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Some Seed Traits and Their Relationships to Seed Germination and Field Emergence in Pea (*Pisum sativum* L.)

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Abstract: This study investigated relationships among some seed traits, laboratory germination percentage and seedling emergence under field conditions in pea (*Pisum sativum* L.) cultivars. Jumbo, Jof, Green Pearly, Agromar AG-7306, Bolero, and Karina pea cultivars were used. It was determined that 100 seed weight negatively and highly significantly correlated with laboratory germination and field emergence percentages. Pea cultivars with high seed coat ratio gave lower electrical conductivity values than lower ones and their laboratory germination percentages were significantly higher. Electrical conductivity values showed positive and highly significant correlation with 100 seed weight, while it negatively and highly significantly correlated with laboratory germination and field emergence percentages. It was also found that emergence periods were prolonged with increases in electrical conductivity values and 100 seed weight.

Key words: Seed, germination, emergence, pea, *Pisum sativum* L.

INTRODUCTION

The components of seed quality include genetic and mechanical purity, seed germination and vigour, and seed health testing[1]. The germination percentage indicates the potential of a seed lot to establish seedlings under good field conditions. Although most seed lots will not reach the predicted value, seed lots with a higher germination capacity will always prove to establish more seedlings than those with a lower germination capacity, especially under suboptimal conditions[2]. Testing under field conditions is normally unsatisfactory as the results cannot be repeated reliably, so laboratory methods have been developed in which most or all external conditions can be controlled to give the most regular, rapid, and complete germination for most samples of a particular kind of seed. Germination test results can be used to compare the quality of different seed lots[3] .

As seeds age, the seed membrane becomes more permeable, so many substances in seeds such as sugars, free amino acids, organic acids, and various elements leach out in the presence of water. The concentration of leachates is normally measured either by the electrical conductivity or chemical methods. It was determined that leaching of sugars was related to the total soluble sugars present in seeds[4]. The integrity of cell membranes, as determined by deteriorative biochemical changes, the ability to re-organize and repair damage and/or physical disruption, can be considered to be the 4 fundamental causes of the differences in seed vigour which are indirectly measured as electrolyte leakage during the conductivity test[5-7]. Seed lots with high laboratory germination which yield large quantities of electrolytes following soaking are rated as being low in vigour, and consequently seed lot performance is likely to be poor under stressful conditions. Conversely, high germinating seed lots with low electrolyte leakage are considered to be high in vigour and better able to withstand stressful conditions[8]. Vigour may be reduced by damage to the embryo or seed coat during harvesting and processing. Other factors affecting vigour include environment and nutrition of the parent plant, stage of maturity at harvest, seed size, senescence caused by long storage, and pathogens. Discrepancies between germination capacity and field performance are not equally important in different species; in pulses, for instance, discrepancies occur much more commonly than in cereals[2]. Symptoms of vigour loss are reductions in germination rate and uniformity, reductions in tolerance to environmental stress and inferior seedling emergence and growth[9]. Changes in seed quality have important effects on emergence and seedling and plant development[10].

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The objective of this study was to investigate the relationships among percentage water absorption during imbibition, the leaching of electrolytes from seeds into steep water, germination and field emergence of pea cultivars (*Pisum sativum* L.).

MATERIALS AND METHODS

Pea cultivars of Jumbo, Jof, Green Pearly, Agromar AG-7306, Bolero and Karina were used in the study. Germination tests were performed according to ISTA rules. Initial seed Moisture Contents (MC) of seed lots were determined using the high constant oven method described by ISTA[11,12]. To determine the percentage water absorption by the seeds, 50 seeds with 3 replications were soaked in distilled water at 20°C during a 24 h period. They were removed from the distilled water and surface dried. Water Absorption Rate (WAR) was calculated using the following equation.

Water Absorption Rate (WAR) (%) = 100 (a-b)/b

a: weight (g) of seeds after soaking in distilled water for 24 h

b: initial weight (g) of seed sample

Seed coats of 50 seeds, with 3 replications for each cultivar, were removed from cotyledons by hand. Dry weights of testa and cotyledonary tissue were determined by drying in an oven at 80°C for 48 h. Seed Coat Ratio (SCR) was expressed as a percentage of dried whole seed weight[13]. Electrical Conductivity (EC) of seed soaking water was measured by a digital conductivity meter. A method described by Hampton *et al.*[14] was used in the EC test except for the use of distilled water instead of deionised water. Seed MC was not adjusted due to their MC range of between 10.12 and 13.72% (Table 1). In a field emergence trial, 100 seeds were sown by hand in 4 row plots, with 30 cm between the rows and 10 cm between plants. The experimental design was a randomized complete block design with three replications. Sowing was performed on October 31, 2001. The soil of the experimental area was heavy clay, slightly acidic, without lime and salt, medium in phosphorus, and rich in potassium and organic matter. Field Emergence (FE) was recorded as the number of days from sowing to seedling emergence. Emerging seedlings at the soil surface were counted at the end of the 21st and 40th days in the middle two rows of each experimental plot to determine field emergence percentage.

Table 1: Initial seed Moisture Content (MC), Water Absorption Rate (WAR), Seed Coat Rate (SCR), 100-seed weight and Electrical Conductivity (EC) values of pea cultivars

Cultivars	MC (%)	WAR (%)	SCR (%)	100 seed weight (g)	EC (µS cm^{-1} g^{-1})
Jumbo	10.16c**	154.79b**	12.16b**	27.34a**	55.44a**
Jof	10.14c	144.69bc	14.28a	17.05c	17.50c
Green Pearly	10.14c	156.39b	14.06a	18.74b	23.32bc
Agromar AG-7306	13.72a	145.97bc	12.38ab	27.39a	31.31b
Bolero	10.12c	172.06a	14.31a	17.89bc	24.75bc
Karina	12.50b	138.56c	14.15a	17.31bc	23.36bc

**significant at $p<0.01$ level

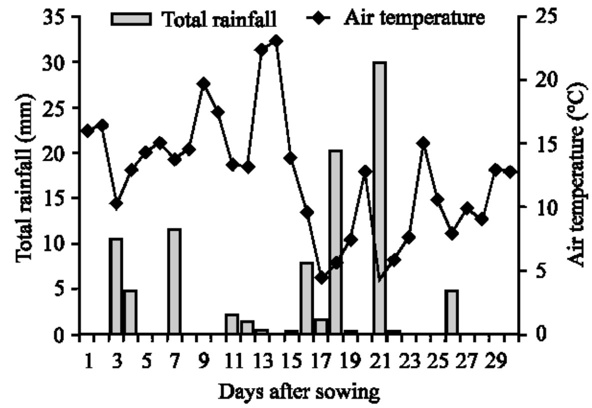

Fig. 1: Daily rainfall and average air temperatures during the month after sowing

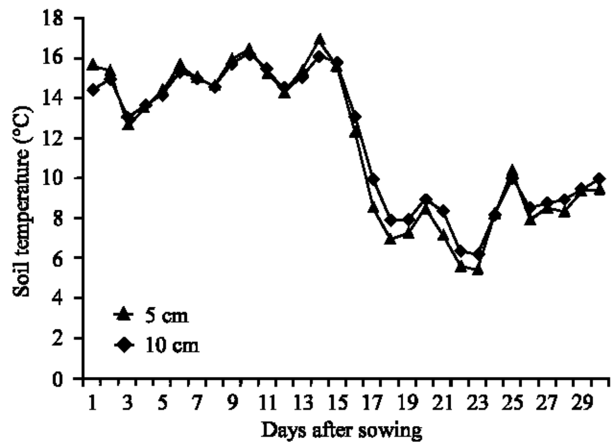

Fig. 2: Temperatures at 5 and 10 cm soil depth during the month after sowing

All statistical analyses were conducted with the SPSS programme. Means showing statistical significance were compared using Duncan's Multiple Range Test. Correlations between all investigated parameters were also examined.

Data for daily rainfall (mm) and average air temperature (°C) were taken from Samsun Meteorological Station records. Daily soil temperatures at 5 and 10 cm depth were measured with a soil thermometer at 10 a.m. for a month after sowing (Fig. 1 and 2).

RESULTS AND DISCUSSION

Initial seed MC was determined for all seed lots to avoid misleading EC results based on the recommendations of AOSA[15], Loeffler *et al.*[16] and Hampton *et al.*[14]. Pea cultivars showed highly significant differences ($p<0.01$) for seed MC and WAR. The highest MC was found in Agromar AG-7306 (13.72%), followed by Karina (12.50%). The other pea cultivars were not statistically different. WAR varied between 138.56% in Karina and 172.06% in Bolero (Table 1). There was no significant correlation between MC and WAR.

The results showed that SCR was influenced by cultivars ($p<0.01$). It ranged from 14.31% in Bolero to 12.16% in Jumbo. There was a highly significant difference ($p<0.01$) for 100 seed weight among pea cultivars. Agromar AG-7306 and Jumbo were the largest seeded cultivars while Jof was the smallest one (Table 1). Weight of 100 seed was negatively and highly significantly correlated with Laboratory Germination Percentage (LGP) (Table 2) at the first and final count ($r = -0.8574$** and $r = -0.8626$**). A negative and highly significant relationships was found between SCR and 100 seed weight ($r = -0.7052$**). SCR increased with reduction in 100 seed weight. There was a negative and highly significant correlation between SCR and EC ($r = -0.6012$**). SCR was also positively and highly significantly correlated with LGP ($r = 0.7346$** and 0.7268**).

Large differences ($p<0.01$) were found among the pea cultivars for EC values (Table 1). The highest EC value of 55.44 $\mu S\ cm^{-1}\ g^{-1}$ was determined in Jumbo. This was followed by Agromar AG-7306 (31.33 $\mu S\ cm^{-1}\ g^{-1}$). Jof gave the lowest EC reading (17.50 $\mu S\ cm^{-1}\ g^{-1}$). EC was negatively and highly significantly correlated with LGP at the first and final count ($r = -0.6025$** and $r = -0.5972$**) and with FE at the end of the 21st and 40th day ($r = -0.6555$** and $r = -0.6403$**). This was in agreement with previous study results[17,18]. A positive and highly significant correlation was found between EC and 100 seed weight ($r = 0.7333$**). It was probable that the large seeds gave higher EC values than smaller ones due to their larger cotyledons which store more water soluble compounds. Emergence time was prolonged with increases in EC values and 100 seed weight.

Highly significant differences were found among pea cultivars for LGP (Table 2). Pea cultivars were ranked as Green Pearly (72 and 72%), Jof (64 and 65%), Bolero (57 and 58%) and Karina (56 and 56%) for LGP at the first and final count respectively, although there were no significant differences among these 4 cultivars. The lowest LGP was found in Agromar AG-7306 (8 and 9%) and Jumbo (28 and 29%). They had also the lowest SCR, the highest 100 seed weight and highest EC values (Table 1). Rapid water uptake occurred in Agromar AG-7306 and Jumbo at the beginning of the germination process. It is probable that there was rapid water uptake injury in Agromar AG-7306 and Jumbo cultivars. Rapid water uptake by seeds is an important cause of seed viability loss in legumes[19]. Powell and Matthews[20] reported that rapid water uptake by seeds has destructive effect on cell membranes. High levels of exudates from seeds into the soil as a result of rapid water absorption is known to stimulate and encourage pathogen growth surrounding seeds and roots, and consequently lead to pre-emergence damping off [21, 22].

Table 2: Laboratory germination, field emergence percentage and days to emergence of pea cultivars

	LPG (%)		FE (%)		
Cultivars	First count	Final count	21 DAS[1]	40 DAS	Days to emergence
Jumbo	28b**	29b**	20.33b**	23.67b**	13.33a**
Jof	64a	65a	45.33a	48.00a	10.67ab
Green Pearly	72a	72a	50.67a	59.00a	8.33b
Agromar AG-7306	8c	9c	57.67a	65.33a	9.67b
Bolero	57a	58a	46.33a	52.00a	9.33b
Karina	56a	56a	61.00a	62.33a	8.00b

[1]Days after sowing, **significant at $p<0.01$ level

Cultivar differences were highly significant ($p<0.01$) for FE at the 21st and 40th days after sowing. FE varied between 20.33% in Jumbo and 61.00% in Karina at the end of the 21st day. FE was significantly lower in Jumbo than the other cultivars. Results for FE at the end of the 40th day were statistically similar to results for the 21st day. Daily rainfall and average air and soil temperatures were suitable for seed germination during the month period after sowing (Fig. 1 and 2). Elapsed time from sowing to seedling emergence under field conditions was significantly different ($p<0.01$) among pea cultivars (Table 2). The shortest seedling emergence periods were determined in Karina (8.00 d), Green Pearly (8.33 d), Bolero (9.33 d) and Agromar AG-7306 (9.67 d).

The results showed that cultivars with low 100 seed weight gave lower EC and higher LGP than larger seeded cultivars. It was found that LGP's were not correlated with FE. EC test gave strong and reliable results to predict both LGP and FE of pea cultivars. The lowest LGP's were determined in Agromar AG-7306 and Jumbo which also gave the highest EC values. Cultivars may be differ in seed storage water soluble compounds, especially soluble sugars. Determination of water absorption speed and the amount of seed storage water soluble compounds can help to explain poor laboratory germination and field emergence.

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