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Some Seed Traits and Their Relationships to Seed Germination, Emergence Rate Electrical Conductivity in Common Bean (*Phaseolus vulgaris* L.)

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Abstract: The size of the seeds, shape index, shape of the seeds, 100-seed-weight, germination and emergence tests, the values of the test a rates, the speed of the imbibition and electrical conductivity were determined in 10 common bean cultivars in two group of red and white bean (*Phaseolus vulgaris* L.). In bean cultivars, the seed lengths (11.24-14.35 mm), the seed width (6.57-8.99 mm), the seed thickness (4.78-5.57 mm), shape index (1.66-2.09), 100-seed-weight (33.69-23.20 g), the power of germination (76-100%), the rate of emergence (86.66-100%), seed coat rate (7.76-10.53%), water imbibition (52.5-108.6%) and electrical conductivity (1.99-5.87 m Sc mg/seed) were found. In all bean cultivars, there was a positive correlation between the values of electrical conductivity (used as an indicator of seed secretion) and imbibition rate. Also, there was a negative relation between the values of electrical conductivity and power of germination (r = -0.78298**), between seed coat rate and water absorption at 3 h (-0.54**) between power of germination and water absorption at 3 h (-0.46**). There was a negative relation, but not significant between electrical conductivity and seed emergence. There was a very significant and negative relation between seed coat rate and power of germination between electrical conductivity and power of germination. Also there was a significant relation between power of germination and water absorption between seed weight and water absorption and there was a very significant positive correlation between seed coat rate and electrical conductivity in white bean. In red bean, there was a very significant negative correlation between electrical conductivity and seed weight positive significant correlation between water absorption at 19-23.5 h and power of germination. Also, correlation between water absorption at 1.5 h and electrical conductivity rate of emergence and electrical conductivity was positive and significant.

Key words: Common bean, seed characteristics, water imbibition, germination power, emergence rate, electrical conductivity

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is a plant species widely cultivated due to its good nutritional composition (high protein content in dry seed and a good source of fibre in snap bean) and its high market value is consumed either as a dry bean or as a snap bean (fresh vegetable). Consumers have progressively shown specific preferences for various combinations of size and shape of bean seeds and pods and the market reflects this trend by giving preference to types of good quality rather than high yield (Santalla *et al*., 1999; Marzo *et al*., 2002).

The common bean has the largest number of varieties the most culinary uses. The various varieties of common beans are well known for their ability to produce seed coats in a wide array of colors (Aparicio Fernadez *et al*., 2005), covering nearly the whole color spectrum (McCormack, 2004). In a few cases, the seed coat color is distinctive enough to identify a particular variety of bean, though the color darkens with age (McCormack, 2004).

Seeds, as reproductive units, are expected to produce plants in the field. Although all the factors affecting plant growth and development are at an optimum level, obtaining higher yield depends on seed quality. For this reason, seed quality is very important in plant growing. The quality of seed means that, a stability of genetically structure, uniform germination in short period, high seed vigour and free from insects and diseases (Balkaya, 2004).

The seed quality is affected by many factors as ecologically and genetically. Besides ecological factors, some seed characters are effective in legume crops growing in order to obtain a desirable yield and quality. After seed sowing, a uniform germination and seedling emergence are desirable to the farmers (Balkaya, 2004). The germination begins when the seed takes up water (imbibition) and the seed coat cracks (Anonymous, 1998). In bean, especially in cultivars with white test a seed quality may be low concerning with heredity. The colored cultivars get water more slowly. One of the problems faced in producing is that the emergence rates of the

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seeds of beans which have been sown are low and as a result of this desirable fertility couldn't be obtained in unit area. In a study on bean seeds, it is stated that white cultivars have got higher water absorption rate than the colored ones thus, seed secretion and cotyledon cracking will be increased in white cultivars and it is stated that these characteristics are among the factors which makes the seed emergence rates low (Balkaya and Odabas, 2002). Germination experiments at laboratory conditions are carried out in order to determine the favorable characteristics of the seeds before sowing. Germination speed can be different between species and also varieties. Seed test is also effective on the germination speed of seeds beside temperature. A highly significant negative correlation (r = -0.73**) between seed coat rate and germination speed in different cow pea genotypes were determined. A thick test had a negative effect for imbibition during germination (Dubbern De Sousa and Marcos Filho, 2001; Wu, 2002). It was notified that in dwarf types of bean, colorfull seeds had higher germination and emergence rate than the white seeds (Balkaya and Odabas, 2002). In another research, it was found that there was a significant and negative relationship (R = -0.7719*) between testa rate and germination power in colored cultivar (Balkaya, 2004; Balkaya and Odabas, 2002). The pea cultivars with high seed coat ratio gave lower electrical conductivity values than lower ones and their laboratory germination percentages were significantly higher. The 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 (Pekõen *et al*., 2004). It was also found that emergence periods were prolonged with increases in electrical conductivity values and 100 seed weight (Pekõen *et al*., 2004). It was determined that 100 seed weight negatively and highly significantly correlated with laboratory germination and field emergence percentages. Testing under field conditions is normally unsatisfactory as the results can not 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 complete germination for most samples of a particular kind of seed. The germination test results can be used to compare the quality of different seed lots (Pekõen *et al*., 2004). It was stated by different researchers, that although the seeds of Leguminosae vegetables especially the seeds of the *Phaseoulus vulgaris* L. could germinate well in laboratory conditions, they showed big differences in field emergence rates (Balkaya and Odabas, 2002). It is stated that the results of germination test carried out in the laboratory didn't reflect the field emergence rates exactly, however the results of electrical conductivity tests determined the seed power in a better way (Balkaya and Odabas, 2002). There is a need for the development of rapid seed quality tests that determine viability (defined as the viability to germinate) without the necessity for completion of germination. The increase in conductivity has been found to be correlated with the decrease in germination and seed vigour in several crop species (Tajbakhsh, 2000). In a research on snap bean seeds, it was determined that electrical conductivity values of white cultivars were higher than the coloured ones and they were less susceptible (Balkaya and Odabas, 2002). In addition, the researchers stated that as electrical conductivity values increased seed emergence was delayed as well.

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, the power of germination, seed weight, seed size, seed color field emergence of bean cultivars (*Phaseolus vulgaris* L.) and compare, this characterize among different cultivars, especially, between two group of red and white bean.

MATERIALS AND METHODS

The present study was carried out in Agricultural Research Center of Arak, Iran. In the experiment the seeds which were produced in 2004 were used that those were growed at warm sunny position in a rich well-drained preferably light soil with plenty of moisture in the growing season in the Research Station Of Khomein 's Bean. The names and growth type of the bean genotype used as seed material in the research presented in Table 1. There are three growth habits of dry bean (Table 1): Type I: determinate bush type; Type II: indeterminate bush type; and Type III: indeterminate vine type (Anonymous, 2004). In the research 10 genotype of dry bean were used. The characteristics of the seeds, were examined in this study are given below in detail:

The length, width and the thickness of the seed (mm): With the help of caliper with scale 0.05, length, width and the thickness values (from hilum) of the seeds were

Table 1: The names and growth type of bean varieties used in the experiment

No.	Variety names	Growth type	No.	Variety names	Growthtype
1	Akhtar	1	6	Emerson-74	3
2	D-81083	1	7	G11867	3
3	Goly	3	8	Wa 8563-1	2
4	Sayad	2	9	Daneshkadea	3
5	Azna red	3	10	W4502-1	1

Table 2: The size of the seed, shape index, seed shape, 100 seeds weight and color of the varieties and lines of the bean used in the experiment

Genotype name	The length (A) (mm)	The width (B) (mm)	The thickness (mm)	Shape index (A/B)	Seed shape	100 seeds weight (g)	The bigness of the seed	Seed color
Akhtar	13.85±0.94cb	7.28±0.44c	5.29±0.48b	1.90b	Long	35.65c	Medium	Light Red
D-81083	14.35±1.32a	8.17±0.49b	4.84±0.37d	1.87b	Long	36.70b	Medium	Dark Red
Goly	11.24±0.9c	6.76±0.44c	5.15±0.69c	1.66d	Elliptic	25.39g	Small	Dark Red
Sayad	11.63±1.5fe	6.81±0.66c	4.91±0.71d	1.71c	Egg	24.95g	Small	Dark Red
Azna red	11.75±1.05e	7.14±0.56c	5.47±0.56a	1.65d	Elliptic	28.87e	Small	Red
Emerson-74	13.63±1.15c	8.28±0.58b	5.13±0.67c	1.65d	Elliptic	38.43a	Medium	White
G11867	12.41±0.83d	8.99±0.42a	5.45±0.57a	1.72c	Egg	32.86d	Medium	White
Wa 8563-1	11.41±0.99fg	6.57±0.51c	4.78±0.46d	1.73c	Egg	23.20h	Small	White
Daneshkadea	11.31±0.93g	6.84±0.50c	4.82±0.42d	1.66d	Elliptic	27.31c	Small	White
W4502	14.01±1.19b	6.73±0.58c	5.57±0.53a	2.09a	long	35.62c	medium	White

Hems with different superscript letter(s) on the same row differ significantly

Table 3: The power of seed germination, emergence rate seed coat rate, water imbibition electrical conductivity of the varieties and lines of the bean used in the experiment

Genotype name	Germination power	Emergence rate (%)	Seed coat rate (%)	Water imbibition (%) 1.5 h§	3 h	19 h	20.5 h	22 h	23.5 h	E CЖ (mScm g/seed)
Akhtar	98.67^{ba}	96.66^{a}	9.13^{d}	0.80^{e}	1.10^{f}	46.23^{d}	55.70^{ed}	57.50^{d}	62.00^{e}	1.99^{g}
D-81083	100.00^{a}	100.00^{a}	9.90^{c}	6.90^{bac}	18.00^{c}	70.10^{ba}	90.83^{a}	98.26^{a}	101.70^{b}	2.63^{f}
Goly	99.33^{ba}	100.00^{a}	8.57^{e}	4.60^{bdc}	21.57^{b}	59.20^{c}	64.70^{cb}	68.43^{c}	69.70^{d}	3.20^{e}
Sayad	98.66^{ba}	100.00^{a}	10.53^{a}	7.46^{ba}3.	11.96^{d}	65.00^{bac}	71.10^{b}	76.87^{b}	79.90^{c}	3.88^{c}
Azna red	95.33^{c}	100.00^{a}	10.23^{b}	10.00^{ed}	5.63^{e}	43.96^{d}	47.80^{e}	50.46^{e}	52.50^{f}	3.24^{e}
Emerson-74	97.33^{bc}	100.00^{a}	7.76^{f}	4.10^{de}	16.30^{c}	73.66^{a}	93.30^{a}	98.73^{a}	99.30^{b}	4.08^{cb}
G11867	92.66^{d}	86.66^{b}	7.86^{f}	5.00^{bdc}	22.50^{ba}	56.40^{c}	59.70^{dc}	61.70^{dc}	65.40^{ed}	4.20^{b}
Wa 8563-1	82.66^{e}	96.67^{a}	7.93^{f}	5.20^{bdc}	25.30^{a}	72.10^{ba}	96.77^{a}	108.00^{a}	108.60^{a}	4.10^{cb}
Daneshkadea	99.33^{ba}	96.67^{a}	7.96^{f}	8.83^{a}	22.30^{ba}	62.90^{bc}	73.23^{b}	77.50^{b}	82.50^{c}	3.54^{d}
W4502	76.00^{f}	93.33^{ba}	8.90^{d}	6.90^{bac}	24.20^{b}	66.0^{bac}	71.66^{b}	77.00^{b}	77.70^{c}	5.87^{a}

Ж: Electrical conductivity, §: h, Hems with different superscript letters on the same row differ significantly

measured in 30 seeds randomly chosen from every genotype (in four repetition) used in the experiment were measured.

The weight of 100 seeds: Hundred seeds randomly chosen were counted four times and were weighed with an analytical balance (Sartorius BP2100S) with scale, 0.01. The averages of weight values were recorded as 100-seeds-weight.

The bigness of the seed: Bigness evaluation was made as to the weight of 100 seeds. According to this, they were described as Balkaya and Odabas (2002);

The ones less than 20 g are the smallest
The ones between 20-30 g are small
The ones between 30-40 g are medium
The ones between 40-50 g are big
The ones more than 50 g are the biggest

The shape index and the shape of the seed: With this purpose in 120 seeds the rates of the length to width were determined by measuring the length and they have been described as:

The rates of the length/width; the ones between 1.20-1.50 are round
The rates of the length/width; the ones between 1.51-1.70 are elliptic
The rates of the length/width; the ones between 1.71-1.85 are egg shaped
The rates of the length/width; the ones between 1.86-2.31 are long (Balkaya and Odabas, 2002).

Colour: Seeds were studied in this research, were divided to two groups, white and red beans.

Germination experiment: Germination determined by using 50 seeds in three replicate of every genotype. The seeds were placed within the Petri dish in a tray on moist paper towels and germinated in an incubator maintained at 25°C for 9 days. The beans were moistened twice a day during the 9 days germination period. Germinated beans were defined as beans with minimum sprout length of 0.5 cm (Berrios *et al*., 1999).

Emergence experiment: Emergence tests carried out in greenhouse (in three replicate), the seeds emerged during 20 days were counted daily. The bean seeds were calculated. Until the end of the 20 day beginning from seeing the first the emerged seed, the percentage of the seeds emerged were calculated as the emergence rate (Balkaya and Odabas, 2002).

Seed coat rate (%): In order to determine the coat rate the 10±0.01 g seeds from each genotype were determined. These seeds were boiled in water bath 15 min. After that seed coats were separated and dried in oven in temperature of 70°C for 24 h, percentage of coat rate was estimated (Berrios *et al*., 1999).

Water absorption: 10±0.01 g of beans on a dry weight basis were placed in 100ml distilled water at 20±2°C for 23.5 h (Berrios *et al*., 1999). Within this time the seeds 1.5, 3, 19, 20.5, 22 and 23.5 h later were taken out from water and weighed. Before the seeds were weighed the moisture of seeds was wiped with drying paper. The rate of water imbibition of the seed was calculated as percentage (Berrios *et al*., 1999; Balkaya and Odabas, 2002).

Electrical conductivity: After determining the weight, the seeds taken as 2 each repetition and 20 each in every repetition for the electrical conductivity test made to determine the power of the seed were held closed for 24 h in 50 mL deionized distilled water at 20±2°C. After the seeds were taken out of water the electrical conductivity of water in jams was measured. To prevent the loss of water imbibition, the seeds were held for 24 h in an environment with high rational moisture before being put into water. Electrical conductivity was determined as micro siemens/centimetre-gram) (Balkaya and Odabas, 2002).

Statistical analyses: Analysis of variance (ANOVA) was calculated according to the procedure of general linear model and Statistical Analysis System software (SAS Institute 1989-1986). Least significant differences selected at $p \leq 0.05$ were used for triplicate Analyses. Compare of means was carried with Duncan multiple range test.

RESULTS AND DISCUSSION

Seeds were different in size (length, width and thickness) ($p<0.01$), shape index and color ($p<0.01$). According to the results of measurement the seed length of the beans genotype were between 11.24 and 14.35 mm. It was seen that seeds of bush types were taller than seeds of climbing types regarding the seed length, against that which have reported by Balkaya and Odabas (2002). The seed width was between 6.57-8.99 mm and the seed thickness was 4.78-5.57 mm. In the present research the shapes of seeds were established as to the values of shape index found according to length/width rates (Table 2).

Hundred seeds weight is important in terms of the quality of the seeds. Both agricultural and commercial this characteristic has always been considered (Balkaya and Odabas, 2002). It was desired that 100 seeds weight was much in the bean types to use in production. In the bean types used in experiment in the research made regarding 100 seed weight, they were between 27.23 and 38.42 g and big differences were seen the types regarding weight of the seeds ($p<0.01$).

The bigness of the seed was determined according to the classification made regarding 100 seeds weight. The seeds were small and medium (Table 2).

The bean types used in this study were single colored. The colors of the seeds were white and red.

The results with regard to power of germination, the rate of emergence, testa rate, water imbibition at the end of 24 h and electrical conductivity in the seeds of bean are given in Table 3.

Germination power of bean varieties significantly ($p<0.01$) differed between cultivars, that was 76-100% (Table 3). The power of germination in red bean was more than white bean. Power of germination in white bean, genetically is low (Balkaya and Odabas, 2002). It has been observed that D-81083 line with red testa had the highest power of germination W4502-1 line with white testa had the smallest.

The bean type were examined for values of emergence rates. Goly, Sayad varieties and D-81083, Azna red (white red testa) and Emerson-74 (with white testa) lines had the highest emergence rates (100%) (Table 3). Not significant difference observed in bean type in power of emergence. It was also found that G11867 line (86.7%) and W4502-1 line (93.3%) had the lowest emergence rates. The emergence rate in white genotypes was lower than red genotypes. In the genotypes with

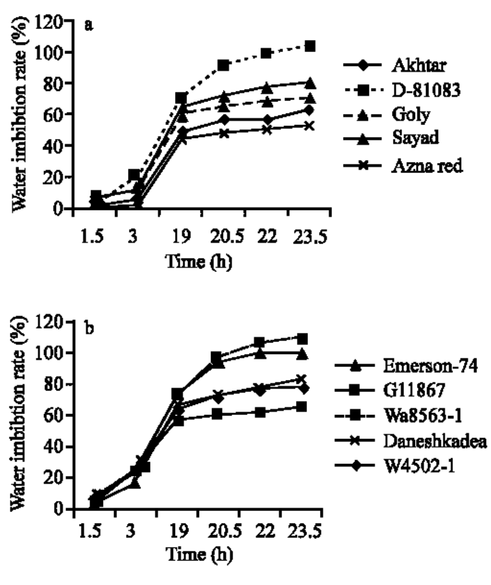

Fig. 1: The water imbibition rate as to hours at red (a) and white (b) cultivars

white testa, seed coat rate is less and water imbibition is more and faster than color cultivars. According to the results of the research while in the cultivars with black and brown testa the emergence rate was 91%, in the cultivars with white testa it was 67%. Balkaya and Odabas (2002), were observed 4F-89 with claret red seed color had the highest emergence rate (93.3%). Also, in the cultivar with white testa used in tests of Balkaya and Odabas (2002), it was stated that the emergence rate were had lower than the colorful types, although, in Gina and Tina cultivars with white testa, the emergence rates were had higher than the colorful types the high emergence rates of these types were result from their genetic structure. In another research (Dubbern De Sousa and Marcos Filho, 2001) it was notified that colorful bean, had the higher emergence rate than the white seeds and also stated that resistance of seedling was better than the white ones (Deakin, 1974).

Testa rate in bean differed according to cultivars, that was 6.6-9.59% (Balkaya and Odabas, 2002) 8.5-10% (Wu, 2002) part of the seeds. In this experiment it was determined that the testa rates of the genotypes used were between 7.76 and 10.53% (Table 3). It was revealed by different researchers that seed coat's dried weight and thickness of the colored bean were far more than the cultivars with white testa (Wu, 2002; Balkaya and Odabas, 2002). The results of this experiment were proper to the literatures. In cultivars with colored testa, the seed coat rate was higher than white bean and testa rate (10.53%) of Sayad variety was highest than the other genotypes.

In bean types, water imbibition rate as to hour were given in Fig. 1a and b. The line of Wa 8563-1 with white testa imbibed more than other genotypes. It was determined that in Azna red with red testa, water imbibition was at the lowest level. The rate of water uptake is proportional to the diffusivity of water, which is determined by a complex cluster of factors, such as chemical composition, microstructure, moisture and the temperature of the seed. Both the seed coat microstructure and composition may affect the imbibition rate. The imbibition rate may also be related to seed coat thickness, numbers of seed coat pores, size of micropyle and hilum the cellular arrangement of the raphe. A darker-colored seed coat, which results from high phenolic content, has been reported to impede water permeability. Hydrophobic substances generated by the oxidative reaction of phenolic substance in seed coat are possibly responsible for the lowered water permeability (Del Valle and Stanley, 1992; Wu, 2002; Asiedu and Powell, 1998). Researchers was reported that, the measurement of water absorption at 24 h in white bean it was revealed that the differences among the cultivars were less and close to each other in the end of 24 h (Balkaya and Odabas, 2002). In present study measurement water imbibition rate at 24 h in white bean, it was revealed that the differences among the genotypes were less and close to each other in primary hours and more and far to each other in the end of 24 (Fig. 1b) it may be result of present of the testa with same thickness in White cultivar, because thickness of the seed coat play important role in water imbibition in primary hours (Dubern de Souza and Marcos Filho, 2001). It was stated that at the end of 24 h water imbibition rates of cultivars with white testa were more than the colored cultivars. Rapid water imbibition characteristics have caused low emergence rate and weak seedling growth in all legumes including dry bean (Balkaya and Odabas, 2002). Sefa-Dedeh and Stanley (1979) concluded that during the first 3 to 12 h the hilum size was the most important controller of imbibition in cowpea (*V. unguiculata*) seeds while the percentage of protein in the cotyledon was important between 12 and 24 h of imbibition. However, since the seeds absorbed nearly 80% in the first three hours, it was concluded that thickness of the seed coat was the most important factor. In soybean, the seed coat initially retards water absorption but gradually facilitates the movement of water to the embryo (Dubbern De Sousa and Marcos Filho, 2001). In this study, significant negative correlation were observed between seed coat thickness and water absorption rate in 3 h ($r = -0.57^{**}$) (Table 4). The electrical conductivity significantly ($p \leq .01$) differed between genotypes. The genotypes with white testa had more electrical conductivity. There was a positive and crucial relation between the values of electrical conductivity used as an indicator of seed secretion and imbibition rate of cultivars ($r = 0.38^{*}$ in 1.5 h, $r = 0.62^{**}$ in 3 h, $r = 0.39^{*}$ in 19 h that was not significant at 20.5-23.5 h). It can be explained like that because the cultivars with high imbibition rates secreted the cell solution they had higher electrical conductivity (Balkaya and Odabas, 2002). Also, there was a negative relation between the values of electrical conductivity and power of germination ($r = -0.78^{**}$). There wasn't seen significant relation between electrical conductivity and seed emergence.

The correlation coefficients belong to the relations between the seed characteristics of whole bean types, red and white bean are given in (Table 4). In white bean there was a very significantly negative correlations between seed coat rate and power of germination between electrical conductivity and power of germination. Also there was a significant negative correlations between power of germination and water absorption, according to Balkaya and Odabas (2002) experiments about color

Table 4: The relations among some characteristics belonging to the red and white varieties

Seed characteristics	Germination power	Emergence rate	Ec[£]	Water imbibition 1.5 h	3 h	19 h	20.5 h	22 h	23.5 h
Whole bean varieties									
Seed weight	0.23	-0.009	-0.01	-0.20	-0.02	0.04	0.08	0.06	0.03
Seed coat rate	-0.24	0.30	-0.28	-0.01	-0.57**	-0.29	-0.32	-0.29	-0.29
The power of ger		0.25	-0.78**	-0.12	-0.46**	-0.22	-0.17	-0.19	-0.17
The rate of em			-0.25	-0.03	-0.28	-0.03	0.07	0.013	0.12
Ec				0.37*	0.62**	0.39*	0.20	0.22	0.17
Red bean varieties									
Seed weight	0.22	-0.3	-0.86**	-0.27	-0.29	-0.02	0.28	0.27	0.31
Seed coat rate	-0.32	0.21	0.47	0.39	-0.24	0.15	0.14	0.16	0.17
Germination power		-0.24	-0.24	0.20	0.029	0.51*	0.59*	0.58*	0.60*
The rate of em			0.46*	0.35	0.35	0.29	0.13	0.18	0.14
Ec				0.61*	0.38	0.31	0.04	0.06	0.02
White bean varieties									
Seed weight	0.07	-0.001	0.44	-0.26	-0.61	-0.01	-0.20	-0.22	-0.33
Seed coat rate	-0.76*	-0.156	0.88**	0.27	-0.40	-0.004	-0.20	-0.22	-0.27
Germination power		0.049	-0.83**	-0.0002	-0.62*	-0.46	-0.03	-0.08	-0.47
The rate of em			-0.08	-0.22	-0.33	0.18	0.80	0.45	0.43
Ec				-0.03	0.04	-0.03	-0.22	-0.18	-0.36

*,**: Significant at the level of $p<0.05$, 0.01, respectively, £ : Electrical conductivity

cultivar. Also, there was a significant negative relation between seed weight and water absorbtion a positive correlation between seed coat rate and electrical conductivity in white bean (Table 4), it may because of some physicochemical factors within the seed coat might play an important role in the integrity of the seed coat during soaking in water. These factors include, sodium, calcium iron content in the seed coat other physicochemical characters of the seed coat, as yet not examined, may also play important roles in seed coat integrity (Wu, 2002) and electrical conductivity of seed. This results not revealed in research of Balkaya and Odabas (2002) about white bean.

In red bean, there was a very significant negative correlation between electrical conductivity and seed weight, opposite that which reported by Pekõen *et al.* (2004). A significant positive correlation was determined between water absorption at 1.5 h and electrical conductivity (Balkaya and Odabas, 2002), between water absorption at 19-23.5 h and power of germination and between rate of emergence and electrical conductivity (opposite that which reported by Balkaya and Odabas, 2002). The cause of those differences may be the low rate of water absorption of red bean which had used in this study, in comparison to color cultvars which tested by Balkaya and Odabas (2002).

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