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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 5(4): 382-387, 2002

Determination of the Seed Characteristics in Some Significant Snap Bean Varieties Grown in Samsun, Turkey

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Abstract: The size of the seeds, shape index, shape of the seeds, 100-seed-weight, the colour of testa, germination and emergence tests, the values of the testa rates, the speed of the imbibition, moisture content of the seeds and electrical conductivity were determined in 13 snap bean cultivars (*Phaseolus vulgaris* L.). In snap bean cultivars, the seed lengths (12.0-17.24 mm), the seed width (7.07 –9.17 mm), the seed thickness (4.66-7.23 mm), shape index (1.52-1.98), 100-seed-weight (33.69-67.21 g), the speed of germination (24.0-98.0%), the power of germination (32.0-100.0%), emergence time (8.0-14.0 days), the rate of emergence (37.8-93.3%), seed coat rate (6.5-8.9%), water imbibition (89.3-122.5%), the seed moisture (4.1-9.8%) and electrical conductivity (4.3-14.5 mScmg/seed) were found. There was a significant and negative relation between testa rate and germination power (r= -0.7719), electrical conductivity and emergence rate (r= -0.8522), imbibition and seed moisture (r= -0.8617) in colored cultivars. A significant and positive relation was observed between water imbibition and electrical conductivity (r = 0.9207) and there was a significant negative relation between seed moisture and electrical conductivity. However, there was no significant relation in white cultivars.

Key words: Snap bean, seed characteristics, seed vigour, water imbibition, Samsun, Turkey

Introduction

Snap bean (*Phaseoulus vulgaris* L.) belonging to Leguminosae family is a kind of vegetable which is produced both in field and greenhouse. Bean can be consumed in many different ways, such as fresh, tinned, pickle, dried and frozen. In addition, due to the fact that bean is nutritious and people find it delicious, it has been spreading all over the world and also in our country. One of the areas where snap bean is produced mostly in our country is Black Sea Region. Samsun is the first with regard to producing snap bean in our country (74.675 metric-tone) (Anonymous, 2001). In Samsun snap bean is produced mostly in Carsamba, Terme and Bafra towns. According to the statistics of Provincial Directorate of Agriculture, these three towns have provided 82% of bean production in Samsun. In the research carried out to state the last condition of Samsun regarding bean production, climbing type are mainly used in Samsun, but in recent years as a result of introducing different cultivars, which are suitable to consume fresh, these new cultivars are accepted and it is determined that dwarf type has begun to be used in production as well (Balkaya *et al*., 1999). With the same study it has been determined that snap bean producers have not used modern production techniques efficiently and are not conscious about choosing the cultivar and supplying the seed.

Besides ecological factors some seed characteristics are effective in producing snap bean in order to obtain a desirable fertility and quality (Ceylan, 1996). Soil warmth in sowing time is one of the important ecological factors which has caused the differences among field emergence of bean cultivars (Kolasinska *et al*., 2000). In snap bean, especially in cultivars with white testa seed quality may be low concerning with heredity. In contrast coloured cultivars get water more slowly, cotyledons show a homogeneous swelling, they are more durable to cotyledon split and cracking of testa (Demir, 1994). One of the problems faced in producing is that the emergence rates of the seeds of snap 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 snap bean seeds, it is stated that white cultivars have got higher water absorption rate than the coloured ones, there is seed secretion in large amounts and cotyledon cracking in width and it is stated that these characteristics are among the factors which makes the seed emergence rations low (Kantar and Guvenc, 1995). 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 (Matthews, 1980; Ceylan *et al*., 1996, Kolasinska *et al*., 2000). It is stated that the results of germination test carried out in the laboratory didn't reflect the field emergence rations exactly, however the results of electrical conductivity tests determined the seed power in a better way (Hegarty, 1977). 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 (Powell, 1989). In addition, the researchers stated that as electrical conductivity values increased seed emergence was delayed as well. In this research the seed quality characteristics of some snap bean cultivars used in producing fresh bean and are important for the region are revealed. In addition, the factors which have affected the emergence of seeds belonging to cultivars used in the trial and the relations among them were examined.

Materials and Methods

The research was carried out at Ondokuz Mayis University, Faculty of Agriculture, Department of Horticulture and Department of Field Crops during 2001 in Samsun, Turkey. The names and growth type of the bean cultivars used as seed material in the research and the seed firms from which they were provided are in Table 1. In the research 8 dwarf cultivars and 5 climbing cultivars totally 13 cultivars of snap bean were used. In the experiment the seeds which were produced in 2000 were used.

On examining the characteristics of the seeds, the criteria of evaluating the bean cultivars improved by UPOV was used (Anonymous, 1982). Besides these criteria, some of the seed characteristics were examined. The characteristics examined are given below in detail.

The length and width of the seed (mm): With the help of digital compass, length and width of the seeds were measured in 50 seeds randomly chosen from every cultivar used in the experiment.

The thickness of the seed: With the help of the digital compass, the thickness values in 50 seeds from hilum of the seed were measured.

The weight of 100 seeds: 100 seeds randomly chosen were counted four times and were weighed in an oversensitive scale (0.0001). The averages of weight values were recorded as 100-seeds-weight.

Table 1: The names and growth type of snap bean varieties used in the experiment and the firms from which they were provided.

Variety names	Growth type	Seed firms	Variety names	Growth type	Seed firms
Barbunya (Dwarf)	Dwarf	Bursa Toh.	Romano	Dwarf	Bursa Toh.
Gina	Dwarf	May Toh.	Sirik 97	Climbing	Bursa Toh.
Toya	Dwarf	May Toh.	Alman Ayse	Climbing	Bursa Toh.
Yalova 5	Dwarf	Ataturk Bah. Kul. Ars. Enst.	Gitan	Climbing	May Toh.
Yalova 17	Dwarf	Ataturk Bah. Kul. Ars. Enst.	Dade	Climbing	May Toh.
Balkiz	Dwarf	Bursa Toh.	4F-89	Climbing	Altin Toh.
Tina	Dwarf	Doga Tarim			

The bigness of the seed: Bigness evaluation was made as to the weight of 100 seeds.

According to this, they were described as (Anonymous, 1979);
The ones less than 20g are the smallest
The ones between 20-30g are small
The ones between 30-40g are medium
The ones between 40-50g are big
The ones more than 50g are the biggest

The shape index and the shape of the seed: The classification made as to the shapes of the seeds was arranged in the light of various researchers' results (Sehirali,1971; Akcin, 1974; Balkaya, 1999). With this purpose in 50 seeds the rates of the length and width were determined by measuring the length and width with digital compass.

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

The dispersion of colour: It was evaluated as plain coloured, double-coloured and multicoloured.

Main colour: It was classified as white, cream, green, brown, blue, dark blue, black, yellow, red, claret-red and purple.

The number and dispersion of the main colour: It was taken into consideration for the multicoloured seeds. In the seeds the dispersion of the second main colour was described around the hilum as greying, half and half and multicoloured.

The colour of the hilum: It was described as the same colour with the main colour of the seed (in its colour) and not the same colour. In the latter different colour was determined.

Germination experiment: The seeds within the petri pots were put on the drying sheets as in the number of 100 and were covered with drying sheets. For each cultivar practice was done four times repeatedly at 20°C. The rates of the normal germination counted at the end of the 7^{th} day were described as the speed of germination and the rates of the germination at the end of the 9^{th} day were also described as the power of germination (Sehirali, 1997).

Emergence experiment: In emergence tests the seeds emerged during 20 days were counted daily. According to the following formula emergence time of the bean seeds was calculated (Ellis and Roberts, 1980).

The average of emergence time: $(n \times D) / \sum_n$

$\sum_n$: Total number of the germinated seeds
D : The number of the days the seeds germinated
n : seedling emerged in counting of D days

Until the end of the 20^{th} day beginning from seeing the first emergence of the seeds, the percentage of the seeds emerged were calculated as the emergence rate.

Seed coat rate (%): In order to determine the coat rate the weight of 20 seeds randomly chosen from each cultivar were determined. These seeds were boiled in water bath 15 minutes. After that seed coats were separated with the help of pliers and dried in oven. After the dried weight was found the percentage of coat rate was estimated.

The speed of water imbibition (%): After having weighed the dried weight of 10 seeds randomly chosen from each cultivar. Erlenmeyer were put in distilled water at 20 ± 2°C for 24 hours. Within this time the seeds 1,2,4,6,12 and 24 hours later were taken out from water and weighed. Before the seeds were weighed the moisture of seeds was wiped with drying paper. Because the seed weight was known before putting into the water, the speed of water imbibition of the seed was calculated as percentage (Deakin, 1974; Kantar and Guvenc, 1995).

Determination of the level of seed moisture: The determination of seed moisture was made according to ISTA's gravimetric method (Anonymous, 1985). Ten at a time as two groups from each cultivar weighed then were mashed and according to ISTA method held in oven at 130°C during one hour. After one hour the samples were held in desiccator for ten minutes. The level of seed moisture was determined as percentage as to dried weight.

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 hours in 50ml deionized distilled water at 20 ± 2 °C. After the seeds were taken out of water the electrical conductivity of water in jams was measured with the electric conductivity fire-rake HD 8706. To prevent the loss of water imbibition, the seeds were held for 24 hours in an environment with high rational moisture before being put into water. Electrical conductivity was determined as micro siemens / centimetre-gram) (Demir *et al.*, 1994).
Correlation analysis was made to determine the relations among some seed characteristics in coloured and white snap bean cultivars (Tosun, 1991).

Results and Discussion

According to the results of measurement the seed length of the snap bean cultivars were between 12.0 and 17.24 mm. It was seen that climbing types were taller than dwarf types regarding the seed length. The tallest seed length in Gitan was measured as 17.24 mm. In dwarf type Barbunya (dwarf) was the tallest one (14.49mm) (Table 2).
In all types of both dwarf and climbing Gitan had the biggest value (9.17 mm) about seed width (Table 2). Sirik 97 (8.58 mm) and Yalova 5 (8.40 mm) followed Gitan.
It was seen that in dwarf types the thickness values of the seed were between 5.97 and 6.79 mm, however, in climbing types these values were between 4.66 and 7.23 mm. The thickness of the seeds was measured mostly in Sirik 97 (7.23 mm) and Gitan (7.21 mm). In other climbing types (Dade, Alman Ayse and 4F-89) the thickness values of the seed were less than the dwarf types.

Table 2: The results about the size of the seed, shape index, seed shape and 100 seeds weight of the snap bean varieties used in the experiment.

Variety names	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
Dwarf							
Barbunya oturak	14.49± 1.59	8.12± 0.90	6.37± 0.75	1.78	Egg shape	50.79	The biggest
Gina	12.80± 0.62	7.50± 0.24	6.43± 0.32	1.71	Egg shape	46.72	Big
Toya	12.58± 1.39	8.27± 0.65	6.44± 0.74	1.52	Elliptic	45.68	Big
Yalova 5	14.13± 0.77	8.40± 0.59	6.67± 0.33	1.68	Elliptic	50.65	The biggest
Yalova 17	12.66± 0.77	7.89± 0.36	6.79± 0.35	1.61	Elliptic	34.65	Medium
Balkiz	13.17± 0.56	8.19± 0.64	6.06± 0.66	1.61	Elliptic	40.69	Big
Tina	13.13± 0.87	7.83± 0.61	6.70± 0.59	1.68	Elliptic	44.98	Big
Romano	12.00± 0.89	7.07± 0.49	5.97± 0.69	1.70	Elliptic	33.69	Medium
Climbing							
Sirik 97	16.41± 0.98	8.58± 0.89	7.23± 0.52	1.91	Tall	55.21	The biggest
Alman Ayse	15.23± 0.92	8.11± 0.42	4.94± 0.43	1.88	Tall	41.46	Big
Gitan	17.24± 0.99	9.17± 0.75	7.21± 0.75	1.88	Tall	67.21	The biggest
Dade	14.99± 0.75	7.58± 0.42	4.66± 0.44	1.98	Tall	40.23	Big
4F-89	15.20± 0.84	8.10± 0.47	4.90± 0.56	1.88	Tall	62.30	The biggest

Table 3: The characteristic of the bean types used in the experiment concerning with testa colour and becoming coloured of the seeds

Variety names	Colour Dispersion	The Main colour	The number of main colour	Other Main Colour	Colour of Hilum
Dwarf					
Barbunya oturak	Two	Brown	2	Yellow	Dark Brown
Gina	One	White	1	-	White
Toya	Two	Beige-Black	2	Yellow	Black
Yalova 5	One	White	1	-	White
Yalova 17	One	White	1	-	White
Balkiz	One	Brown	1	-	Black
Tina	One	White	1	-	White
Romano	One	White	1	-	White
Climbing					
Sirik 97	Two	Cream coloured-Claret Red	2	Yellow	Dark Brown
Alman Ayse	One	White	1	-	White
Gitan	Two	Beige-Black	2	Yellow	Black
Dade	One	White	1	-	White
4F-89	One	Claret Red	1	-	Claret Red

Table 4: Germination and emergence results.

Variety names	The speed of germination (%)	The power of germination (%)	Emergence time (day)	The rates of emergence (%)
Dwarf				
Barbunya oturak	38.0	94.0	13.0	48.9
Gina	45.0	84.0	8.0	82.3
Toya	25.0	80.0	12.0	66.7
Yalova 5	42.0	90.0	14.0	44.4
Yalova 17	42.0	48.0	12.0	54.8
Balkiz	24.0	52.0	9.0	60.9
Tina	96.0	100.0	8.0	66.7
Romano	82.0	86.0	12.0	37.8
Climbing				
Sirik 97	98.0	100.0	9.0	53.3
Alman Ayse	29.0	32.0	9.0	40.0
Gitan	40.0	92.0	12.0	64.4
Dade	81.0	90.0	9.0	57.8
4F-89	20.0	72.0	9.0	93.3

Table 5: The results with regard to seed coat rate, water imbibition the seed moisture and electrical conductivity.

Variety names	Seed Coat Rate (%)	Water Imbibition (%)	The seed moisture (%)	Electrical conductivity (mScmg/seed)
Dwarf				
Barbunya oturak	7.3	118.7	6.2	10.1
Gina	6.5	115.7	4.2	7.4
Toya	7.6	120.0	6.5	8.8
Yalova 5	7.4	117.0	7.2	14.5
Yalova 17	8.3	99.7	8.6	7.4
Balkiz	8.9	119.5	5.8	9.6
Tina	6.9	109.3	8.5	10.2
Romano	8.2	110.1	9.4	13.6
Climbing				
Sirik 97	7.0	102.0	8.2	8.2
Alman Ayse	7.3	122.5	4.5	13.7
Gitan	7.7	117.2	4.1	10.1
Dade	7.2	122.0	4.2	12.1
4F-89	7.1	89.3	9.8	4.3

Table 6: The relations among some characteristics belonging to the coloured and white varieties.

Coloured snap bean varieties	Seed weight	Seed coat rate	The power of germination	The rate of emergence	Water imbibition	The Seed moisture
Seed weight	-0.5738	0.5046	0.3896	-0.5072	0.0078	-0.3303
Seed coat rate		-0.7719*	-0.1423	0.5835	-0.5023	0.4453
The power of germination			-0.4153	-0.0564	-0.1264	0.1963
The rate of emergence				-0.6637	0.6149	-0.8522*
Water imbibition					-0.8617*	0.9207**
The Seed moisture						-0.9216*
SD:5 r:0.05 0.754 r:0.01 0.874						
White snap bean varieties	**Seed weight**	**Seed coat rate**	**The power of germination**	**The rate of emergence**	**Water imbibition**	**The Seed moisture**
Seed weight	-0.7628	0.3718	0.2553	0.4601	-0.3843	0.1147
Seed coat rate		-0.3505	-0.6216	-0.5580	0.6592	0.1699
The power of germination			0.4462	0.0346	0.1880	0.0550
The rate of emergence				-0.1599	-0.2290	-0.7772
Water imbibition					-0.7889	0.5656
The Seed moisture						0.02146
SD:4 r:0.05 0.811 r:0.01 0.917						

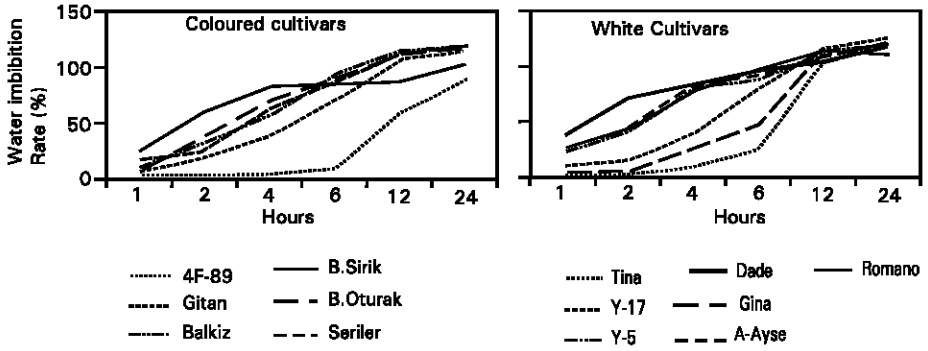

Fig. 1: In snap bean types water imbibition rate as to hours at coloured and white cultivars

The seeds of Gitan and Sirik 97 cv. were longer, wider and thicker than the other types of bean as to seed size (length, width, thickness). However, in dwarf types there was no big difference as to the seed size and it was stated that they were in close size to each other. In the research the shapes of seeds were established as to the values of shape index found according to length / width rates. At the end of the classification it was seen that the seeds of Barbunya (dwarf) and Gina from dwarf types were like egg shaped and the seeds of the other dwarf bean types were like elliptic. It was also seen that the seeds of all the climbing types were long.

Thousand seeds weight is important in terms of the quality of the seeds. Both agricultural and commercial this characteristic has always been considered (Sagsoz, 1990). It was desired that 1000 seeds weight was much in the types to use in production. In the bean types used in experiment in the research made regarding 100 seeds weight, they were between 33.69 and 67.21 g and big differences were seen among the types regarding weight of the seeds. It was determined that Gitan (67.21 g), 4F-89 (62.30 g) and Sirik 97 (55.21 g) had the highest values of seed weight. Hundred seeds weights of dwarf types were less than climbing types. It was seen that 100 seeds weight of Gitan type was approximately as twice as Romano type.

The bigness of the seed was determined according to the classification made regarding 100 seeds weight. There were differences between the types regarding bigness at the end of the classification. It was found that the seeds of two of the dwarf types were medium, two of them were big and two of them were very big. The differences among the bigness of the seeds that have resulted from the values among 100 seeds weight of the dwarf types are much. Regarding the bigness two of the seeds of the climbing types are big and three types of them are very big. Regarding the bigness all the big ones have also the highest values in terms of the size of the seeds.

When the dispersion according to the colour of the seed was examined (Table 3), it was seen that the snap bean types used in the research were single coloured and double coloured. It was observed that in the types which had single and double colours the main colours of the seed were white, claret red, brown, beige-black and beige and in the types which had double colours the dispersion of the colour was greying. When the colours of the hilum was examined, it was seen that the colour of the hilum was white in the ones which were white colour. It was determined that in the coloured cultivars except for 4F-89, the colour of the hilum was dark brown and black.

The rates of germination speed of snap bean types differed between 20-98% (Table 4). It has been observed that Sirik 97 and Tina cultivars had the higher germination speed values than all other cultivars. When we examine the values of the germination power the results are similar to germination speed values and germination power value of Sirik 97 and Tina cultivars are found as 100%. The rates of germination power of Yalova-17 and Alman Ayse cultivars are lower than the other cultivars. The changes happened in the seed quality influenced the growth of plant and especially the emergence and seedling (Demir and Gunay, 1994). In the experiment of emergence tests made in the greenhouse it was determined that emergence time of the cultivars as to the formula stated in the method was between approximately 8-14 days (Table 4). The emergence time of Gina and Tina, dwarf types of bean, was the earliest and it took 8 days, and the emergence time of Yalova 5 was the latest and it took 14 days. It was stated that according to ecological conditions the emergence of snap bean could differ between 7 and 30 days and the desired temperature for germination was 18 – 20 °C (Sehirali, 1988). The approximate emergence times of cultivars used in the experiment were among the values described in literature.

When we examined the values of emergence rates 4F-89 (93.3%) and Gina (82.2%) had the highest emergence rates (Table 4). It was also found that Yalova 5 and Romano cultivars had the lowest emergence rates. In a research made to determine the effects of water imbibition damage in snap bean, the emergence tests made in the seeds of Yalova 5, which had different moisture content, it was found that the values of emergence rates were under 50% (Ceylan, 1996). That the emergence rates of Yalova 5 were low that could result from the cultivar characteristics. In another study, the emergence trial on 30 dwarf types of bean the researchers determined that the field emergence differences of the seeds were related to testa colour (Powell *et al.*, 1986b). 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%. In emergence trial we made 4F-89 with claret red seed colour having the highest emergence rate (93.3%). It was stated that although in the cultivars with white testa colour used in the experiment the emergence rate was lower than the colourful types, in Gina and Tina cultivars the emergence rates were higher than the colourful types. That the emergence rates of these types were high could result from their genetic structure. In another research it was notified that in dwarf types of bean, colourful seeds had the higher emergence rate than the white seeds and also stated that resistance of seedling was better than the white ones (Deakin, 1974).

The results with regard to testa rate, water imbibition at the end of 24 hours, the seed moisture and electrical conductivity in the seeds of snap bean are given in Table 5. Testa in snap bean differed according to the cultivars, and it is 6.6 - 9.59% part of the seeds (Sehirali, 1997). In our experiment it was determined that the testa rates of the cultivars used were between 6.5 and 8.9% (Table 5).

It was revealed by different researchers that seed coat's dried weight and thickness of the coloured snap bean were far more than the cultivars with white testa (Kantar and Guvenc, 1995; Demir and Ozcoban, 1996). When Table 5 was examined it was seen the results were proper to the literatures. Testa rate (8.9%) of Balkiz cultivar was higher than the other cultivars. In white colour cultivars such as Yalova 5, Yalova 17, Romano and Dade the values of testa rates were close to coloured cultivars. However, in Gina (6.5%) and Tina (6.9%) testa rates were lower than other cultivars. That testa rate was high delayed germination and emergence. In Gina and Tina cultivars emergence (8 days) was earlier than other cultivars. In emergence rates except for 4F-89 in other cultivars the highest values were handled.

In snap bean types water imbibition rate as to hours were given in Fig.1a and b.

Alman Ayse and Dade with white testa imbibed more than other cultivars. It was determined that in 4F-89 water imbibition was at the lowest level. The differences among imbibition rates of snap bean with white testa colour showed a remarkable and fast increase from the first to sixth hour. However, in the measurement at 24th hour it was observed that the differences among the cultivars were less and close to each other (Fig.1b). In another research on seeds it was determined that the water imbibition rate of Yalova 5 was higher than Yalova 17 (Guvenc, 1998).

In our research in Yalova 5 and Yalova 17 cv. regarding water imbibition similar results were handled (Fig. 1b). In coloured cultivars except for 4F-89 water imbibition rate between 1-6th hours increased remarkably and fast (Fig.1a). In 4F-89 water imbibition rate was lower than the other coloured cultivars. Water imbibition of this cultivar from the sixth hour began to get fast and after the 12th hour it reached its maximum. Although in Sirik 97 water imbibition rate was faster at the beginning than other cultivars after the fourth hour it was observed that this increase began to decline (Fig. 1a). When we made an evaluation regarding water imbibition rate among the cultivars, it was stated that at the end of 24 hours water imbibition rates of cultivars with white testa were more than the coloured cultivars. Rapid water imbibition characteristics have caused low emergence rate and weak seedling growth in all legumes including snap bean (Powell *et al.*, 1986a). In Blacksea region where spring is cool and rainy this situation is very important. Therefore in Turkey, Samsun, which has the most extensive production area and the most excessive amount of snap bean, the seeds have been damaged because of the heavy rain and as a result of this there is a decline in yield (Balkaya and Gulumser, 1999). At this season, if producers want to sow snap bean they should prefer the coloured cultivars because, they are more resistant than the white ones (Demir, 1994; Kantar and Guvenc, 1995).

Electrical conductivity differed according to testa colour and seed moisture rate of cultivars. When the values of electrical conductivity were examined the highest ones were determined in Yalova 5, Romano and Alman Ayse cultivars (Table 5). The lowest values of electrical conductivity were seen in coloured cultivars. In the emergence tests made in greenhouse the emergence times of Yalova 5 (14 days) and Romano (12 days) were longer than other cultivars. But, in cultivars with white testa such as Alman Ayse, Gina and Tina the emergence times were earlier. This could result from the low seed moisture. In this research it was stated that there was a negative relation between the seed moisture rate and electrical conductivity (Taylor and Dickson, 1987). In the seeds which had 12% moisture content the electrical conductivity was low and in the ones with 8% moisture content it was high. In our research it was the claret red 4F-89 which had 9.8% moisture content with lowest electrical conductivity. In other cultivars having different moisture contents the electrical conductivity changed according to testa colour and was like in the literature above. In the emergence test made in the greenhouse the highest emergence rate (93.3%) was in the seeds of 4F-89. Although emergence rate in coloured cultivars was low than Gina and it was higher than other white cultivars. It was observed that there was a negative and significant relation between the electrical conductivity and emergence rate of snap beans with coloured testa (r: -0.8522) and the seed resistance of these cultivars was higher than the ones with white testa. While in the seeds with electrical conductivity increased the emergence rate decreased. A similar relation was found in a study on Yalova 5, 4F-89 and Karasu (Ceylan, 1996). 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 = 0.9207). It can be explained like that because the cultivars with high imbibition rates secreted the cell solution they had higher electrical conductivity. Literature (Taylor and Dickson, 1987) have supported the result.

The correlation coefficients belong to the relations between the seed characteristics of snap bean types are given in (Table 6). It was stated that there was a significant and negative relation between testa rate and germination power (r = -0.7719) in coloured snap bean types. The testa was thick and had a negative effect on imbibition during germination.

It was determined that there was a negative and significant relation between imbibition and seed moisture (r = -0.8617). The seed moisture was high in coloured cultivars affecting the imbibition rate of testa negatively.

In correlation of white cultivars seed characteristics were found statistically insignificant (Table 6). This can be resulted from the genotype of cultivars used in the study and the environmental conditions in which the seeds have been produced. In our study, although there was not a significant relation statistically in white cultivars it was seen that like in coloured cultivars there was a similar relation among some seed characteristics. Therefore, by using the cultivars which had different white testa regarding determination of seed characteristics making new research can be very beneficial.

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