % for dry, wet and Atonik treated seeds, respectively (Table 14a).

A non-significant interaction effect on seedling emergence indicates that both of the two factors are independently. Nati F_1 seedling emergence at the various seed treatments

ranges from 92.5 to 93.5 % while seedling emergence for Budai félhosszú F_1 at the various seed treatments ranges from 44 to 52 % (Table 15a). Although the differences between Nati F_1 and Budai félhosszú F_1 are very high, but statistically they are similar at any seed treatment.

Data of mean emergence time are represented in (Tables 13, 14a and 15a). Analysis of variance reveals that the effect of variety types is very highly significant while the effects of seed treatments and the interaction are not.

Table 13 shows the effect of variety types on mean emergence time. The very significantly shorter mean emergence time 6.79 days is established by Nati F_1. Budai félhosszú F_1 mean emergence time is 8.39 days.

Mean emergence time for the three seed treatments is similar. The averages are 7.46, 7.58 and 7.74 days for water soaked, Atonik soaked and dry seeds, respectively (Table 14a).

Absence of significant interaction effects on mean emergence time indicates that both of the two factors are independently. Nati F_1 mean emergence time at the various seed treatments ranges from 6.6 to 7.12 days while mean emergence time for Budai félhosszú F_1 at the various seed treatments ranges from 8.32 to 8.49 days (Table 15a). Although the differences between Nati F_1 and Budai félhosszú F_1 are high, but statistically they are similar at any seed treatment.

Hypocotyl length is highly significantly influenced by the variety types but seed treatments and the interaction of seed treatment and variety types have no significant effect.

Budai félhosszú F_1 hypocotyl length is highly significantly shorter than the hypocotyl length of Nati F_1. The averages are 8.28 and 11.84 cm for Budai félhosszú F_1 and Nati F_1, respectively (Table 13).

Hypocotyl length at the various seed treatments is comparable, however the differences between them are not significant. The means are 9.86, 10.03 and 10.29 cm for dry, water soaked and Atonik soaked seeds, respectively (Table 14a).

Although the hypocotyl length of Nati F_1 is longer than that of Budai félhosszú F_1 at the various seed treatments, there are no significant differences between any two means (Table 15a). The means are 8.09, 8.33 and 8.40 cm for Budai félhosszú F_1 at dry control, Atonik and water soaked control seeds, respectively. The averages of hypocotyl length for Nati F_1 are 11.63, 11.64 and 12.26 cm at dry control, water control and Atonik soaked seeds, respectively.

Statistical analysis of photochemical efficiency measurements revealed that the effects of seed treatment, cucumber variety and their inter-action were not significant.

Plants photochemical efficiency was not significantly improved by Atonik seed treatment compared with the control, although photochemical efficiency of Atonik treated

seeds was higher than that for the control. The averages were .8033 and .7987 for Atonik treated and control seeds, respectively (Table 14b).

Although the photochemical efficiency of Nati F_1 0.8029 was higher than that for Budai félhosszú F_1 0.7991, the difference between them was not significant (Table 13).

Photochemical efficiency of plants of Atonik treated seeds was 0 .8053 and 0.8013 for Nati F_1 and Budai félhosszú F_1, respectively. Photochemical efficiency for the control was 0.8005 and 0.7969 for Nati F_1 and Budai félhosszú F_1, respectively. The differences among them were not significant (Table 15b).

Table 13: Effects of cucumber variety types on seedling emergence % (SE %), mean emergence time (MET), hypocotyl length cm (HL cm) and photochemical efficiency (Ph.E)

Variety types	**SE %**	**MET**	**HL cm**	**Ph. E**
Budai félhosszú F_1	**48.67**	**8.39**	8.28	**0.7991**
Nati F_1	**93.17**	**6.79**	11.84	**0.8029**
LSD 0.01	* *	* *	* *	**NS**

*** *** = P = 0.01.

NS = non-significant.

Table 14a: Effects of cucumber variety types seed treatments on seedling emergence % (SE %), mean emergence time (MET), hypocotyl length cm (HL cm) and photochemical efficiency (Ph.E).

Seed treatment	*SE %*	**MET**	**HL cm**
Dry control	**72.25**	**7.74**	**9.86**
Wet control	**71.75**	**7.46**	**10.03**
Atonik	**68.75**	**7.58**	**10.29**
LSd 0.05	**NS**	**NS**	**NS**

NS = non significant differences.

Table 14b: Effect of seed treatments on photochemical efficiency (Ph.E).

Seed treatment	*Ph.E*
Control	**0.7987**
Atonik	**0.8033**
LSd 0.05	*NS*

NS = non significant differences.

Table 15a: Effects of cucumber variety types and seed treatments on seedling emergence % (SE %), mean emergence time (MET) and hypocotyl length cm (HL cm) and photochemical efficiency (Ph.E).

Variety types	Seed treatment	SE %	MET	HL. Cm
Budai félhosszú F_1	**Dry**	**52.00**	**8.36**	**8.09**
	Wet	**50.00**	**8.32**	**8.41**
	Atonik	**44.00**	**8.49**	**8.33**
Nati F_1	**Dry**	**92.50**	**7 .12**	**11.63**
	Wet	**93.50**	**6.60**	**11.64**
	Atonik	**93.50**	**6.66**	**12.26**
LSD 0.05		**NS**	**NS**	**NS**

NS = Non-significant differences.

Table 15b: Effects of and seed treatments and cucumber variety types on photochemical efficiency (Ph.E).

Seed treatment	Cultivar	*Ph.E*
Control	**Budai félhosszú**	0.7969
	Nati F_1	0.8005
Atonik	**Budai félhosszú**	0.8013
	Nati F_1	0.8053
LSD 0.05		NS

NS = Non-significant differences.

The experiment was conducted in June in the glasshouses.

Data of seedling emergence, mean emergence time and seedling hypocotyl length as affected by variety types, seed treatments and their interaction are represented in (Tables 16, 17, 18 and Figures 13-14).

Statistical studies indicate that seedling emergence do not influenced by any factor or by their interaction.

Table 16 shows the results of variety types on seedling emergence percentage. Seedling emergence of both variety types is similar with averages of 96.5 and 99 % for Budai félhosszú F_1 and Nati $F_{1,}$ respectively.

Table 18 represents the data of seedling emergence as affected by seed treatments. Atonik seed treatment does not cause any significant effect compared with the control. Seedling emergence percentages are 97.5 and 98 % for Atonik and control, respectively.

Interaction between variety types and seed treatments does not impose any statistical influence on seedling emergence percentage (Table 18). Nati F1 seedling emergence at the various seed treatments is 98 and 100 % for control and Atonik respectively. Seedling emergence of Budai félhosszú F_1 at the two seed treatments is 98 for control and 95 % for Atonik

Statistical analysis of the variance indicates that the effect of variety types and the interaction between variety types and seed treatment is highly significant. The effect of seed treatments is not significant.

The data presented in Table 18 show the effect of the interaction between variety types and seed treatments on mean emergence time. The results show that Budai félhosszú F_1 has shorter mean emergence time 3.27 days at the control and 3.49 days at the Atonik seed treatment with no significant difference between them. Atonik seed treatment significantly reduced mean emergence time of Nati F_1 from 5.51 days at the control to 5.07 days.

Table 16 shows the mean emergence time of both the varieties. The data presented in this table show that Budai félhosszú F_1 variety has the highly significantly shorter mean emergence time 3.38 days, while Nati F_1 variety requires longer period 5.29 days compared to Budai félhosszú F_1. The difference between Budai félhosszú F_1 and Nati F_1 in mean emergence time is 1.88 days, very highly significant.

Mean emergence time of the both seed treatments is similar indicating that Atonik does not affect this character in this study. The averages of mean emergence time are 4.28 and 4.39 days for Atonik soaked and water soaked seeds, respectively (Table 17)

Analysis of variance reveals that seedling hypocotyl length highly significantly affected by variety types and by the interaction between variety types and seed treatments, while effect of seed treatments is not significant.

The data presented in Table 18 show that the seedling hypocotyl length of Budai félhosszú F_1 is very significantly taller than Nati F_1 seedling at the both of seed treatments. Although Atonik seed treatment highly significantly increased hypocotyl length of Budai félhosszú F_1 seedling from 5.56 cm with control to 6.26 cm with Atonik, it highly significantly decreases the seedling hypocotyl length of Nati F_1 from 4.65 cm with control to 4.14 cm with Atonik seed soak.

The results presented in Table 16 show that the seedling hypocotyl length 5.91 cm is longer in Budai félhosszú F_1 seedling while the shorter seedling hypocotyl 4.39 cm is established by Nati F_1.

Seedling hypocotyl length presented in Table 18 reveals that hypocotyl length of both seed treatments are similar giving means of 5.1 and 5.2 cm for the control and the Atonik seed treatments, respectively.

Table 16: Effects of cucumber variety types on seedling emergence % (SE %), mean emergence time (MET) and hypocotyl length cm (HL cm).

Variety types	**SE %**	**MET**	**HL cm**
Budai félhosszú F_1	**96.5**	**3.38**	**5.91**
Nati F_1	**99.00**	**5.29**	**4.39**
LSD 0.05	**NS**		
LSD 0.01		**	**

** = P = 0.01.

NS = Non-significant differences.

Table 17: Effects of cucumber seed treatments on seedling emergence % (SE %), mean emergence time (MET) and hypocotyl length cm (HL cm).

Seed treatment	**SE %**	**MET**	**HL cm**
Control	98.00	4.39	5.10
Atonik	97.50	4.28	5.20
LSD 0.05	**NS**	**NS**	**NS**

NS = Non-significant differences.

Table 18: Effect of cucumber variety types and seed treatment on seedling emergence % (SE %), mean emergence time (MET) and hypocotyl length cm (HL cm)

Variety types	Seed treatment	**SE %**	**MET**	**Hl cm**
Budai félhosszú F_1	**Control**	98.00	3.27	5.56
	Atonik	95.00	3.49	6.26
Nati F_1	**Control**	98.00	5.51	4.65
	Atonik	100.00	5.07	4.14
LSD 0.05		**NS**	**0.32**	**0.41**
LSD 0.01			**0.45**	**0.58**

NS = Non-significant differences.

Data of seed germination and mean germination time as affected by variety types , seed treatments and incubation temperatures are represented in (Table 19, 0, 21, 22, 23, 24 and 25).

No seed germination was observed at all at 10°C after 30 days incubation of the variety types regardless seed treatment. However, when those non-geminated cucumber seeds were transferred to 20°C, they germinated normally and more quickly than those incubated at 20°C from the begging. This result indicates that cucumber seeds at least of these two variety types may be incubated for 30 days at 10°C and still retain their ability to germinate in shorter time under suitable temperature of 20°C.

Statistical analysis reveals that the effects of variety types and germination temperatures are highly significant but the effect of seed treatment is not. Also the effects of all interactions are highly significant except the interaction between temperature and treatment is not significant.

Data in Table 19 show, that 15°C highly significantly reduces seed germination of the variety types compared to higher temperatures 20 and 25°C. The reduction is higher with Nati F_1. Seed germination at 15°C was 60.25 % and 19% for Budai félhosszú F_1 and Nati F_1, respectively. Effect of cucumber variety types and incubation temperatures on seed germination % and mean germination time represent in Table 19.

Seed germination of the two variety types are similar at 20 and 25°C incubation, ranging from 99 to 99.75%.

The effect of interaction between variety types and seed treatment is highly significant (Table 20). Budai félhosszú F_1 has very significantly higher seed germination than Nati F_1 at both treated and non-treated seeds. Seed germination of Budai félhosszú F_1 is not affected by seed treatment, giving means ranges from 84.17 % with Atonik to 88.67 % with control. Atonik seed treatment highly significantly increases seed germination of Nati F_1 from 69.17 % with control to 76 %.

Analysis of variance shows that seed germination is not affected by this interaction. Although the differences in seed germination between 15°C and the other higher temperatures (20 and 25°C) are very high about 48.5 % with Atonik and nearly 61 % with control, they are not significant (Table 21.).

Seed germination of the two variety types is similar at the higher incubation temperatures as (20 and 25°C) well as with the tow seed treatments, ranging from 98.5 to 100 %. Incubated at 15°C of Atonik seed treatment highly significantly reduces seed germination of Budai félhosszú F_1 seeds from 67 % with control to 53.5 %. On the other hand, Atonik seed treatment incubated at 15°C highly significantly improves seed germination of Nati F_1 seeds from 9.5 % with control to 28.5 %. This improvement is not acceptable in commercial

production. Nati F_1 seeds in this study appeared to be more sensitive to low temperature 15°C than seeds of Budai félhosszú F_1 in control or treated case Interaction between variety types , seed treatments and incubation temperatures (Table 22.).

Table 23 shows the effects of variety types on the seed germination. Analysis of variance shows that there is a highly significant difference between the two cultivars. Budai félhosszú F_1 seed germination is 86.42 % while Nati F_1 seed germination is 72.58 %.

Data of seed treatment effects are represented in Table 24. Statistical study indicates absence of significance influence. Seed germination is similar of the two seed treatments. Atonik seed treatment produces little bit higher seed germination (80.08 %) than control seeds (78.92 %).

Results of temperature effects are shown in Table 25. Analysis of variance reveals that the influence of incubation temperatures is highly significant. The lowest highly significantly seed germination at (39.63 %) 15°C is established compared with the two higher temperatures (20 and 250C). Seed germination is comparable of the two incubation temperatures, 99.63 % for 20°C and 99.25 for 25°C. acceptable seed germination percentage can only be expected that above 15°C thus early seeding in cold soils should be avoided.

Mean germination time (MGT) is highly significantly influenced by variety types, incubation temperatures and also by the interaction between variety types and incubation temperatures. While seed treatments, interaction between variety types and seed treatments, interaction between seed treatments and incubation temperatures and interaction between variety types , seed treatments and incubation temperatures do not have any significant influence on mean germination time.

The highest mean germination time is obtained at 15°C by Nati F_1 (8.02 days) followed by Budai félhosszú F_1 (6.01 days). The difference between them is highly significant. Interaction between variety types and incubation temperatures (Table 19.).

The shorter mean germination time at 25°C is established with Budai félhosszú F_1 (1.35 days) followed by Nati F_1 (2.05 days) as compared to that other incubation temperatures. The difference between them is significant.

Incubation at 20°C yields intermediate mean germination time of the tow cultivars, 2.06 and 3.04 days for Budai félhosszú $F_1$and Nati F_1, respectively. The difference between them is significant.

Mean germination time of Budai félhosszú F_1 is significantly shorter than Nati F_1 at 0.01 and 0.05 significance levels at both 15 and 20°C and 25°C incubation temperatures, respectively.

Mean germination time is not affected by the interaction between variety types and seed treatments. Highest mean germination time is observed with Nati F_1 4.44 days for

control and 4.30 days for Atonik. Mean germination time of 3.07 and 3.21 days are established with Budai félhosszú F_1 at the control and the Atonik seed treatment, respectively (Table20.).

Mean germination time is similar of both Atonik and control seed treatments at the various incubation temperatures. The average means are 6.99, 2.58 and 1.69 for Budai félhosszú F_1 and 7.04, 22.53 and 1.71 for Nati F_1 at 15, 20 and 25°C incubation temperatures, respectively. Interaction between seed treatments and incubation temperatures (Table 20)

Although it appeares that the differences in mean germination time among Budai félhosszú F_1 and Nati F_1 with Atonik or control seed treatments at the various incubation temperatures are great, these differences are not significant.

The longest mean germination time 8.21 days is establishes by Nati F_1 with control seeds incubated at 15°C followed by 7.84 days, which established by Atonik treatment. The third longest mean germination time is 6.15 days recorded for Budai félhosszú F_1 incubated at 15°C with Atonik followed by 5.87 days with control. Incubation at 20 or 25° with Atonik or control for Budai félhosszú F_1 and Nati F_1 has mean germination time ranges from 3.06 to 1.3 days.

Table 23 shows the mean germination time as affected by the variety types **.** Mean germination time for Budai félhosszú F_1 3.14 days is highly significantly lower than that for Nati F_1 4.37 days.

Data of mean germination time as affected by incubation temperatures are represented in Table 25. Incubation temperatures highly significantly influence germination time. The difference between any two incubation temperatures is highly significant. The highest mean germination time7.02 days is established at 15°C incubation. The lowest mean germination time 1.70 days is obtained at 25°C incubation. The second lowest 2.55 days is observed at 20°C incubation temperature.

Table 24 represents the effect of seed treatments on mean germination time. Mean germination time do not affected by Atonik seed treatment compared to the control. The averages are 3.75 days and 3.76 days for Atonik seed treatment and control, respectively.

Table 19: Effects of cucumber variety types and incubation temperatures on seed germination % (SG %) and mean germination time (MGT).

Variety types	Temperature °C	SG %	MGT
Budai félhosszú F_1	15	60.25	6.01
	20	99.50	2.06
	25	99.50	1.35
Nati F_1	15	19.00	8.02
	20	99.75	3.04
	25	99.00	2.05
LSD 0.05		6.18	0.63
LSD 0.01		8.30	0.85

Table 20: Effects of cucumber variety types and seed treatments on seed germination % (SG %) and mean germination time (MGT)

Variety types	Seed treatment	SG %	MGT
Budai félhosszú F_1	Control	84.17	3.21
	Atonik	88.67	3.07
Nati F_1	Control	76.00	4.30
	Atonil	69.17	4.44
LSD 0.05		5.05	NS
LSD 0.01		6.78	

NS = Non-significant differences

Table 21: Effects of cucumber seed treatments and incubation temperatures on seed germination % (SG %) and mean germination time (MGT) of Budai félhosszú F_1 and Nati F_1

Seed treatment	Temperature °C	SE %	MGT
Control	15	38.25	7.04
	20	99.75	2.53
	25	98.75	1.71
Atonik	15	41.00	6.99
	20	99.50	2.58
	25	99.75	1.69
LSD 0.05		NS	NS

NS = Non-significant differences

Table 22: Effects of cucumber variety types, seed treatments and incubation temperatures on seed germination % (SG %) and mean germination time (MGT) of Budai félhosszú F_1 and Nati F_1

Variety types	Treatment	Temperature °C	SG %	MGT
Budai félhosszú F_1	**Control**	**15**	67.00	5.87
		20	100.00	2.03
		25	99.00	1.32
	Atonik	**15**	53.50	6.15
		20	99.00	2.09
		25	100.00	1.38
Nati F_1	**Control**	**15**	9.50	8.21
		20	99.50	3.02
		25	98.50	2.10
	Atonik	**15**	28.50	7.84
		20	100.00	3.06
		25	99.50	2.01
LSD 0.05			8.75	0.89
LSD 0.01			11.74	1.20

Table 23: Effects of cucumber variety types on seed germination % (SG %) and mean germination time (MGT) of Budai félhosszú F1 and Nati F1.

Variety types	SE %	MGT
Budai félhosszú F_1	86.42	3.14
Nati F_1	72.58	4.37
LSD 0.01	4.78**	0.49**

** = P = 0.01.

Table 24: Effects of cucumber seed treatments on seed germination % (SG %) and mean germination time (MGT) of Budai félhosszú F1 and Nati F1.

Seed treatment	SE %	MGT
Control	78.92	3.76
Atonik	80.08	3.75
LSD 0.05	**NS**	**NS**

NS = Non-significant differences.

Table 25: Effects of cucumber incubation temperatures on seed germination % (SG %) and mean germination time (MGT) of Budai félhosszú F1 and Nati F1.

Incubation temperatures °C	SE %	MGT
15	39.63	7.02
20	99.63	2.56
25	99.25	1.70
LSD 0.05	4.37	0.45
LSD 0.01	5.85	0.49

Figure 9: Effect of Atonik seed treatment and soaking periods on first count seed germination % (96 hours after sowing) of cucumber Dolge Zelene variety

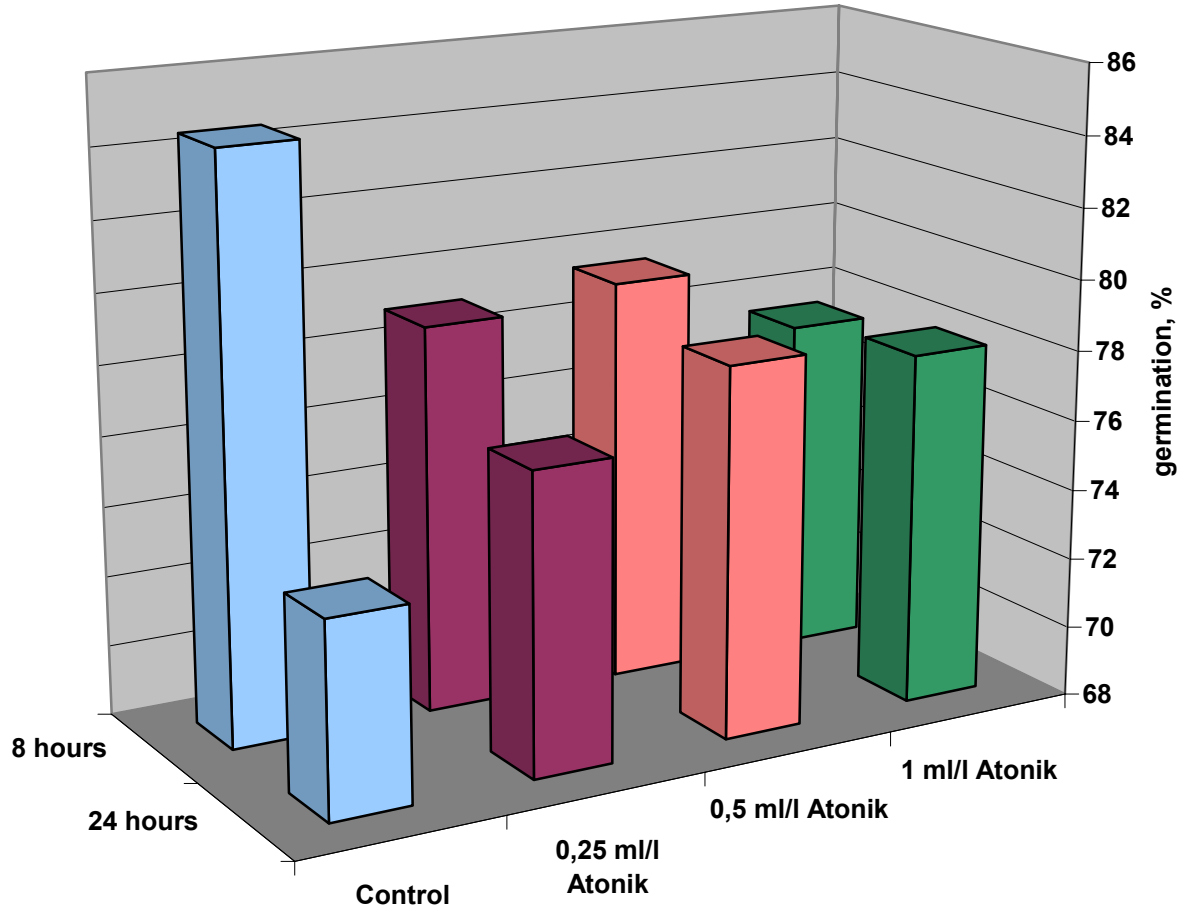


Figure 10: Effect of Atonik seed treatment and soaking periods on final count seed germination % (normal + abnormal seedlings) of cucumber Dolge Zelene variety

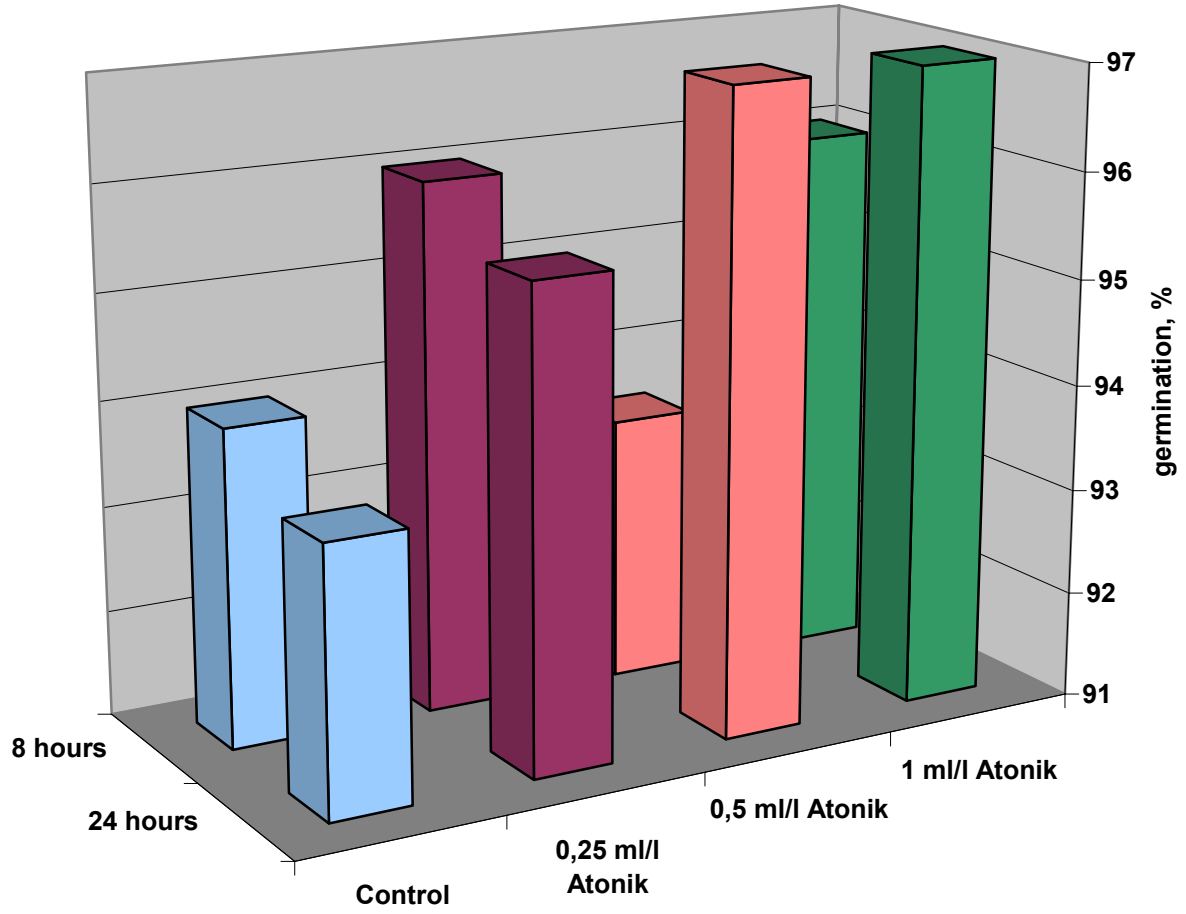


Figure 11: Effect of soaking periods and Atonik seed treatments on seedling hypocotyl length ł 5 cm % 168 ± 2 hours after seeding of cucumber variety Dolge Zelene

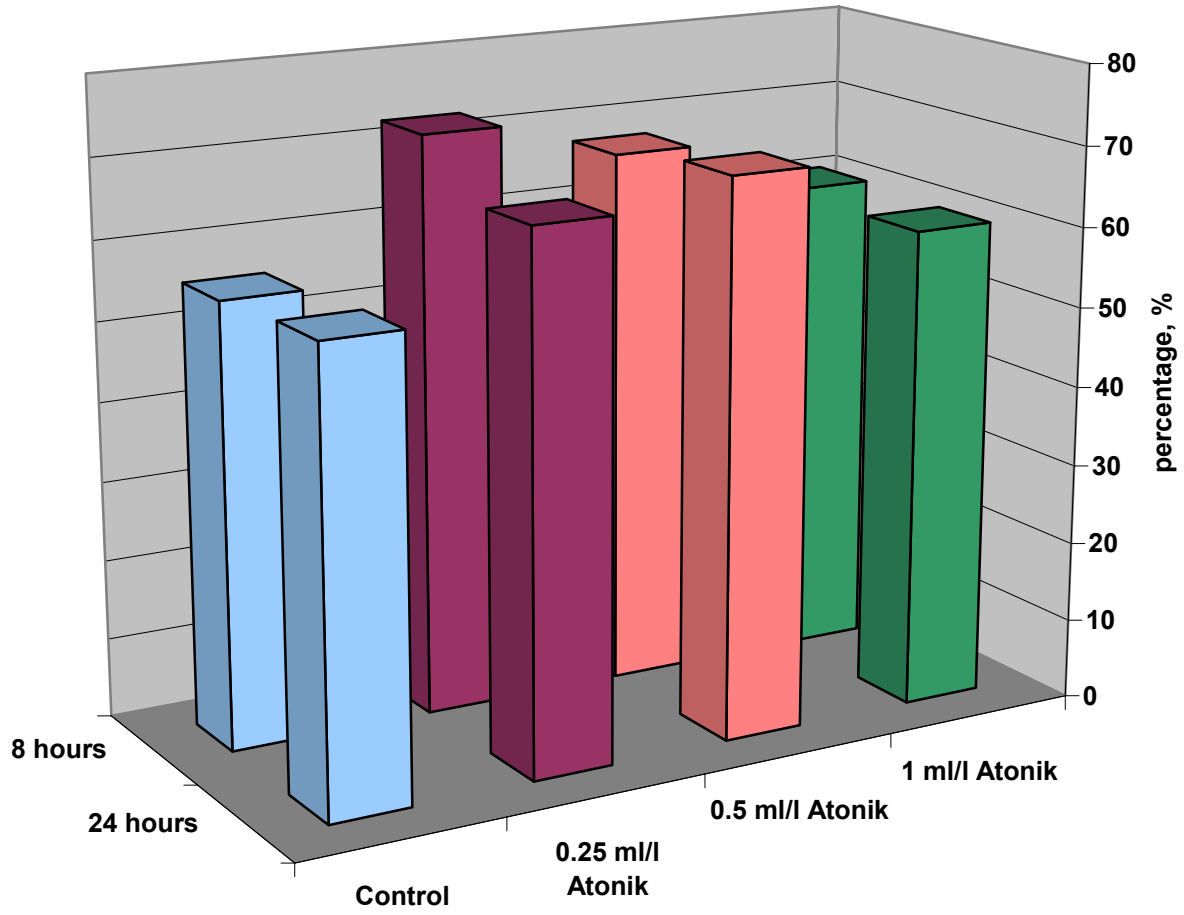


Figure 12: Effect of Atonik seed treatment and soaking periods on seedling hypocotyl length ≥ 5 cm % (186 ± 2 h) of cucumber Dolge Zelene variety

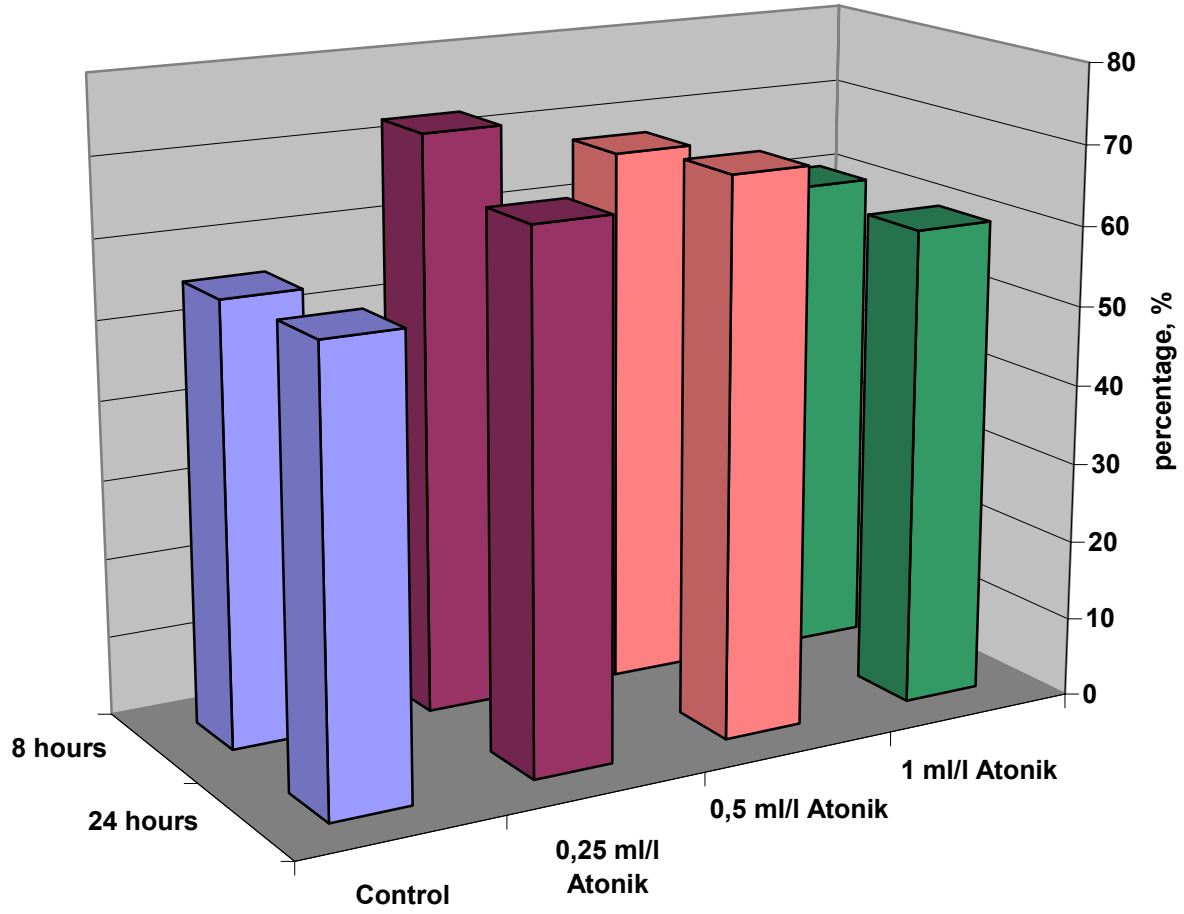


Figure 13: Effect of cucumber cultivars on mean emergence time (MET) and hypocotyl length (HL, cm)

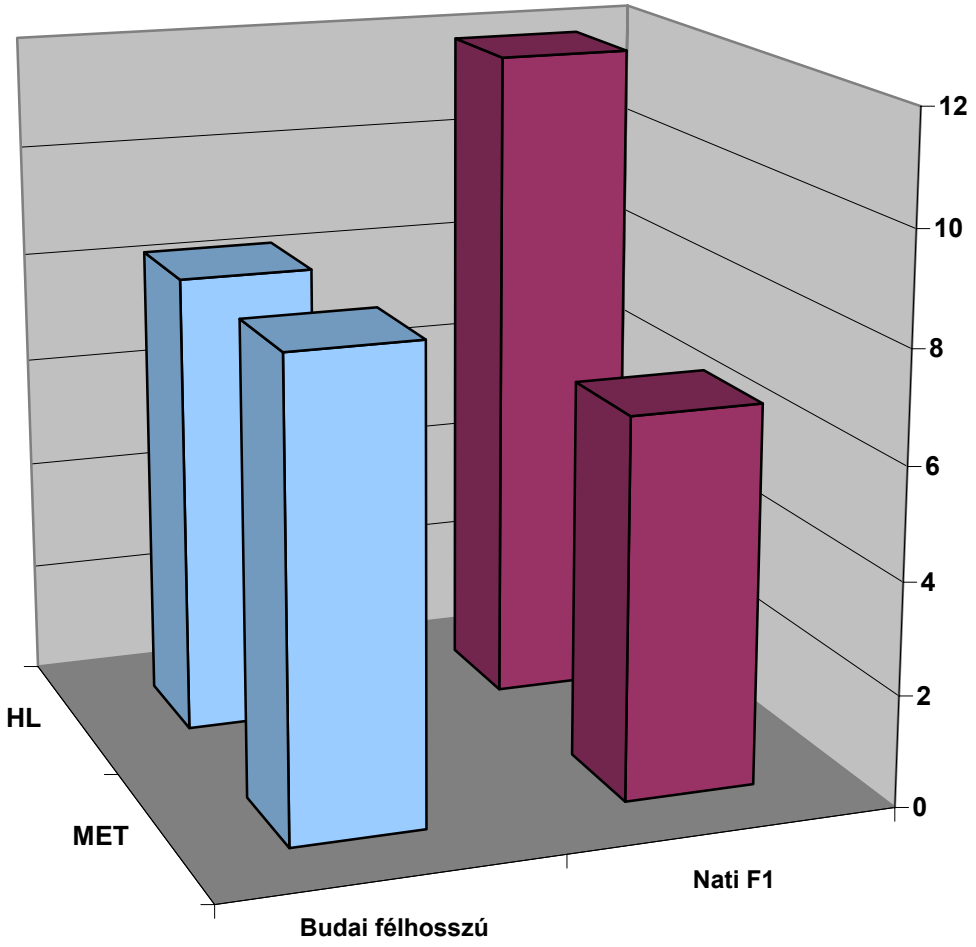
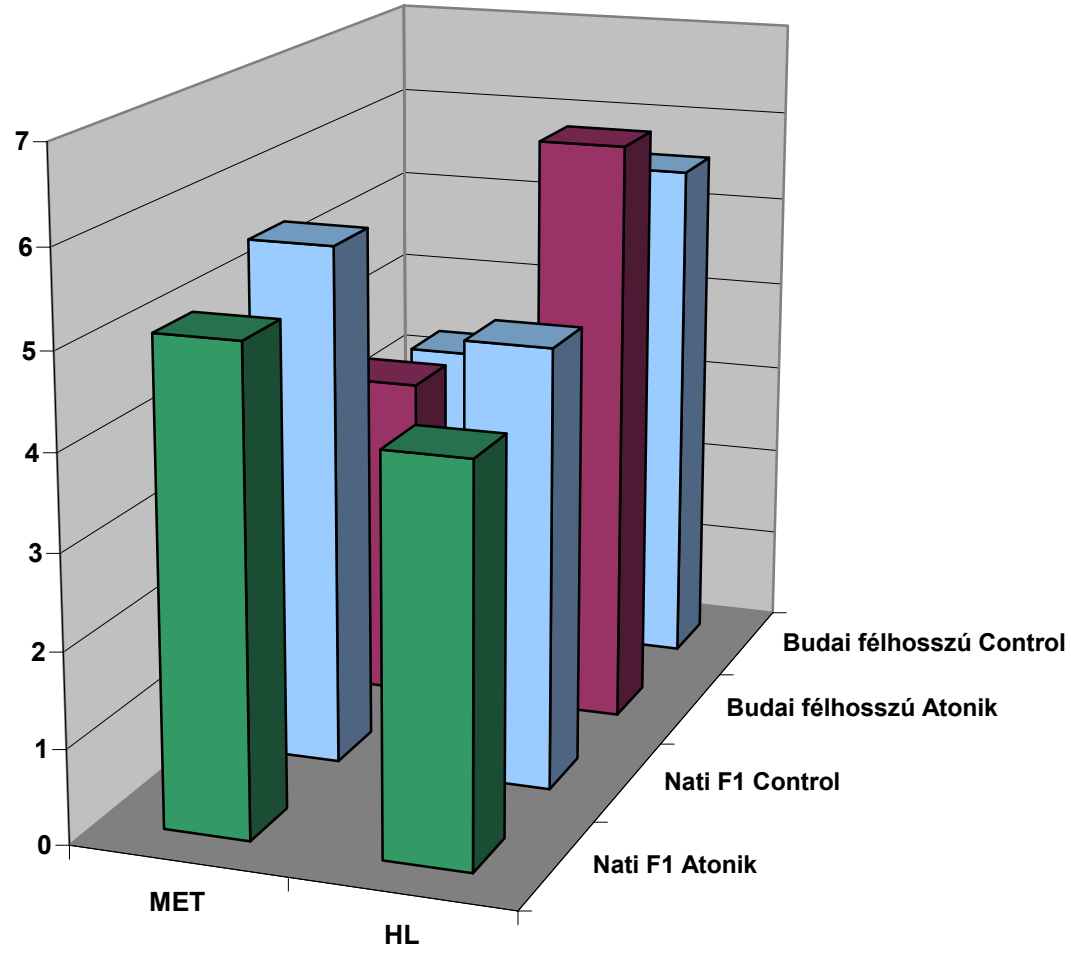


Figure 14: Effect of cucumber cultivar and seed treatment on mean emergence time (MET) and hypocotyl length (HL cm)



4.4. EFFECTS OF WATER SOAKING ON SEED PERFORMANCE OF PEA VARIETY TYPES

4.4.1. Smooth seeded variety (Rajnai Törpe)

The results of pea seed performance Rajnai Törpe represented in Tables from 26 to 28 and Figures 15-20.

Table 26 represents the effects of soaking periods and soaking temperatures on normal germination percentage, abnormal germination percentage, dead seeds percentage and long and short epicotyl percentage.

Statistical analysis indicates that the effects of the interaction on normal germination %, long epicotyl % and short epicotyl % are significantly, while their effects on abnormal germination and dead seed % are less than significance level. The effects of any factor on the normal germination, long epicotyl % and short epicotyl % is dependent on the levels of the other factor. Hence, the comparisons of the effects of main factors do not give true opinion because the interactions hide the effects of the main factors individually.

At the various soaking temperatures, soaking periods do not significantly affect normal germination % except that soaking period for 4 h at 10°C (84 %) as compared with control (90 %). Highest normal germination % (93.5 %) is obtained from soaking seeds for 4 h at 5°C. These results indicate that normal germination is not sensitive to soaking periods at any soaking temperatures studied except soaking for 4 h at 10°C.

Imbibition at 5°C for short period up to 8 h highly significantly reduced the percentage of long epicotyl with 5 cm or more as compared with control (62.75 %). The averages are ranged from 15 to 40.5 %. Imbibition for short period up to 8 h at any soaking temperatures also results in a significant reduction in vigorous seedling percentage as compared with control. The means are ranged from 4 % with 30 min and 20°C to 59.5 % for 8 h at 10 and 15°C. On the other hand, soaking periods for 24-h at 10 or 20°C or for 48 h at 5, 10, 15 and 20°C or soaking for 72 h at 15°C, significantly increased the percentage of vigorous seedling as compared with control with no significant differences among them. The averages are ranged from 74.5 with soaking for 72-h at15°C to 81 % with soaking for 24 h at 20°C.

Soaking periods for 24 h at 5 and 15°C and for 72 h soak at 5, 10, 15 and 20°C, although produce higher percentage of long epicotyl than the control, they do not have significant effect compared to the control. Their averages are 68.5, 64.5, 61, 64, 74.5, 70 and 62.75 %, respectively. The highest percentage of long or vigorous seedling ? 5-cm (81 %) is obtained from soaking for 24 h at 20°C.

Soaking for 24 and 48 h at 20°C or for 48 h at 15°C highly significantly increases the vigorous seedling % compared to control, the averages are 81, 78, 78.5 and 62.75 %, respectively.

The lowest significant percentage of short epicotyl is produced from soaking seeds for 24 h at 20°C or from soaking for 48 h at 5, 15 and 20°C as compared with control, the averages are 11.5, 10, 10.5, 12 and 27.25 %, respectively.

Soaking for short period up to 8 h at any soaking temperatures, except period of 8 h at 10, all increases the percentage of short epicotyl seedlings compared to control

Abnormal germination % ranges from 2 % with 24 h soaking at 20°C to 11.5 % with 72 h soaking at 5°C. The difference between any two means is not significant.

Dead seeds % does not affected by the interaction of soaking periods and soaking temperatures. The averages range from 0.5 % to 7.5 %.

Table:27 shows the effects of soaking temperatures on normal germination %, abnormal germination %, dead seed %, and long and short epicotyl %.

Statistical analysis revealed that the effects of soaking temperatures on the percentage of normal germination, abnormal germination, dead seed are non-significant, while its effects on the percentage of long epicotyl as well as short epicotyl are significant.

Normal germination % does not affected by any soaking temperature under this study. The averages being 88.31, 89, 88.63 and 90.06 % with 5, 10, 15 and 20°C, respectively.

Abnormal germination % does not significantly respond to the various soaking temperatures. Their averages are 7.19, 6.63, 6.75 and 6.5 % for 5, 10, 15 and 20°C, respectively.

Changing soaking temperatures does not significantly influence the percentage of dead seeds. The highest percentage of dead seeds is 4.03 % with 5°C. The lowest is 2.66 % with 20°C.

The over all effects of soaking temperatures on long epicotyl (5 cm and longer) % are highly significant. The highest percentage of long epicotyl (54.72) is obtained at 15°C. The second highest (50.59 %) is resulted from 10°C. The difference between them is significant at .05 level only. Soaking temperature of 20°C gave the lowest percentage of long epicotyl (45.84 %). The difference between 20°C and 5°C is not significant.

Soaking temperature is found to influence the percentage of short epicotyl (shorter than 5 cm) % significantly. Soaking temperature of 20°C produces the highest percentage of short epicotyl (44.22 %). 15°C yields the lowest percentage (33.91 %).

The difference between 44.22 5 and 33.9 % is highly significant. Also the differences between 15 and 10°C or between 10 and 20°C are significant. On the other hand, the differences between 5 and 10°C or between 5 and 20°C are not significant.

Table 28 shows the effects of soaking periods on normal germination %, abnormal germination %, dead seeds %, long epicotyl % and short epicotyl %.

Analysis of variance indicates that the effects of soaking periods on long epicotyl % and short epicotyl % are highly significant, but its effects on dead seed %, abnormal germination % and normal germination % are not significant.

Increasing soaking periods does not show any significant effects on normal germination % as compared with control. The averages are ranged from 87.25 % for 72 h to 90.38 with 30 min. and 90 % for the control.

Soaking periods have no significant influence on dead seeds %. The lowest percentage (2.13 %) is obtained from 1 h soaking followed by 3.13 with 4 h soaking. Untreated seeds as well as seeds soaked for 8 h produces comparable value 3.25 %. The highest percentage of dead seeds (4.25 %) occurs from soaking seeds for 72 h followed by 4.13 % obtained from soaking for 24 and 48 h. The differences between any two means are non-significant.

The effect of soaking periods on abnormal germination % is not significant. The Means are ranged from 4.63 % with 30 min soak to 7.88 % with 4 h soaking.

Long epicotyl (5 cm and longer) % is significantly affected by soaking periods at .01 level. Short soaking periods up to 8 h highly significantly reduced the percentage of long epicotyl as compared with control or with longer soaking periods. Long soaking periods for 24 h and 48 h highly significantly increased the percentage of long epicotyl as compared with control. The averages are 72.63, 77 and 62.75 % with soaking for 24, 48 h and control, respectively. The difference between 24 and 48 h soak is not significant.

Soaking period for 72 h produces little bit higher percentage of long epicotyl (67.38 %) than the control (62.75 %). The difference is not significant.

Short epicotyl (shorter than 5 cm) % is highly significantly affected by soaking periods. Short soaking periods (.5-8 h) is highly significantly increases the percentage of short epicotyl. 8-h soak produces highly significant less percentage of short epicotyl than those of shorter soak periods.

Soaking periods of 24 h and more significantly reduces the percentage of short epicotyl compared to control

The lowest percentage of short epicotyl (11.88 %) is obtained from 48-h soak followed by soaking for 24 h (16.37 %) with no statistical difference between them. The third lowest is obtained from 72-h soak (19.87 %). The difference between 48 h and 72-

h soak is significant at .01 level, While the difference between 24 and 72-h soak is not significant.

Table 26: Effects of soaking temperatures (ST) and soaking periods (SP) on normal germination % (NG%), abnormal germination % (ABG%), long epicotyl (≥ 5 cm) % (Lep%), short epicotyl (shorter than 5 cm) % (Sep%) and dead seed % (DS%) of smooth seeded pea variety Rajnai Törpe.

ST °C	SP	NG %	ABG %	Lep %	Sep %	DS %
5	**Control**	90,00	9,00	62,75	27,25	3,25
	30 min.	89,50	4,00	20,00	69,50	6,50
	1 h.	87,50	10,00	15,00	54,00	1,50
	4 h.	93,50	4,50	27,50	66,00	2,00
	8 h.	91,50	5,50	40,50	51,00	3,00
	24 h.	88,00	8,00	68,50	19,50	3,00
	48 h.	86,50	7,50	76,50	10,00	6,00
	72 h.	80,00	11,50	61,00	19,00	5,25
10	**Control**	90,00	9,00	62,75	27,25	3,25
	30 min.	91,50	5,50	40,00	51,50	2,00
	1 h.	91,00	4,50	12,50	78,50	8,00
	4 h.	84,00	8,50	15,50	68,50	7,50
	8 h.	84,50	11,00	59,50	26,00	4,50
	24 h.	90,50	6,50	76,50	14,00	3,00
	48 h.	90,00	5,50	75,00	15,00	8,50
	72 h.	90,50	5,00	64,00	6,50	4,00
15	**Control**	90,00	9,00	62,75	27,25	3,25
	30 min.	90,00	4,50	32,00	58,00	5,00
	1 h.	89,50	7,00	17,50	72,00	2,50
	4 h.	88,00	8,50	48,50	39,50	2,50
	8 h.	88,50	5,50	59,50	29,00	3,50
	24 h.	85,00	9,50	64,00	20,50	5,00
	48 h.	89,00	5,00	78,50	10,50	5,00
	72 h.	89,00	7,50	74,50	14,50	2,50
20	**Control**	90,00	9,00	62,75	27,25	3,25
	30 min.	90,50	4,50	4,00	86,50	3,00
	1 h.	90,00	7,00	15,00	75,00	1,50
	4 h.	87,50	10,00	8,00	79,50	1,50
	8 h.	90,50	7,50	48,00	42,50	2,00
	24 h.	92,50	2,00	81,00	11,50	5,50
	48 h.	90,00	7,50	78,00	12,00	2,00
	72 h.	89,50	7,00	70,00	19,50	3,50
LSD 0,05		5,57	**NS**	11,44	13,60	**NS**
LSD 0,01		7,38	**NS**	15,17	18,03	**NS**

NS = non-significant differences.

Table 27: Effects of soaking temperatures (ST) on normal germination % (NG%), abnormal germination % (ABG%), long epicotyl (≥ 5 cm) (LEP%), short epicotyl (< 5 cm) % (SEp%) and dead seed % (DS%) of smooth seeded pea variety Rajnai Törpe.

ST °C	NG %	ABG %	L Ep %	S Ep %	DS %
5	88,31	6,81	45,84	33,91	2,78
10	88,63	6,94	46,47	38,41	3,66
15	89,00	7,06	50,66	39,53	3,81
20	90,06	7,50	54,72	44,22	5,09
LSD 0,05	**NS**	**NS**	4,04	4,80	**NS**
LSD 0,01	**NS**	**NS**	5,34	6,35	**NS**

NS = non-significant differences

Table 28: Effects of soaking periods (SP) on normal germination % (NG%), abnormal germination % (ABG%), long epicotyl (≥ 5 cm) % (LEP%), short epicotyl (< 5 cm) % (SEp%) and dead seed % (DS%) of smooth seeded pea variety Rajnai Törpe.

ST °C	NG %	ABG %	L Ep %	S Ep %	DS %
Control	90,00	9,00	62,75	27,25	3,25
30 min.	90,38	4,63	24,00	66,38	4,13
1 h.	89,50	7,13	15,00	69,88	3,38
4 h.	88,25	7,88	24,88	63,38	3,38
8 h.	88,75	7,38	51,75	37,13	3,25
24 h.	89,00	6,50	27,63	16,38	4,13
48 h.	88,88	6,38	77,00	11,88	5,38
72 h.	87,25	7,75	67,38	19,88	3,81
LSD 0,05	**NS**	**NS**	5,71	6,79	**NS**
LSD 0,01	**NS**	**NS**	7,56	8,98	**NS**

NS = non-significant differences

Figure 15: Effects of soaking temperature (5 °C) and soaking periods (SP) on normal germination % (NG), long epicotyl (≥ 5 cm) % (Lep) and short epicotyl (< 5 cm) % (Sep) of pea variety Rajnai Törpe

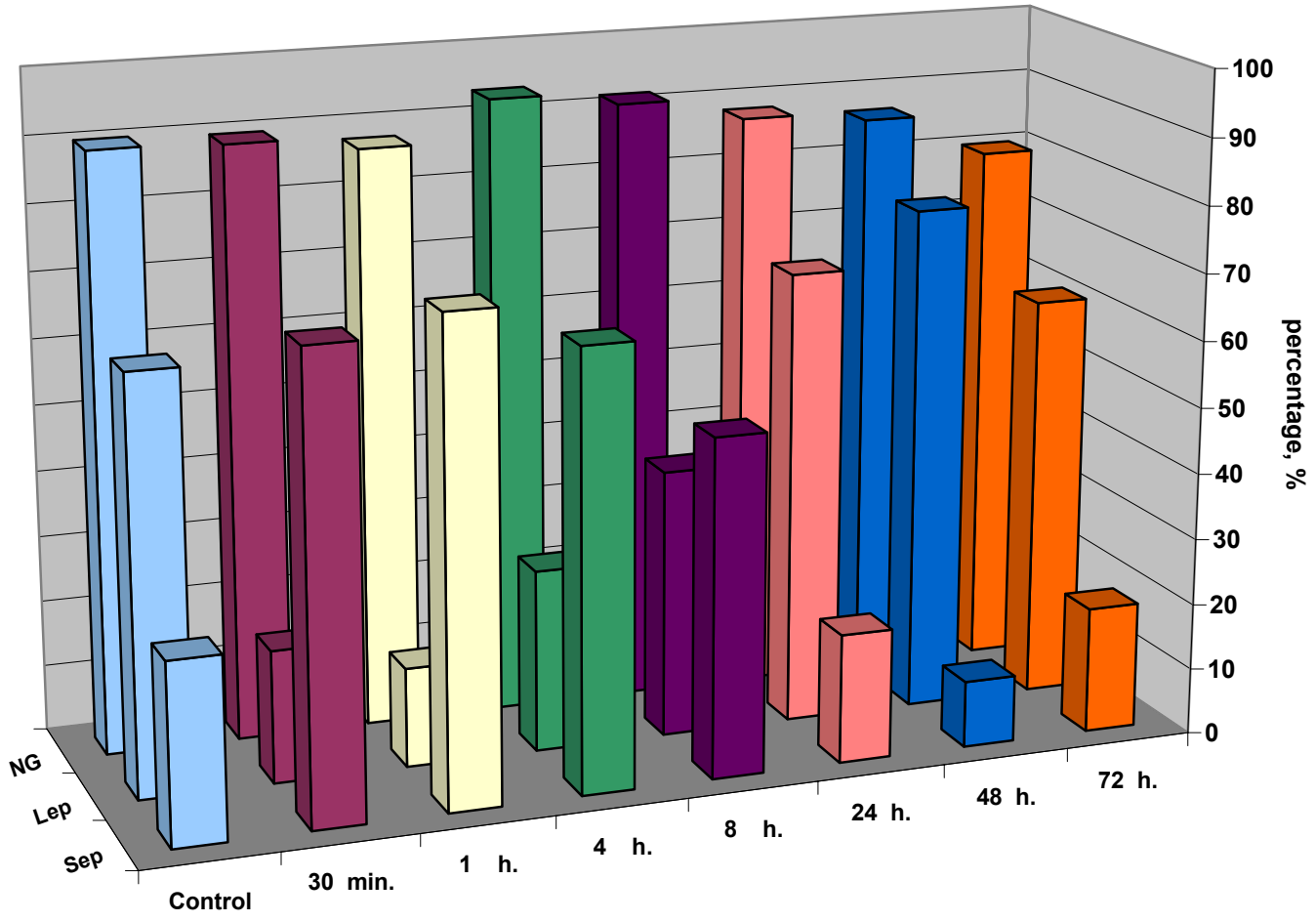


Figure 16: Effects of soaking temperature (10 °C) and soaking periods (SP) on normal germination % (NG), long epicotyl (≥ 5 cm) % (Lep) and short epicotyl (< 5 cm) % (Sep) of pea variety Rajnai Törpe

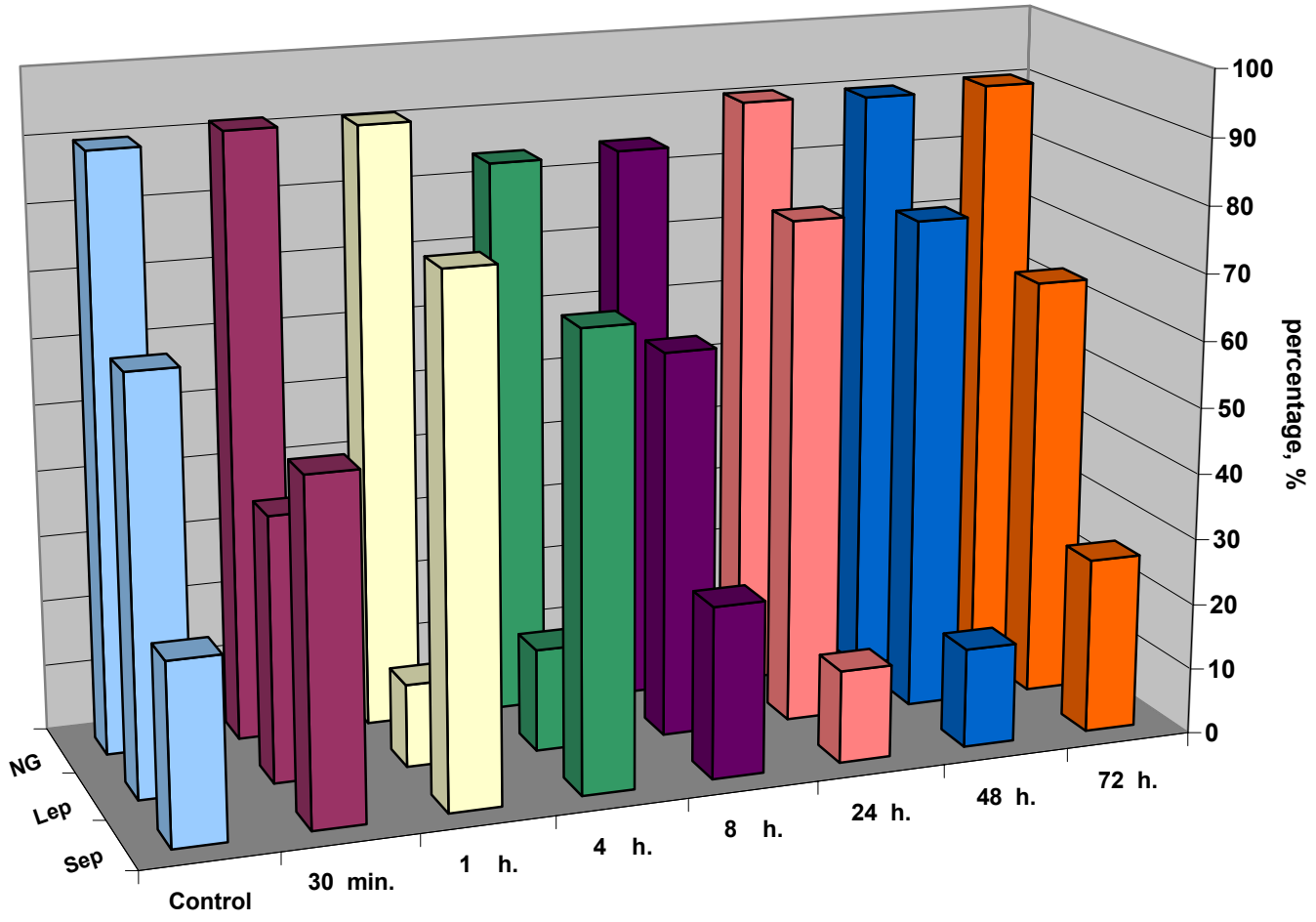


Figure 17: Effects of soaking temperature (15 °C) and soaking periods (SP) on normal germination % (NG), long epicotyl (≥ 5 cm) % (Lep) and short epicotyl (< 5 cm) % (Sep) of pea variety Rajnai Törpe

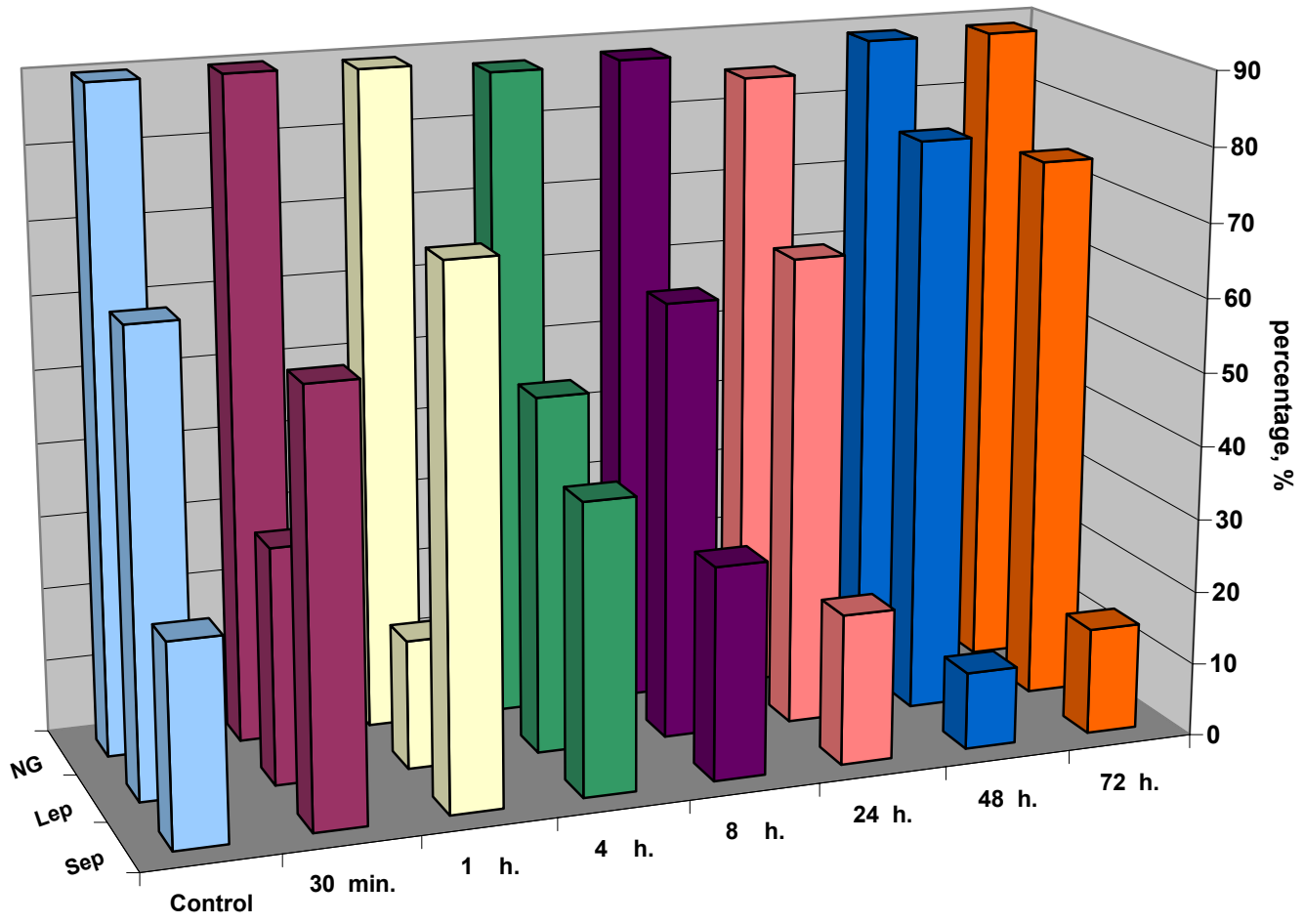


Figure 19: Effects of soaking periods (h) on normal germination % (NG%), long epicotyl (≥ 5 cm) % (LEp), short epicotyl (< 5 cm cm) % (SEp) of pea variety Rajna Törpe

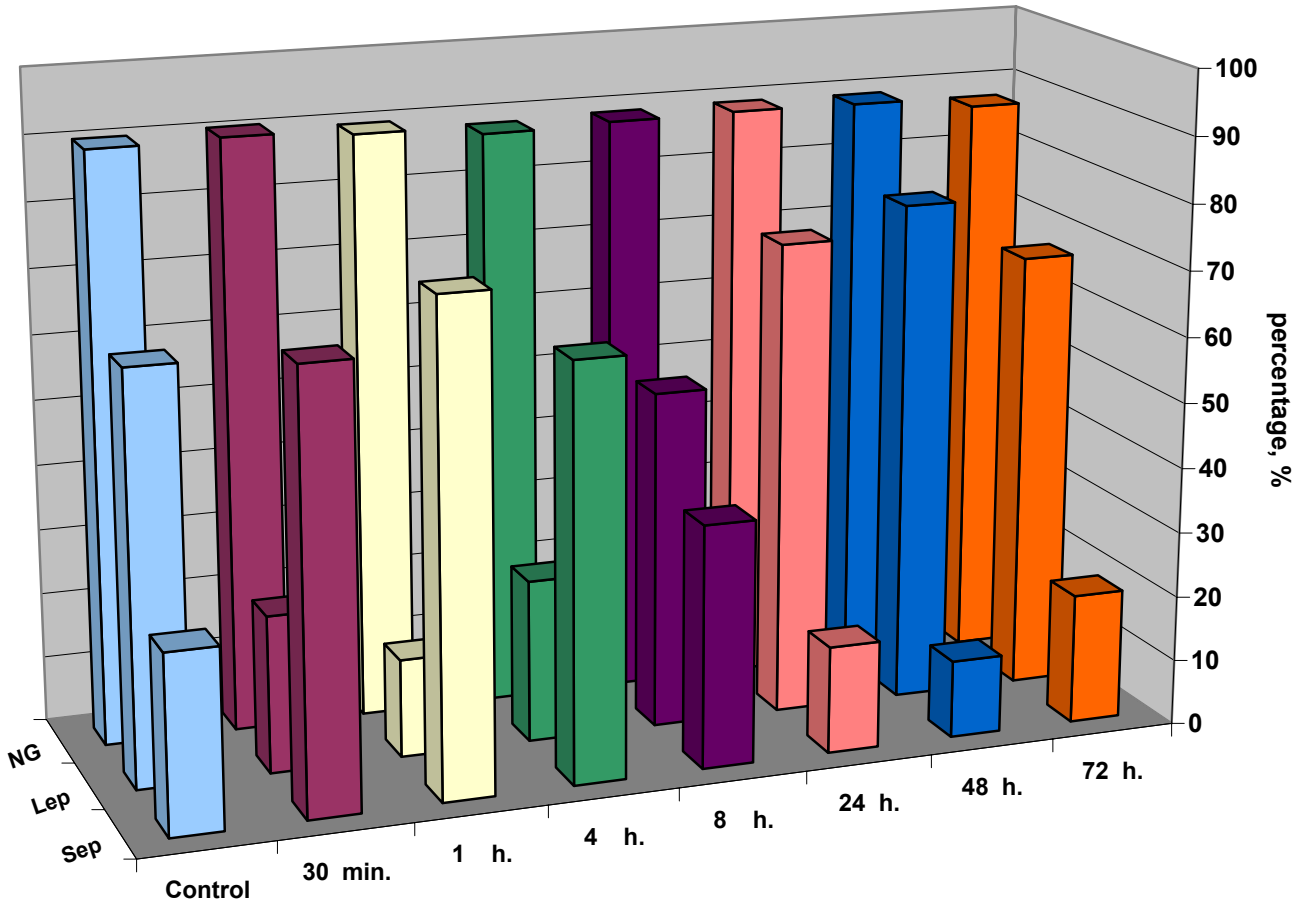


Figure 18: Effects of soaking temperature (20 °C) and soaking periods (SP) on normal germination % (NG), long epicotyl (≥ 5 cm) % (Lep) and short epicotyl (< 5 cm) % (Sep) of pea variety Rajnai Törpe

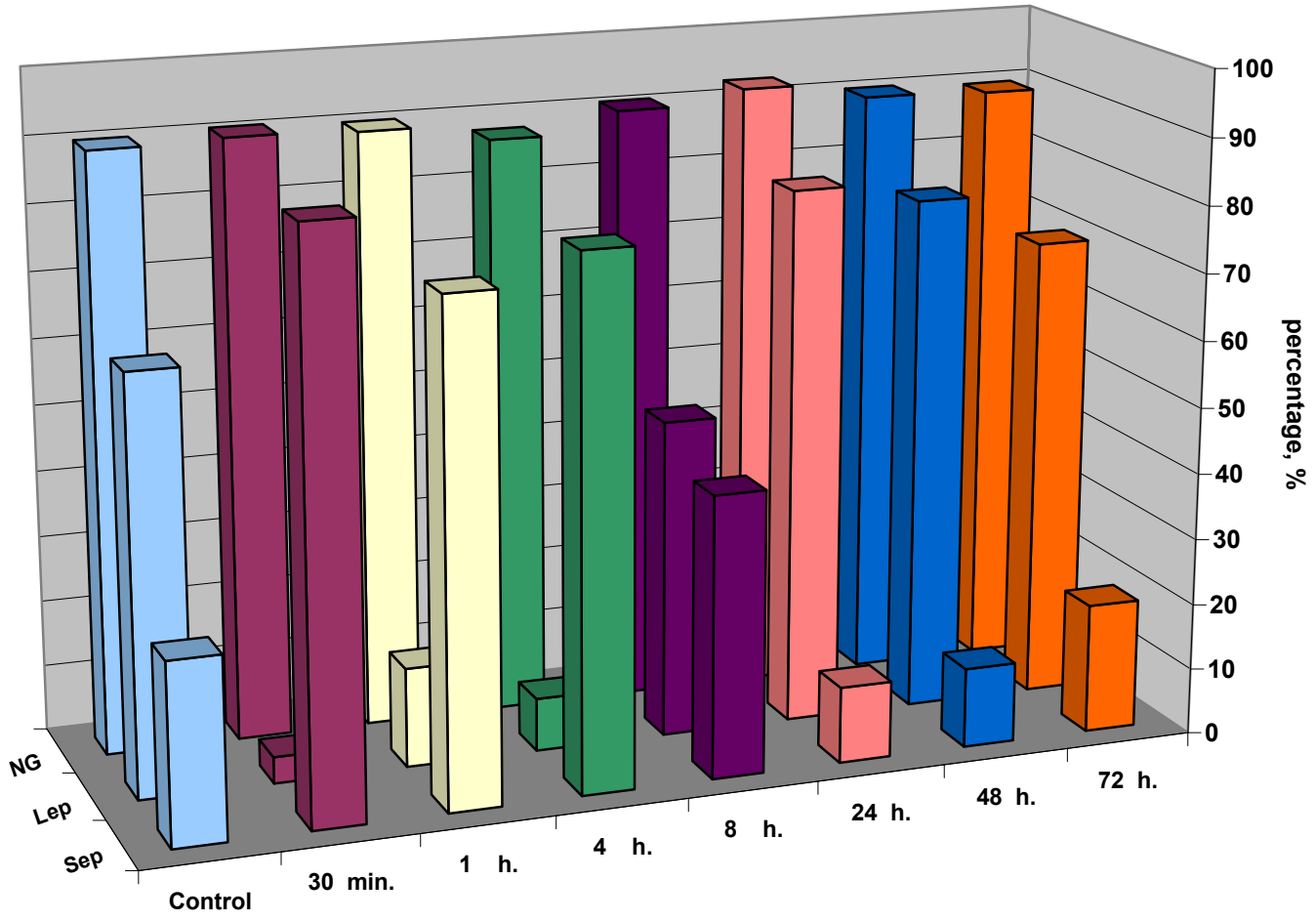
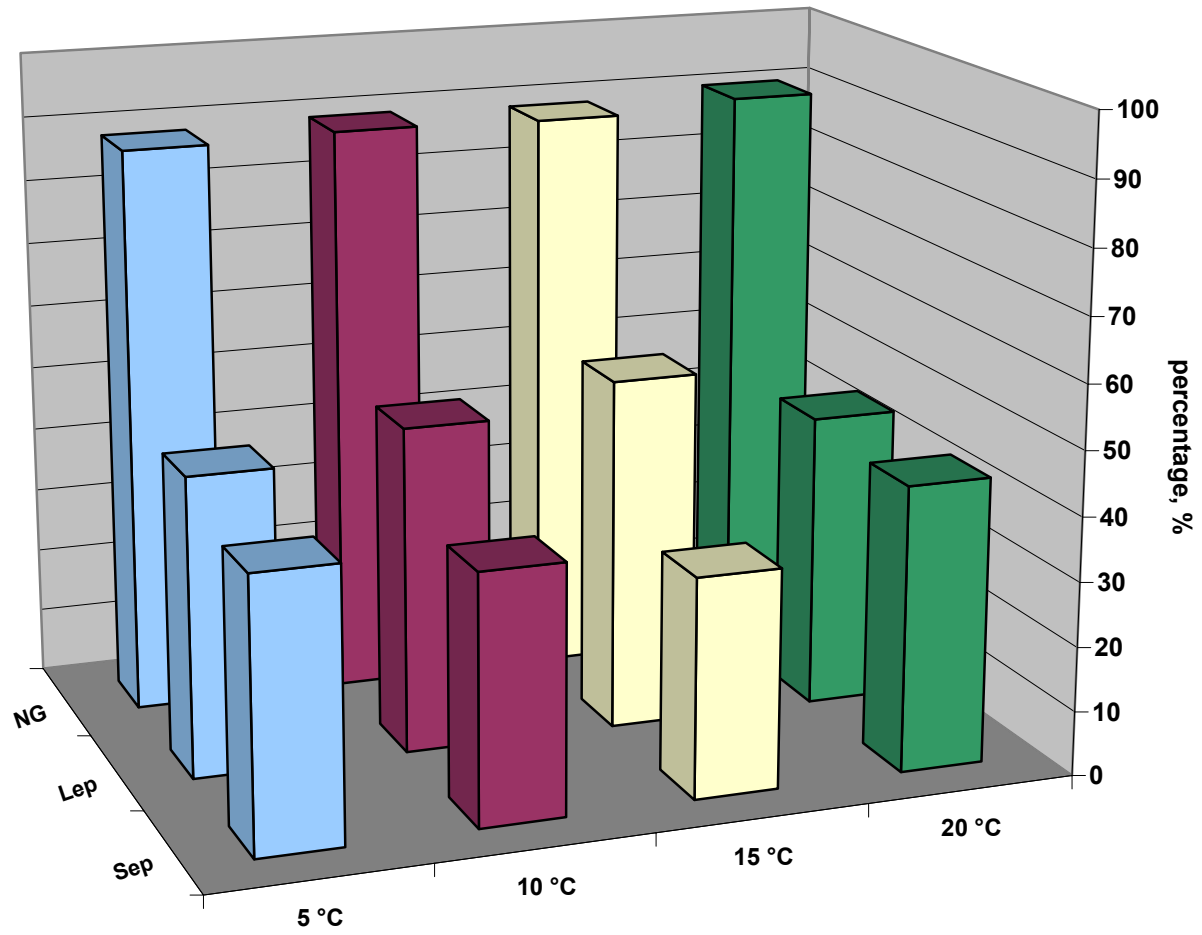


Figure 20: Effects of soaking temperatures on normal germination % (NG%), long epicotyl (≥ 5 cm) (LEP%) and short epicotyl (< 5 cm) % (SEp%) of pea variety Rajnai Törpe



4.4.2. Wrinkle-seeded pea variety (Farida)

The results represented in Tables 29, 30 and 31 show the effects of soaking periods and soak temperatures on Farida seed water uptake %, EC measurements of steep water, percentages of normal germination, abnormal germination, dead seeds, vigorous seedlings 5 cm and longer, less vigorous seedlings shorter than 5 cm and dry weight per seedling.

Measurements of long and short seedlings indicated that the most seedlings after 8 days had more or less respiration, but some of them already had started photosynthesis. Significant relationship among the different treatments was not found. The checking of respiration of the treated germs must be repeated in a younger age of samples.

As has been reported for many seeds, imbibition (water uptake) in intact pea seeds is quite rapid over the first 30 min after being placed in water (Fig.) after which the rate of increase in moisture content gradually decline up to 72 h soak. The amount of water uptake increases throughout the soaking periods till 72 h suggesting that intact pea seeds do not complete water uptake even after 72 h.

Analysis of variance indicates that the soaking periods as well as soaking temperatures and their interaction significantly affect seed imbibition.

The effect of soaking periods is found to be dependent on the soaking temperatures. The differences in water uptake between soaking temperatures of 5 and 10°C for all soaking periods is not significant except with 72 h soak in which the amount of absorbed water is higher at 5°C than at 10°C. The difference between them (11.22 %) is highly significant. Again, the differences between soaking temperatures of 20°C and 15°C are not significant with all soaking periods except that soak period for 4 h in which the water uptake is significantly less at 15°C than at 20°C. Increasing imbibition temperature has no significant effect on water uptake at the soaking periods of 30 min and 1 h soak, but at other soaking periods it has a significant effect. For example, increasing temperature from 5 to 15 or to 20°C at 4, 8 and 48 h soaking increases the amount of imbibition. At 72 h soaking, increasing soaking temperature from 5 to 10°C or reducing it from 20 or 15 to 10°Creduces the amount of water uptake significantly, the differences among 5, 15 and 20°C are not significant. At 24 h soaking, reducing soaking temperature from 20 or 15 to 10°C highly significantly reduces the imbibition, also reducing temperature from 15 to 5°C reduces water imbibition significantly.

Imbibing pea seeds at low temperatures shows to reduce the amount of water uptake. The amount of water taken up becomes progressively lower as temperature of the imbibing water is reduced from 20°C to 10 or 5°C and from 15°C to 10 or 5°C after 4 h soak up to 72 hour. As soaking period is increased, the amount of water uptake by

the seed also increased at the various temperatures up to 48-h soak. Generally, the highest imbibition occurs at 72-h soak with all soaking temperatures (183-188 %) with no significant difference between 48 and 72 h soak, except imbibition at 5°C in which the difference is significant. The lowest amount of water absorbed occurs at 10°C at the various soaking periods compared to others.

Soaking temperatures have a significant effect on the percentage of water imbibition Table 30. It is obvious that reducing soaking temperature from 20°C to lower than 15°C highly significantly reduces water uptake from 130.99 % to 118.2 % at 10°C and to 120.51 % at 5°C. Increasing soaking temperature from 5°C to 10°C as well as from 15°C to 20°C has no statistical effect.

Water imbibition is greatly influenced by soaking periods Table 31. As soaking period is increased, the amount of water uptake by the seed also significantly increased throughout soaking periods from 54.6 % at 30 min soak till 48 h (179.64 %), beyond that the increment is not significant (182.61 %). At 0.01 significance level, there are no differences in the water uptake between 30 min and 1 h soak as well as between 48 and 72 h soak. It is appeared that seeds do not complete water absorption after 72-h soak.

Results of normal germination are presented in Tables29, 30 and 31. Analysis of variance reveals that the effects of soaking periods, soaking temperatures and their interaction are significant. Thus the effect of the interaction is most important because the interaction hides the effects of the main factors

Statistical analysis indicates that the effects of soaking periods on normal germination % depend on the soaking temperatures.

Soaking at 5°C for 30 min., 4h, 24 h and 72 h produces almost similar percentage of normal germination as compared with control (non-soaked seeds). The differences among them are not significant. But soaking at 5°C for 72 h produces significantly higher percentage of normal germination (89.5%) than soaking for 1 h (80.5%) and 8 h (80%).

The greatest significant reduction at 10°C at the various soaking periods is established (77-84%) compared to control (92 %), (or Soaking temperature at 10°C yields significantly less normal germination % (77-84%) than the control (92%) at the various soaking periods).

Normal germination from soaking at 15°C for 30 min (86%) and 48 h (85.5%) are not significantly differing from the control. While at 15°C soaking temperature, the normal germination % produced from soaking for 1. 4, 8, 24 and 72 h are significantly less than that from the control.

Soaking temperature at 20°C for 1 h (83%), 48 h (82.5%) and 72 h (71%) produce statistically lower normal germination % than the control (92%) with no significant differences among them. Normal germination % from 72 h (71%) is highly significantly

lower than the control and the other soaking periods. While soaking for 30 min (88.5%), 4 h (89.5%), 8 h (87%) and 24 h (87.5%) are comparable to the control.

Soaking temperatures at 5°C for 30 min, 4 h, 24 h and 72 h produce comparable percentage of normal germination to that soaking at 15°C for 30 min and 24 h or to soaking at 20°C for 30 min, 4 h, 8 h and 24 h soak. The differences among them and the control are not significant.

Significant reduction in normal germination % is established from soaking for 1 h at the various temperatures as compared with the control. (or normal germination % is significantly less than the control at the various temperatures a compared with the control).

Results of temperature effect on normal germination represented in Table 30. The temperature effect on normal germination % except at 10°C is constant throughout the range from 5 to 20°C. Normal germination percentages at soaking temperature of 5,15 and 20°C are 85.19, 83.69 and 85.13 %, respectively. Normal germination percentage at soaking temperature of 10°C (80.5%) is less than the other three temperatures at .05 significance level. But the difference between soaking temperatures of 10° and 15°C is significant at .01 level.

Table 31 shows the effect of soaking periods on normal germination percentage. Soaking period effects over all soaking temperatures reduces the normal germination % at .01 level of significance compared to control.

No significant differences are found in normal germination % among soaking periods for 30 min, 24 h and 4 h. also, the differences in normal germination % are less than the significance level. Again, normal germination of 8, 72, 1, 48 and 4 h are significantly the same. Generally, normal germination ranges from 79.75 % for 8 h to 92 % for the control.

Data of vigorous seedling percentage presented in Tables 29, 30 and 31. Statistical analysis shows that the vigorous seedling (≥5 cm) % is significantly affected by soaking periods, soaking temperatures as well as their interaction. Significance of the interaction results indicates that the effects of soaking depend upon soaking temperatures. Thus, more attention is given to the effects of the interaction because the effect of any factor individually will be hidden due to the interaction effect.

At low soaking temperature (5°C), the increase of soaking period over 8-h enhanced seedling vigor, but when the soaking time is short (8h or less), the vigor is low.

Based upon the results obtained from the control treatment (65.5%), results of vigorous seedling percentage are grouped into 5 groups as following:

First group-Treatments yield averages highly significantly more than the control such as: A) soaking seeds for 8 h at 20°, giving 82 %. B) Seeds soaked for 24 h at 5 or

20°C giving means of 81 and 83.5 %, respectively. C) Soaking seeds for 72 h at 5 or 15°C giving means of 83.5 and 83 % respectively. The differences among these averages are not significant.

Second group-Treatments produce averages significantly more than the control with no significant differences among them: A) Soaking seeds for 30 min at 10°C giving mean of 76.5 %. B) Soaking seeds for 24 h either at 10 or 15°C, their averages are 76.5 and 76 % respectively. C) Soaking seeds for 48 h at 5 or 15 or 20°C yielding averages of 76.5, 80 and 77.5, respectively.

Third group-Treatments produce averages significantly less than the control: A) Seeds soaked for 30 min at 5°C giving average of 48.5 %. B) Seeds soaked for 8 h at 10°C yielding average of 50.5 %.

Fourth group-Treatments yield averages higher than the control with no significance differences such as: soaking for 30 min at 15 or 20°C, soaking for 1 h at 5, 15 or 20°C, soaking for 4 h at 15 or 20°C, soaking for 8 h at 15°C, soaking for 48 h at 10°C and soaking for 72 h at 10 and 20°C. The averages range from 70 to 74 %.

Fifth group-Treatments produce averages less than the control with no statistical difference among them. A) Soaking seeds for 1 h at 10°C, soaking for 4 h at 5 or 10°C or soaking for 8 h at 5°. The averages range from 56 to 63.5 %.

Table 31 shows the effect of soaking periods on vigorous seedling (≥ 5 cm) %. Soaking for 24, 48 and 72 h give highly significant more vigorous seedling than the control (65.5 %) as well as the other soaking periods. The averages are 79.25, 76.12.13 and 76.75 % for 24 h, 48 h and 72 h respectively. Differences among them are not significant. On the other hand, soaking periods for 30 min, 1 h, 4 h and 8 h produce comparable percentage of vigorous seedlings to the control. The differences among them and the control are not significant. The averages range from 65.25 % with 4-h soak to 68.13 % with 1-h soak.

The greatest highly significant vigorous seedling percentage is established at 15 (73.81 % and 20°C (74.06 %). The seedling vigor is not significantly differing between the higher soaking temperatures (15 and 20°C). While the lowest highly significant

The average percentage of short epicotyl (< 5 cm) of Farida pea seedling is shown in Tables 29, 30 and 31. Analysis of variance shows that there are significant differences due to the tow main effects and their interaction indicating that the effect of any factors depends upon the other factor.

The effect of soaking times on percentages of short epicotyl is dependent on soaking temperatures. The percentage of short epicotyl differs very significantly. The lowest significant reduction in the percentage of short epicotyl at 24, 48 and 72 h at the various soaking temperatures as well as soaking for at 8 h at 20°C is established. The average ranges from 1 % at 15° for 72 h to 6.5 % at 10°C for 48 h Table 29. On the

other hand, the greatest very high significant percentage of short epicotyl 37 % is obtained at 5°C for 30 min or 4 h soaking followed by the control 26 %.

The lowest significantly percentages of short epicotyl (9.69-10.88%) are established from soaking at 15 and 20°C as compared with soaking temperatures at 5°C (18.81 %), which produces the greatest percentage. Difference between soaking temperature at 10 and 5°C is also significant, but difference between 20 and 10°C is not. At .01 significance level, there are no real differences among soaking temperatures at 10, 15 and 20°C, but all are highly significantly differing from soaking temperature at 5°C (Table 31).

Soaking periods for 24, 48 and 72 h yield the lowest short epicotyl % at 0.01 level of significance; their averages are 4.75, 4.25 and 5.75 % respectively with no statistical difference among them. Unsoaked seeds produce the highest percentage (26.5 %) at 0.01 level compared to the other soaking periods followed by soaking for 4 h and 30 min with averages of 19.63 and 18.13 %, respectively. Intermediate percentages 13.25 and 13.13.from soaking for 1 and 8 h, respectively are established (Table 31).

Dead seeds % represented in Tables 29, 30 and 31 are significantly differed due to the effects of the main factors and their interaction.

The effect of soaking periods on dead seeds % is dependent on soaking temperatures. The lowest dead seed % 1.0, 1 5and 2.5 % are obtained from soaking seeds at 20°C for 4 and 24 h and from unsoaked seeds. The highest percentage of dead seeds 11.5, 12 and 12.5 % are established by soaking seeds at 10°C for 4 and 48 h or for 72 h at 20°C and for 1 h at 15°C (Table 29).

The differences among soaking periods on dead seeds % at 20°C for 4, 8, 24 and 48 h and at 15°C for 30 min and 48 h and at 10°C for 24 h and at 5°C for 4 and 72 h are not significant. Their range is from 1.0 to 5.5 %.

The percentages of dead seeds produced by soaking at 20°C for 4, 8, and 24 h and at 15°C for 30 min and 48 h and at 10°C for 24 h and at 5°C for 4 and 72 h are comparable to that produced by the control. Their means range from 1.0 to 5.5 %. Also, percentage of dead seeds obtained from soaking seeds for 72 h at 20 and soaking seeds for 48 h at 10°C and for 4 or 8 5, 10 and 15°C and soaking for 4 h at 10 and 15°C and soaking for 1 h at the various imbibing temperatures and soaking for 30 min at 10°C are similar with no significant differences observed. The range is from 8 to 12.5 %.

Dead seeds of intermediate group ranges from 6 to 7.5 % with no significant differences among them. This group includes soaking seeds at 5°C for 30 min, 24 and 48 h, soaking at 15°C for 24 and 72 h and soaking at 20°C for 30 min.

Dead seeds % are highly significantly affected by soaking temperatures. Reducing imbibition temperatures from 20 to5°C and from 15 to 5°C, both have no significant effect. While reducing imbibition temperatures from 20 to 15°C or to 10°C

significantly increases dead seeds %. The highest dead seed % 8.75 % is established by imbibition at 10°C followed by imbibition at 15°C (7.38 %), the difference between them is not significant. The obtained averages are 5.25, 5.94, 7.38 and 8.75 % from soaking at 20, 5, 15 and 10°C, respectively.

Dead seed %highly significantly affected by soaking periods. Unsoaked seeds produce the lowest percentage of dead seeds 1.5 %, while soaking for 1 h produces the highest percentage 9.75. The difference is very highly significant. The differences among soaking for 1, 8, 72 and 4 h are not significant. Also the differences among soaking for 24, 48 and 0.5 h are not significant too. At 0.01 significant level, neither the differences among soaking for 24 h, 48 h, 30 min 4 h, 72 h, nor the differences among soaking for 48 h, 30 min, 4 h, 72 h, 8 h and 1 h reach the significant level. The averages being 1.5, 7.13, 9.75, 7.38, 8.63, 5.13, 6.87 and 8.25 % for control, 0.5, 1, 4, 8, 24, 48 and 72 h soaking (Table 31).

Tables 29, 30 and 31 show the percentage of abnormal germination. Analysis of variance reveals that the effects of soaking temperatures is not significant while the effects of soaking periods and their interaction are very high significant.

Abnormal germination ranges from 17.5 % with soaking for 72 h at 20°C and soaking for 8 h at 10°C to 5.5 % with soaking for 30 min at 10 and 20°C. Abnormal germination for control is 6.5 %, which does not significantly differ from others, except with soaking for 8 h at 5 and 10°C, with soaking for 24 h at 10 and 15°C and with soaking for 48 and 72 h at 20°C (Table 29).

Soaking temperatures do not influence the germination abnormality percentage. The averages are 8.87, 10.75, 9.06 and 9.62 % for 5, 10, 15, and 20°C, respectively (Table 30).

Soaking periods have very significant influences on the germination abnormality percentage. The averages are ranged from 6.5 for the control to 11.63 for soaking for 8 h. The effect of control is comparable to the effects of soaking periods for 30 min and 1 hour. Also the effects of soaking for 1 h up to 72 h are not different, except soaking for 8 h, which is only significantly different from that soaking for 1 h soak. Soaking for 8 produces highest abnormal seedling percentage (11.63%) with a significant difference as compared with control, 30 min and 1 h soaking. The averages are 6.50, 7.00, 8.75, 9.63, 11.63, 10.87, 11.25 and 11.00 % for control, 30 min, 1, 4, 8, 24, 48 and 72 h soaking, respectively (Table 31).

Table 29: Effects of soaking temperatures °C (ST) and soaking periods h (SP h) on normal germination % (NG%), abnormal germination % (ABG%), long epicotyl (5 cm and longer) % (LEp%), short epicotyl (< 5 cm cm) % (SEp%), dead seed % (DS%) and imbibition % of wrinkle seeded pea variety Farida.

ST °C	SP h	NG %	ABG %	DS %	LEp %	SEp.%	SDW %	Imbibition %
5	**Control**	92,00	6,50	1,50	65,50	26,50	0.1605	
	30 min.	85,00	8,50	6,50	48,00	37,00	0.1661	55,94
	1 h.	80,50	11,00	8,50	67,50	15,00	0.1560	58,51
	4 h.	86,00	9,50	4,50	56,00	37,50	0.1580	88,18
	8 h.	80,00	12,00	8,00	63,00	17,00	0.1702	112,76
	24 h.	86,00	7.00	7,00	81,00	5,00	0.1376	170,16
	48 h.	82,50	10,50	7,00	76,50	6,00	0.1683	174,78
	72 h.	89,50	6,00	4,50	83,50	6,00	0.1407	183,23
10	**Control**	92,00	6,50	1,50	65,50	26,50	0.1605	
	30 min.	84,00	5,50	10,50	76,50	7,50	0.1505	55,41
	1 h.	82,00	9,50	8,50	63,50	18,50	0.1539	55,08
	4 h.	76,00	11,50	12,50	60,50	15,50	0.1686	92,68
	8 h.	72,00	17,50	10,50	50,50	21,50	0.2091	110,89
	24 h.	82,00	12,50	5,50	76,50	5,50	0.1495	165,30
	48 h.	77,00	11,50	11,50	70,50	6,50	0.1752	176,05
	72 h.	79,00	11,50	9,50	74,00	5,00	0.1642	172,01
15	**Control**	92,00	6,50	1,50	65,50	26,50	0.1605	
	30 min.	86,00	8,50	5,50	74,50	11,50	1478	53,67
	1 h.	80,50	7,50	12,00	70,00	9,00	0.1603	62,58
	4 h.	80,50	9,50	10,00	70,50	10,00	0.1575	103,32
	8 h.	80,00	9,00	11.00	70,50	9,50	0.1546	133,70
	24 h.	80,50	12,50	7,00	76,00	4,50	0.1328	179,69
	48 h.	85,50	10,00	4,50	80,00	5,50	0.1499	181,88
	72 h.	83,50	9,00	7.50	83,50	1,00	0.1353	186,72
20	**Control**	92,00	6,50	1,50	65,50	26,50	0.1605	
	30 min.	88,50	5,50	6,00	72,00	16,50	0.1503	53,38
	1 h.	83,00	7,00	10,00	71,50	10,00	0.1477	61,74
	4 h.	89,50	8,00	2,50	74,00	15,50	0.1374	112,96
	8 h.	87,00	8,00	5,00	82,50	4,50	0.1372	136,96
	24 h.	87,50	11,50	1,00	63,50	4,00	0.1327	177,60
	48 h.	82,50	13,00	4,50	77,50	5,00	0.1547	185,85
	72 h.	71,00	17,50	11,50	66,00	5,00	0.1727	188,48
LSD 0,05		7,15	5,46	4,92	11,57	9,42	0.0216	8,23
LSD 0,01		9,48	**NS**	6,53	15,35	12,49	0.0286	10,91

NS = non-significant differences

Table 30: Effects of soaking temperatures °C (ST) on normal germination % (NG%), abnormal germination % (ABG%), long epicotyl (5 cm and longer) % (LEp%), short epicotyl (< 5 cm) % (SEp%), dead seed % (DS%) and imbibition % of wrinkle seeded pea variety Farida.

ST °C	NG %	ABG %	LEp %	SEp %	DS %	SDW	Imbibition %
5	85.19	8.87	67.63	18.81	5.94	0.1572	120.51
10	80.50	10.75	67.19	13.31	8.75	0.1664	118.20
15	83.56	9.06	73.81	9.69	7.38	0.1498	128.8
20	85.13	9.62	74.06	10.88	5.25	0.1491	130.99
LSD 0,05	2.53	**NS**	4.09	3.33	1.74	0.0076	3.11
LSD 0,01	3.35	**NS**	5.43	4.42	2.31	0.0101	4.12

NS = non-significant differences.

Table 31: Effects of soaking periods h (SP h) on normal germination % (NG%), abnormal germination % (ABG%), long epicotyl (5 cm and longer) % (LEp%), short epicotyl (< 5 cm) % (SEp%), dead seed % (DS%) and imbibition % of wrinkle seeded pea variety Farida

SP h	NG %	ABG %	Lep %	SEp %	DS %	SDW	Imbibition %
Control	92.00	6.50	65.50	26.50	1.50	0.1605	
30 min.	85.88	7.00	67.75	18.13	7.13	0.1537	54.60
1 h.	81.50	8.75	68.13	13.25	9.75	0.1544	59.48
4 h.	83.00	9.63	65.25	19.63	7.38	0.1554	99.29
8 h.	79.75	11.63	66.63	13.13	8.63	0.1678	123.58
24 h.	84.00	10.87	79.25	4.75	5.13	0.1381	173.19
48 h.	81.88	11.25	76.13	5.75	6.87	0.1620	179.64
72 h.	80.75	11.00	76.75	4.25	8.25	0.1532	182.61
LSD 0,05	3.57	2.73	5.79	4.71	2.46	0.0108	4.12
LSD 0,01	4.74	3.62	7.67	6.25	3.26	0.0143	5.46

Figure 21: Effects of soaking temperature (5 °C) and soaking periods (h) on normal germination % (NG%), long epicotyl (≥ 5 cm) % (LEp), short epicotyl (< 5 cm cm) % (SEp) and imbibition % of pea variety Farida

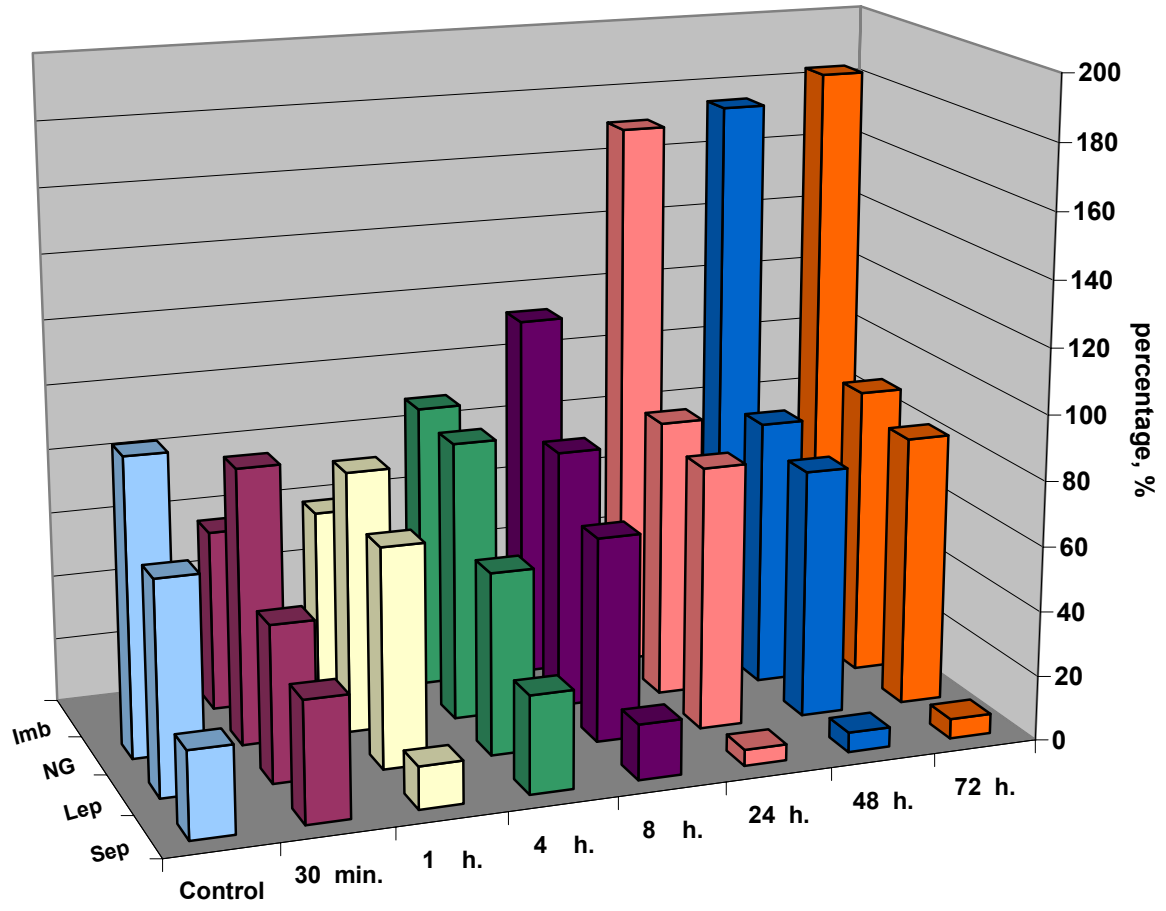


Figure 22: Effects of soaking temperature (10 °C) and soaking periods (h) on normal germination % (NG%), long epicotyl (≥ 5 cm) % (LEp), short epicotyl (< 5 cm cm) % (SEp) and imbibition % of pea variety Farida

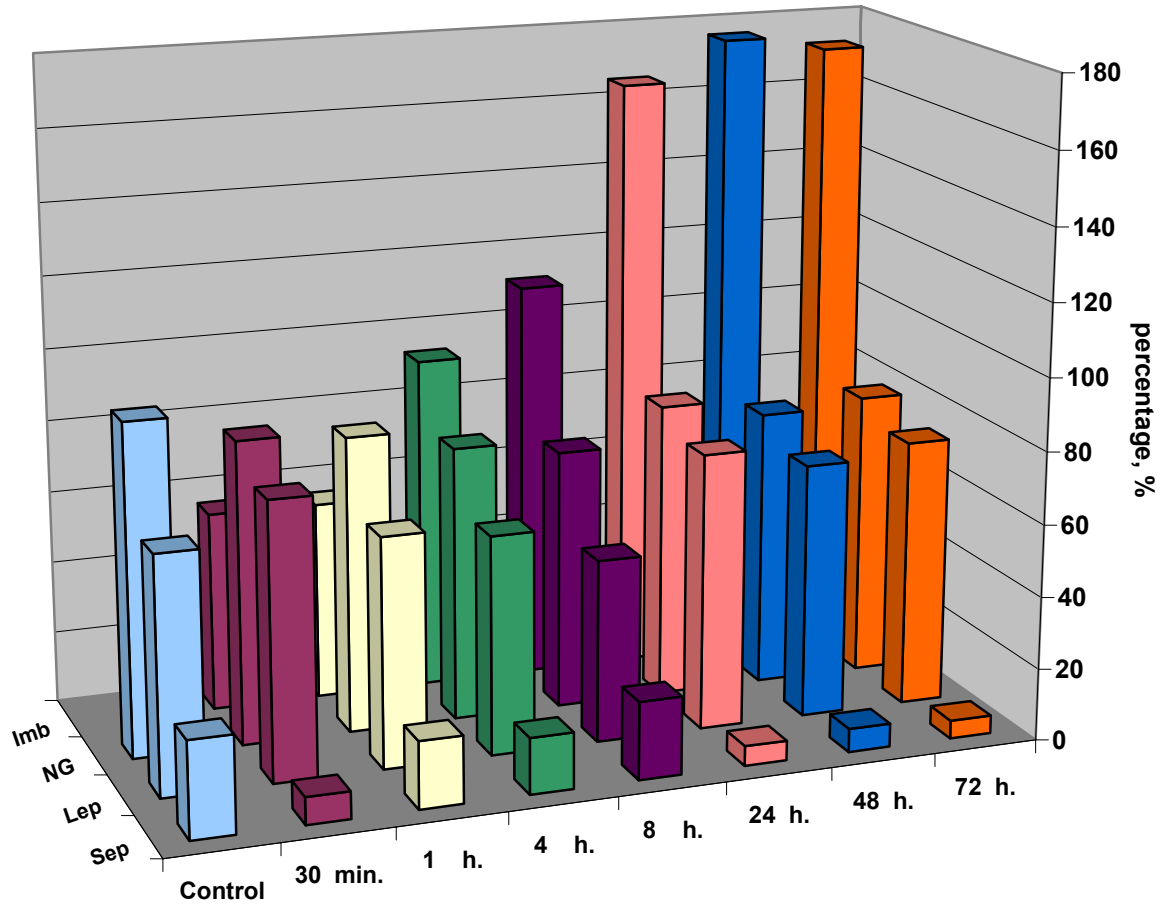


Figure 23: Effects of soaking temperature (15 °C) and soaking periods (h) on normal germination % (NG%), long epicotyl (≥ 5 cm) % (LEp), short epicotyl (< 5 cm cm) % (SEp) and imbibition % of pea variety Farida

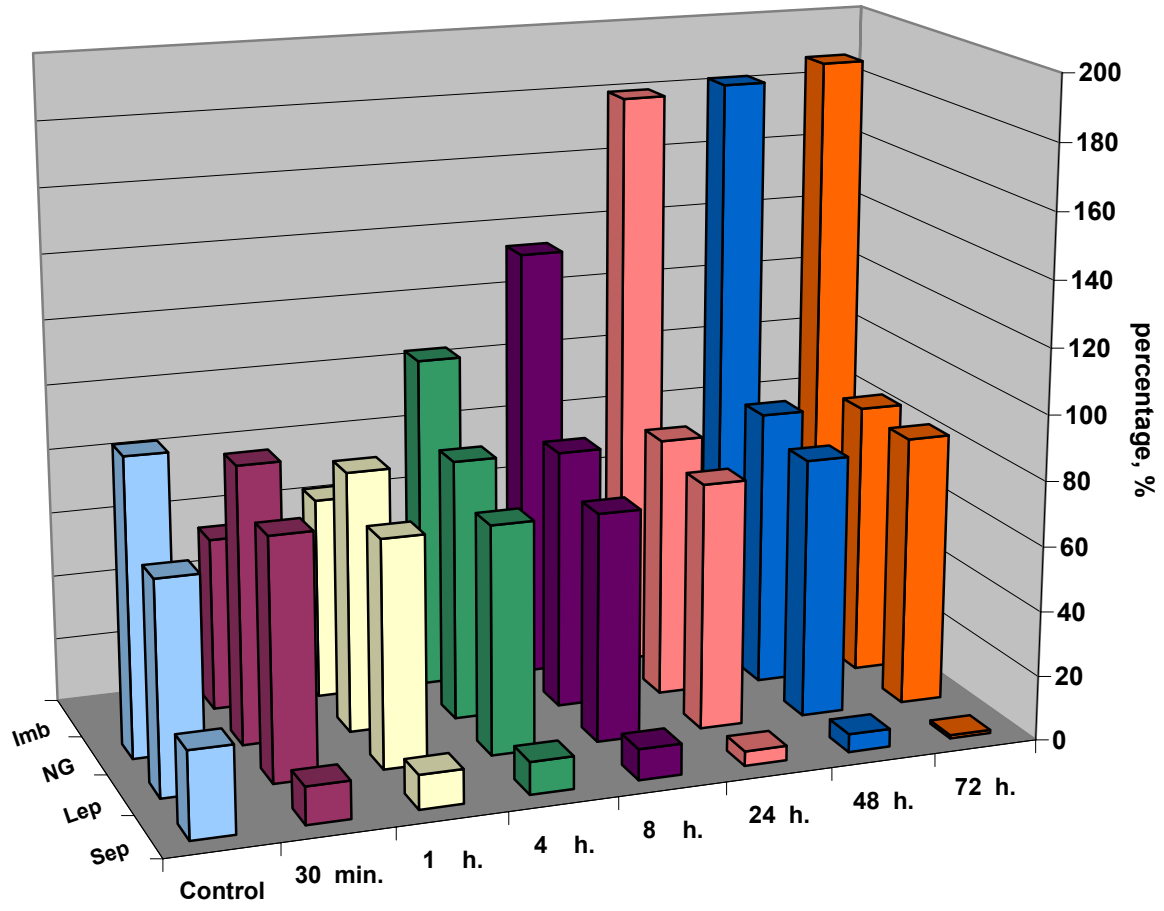


Figure 24: Effects of soaking temperature (20 °C) and soaking periods (h) on normal germination % (NG%), long epicotyl (≥ 5 cm) % (LEp), short epicotyl (< 5 cm cm) % (SEp) and imbibition % of pea variety Farida

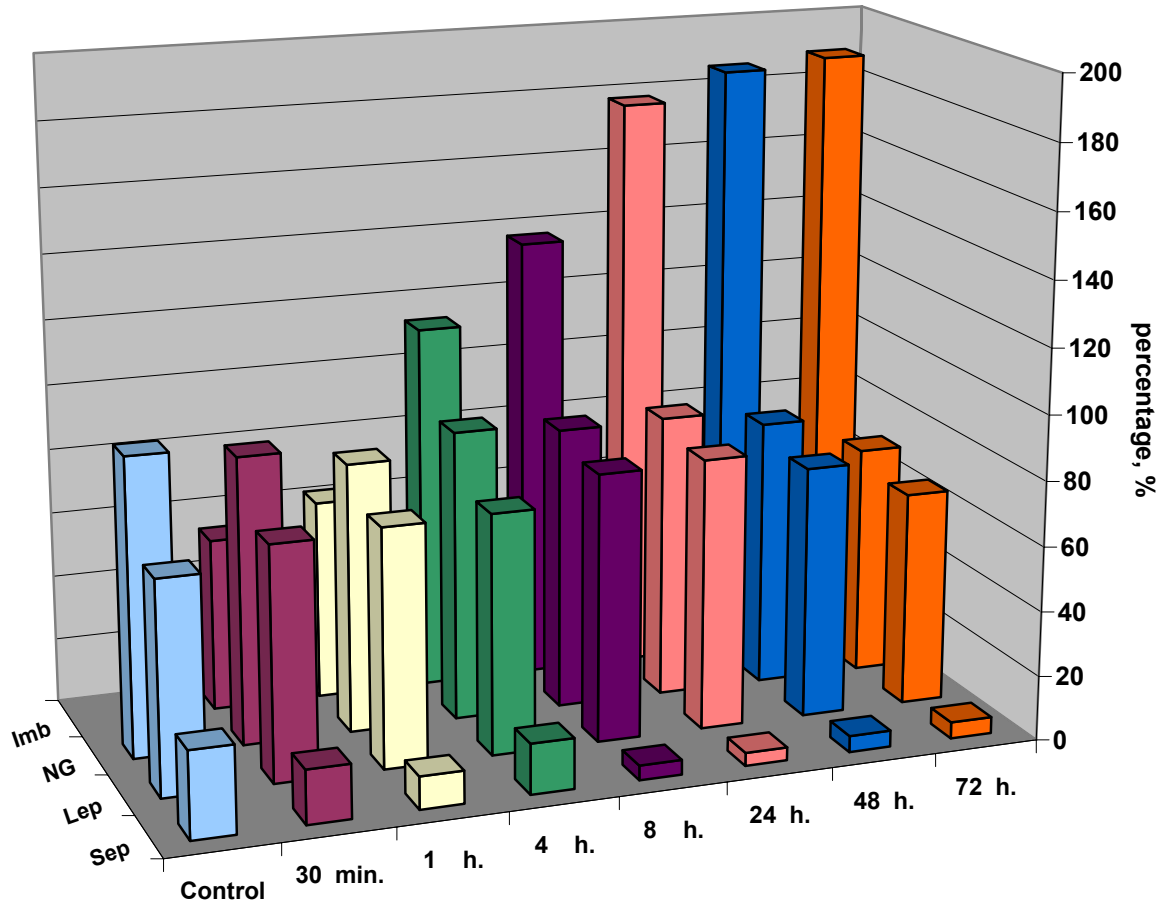


Figure 25: Effects of soaking temperatures on normal germination % (NG%), long epicotyl (≥ 5 cm) % (LEp), short epicotyl (< 5 cm) % (SEp) and imbibition % of pea variety Farida

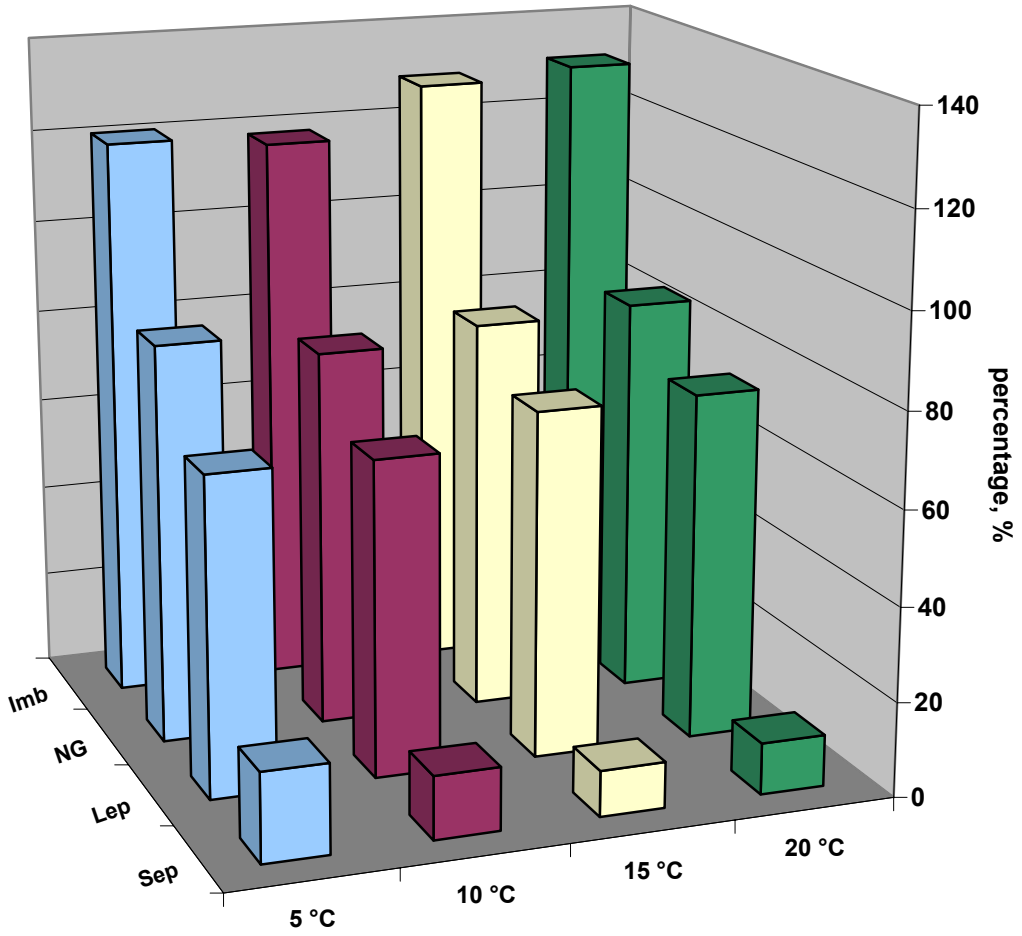
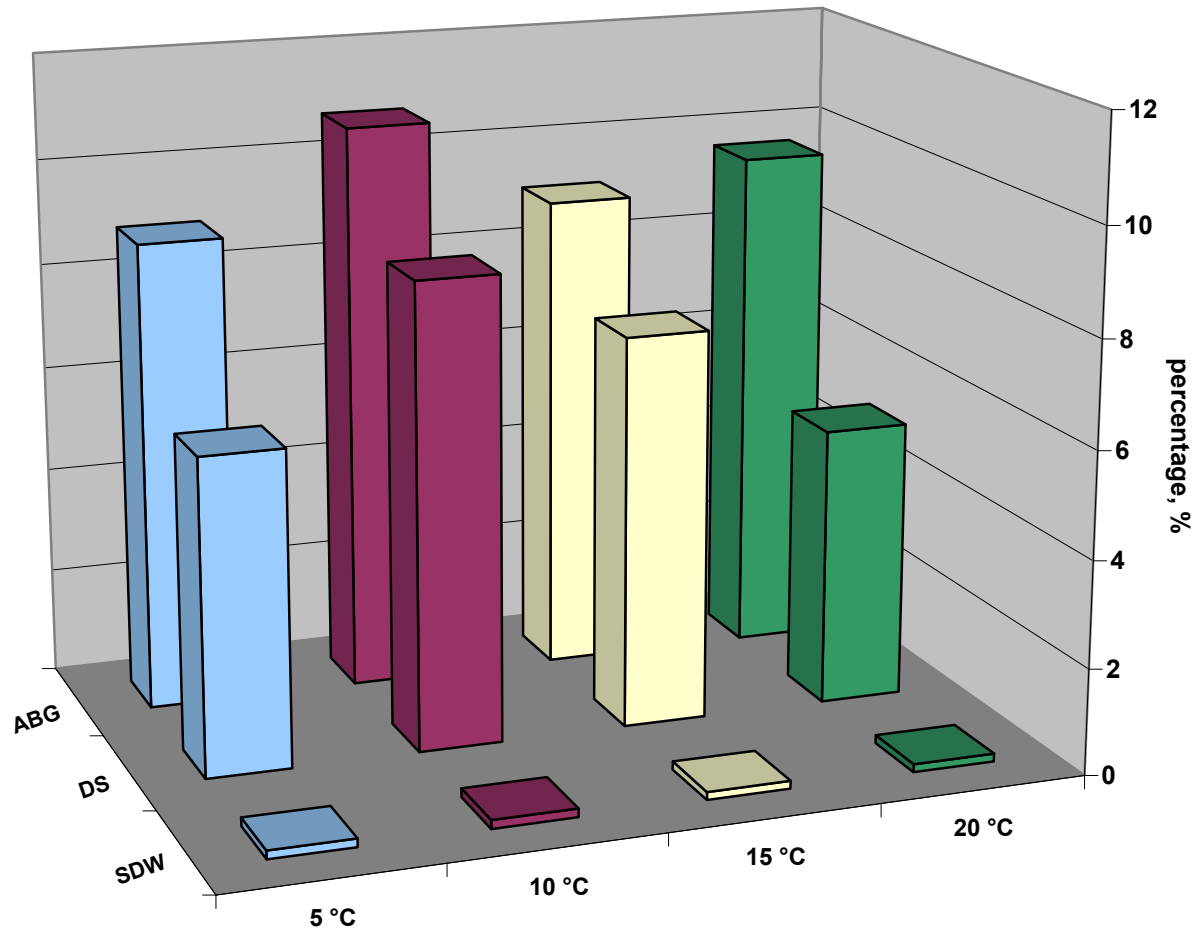


Figure 26: Effects of soaking temperatures on abnormal germination % (ABG), and dead seed % (DS) of pea variety Farida.



4.4.3. Measurement of further germination characteristics (wrinkle seeded pea variety Lambado)

The pattern of imbibition of Lamabdo seeds is not comparable to that of Farida seeds at 20°C, however neither the quantities or the rates throughout soaking periods are similar. This can be attributed to varietal differences as well as to the conditions of the seed samples (seed coat and seed moisture contents).

Table 32 and Figure 27 show the effect of soaking periods on seed imbibition. Statistical analysis indicates that the imbibition percentage increases highly significantly throughout the increasing periods, except increasing soaking from 15 to 30 min, in which the difference is not significant. The imbibition percentages are 3.40, 5.28, 14.28, 62.58, 101.97, 146.97, 158.38 and 166.68 % at 15, 30 min, 1, 4, 8, 24, 48 and 72 h.

Lambado seeds imbibe water at rate of 13.6 %/h during the first 15 min, then after imbibition rate declines markedly to 11.56 %/h by the end of the first 30 min soaking. There after, dramatically increase in water imbibition is observed 14.28 %/h after 1 h and 15.65 5/h after 4 h soak. In the other word, the peak of imbibition rate is established at 4 h soaking followed by dramatically steadily imbibition rate reduction by almost 50 % after 8 h soaking and over up to 48 h soaking. The reduction in the rate of imbibition due to increasing soaking from 48 to 72 h is less than 30 % compared to the rate at 48 h soaking. The imbibing rates are 12.75, 6.12, 3.3 and 2.3 %/h at 8, 24, 48 and 72 h soaking. Water imbibition by Lambado seeds appears to be not completed by 72 h soak.

Leakage of electrolytes, the electrical conductivity readings of steep water increase throughout the increasing soaking time, but the highest reading 18.86$\mu S\ cm^{-1}\ g^{-1}$ is established.

The lowest reading 0.42 $\mu S\ cm^{-1}\ g^{-1}$ is obtained after the first 15 min soaking (Table 32). Exudation at 15 and 30 min imbibition is not significantly different at .05 level of significance. The electrical conductivity values after 15, 30 min,1, 4, 8, 24, 48 and 72 h imbibition are 0.42, 0.82, 2.21, 11.51, 17.50, 18.86 and 17.71 $\mu S\ cm^{-1}\ g^{-1}$, respectively.

Since the electrical conductivity values of the steep water after 24 and over range from 17.51 to 18.86 $\mu S\ cm^{-1}\ g^{-1}$ is less than that value suggested by ISTA (1995) >25 $\mu S\ cm^{-1}\ g^{-1}$. Thus, the Lambado seed lot used in this study is of high seed vigor.

It appears that steeping for longer than 24 h as long as 72 h has little influence on the amount of exudation found among 24, 48 and 72 h imbibition period. However, the difference in the electrical conductivity value among 24, 48 and 72 h imbibition periods is not significant.

The initial rate of released electrolytes is low at the first 15 and 30 min imbibuition. The highest rate 2.21 $\mu S\ cm^{-1}\ g^{-1}$/h is established at 1-h imbibition. Then

after the rate steadily decreases from 2.21 at 1 h to 1.87, 1.44, 0.73, 0.39 and 0.25 μS cm^{-1} g^{-1}/h at 4, 8, 24, 48and 72 h imbibitin time, respectively.

Seedling emergence percentage do not significantly affected by increasing soaking time. The range is between 99 % at 30 min or 24 h and 94.5 for 48 h soaking (Table 32, Figure 28.). The seedling emergence percentage for the control is 89 %.

Soaking period significantly affected the percentage of normal seedlings, indicating that normal seedling emergence is more sensitive than the total emergence percentage. Soaking for 48 and 72 hours give the lowest significant values compared to the control or to the other soaking times, except at 24 hours. Soaking for 24 h does not affect the percentage of normal seedling emergence as compared with all other treatments including the control. The averages are ranged from 96.5 to 86.5 % for 30 min and 72 h imbibition time, respectively (Table 32). Soaking for 72 h highly significantly reduces the percentage of normal seedling emergence compared to the control, which indicating the deleterious effect of this so longer soaking period.

The results of this study with Lambado pea seeds indicating the existence of significant differences among soaking periods. Soaking for 24 h produces 91.5 % vigorous seedling (epicotyl length of ≥5 cm) with no significant difference compared to the control or to the other soaking periods, except with soaking for 48 and 72 h, which produce the lowest significant value 87 and 83 %, respectively as compared with soaking for 15 and 30 min (Table 32).

Table 32 shows the results of seedling length. Longest seedling is obtained by soaking for 24 h (86.7 cm) and it is highly significantly taller than both the control (80.62 cm) and the other treatments, except those soaked for 4, 8 and 48 h, however, they are not significantly different from the 24 h soaking at 0.01 level. The significantly shorter seedling 75.69 cm is established by soaking for 15 min. The differences among the control and soaking for 0.5, 1 and 72 h soaking are not significantly different at 0.05 and 0.01 level of significance.

Table 32 shows the data of mean emergence time. Analysis of variance indicates the absence of significant differences among the soaking periods and the control. The averages being 5.35, 4.88, 4.7, 4.83, 4.88, 4.8, 4.8, 4.95 and 4.88 days for control, 15 min, 30 min, 1, 4, 8, 24, 48 and 72 h, respectively.

Statistical analysis of abnormal emerged seedling data indicates that the effects of soaking periods are highly significant. The significantly highest abnormal emerged seedling 10 % is established by soaking for 72 h compared to all treatments, including the control, except soaking for 24 h, which produces the second highest abnormal seedling percentage 7.5% (Table 32).

Although the lowest percentage of abnormal seedling 1 % produced by soaking for 4 h, the differences between it and soaking for 15, 30 min, 1, 8 h and control are not

significant at 0.05 level. But the difference between soaking for 4 h and 24 or 48 h is significant at 0.05 or 0.01 %.

The percentage of abnormal seedling produced by unsoaked seeds is comparable to that produced by other soaking periods except that soaking for 72 hours.

The abnormal seedling averages are 3.50, 1.25, 2.50, 4.50, 1.00, 4.50, 7.50, 5.50 and 10.00 % for control and soaking for 15, 30 min, 1, 4, 8, 24, 48 and 72 h, respectively (Table 32).

Seedling dry weight results are represented in Table 32. Seedling dry weight is highly significantly affected by the soaking periods.

The highest seedling dry weight 0.0361 g is established at soaking the seeds for 1 hour followed by 0.0360 g and 0.0359 g for soaking for 30 min and 4 h, respectively.

Soaking for 8 h or less produce similar seedling dry weight to that of control. However, the differences among them are not significant.

Soaking for longer than 8 h (24, 48 and 72 h) produce very significantly lighter seedling dry weight as compared with the control as well as with soaking for 8 h or less.

The lowest very significantly seedling dry weight 0.0286 g is established by soaking for 72 h, which is comparable to that of 48 h soak.

Soaking for 24 h yields heavier seedling dry weight than soaking for 48 or 72 h. The difference between 24 and 72 h is significant while the difference between 24 and 48 h is not significant.

Seedling dry weight averages being 0.0286, 0.0302, 0.0307, 0.0340, 0.0345, 0.0346, 0.0359, 0.0360 and 0.0361 g dry weight/seedling for soaking for 72, 48, 24, 8 h, 15 min, control, 4 h, 30 min and 1 h soak, respectively (Table 32)

Assessment of mineral leaching from Lambado seeds in the steep water through out the various soaking periods by ICP indicated that the measurable amounts of potassium, sodium, calcium and magnesium were obvious, while others either they were found in a trivial amount or absent. Pattern of these four minerals leakage was different through out the various soaking periods.

Potassium ions (K^+) leakage was increased throughout soaking periods getting maximum 36.0925 ppm by 24 h soak. After 72 h, the amount of the potassium was 30.9633 ppm (Table 33) Potassium ions accounted for about 75 % of total electrolyte leakage (K^++Na^c+Ca^++Mg^+) during the 24 h followed by sodium 15.4 %, calcium 6.9 and magnesium 2.9 % (Table 34, Figure 29-30.).

After 24 h soaking there was a significant correlation between electrical conductivity and potassium (r^2 = 0.8333). The correlation between potassium and sodium was not significant r^2 = 0.7199. The correlation between potassium and magnesium was significant r^2 = 0.8113. While the correlation between potassium and calcium was non-significant r^2 = 0.6112. Significant correlation was also observed

between potassium and magnesium after 48 h soak while no significant correlation were observed between potassium and the other minerals at 48 h as well as at 72 h, except between potassium and sodium, it was significant after 72 h soak (Table 35).

Sodium ions (Na^{2+}) leakage was almost steady during the first 24 h soaking, however, there were no significant differences. Maximum amount of sodium 9.24 ppm was established after 48 h then decreased to 8.7703 ppm at 72 h. Sodium leaching amount ranked the second level. Sodium had significant correlation only with potassium at 72 h (Table 33).

Calcium ions (Ca^{2+}) reached maximum level 3.8 ppm after 72 h. No significant correlation was established between calcium and other minerals at soaking of 24, 48 and 72 h, except with magnesium (Mg^{2+}) after 72 h (Table 35).

Electrical conductivity (EC), after 24 h was significantly correlated with potassium, and magnesium and highly significant with sodium r^2 = 0.8333, 0.8113 and 0.9217, respectively. After 48 h, EC was correlated highly significantly only with sodium r^2 = 0.9559 while after 72 h it was highly significantly correlated with magnesium r^2 = 1.0 and just significant with calcium r^2 = 0.8680 (Table 35)

Table 32: Effects of soaking periods h (SP h) on imbibition % (imb %), electrical conductivity µS cm^{-1} g^{-1} (EC), seedling emergence % (SE %), normal seedling % (NS %), abnormal seedling % (ABS %), mean emergence time (MET), seedling length cm (SL cm), vigorous seedling (epicotyl length of ≥5 cm) % (VS %) and seedling dry weight g (SDW g) of Lambado wrinkle seeded pea variety seeds

SP h	Imb %	EC	SE%	ND%	ABS%	MET	SL	VS%	SDWg
Control	-----	-----	98.0	94.5	3.50	5.35	80.62	92.5	.0346
15 min	3.40	0.424	98.0	96.0	1.25	4.88	75.60	93.5	.0345
30 min	5.28	0.817	99.0	96.5	2.50	4.70	78.91	94.5	.0360
1 h	14.28	2.214	98.0	93.0	4.50	4.83	77.34	90.0	.0361
4 h	62.58	7.476	95.5	95.0	1.00	4.88	84.66	91.5	.0359
8 h	101.97	11.506	96.5	92.5	4.50	4.80	83.29	90.5	.0340
24 h	146.97	17.499	99.0	91.5	7.50	4.80	86.70	91.5	.0307
48 h	158.38	18.859	94.5	89.0	5.50	4.95	84.05	87.0	.0302
72 h	166.68	17.709	96.5	86.5	10.00	4.88	79.85	83.0	.0286
LSD .05	3.83	1.465	NS	5.82	4.19	NS	4.47	5.54	.0019
LSD .01	5.18	1.985		7.86	5.65		6.04	7.48	.0025

NS = non-significant differences

Table 33: Effects of soaking periods h (SP h) on imbibition % (imb %), electrical conductivity µS cm^{-1} g^{-1} (EC), Potassium (K^{+}), Sodium (Na^{2+}), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), (Na^{2+}+Ca^{2+}+Mg^{2+}) and (K^{+}+Na^{2+}+Ca^{2+}+Mg^{2+}) leaching expressed in ppm from Lambado of wrinkle seeded pea variety seeds.

SP h	Imb %	EC	K	Na	Ca	Mg	Na,Ca,Mg	K,Na,Ca,Mg
15 min	4.45	0.3445	1.0108	5.7558	0.7169	0.3242	6.7959	7.8067
30 min	7.76	0.4775	1.4085	4.7685	0.5509	0.2817	5.6011	7.0096
1 h	27.53	1.3989	3.9933	5.3093	0.8695	0.3611	6.5399	10.5332
4 h	91.82	5.7841	16.3975	5.8000	1.4315	07136	7.9451	24.3426
8 h	125.25	7.5517	20.8925	6.5910	1.6610	0.7563	9.0083	29.9008
24 h	151.13	12.1363	36.0925	7.4340	3.3300	1.3808	12.1448	48.2373
48 h	161.18	12.8353	27.8150	9.2400	3.0693	1.2443	13.5536	41.3686
72 h	162.45	13.7597	30.9633	8.7703	3.8000	1.6270	14.1973	45.1606
P= .05	4.1	0.9001	4.0126	2.0861	0.4955	0.2242		
P= .01	5.58	1.2198	5.4375	2.8268	0.6714	0.3038		

Table 34: Imbibition % (imb %), electrical conductivity µS cm^{-1} g^{-1} (EC) and the percentage of Potassium (K^{+}), Sodium (Na^{2+}), Calcium c (Ca^{2+}) and Magnesium (Mg^{2+}) ions expressed in ppm of the total electrolyte (K^{+}+ Na^{2+}+ Ca^{2}+$^{+}Mg^{2+}$) leakage from Lambado pea seeds during various soaking periods.

SP h	Imb %	EC	K	Na	Ca	Mg
15 min	4.45	0.3445	12.95	73.72	9.18	4.15
30 min	7.76	0.4775	20.09	68.03	7.86	4.02
1 h	27.53	1.3989	37.91	50.41	8.25	3.48
4 h	91.82	5.7841	67.64	23.83	5.88	2.93
8 h	125.25	7.5517	69.87	22.04	5.56	2.53
24 h	151.13	12.1363	74.82	15.41	6.90	2.86
48 h	161.18	12.8353	67.24	22.34	7.422	3.01
72 h	162.45	13.7597	68.56	19.42	8.41	3.60

Table35: Correlation between electrical conductivity µS cm^{-1} g^{-1} and potassium, sodium, calcium and magnesium ions expressed in ppm after leaching 24, 48 and 72 h soaking from wrinkle seeded pea variety seed (Lambado)

24 h

Variable	EC.µS cm^{-1} g^{-1}	K. ppm	Na. Ppm	Ca. ppm	Mg. ppm
EC	-----	0.8333*	0.9217**	0.2222^{NS}	0.8113*
K	0.8333*	-----	0.7199^{NS}	0.6112^{NS}	0.8766*
Na	0.9217**	0.7199^{NS}	-----	0.1167^{NS}	0.5704^{NS}
Ca	0.2222^{NS}	0.6112^{NS}	0.1167^{NS}	-----	0.5308^{NS}

48 h

EC	-----	0.0029^{NS}	0.9559**	$8E\text{-}5^{NS}$	0.0003^{NS}
K	0.0029^{NS}	-----	0.4438^{NS}	0.6079^{NS}	0.9517**
Na	0.9959**	0.4438^{NS}	-----	0.0031^{NS}	0.6481^{NS}
Ca	$8E\text{-}5^{NS}$	0.6079^{NS}	0.0031^{NS}	-----	0.3922^{NS}

72 h

EC	-----	0.5819^{NS}	0.6981^{NS}	0.6880^{NS}	1.000**
K	0.5819^{NS}	-----	0.9853**	0.2263^{NS}	0.5855^{NS}
Na	0.6981^{NS}	0.9853	-----	0.3350^{NS}	0.7015^{NS}
Ca	0.8680	0.2263^{NS}	0.3350^{NS}	-----	0.8655*

Figure 27: Effects of soaking periods (h) on seed imbibition % (Imb) and electrical conductivity (µS cm-1 g-1) of seeds of pea variety Lambado

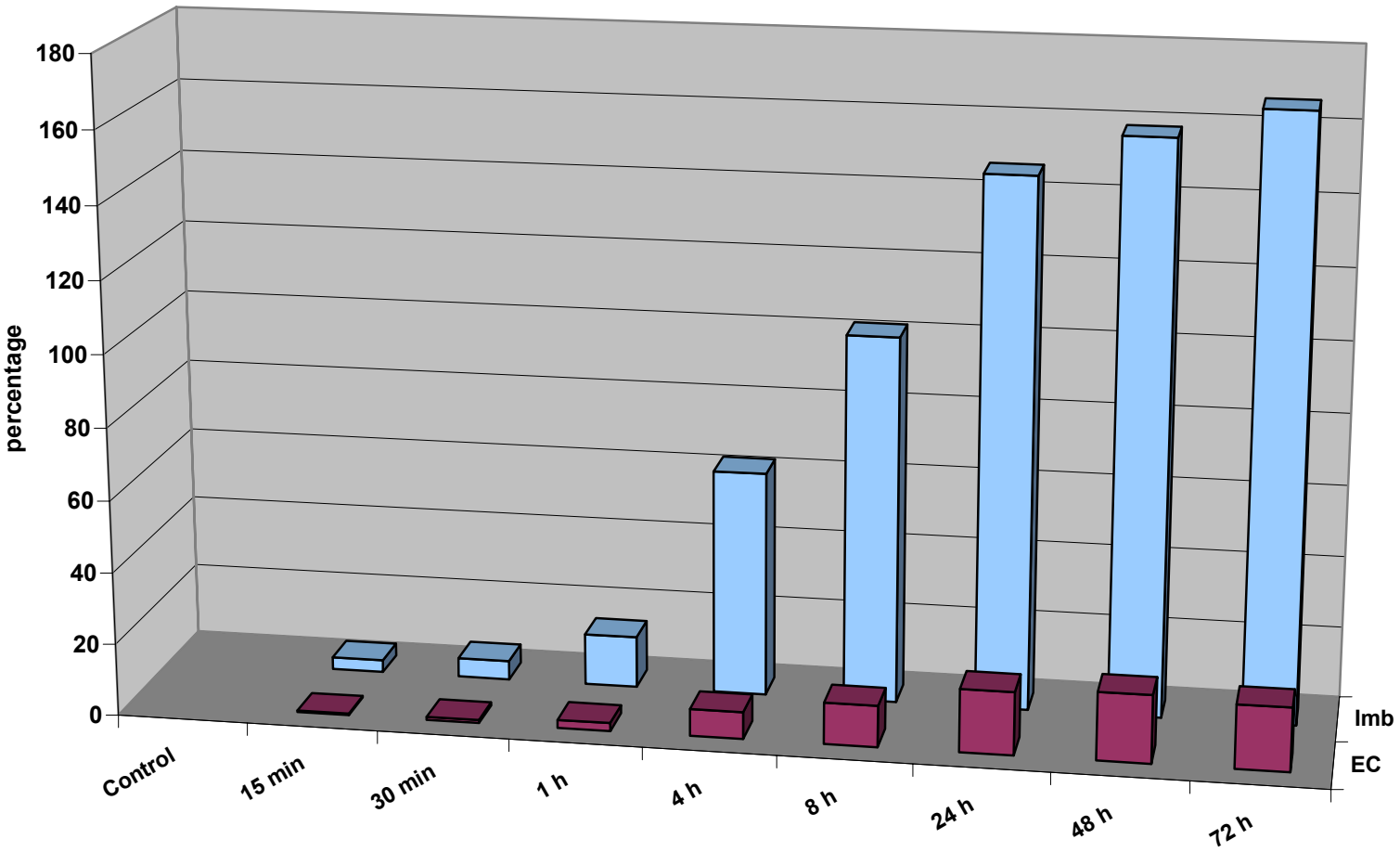


Figure 28: Effects of soaking periods (h) on seedling emergence % (SE), normal seedling % (NS %), seedling length (SL, cm) and vigorous seedling (epicoty length of ≥5 cm) % (VS) of Lambado pea seeds

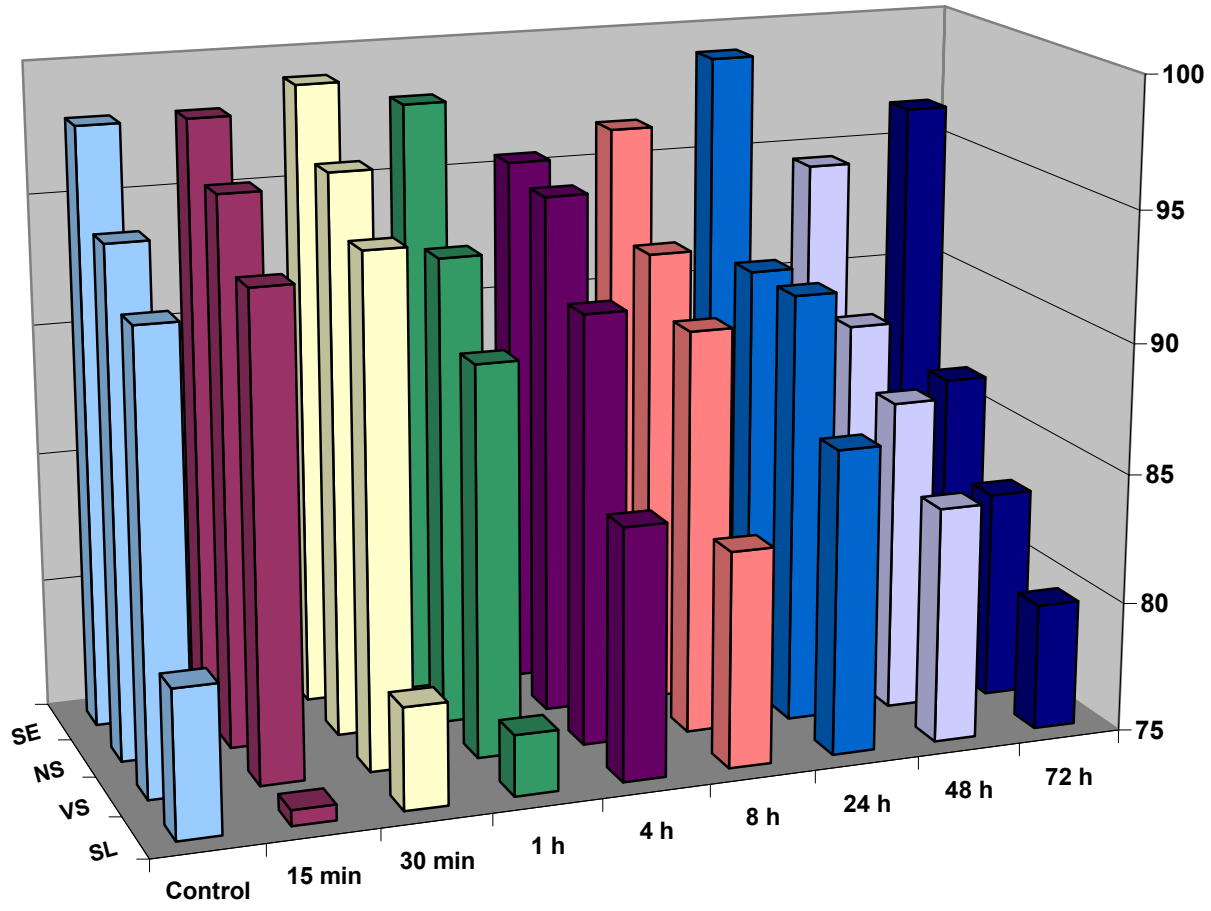


Figure 29: Effects of soaking periods (h) on electrical conductivity (µS cm^{-1} g^{-1}, EC), Potassium (K^{+}), (Na^{2+}+Ca^{2+}+Mg^{2+}) and (K^{+}+Na^{2+}+Ca^{2+}+Mg^{2+}) leaching expressed in ppm from Lambado pea seeds

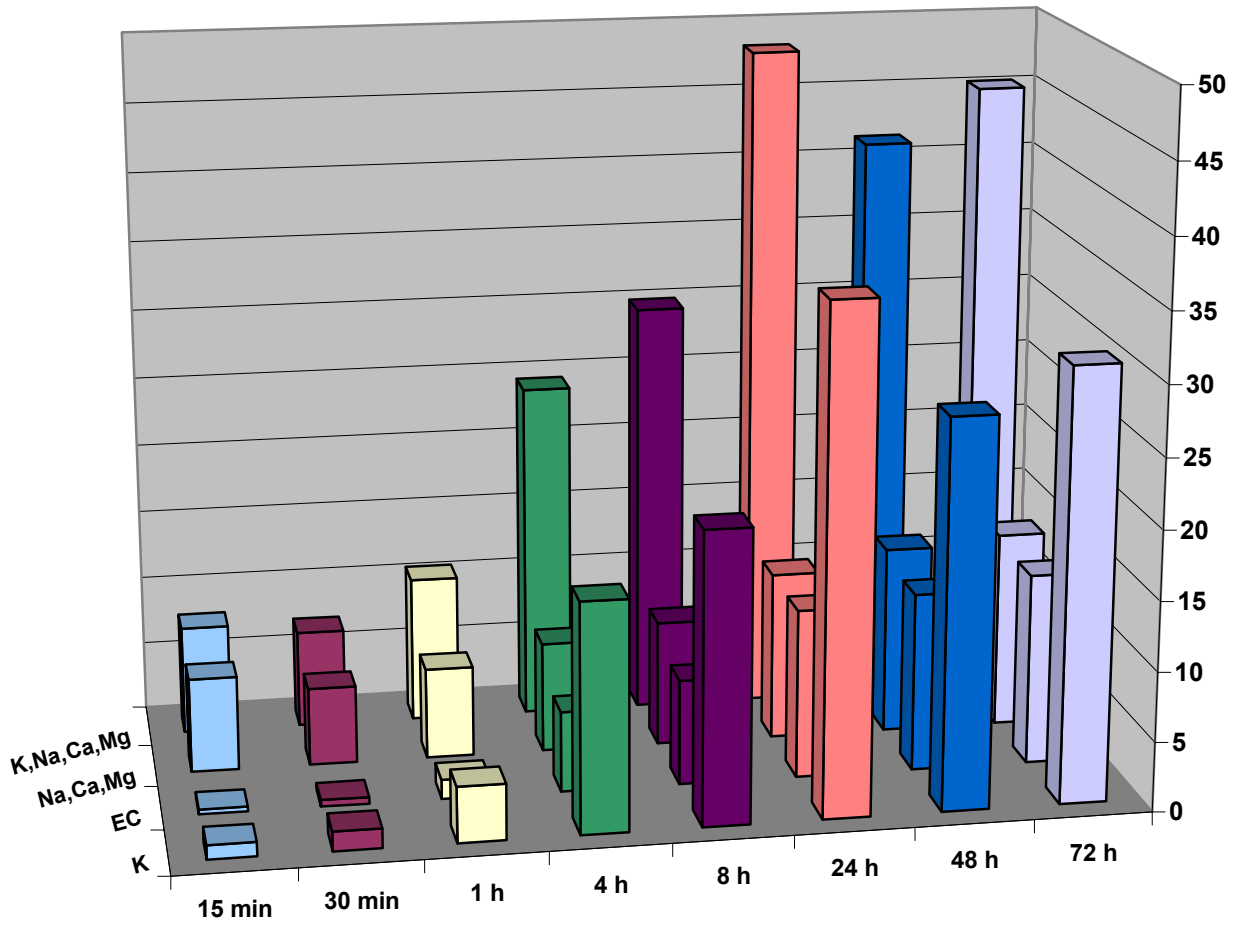


Figure 30: Effects of soaking periods (h) on Sodium (Na^{2+}), Calcium (Ca^{2+}) and Magnesium (Mg^{2+}) leaching expressed in ppm from Lambado pea seeds

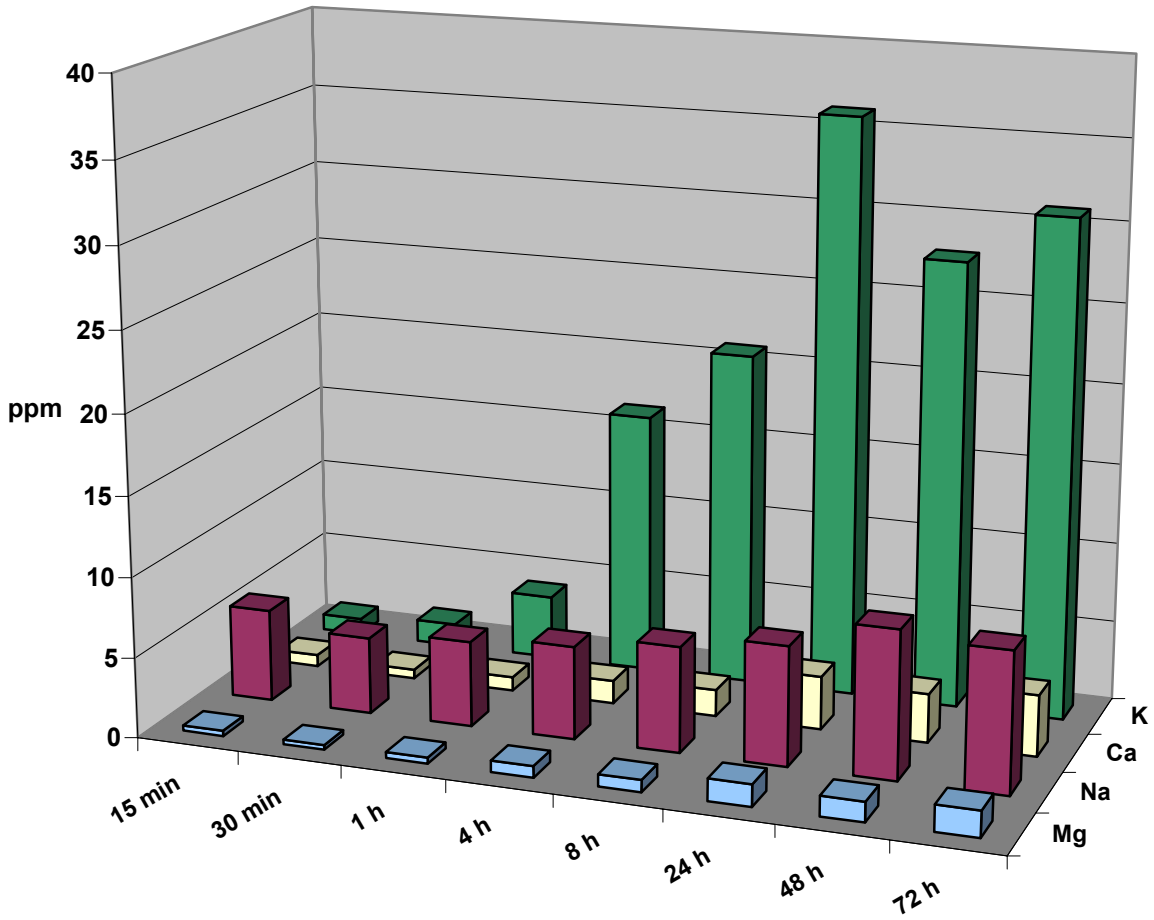


Figure 31. Illustrating seedling growth of Lambado variety. The left tray represents seedlings resulted from soaking for 24 h. The middle tray represents seedlings of non-soaked seeds. The right tray represents seedlings resulted from soaking for 72 hours.

Figure 32.: Different pea seedlings

5.DISCUSSION

5.1. Efects of Vitavax on pepper variety types seed performance

It is evident from the data presented in Table 4 that the three pepper variety types: Kalocsai 622 (sweet spicy), Fehérözön (sweet open field) and Csipke (hot long forcing pepper) showed significant differences with regard to the percentages of seedling emergence16 days after sowing, seedling survival, normal seedling and abnormal seedling 35 days after sowing. These results are in agreement with the results of other workers (**Gerson and Honma, 1978; Randle and Honma, 1981 and Cavero et al. 1995**), where differences in seed germination and seedling emergence behavior among pepper varieties were observed.

The three pepper varieties showed significant differences in the nitrogen, phosphorus and potassium contents. The responses of the three pepper variety types to the Vitavax seed treatment were different. Nitrogen and potassium seedling contents significantly increased in the all the three variety types due to Vitavax seed treatment as compared with non-treated ones (Table 2). The increase in nitrogen and potassium contents of the seedling of Vitavax treated seeds could probably be due to improvement of root system by Vitavax application and the availability of the nutrients to the root zone. Phosphorous content of the seedling was not affected, which may be related to its unavailability in the soil.

The seedling emergence and normal seedling % of Csipke (hot, long green, forcing) and Fehérözön (sweet, white, open field) varieties were significantly reduced by Vitavax seed treatment, however, for variety Kalocsai 622 (Sweet spicy), it showed higher seedling emergence and normal seedling %, but the increase was non-significant. The survival of seedlings was not affected by the treatment in Csipke (hot, long green, forcing) and Kalocsai 622, (Sweet spicy) but was reduced in Fehérözön (sweet, white, open field) at 0.01 level of significance.

Improvements in seed germination and seedling growth in rough lemon, in rice, in wheat, in check peas and in cotton and ground nut has been reported by other workers (**Dhyani et al., 1991; Sharma, 1989; Misra et al. 1990; Buffa et al. 1991; Zaidi et al. 1991; Ertseyné and Horváth, 1993; Poswal et al. 1992 and Emmimath, 1994**). **Raj et al.(1990) and Salazar (1993**) reported no effect in wheat and in Phaseolus mungo, respectively but **Buffa et al**. (1995) stated that double doses of Vitavax seed treatment had phytotoxic effects on rice varieties Roma and Ariete.

The reduction in the percentage of normal seedling of Csipke (hot, long green, forcing) and Fehérözön (sweet, white, open field) may be due to delayed seed germination and seedling emergence of treated seeds, thus a high number of abnormal seedling were

found. It may also be possible that the seedlings, which were randomly taken to the laboratory were containing more abnormal and less normal seedlings for the Vitavax treatment than that for the control (Table 1). These factors may also affect the fresh and dry weight and stem-leaf area (Table 3). The results show that the Vitavax seed treatment had most effective for the seed of spicy pepper variety, We suggest to use it in the growing.

5.2. Effects of Atonik solution on tomato seed performance

The results indicated that tomato varieties did not respond to the application of the Atonik solution at different concentrations (Table 5), which disapproves the claim of the producer company Asahi Chemical, MFG. Co. LTD, that Atonik application improves germination and seedling growth of tomato. However, **Zaghdani et al. (1996)** reported earlier about the effectiveness of Atonik application in increasing the percentage of long seedlings in cucumber.

5.3. Effects of Atonik solution on cucumber seed performance

5.3.1. Performance of the high germination cucumber seed samples (variety Dolge Zelene)

The results of the present study are in agreement with the Atonik producer company, where Atonik at 0.25 ml/l or 0.5 ml/l improved seedlings vigor (Table 12). On the other hand, Atonik seed treatments did not enhanced seed germination percentage, which is contrary to claim by the producer company and other workers (**Sheteawi, 1993 and Kar et al., 1993**). However, improvement of seed germination by utilizing plant regulators such as IAA, NAA and GA has been reported by other workers for ornamental plants, soybean and tomato (**Renard and Clere, 1978; Abdulla and McKelvie, 1980; Grzsesik and Chojnowsik, 1992**).

5.3.2. Vigorous (Budai félhosszú F1) and medium plant growth (Nati F1) cucumber varieties seed performance

Highly significant differences in seedling emergence, mean emergence time and in hypocotyl length between the two different vigorous cucumber varieties; Budai félhosszú F1 and Nati F1 (Table 13) were observed. However, Budai félhosszú F1 seedling emergence was 48.67 %, mean emergence time 8.39 days and hypocotyl length 8.28 cm. On the other hand, seedling emergence %, mean emergence time and hypocotyl length of Nati F1 were 93.17 %, 6.79 days and 11.84 cm, respectively. While, neither seed treatments (soaking in water or in Atonik) nor the interaction between seed treatments and the varieties affected the seed performance under the glasshouse

condition during the month of February (Tables 14a and 15a). The difference between the two varieties in this experiment can be attributed to the variety effect and to the differential response to the temperature of the glasshouse. Similar results were recorded for seed germination or seedling emergence and in time to germinate or emerge among cucumber varieties, especially under less optimal temperatures (**Milotay et al., 1991; Jenning and Saltveit, 1994; Russo and Biles, 1996**).

Seedling emergence of the both cucumber varieties Budai félhosszú F1 and Nati F1 planted in the glasshouse during June (temperature and light intensity higher than that during February) was similar and not affected by the seed treatments, the interaction or the varieties (Tables 16, 17 and 18). These observations agree with that of **Jennings and Saltveit (1994),** however, they reported no differences in seed germination between the two cucumber varieties of the same age planted at optimal temperature condition.

Mean emergence time and hypocotyl length of the both varieties were significantly affected by the varieties and by the interaction between variety and seed treatment, but not by seed treatment (Tables 16, 17 and 18). Mean emergence time of Nati F1 was significantly longer than that for Budai félhosszú F1 at Atonik or untreated seeds. This result confirms the result recorded by **Jennings and Saltveit (1994)**. Atonik seed treatment significantly shortened the mean emergence time of Nati F1 seedling, which is in agreement with the suggestion made by the Atonik Producer Company (Asahi Chemical, MFG. Co., LTD, Osaki, JAPAN). Mean emergence time of Budai félhosszú F1 was not affected by seed treatment.

Hypocotyl length was very greatly affected by both the varieties and by the interaction between the variety and the seed treatment, but seed treatment had no effect (Table 16, 17 and 18). Although Atonik seed treatment highly significantly improved hypocotyl length of Budai félhosszú F1, it significantly decreased the hypocotyl length of Nati F1 seedling. The improvement reported by the Producer Company seems to be related to the variety in concern.

In this study, it has been observed that both the varieties; Budai félhosszú F1 and Nati F1 seeds were sensitive to suboptimal germination temperature. Seed treatments resulted in total inhibition of germination in both the varieties at 10°C incubation temperature after 30 days. These findings are in accordance with reports of other workers (**Simon et al. 1976, Jennings and Saltveit 1994, Russo and Biles, 1996 and Jennings, 1999**). Roots of cucumber seeds germinating at 10°C were probably unable to elongate sufficiently to pierce the seed coat, thereby suggesting that their progress towards germination was blocked (**Simon et al., 1976**).

When seeds of Budai félhosszú F1 and Nati F1 were transferred from 10°C or 15°C after 30 days incubation to 25°C, they germinated sooner than those incubated at 20°C or 25°C from the start. (data are not shown), suggesting that Budai félhosszú F1 and

Nati F1 seeds incubated for 30 days at 10°C still retain their ability to germinate normally and quickly at optimal incubation temperature with no sign of injury. **Simon et al. (1976), Jennings and Saltveit (1994), Abdur Rab and Saltveit (1996), Russo and Biles (1996) and Jennings (1999)** reported similar results.

The failure of these two varieties to germinate at 10°C can be attributed to the lagged or blocked development of enzymes associated with seed germination (**Simon et al., 1976; Yang and Sung, 1994, Russo and Biles, 1996**).

At 15°C incubation temperature, significant differences were observed in the germination percentage and the mean germination time between both the varieties by various seed treatments. Incubation at 15°C significantly reduced germination % and increased the mean germination time of both the varieties by various seed treatments as compared to the higher incubation temperatures. (Table 22). These findings agree with the previous results obtained by **Sachs (1977), Simon et al. (1976), Kapitsimadi et al. (1990), Milotay et al. (1991), Jennings and Saltveit (1994), Yang and Sang (1994) and Russo and Biles (1996).**

Atonik seed treatment at 15°C effects seed germination and mean germination time depending on cucumber variety. It significantly increased germination % of Nati F1 from 9.50 % to 28.50 % (Table 22). On the other hand, it significantly reduced the germination % of Budai félhosszú F1 from 67.00 % to 53.50 %, indicating that effect of Atonik is dependent upon cucumber varieties. Mean germination time was not affected by the interaction of the three factors (varieties, seed treatments and incubation temperatures). Atonik Producer Company generalized the improvement effects of Atonik on cucumber seed performance.

Neither germination % nor mean germination time of both the varieties: Budai félhosszú F1 and Nati F1 were affected when incubated at 20°C or 25°C (Tables 19 and 22). **Jennings and Saltveit (1994)** recorded similar results. It means the Atonik seed treatment under optimal condition very effective on germination and growing on young cucumber plants.

5.4. Effects of water soaking on seed performance of pea varieties

5.4.1.Imbibition

The pattern of imbibition of Lamabdo seeds was not comparable to that of Farida seeds at 20°C, however, neither the quantities nor the rates were similar throughout soaking periods. This could be attributed to varietal differences (**Powell and Mathews, 1979**) as well as to the conditions of the seed samples such as seed coat (**Mathews et al.,1980; Powell and Mathews, 1979) and seed moisture contents (Sivritepe and Dourado, 1995**).

Water imbibition rapidly occurred immediately after immersion of wrinkle-seeded pea variety Farida in free water. The rate markedly declined thereafter and remained so throughout the soaking periods at the various soaking temperatures. The rate of imbibition became progressively lower as the temperature of imbibing water was reduced at the various periods and as the soaking periods was prolonged at the various soaking temperatures (Table 29). These findings are in accordance with the reported results of Perry and Harrison (1970) and Simon and Wiebe (1975). The rate of imbibition at the different soaking temperatures was markedly different between 10° and 15° or 20°C at all soaking periods, except at 30 min soaking. The highest rates 118.88 %, 110.82 %, 107.34 % and 106.76 % were observed after 30 min soak at 5°, 10°, 15°C and 20°C soaking temperatures, respectively, while the lowest rates were 2.54, 2.39, 2.59 and 2.62 % after 72 h soaking at 5°, 10°, 15°C and 20°C, respectively. The highest water imbibition % was obtained after 72 h soak at the various soaking temperatures, except at 10°C, it was after 48 h soaking (Table 29).

Effect of soaking temperature on both amounts and rates of water imbibition appeared to be dependent on soaking period. However, neither the amounts nor the rates of water absorption were significantly affected by chancing soaking temperature at soaking periods of 30 min and 1 h. Also, increasing temperature from 5 to 10°C at soaking periods of 4 h, 8 h, 24 h and 48-h had no significant effect. Reducing soaking temperature from 20° to 15°C did not significantly influence the amount of water uptake at 8 h, 24 h, 48 h and 72 h soaking periods. On the other hand, increasing soaking temperature from 5° to 15° or 20°C and from 10° to 15° or 20°C at 4 h soaking significantly increased the imbibition %.

Increasing soaking temperature from 5°C to 15°C or from 10° to 15°C or 20°C also significantly increased the imbibition % at 24 h soak. At 48 h soaking, reducing temperature from 20° to 10° or to 5°C significantly decreased the imbibition %. Imbibition % after 72 h soaking was increased by either reducing soaking temperature from 10° to 5°C or by increasing it from 10° to 15 or 20°C soaking temperature. Generally slower imbibition was observed at low temperature in this study, which is in agreement with results of **Powell and Matthews (1978)** with pea and **Murphy and Noland (1982)** with radish seeds and sugar pine embryos. **Murphy and Noland (1982)** attributed the slower imbibition at lower temperature to the increased water viscosity.

Water entry to the seed is a physical process depending on both properties of water and the seed. Seed water imbibition was not limlted by regaining membranes function of pea **(Waggoner and Parlang, 1976)**. Contrarily **Murphy and Noland (1982)** suggested an involvement of membranes in water imbibition in sugar pine and radish. Water entry rate may be atrributed to the function of membranes and the hydration of the seed colloids. **Leopold (1980)** reported that water rate entry in soybean seed could be

principally attributed to the function of diffusion of water and hydration of dead colloids.

Different patterns of water imbibition % and rates were observed with Lambado wrinkle-seeded variety seeds. However, the amount of water imbibed is markedly less than that for Farida. Also the rates of imbibition of Lambado variety during the first intervals up to 4 h were dramatically different to that of Farida variety. After that both varieties exhibited nearly the comparable imbibitional rates.

Lambado seeds take up little water (3.4 %) in the first 15 min with a rate of 13.6 %/h soaking. At 30 min soaking, the imbibition % increased to 5.28 %, the rate decreased to 11.56 %/hour. Then after, the seeds showed a more rapid increase in the both imbibition % to 14.28 % and in the rate to 14.28 %/h at 4 h up to 8 h of soaking, when the rate of increase in moisture content declined slightly up to 12.75 %/hour. After that, seeds showed steady and dramatic decrease in the rate of imbibition nearly to 50 % (6.12 5/h at 24 h and 3.3 %/h at 48 h soaking). After 72 h, the reduction in the rate was less (2.32 %/h (Table 32). Similar patterns have been reported by **Powell and Matthews (1978)**.

At 72 h of imbibition, the imbibition percentage was 183.3, 172.01, 186.72 % and 188.64%at the soaking temperature of 5°, 10°, 15°and 20°C, respectively for Farida pea seeds and 166.68 % for Lambado pea seeds after 72 h indicating that intact pea seeds of these two varieties have not completed water uptake after 24 or 48 h soak. This is in conformity with the results of **Powell and Matthews (1978)** that intact pea seeds had not completed water uptake up to 24 h.

5.4.2. Leakage

In this study, the assessment of electrolytes leakage has been successfully applied to evaluate pea seed quality.

Conductivity test results have been used to rank pea varieties and seed lots on the basis of their vigor. Seeds with >25 µS cm-1 g-1 level of conductivity after 24 h soaking were classified as seeds suitable for early sowing or for sowing under adverse conditions and give the best germination **(ISTA, 1995)**. The maximum electrical conductivity (18.859 µS cm-1 g-1) of Lambado seeds steep water after 48 h indicated that the seed lot used in this study were of high seed vigor.

When air-dry pea seeds were immersed in water, initially there was a rapid efflux of electrolytes, but quickly it slowed down as the seeds became hydrated. It is true that water uptake and leakage were both rapid when seeds were first placed in water. Rapid leakage was always associated with the early stages of imbibition. As soon as the seeds absorbed much water, leakage slowed down. The rate of leakage declined steadily as water contents rose from air-dry value, leveled off at of 62.58 % and then declined

further as seeds became more hydrated. At water contents of 166.68 %, leakage was reduced to a relatively trivial rate (0.243 µS cm-1 g-1/h).

The values of electrical conductivity of steep water recorded after soaking periods of 15, 30 min, 1, 4, 8, 24, 48 and 72 h are 0.424, 0.818, 2.215, 7.477, 11.507, 17.500, 18.859 and 17.710 µS cm-1 g-1, respectively (Table 32). These trends of electrical conductivity reading of Lambado seeds in this study are in agreement with the results reported previously (**Perry and Harrison, 1970; Simon and Raja Harun, 1972; Simon and Wiebe, 1975**).

Semi-permeable membranes, which naturally retain solutes within cells, have lost their function as a barrier in air-dry seeds, thus they did not act as retentive barriers when seeds were first placed in water. But as the cells absorbed more water, the membranes regain their function as selective barriers and then the rate was reduced to a relatively trivial level. **Larson (1968), Perry and Harrison (1970) and Simon and Raja Harun (1972)** reported that in dry pea seeds, the membrane were intact, but got ruptured by the rapid water inrush during imbibition. **Duke and Kakefuda (1981)** have suggested that rupture of membranes does not occur after hydration of intact seeds of pea. Since the magnitude of solute loss declined significantly in imbibing pea seeds after certain period of time the membranes in the dry seed were not capable of functioning as retentive barriers when they were first placed in water. Thus, initially leakage of solutes was observed, but as the cells imbibed water the membranes became effective barriers. (**Simon and Wiebe, 1975**). It was suggested by **Simon and Raja Harun (1972) and Simon (1974, 1978)** that the membranes in dry seed were relatively porous (hexagonal state). As cells became hydrated, the architecture of the membranes changed to the more stable lamellar configuration. Other investigators proposed that the membranes in the dry seed were bilayer and leakiness may be more related to the degree of order within the bilayered membrane than to a primary reorganization of the membrane components **(Thomson and Platt-Aloia, 1982).**

5.4.3. Mineral ions

Assessment of K, Na, Ca and Mg indicated that they did not follow the same pattern, but generally the rate of their leakage was decreased as the seed became hydrated (**Woodstock, 1988**). At 24 h soaking, K represented about 75 % of the total amount (K + Na + Ca + Mg) followed by Na, Ca and Mg. This could be because the K was deposited between the embryo and testa as the seed matured and dehydrated **(Cortes and Spaeth, 1994). Wood (1990)** reported that the main inorganic ion leached by pea seed during imbibition was K+ followed by sodium and calcium. The strong relationship between the electrolytes leakage of (K, Na and Mg) and electrical conductivity, particularly at 24 h was in agreement with other reported studies.

However, **Simon and Raja Harun (1972), Matthews and Rogerson (1976) and Pandy (1988)** found that evaluation of potassium exudation yielded comparable results to those of the electrical conductivity test.

Imbibition and leakage of pea seeds in water, also occurred when seeds were allowed to imbibe in soil. Under field conditions these exudates provide the nutrients which were necessary for stimulation of the germination and growth of the fungal pathogens present in the soil (**Flentji and Saksena, 1964; Schroth et al., 1966; Matthewq and Bradnock, 1968, Shorth and Lacy, 1976**).

Severity of damping-off disease could be reduced by prevation the fungal pathogens present in the soil or reducing the amount of exudates, which were necessary for their germination and growth. This can be established by planting germinated seed instead of non-germinated ones or by soaking vigorous seeds in water for certain period of time at a suitable temperature or by using fungicides.

Seed germination or seedling emergence and subsequent seedling growth.

The present findings on the improvement in the proportion of pea seeds normally germinated (Rajnai Törpe and Farida) or emerged (Lambado) when the seeds were first soaked in water (Table 26, 29 and 32) are consistent with the observations previously made on peas and by other workers (**Flentje and Saksena, 1964; Powell and Matthews, 1978; Jyotsna et al., 1998**). Also, Kidd and West (Simon, 1984) found that Broad beans seeds germinated more rapidly and produced taller plants if they were first soaked in water at 17°C for up to 72 hours. While, seeds of pea germinated less rapidly and produced less vigorous plants when soaked for longer than 24 h.

6. SUMMARY

Experiments were conducted at the glasshouse of the University of Horticulture and Food Industry, Budapest (at present Szent István University) and at the laboratory of National Institute for Agricultural Quality Control, Budapest, Hungary. The work was carried out during 1995 to 2000 to study the effects of different seed treatments on various vegetable crops. The experiments were:

Effect of Vitavax, seed treating chemical on seed samples of three different type of pepper varieties (*Capsicum annuum* L.) , hot long forcing variety Csipke, sweet open field variety *Fehérözön* and *Kalocsai-622* sweet spicy pepper.

Effects of Atonik solution on seed samples of tomato (*Lycopersicon lycopersicum* /L/ kars.ex Farw/Mill.) having different germination ability: germination (variety K-Jubileum) 57% and germination, pursuant to the standard (variety Delta).77%.

Effects of Atonik solution and incubation temperature on seed samples of three different type of cucumber varieties (*Cucumis sativus* L.): high germination cucumber seed sample variety *Dolge Zelene* from Slovenia, *Budai félhosszú F1* vigorous and *Nati F1* medium plant growth.

Effects of water soaking on seed samples of three different type of pea varieties : smooth-seeded pea variety *Rajnai törpe* and wrinkle-seeded pea varieties *Farida* and *Lambado*.

All data were subjected to analysis of variance and means were separated by LSD. The findings of the present investigation are summarized below

6.1. Pepper

Seeds of Kalocsai-622 (sweet spicy pepper variety, treated by Vitavax seed 16 days after sowing showed tendency to increase seedling emergence %, ratio of the normal seedling, seedling survival % and N seedling content significantly improved seedling K content of normal seedling %,.

Csipke (hot long forcing variety) and *Fehérözön* (sweet open field variety) treated by Vitavax didn't give such a clear results, but significantly improved K content of the seedlings.

6.2. Tomato

Seeds of tomato treated by Atonik at 0.25ml/l had a trend to increase seed germination %, normal seedling % and radicle length of *Delta* and *K-Jubileum* varieties.

6.3.Cucumber

High germination cucumber seed sample *(Dolge Zelene variety)*

High germination cucumber seed sample treated by Atonik , dose 0.25 ml/l soaked during 8 h significantly increased the percentage of the ratio of vigorous seedlings (hypocotyl length of 5 cm and more) and had tendency to increase the percentages of final seed germination and the ratio of normal seedlings.

Vigorous *(Budai félhosszú F_1)* **and medium plant growth** *(Nati F_1)* **cucumber varieties**

The cucumber seeds treated by Atonik showed a tendency to increase mean emergence time and hypocotyl length of *Budai félhosszú F_1*. *Nati F_1* hypocotyl length. This seed treatment showed a trend to improve efficiency of photosynthesis of both varieties.

In the experiment when the sowing time was earlier (in February), *Nati F_1* was significantly superior to *Budai félhosszú F_1* in seedling emergence % (93.17-48.67 %), mean germination time (6.79-8.39 days) and hypocotyl length (11.84-8.28 cm).

In the experiment when the sowing time was later (in June), *Budai félhosszú F_1* was significantly superior to *Nati F_1* in mean emergence time and hypocotyl length.

At 10°C incubation temperature, no germination was observed for both the varieties at the two seed treatments. When these seeds were transferred to 25°C, they germinated faster than those incubated at 20 or 25°C. Incubation at 10°C during 30 days was not damaging seed ability if germination was under suitable temperature.

Mean germination time of both the varieties was significantly decreased as incubation temperature increased to 20 °C or 25°C .

The Athonik seed treatments is effective if specialised for varieties and climatic factors.

6.4. Pea

Smooth-seeded variety type ***(****Rajnai Törpe)* **and wrinkle-seeded variety type** (Farida) **seed performance**

Study of the effect of the soaking time and period gave a results that at 5°C soaking temperature, high significant percentages of long seedling, vigorous epicotyl (5 cm and

more) were obtained by soaking for 48 h and 24 h for both varieties, respectively. Soaking at 10°C had a same tendency for 30 minutes and 24 h., At 15°C, soaking for 48 h and 72 h significantly improved the percentages of vigorous seedling epicotyl ,. At 20°C, maximum percentages of vigorous epicotyl obtained by soaking for 8 h and 24 h .

Seed water absorption of variety Farida at 5, 15 and 20°C increased soaking period up to 72 h, except at 10°C, the maximum water uptake was observed by 48 h. The general experience, effect of increasing the soaking temperature increased the ratio of water absorption and the rate of water of water uptake decreased during the soaking period

Imbibition and leakage of wrinkle-seeded pea variety type(*Lambado*) **during soaking**

Increasing soaking period from 15 min to 1 h or more significantly increased electrical conductivity up to 24 h. Further increase in soaking time did not bring further similar, significant effect. Soaking for 72 h significantly decreased the percentage of normal seedling and vigorous seedling

Soaking for 15 and 30 min tended improved the ratio of vigorous seedling and till 4 h showed a tendency to improve seedling fresh and dry weight (shoot + root).

Potassium ions (K^+) leakage was increased throughout the soaking period and was maximum by 24 h. Potassium ions accounted for the highest percentage of total electrolyte leakage (K^++Na^++Ca^{2+}+Mg^{2+}) followed by sodium, calcium and magnesium.

Electrical conductivity (EC) after 24 h showed significant correlation with potassium, sodium and magnesium.

We determined the exact time and the temperature of soaking very critical on mechanism of efficiency of different seed treatments

6.ÖSSZEFOGLALÓ

A kísérleteket a Kertészeti és Élelmiszertudományi Egyetem (jelenleg Szent István Egyetem Budai Karok) Budapesti üvegházában és laboratóriumaiban és az Országos Mezőgazdasági Minősítő Intézet laboratóriumaiban végeztük. A kísérletek 1995 és 2000 között folytak, különböző zöldségnövények vetőmagjainak kezeléseit vizsgáltuk a vetőmagminőség javítása érdekében.

A **Vitavax** magcsávázó-szer hatását vizsgáltuk három különböző típusú paprika (Capsicum annuum L.) - ,hajtatási hegyes erős, *Csipke*, szabadföldi fehér étkezési: *Fehérözön*, és csípősségmentes fűszerpaprika *Kalocsai 622*) vetőmagmintáinak csírázóképességére.

Az **Atonik** magcsávázó-szer hatását különböző csírázóképességű paradicsom (Lycopersicon exculentum /L/ kars.ex. Farw/Mill) (57 % *Kecskeméti jubileum* és 77 %-os szabványos *Delta*) vetőmagvak csírázóképességének alakulására.

Az **Atonik** és az inkubációs hőmérséklet és idő hatását háromféle típusba tartozó uborka (Cucumis sativus L.) fajta vetőmag mintáin elemeztük. Ezek a következők voltak: magas csírázóképességű konzervuborka fajta: *Dolge Zelene* (szlovén), erős növekedésű salátauborka fajta: *Budai félhosszú* F_1, és közepes növekedésű *Nati* F_1.

A zöldborsó (Pisum sativum L.) kísérletekben a kifejtő (*Rajnai törpe*) és velőborsó (*Farida* és *Lambado*) fajták magtételeit használtuk fel a mag vízfelvevő képesség, áztatás és a hőmérséklet hatását vizsgálva a csírázóképességre, a magonc növekedésére és az elektromos konduktivitásba bekövetkezett változásokra. Mértük a vetőmagvakból kiáramló elemek összetételét.

6.1. Paprika

A fűszerpaprika (K-622) magok **Vitavax**-szal való kezelése 16 nappal a vetés után növelte a kicsírázott magvaknak, a túlélő magoncoknak a százalékos arányát, hatására emelkedett a növénykék nitrogén és foszfor tartalma, és legnagyobb mértékben a kálium tartalom nőtt.

Az étkezési paprika fajtáknál, ez az egyértelmű hatás nem volt tapasztalható bár a szabadföldi fehér étkezési paprika, a Fehérözön és Csipke fajta nitrogén tartalma a kezelés hatására szignifikánsan nőtt.

6.2. Paradicsom

Az Atonik magcsávázószer 0,25ml/l töménységben kísérleteinkben egyaránt növelte a Delta és a K-Jubileum paradicsom fajta csírázása során a normál csírák százalékát és a gyököcske hosszát. Az Atonik használatát a gyakorlati paradicsom termesztéshez is ajánljuk.

6.3. Uborka

Jól csírázó magtétel vizsgálata (Dolge Zelene fajta)

Az Atonik magcsávázószeres kezelés 0.25 ml/l- es töménységű oldatában való 8 órás áztatása szignifikánsan növelte az erőteljes növekedésű ,az 5 cm-es és annál hosszabb hypocotyl méretű csíranövények arányát és megfigyelhető volt az a tendencia, hogy növekedett a csírázóképesség és a normál csírák százalékos aránya.

Az erőteljes- (Budai félhosszú F_1) **és a közepes növekedésű** (Nati F_1) **uborkafajták magkezelése**

Az Atonik magcsávázószer hatásosnak bizonyult az átlagos csírázási idő rövidülésében, és Az erőteljes- (Budai félhosszú F_1) és a közepes növekedésű (Nati F_1) uborkafajták hypocotyl hosszának erőteljesebb növekedésében. Az Atonik kezelés emelkedő tendenciát mutatott a kezelt növények fotoszintetikus működésében mindkét fajta vizsgálatakor.

A korábbi (február) magvetési időpontban kezelt és elvetett közepes növekedésű Nati F_1 uborka fajta magjának csírázási százaléka (93,17-48,67%), átlagos csírázási ideje (6,79-8,39), a hypocotyl hossza(11,84-8,28) szignifikánsan jobbnak bizonyult az erőteljesebb növekedésű Budai félhosszú F_1 fajtáénál.

A későbbi (június) vetési időpontban ellenben az erőteljesebb növekedésű Budai félhosszú F_1 fajta csírázóképessége és a csíranövényeknél mért hypocotyl hossza volt szignifikánsan jobb.

A 10 ^{o}C inkubációs hőmérsékletet követően egyik fajtánál sem tapasztaltunk csírázást. Amikor ezeket a magvakat 25 ^{o}C-os inkubációs hőmérsékletre helyeztük gyorsabban csíráztak, mint a korábban 20 vagy 25 ^{o}C-on kezelt magvak. A 10 ^{o}C inkubációs hőmérséklet 30 nap után sem okozott csökkenést a csírázóképességben, ha a mag később optimális hőmérsékletre került. Az inkubációs hőmérséklet emelése 20-25 ^{o}C-ra csökkentette az átlagos csírázási időt.

Az Atonik kezelést fajtára és klimatikus körülményekre speciálisan kidolgozva lehet hatásosan alkalmazni.

6.4. Borsó

Kifejtő- (Rajnai törpe) **és velőborsó** (Farida fajta) **magkezelése**

A mag áztatási idejének és az áztatási hőmérsékletnek a hatását vizsgálva megállapítottuk , hogy 5 ^{o}C-os hőmérsékleten mindkét fajtánál a legnagyobb arányban mértük az 5cm és annál hosszabb (erőteljes) méretű hypocotill-al rendelkező csíranövényeket 24és 48 órás áztatás után .10 ^{o}C-on ezt az eredményt 30 perces és 24 órás áztatás után kaptuk, 15 ^{o}C-on 48 és 72 –on voltak legerőteljesebbek a csíranövények, 20 ^{o}C-on a 8 és 24 órás áztatás eredményezte a legerőteljesebb csíranövényeket .

A borsó magvak vízfelvétele (Farida fajta) 72 órás áztatás során folyamatosan nőtt valamennyi vizsgált hőmérsékleten ,kivéve 10 ^{o}C-on , ahol a maximális vízfelvétel 48 óra után következett be. Általánosságban megállapíthatjuk, hogy a vízfelvétel aránya nőtt a hőmérséklet növekedésével és a felvehető vízmennyiség folyamatosan csökkent az áztatás során.

A vízfelvétel és a kiáramlás velő borsó (Farida fajta) **áztatásakor**

A borsó magvak áztatási ideje alatt 15 perc és 1 óra között és 24 óráig folyamatosan, szignifikánsan nőtt az elektromos konduktivitás. Az áztatási idő további emelése nem adott hasonló eredményt. A 72 órás áztatás szignifikánsan csökkentette a normál csírák és az erőteljes csíranövények arányát.

A 15 és 30 perces áztatási idő növelte az erőteljes csírák számát és 4 órás áztatásig növekedett a csíranövények (gyökérrel együtt) súlya és szárazanyag tartalma.

A K^{+} ionok kiáramlása a magvakból folyamatosan emelkedett a 24 órás áztatás során. A kálium ionok adták a kiáramló elemek közük a legnagyobb arányt a K^{+} elektrolitos kiáramlását követte a nátrium (Na^{+}), a Kalcium (Ca^{+}) és a Magnézium (Mg^{+}).

Az elektromos konduktivitás (EC) szoros korrelációt mutatott a mért kálium, nátrium és magnézium kiáramlási adataival.

Megállapítottuk, hogy az áztatás ideje, hőmérséklete kritikus a magkezelések hatásmechanizmusában.

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DECLARATION

I declare that the dissertation “Effect of Pre-sowing Seed Treatments for Quality of Cucumber, Pepper, Tomato and Pea seeds” is fully written by me and that all information and sources of information which, I mentioned in the text are in the list of literature.

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