ASIAN JOURNAL OF NATURAL & APPLIED SCIENCES
ISSN: 2186-8476, ISSN: 2186-8468 Print
Vol. 2 No. 3 September 2013

CHANGES IN SOYBEAN SEED QUALITY AND VIGOUR UNDER DIFFERENT PLANTING DATES

A. Muhammad[1], S. K. Khalil[2]

[1]Department of Botany, University of Science & Technology, Bannu,
[2] Department of Agronomy, Agricultural University, Peshawar,
PAKISTAN.

[1] asimmuh@ yahoo.com

ABSTRACT

Low seed quality resulting into poor stand establishment is one of the major constraint in promotion of soybean production. The present study aimed at assessing the seed quality of three indigenous varieties (Kulat brown, Kulat white, Mothi) and two improved varieties (NARC-II, Swat-84) planted at monthly interval from April to July, 2004 and 2005 at Agriculture University, Peshawar, Pakistan. The seed harvested from each treatment was subjected to accelerated aging, tetrazolium test, electrical conductivity and seedling dry weight. Maximum values for accelerated aging (73.9 %) and tetrazolium test (75.3 %) were recorded in seeds harvested from May and April planted crop respectively. However, maximum electrical conductivity (0.37 dsm^{-1}) and seedling dry weight (15.7 mg) was recorded from July and June planted crops respectively. Maximum accelerated aging germination (72.2 %) and tetrazolium test values (82.4 %) were recorded for Kulat brown and Mothi respectively. Swat-84 exhibited maximum electrical conductivity (0.59 dsm^{-1}) and seedling dry weight (15.9 mg). Land races demonstrated maximum values for accelerated aging test (71.2 %) and tetrazolium test (80.6 %). Improved varieties had greater electrical conductivity values (0.49 dsm^{-1}) and seedling dry weight (15.7 mg). It is concluded that maximum seed quality and vigour values were determined for land races except seedling dry weight and electrical conductivity values.

Keywords: Dates, Soybean, Accelerated aging, Electrical conductivity, Tetrazolium, Seedling dry weight

INTRODUCTION

Poor stand establishment is one of the major constraint in restricting soybean (*Glycine max* L. Merrill) promotion in the country, because of unavailability of quality seed. Seed has the highest germination and vigour, at physiological maturity but deterioration starts soon after physiological maturity (Delouche 1982). Under cool and dry conditions germination may be barely maintained for 7 to 10 months and may be lost within 2 to 3 months under hot moist conditions (Hinson and Hartwig, 1982). Uniform germination and fast seedling establishment under field conditions is an important prerequisite to obtaining high yield with good quality (Kaya *et al*. 2010). The environmental conditions in Pakistan are usually hot and moist and not suitable for maintaining soybean seed quality at the required standard. Moreover Delouche, (1982) reported that almost all of the prevailing improved varieties have this inherited deficiency. To overcome this problem, it was thought appropriate to explore the seed quality of indigenous land races of soybean characterized with small seed size. The role of small seed size is well documented in maintaining seed viability. Johnson (1987) found that small seeded cultivars had better seed quality than larger seeded cultivars. Vermand Ram (1989) stated that seed size was negatively correlated with germination. Horlings *et al*. (1991) reported that deterioration of seed quality was associated with large seed size. Accelerated

ISSN: 2186-8476, ISSN: 2186-8468 Print
Vol. 2 No. 3 September 2013

aging test was considered the best indicator of performance of seed (Boersma *et al.,* 1996) and seeds from the optimum planting dates had higher percentage of normal seedlings in this test (Uem and Unioeste, 2003). Rehman *et al.* (2006) reported that seed vigour assessed by accelerated aging and conductivity was reduced when planting was delayed. Direct relationship between electrolytes leacheates and field seedling emergence was observed by Vieira *et al.* (2004). Seedling axis dry weight decreased with delayed planted crop (Khan, 2007), and increased with increased seed size (Fatima, 1999). Chattopadhyay *et al.* (2011) confirmed that early sown seeds produced the vigours and best quality seeds than late sowing dates. The present study aimed to assess the seed quality and vigour of indigenous land races and improved varieties of soybean under different planting dates.

MATERIAL AND METHODS

Three indigenous land races (Kulat brown, Kulat white, Mothi) and two improved soybean varieties (NARC-II, Swat-84) were planted at four planting dates at monthly interval from April to July at New Developmental Farm, Khyber Pakhtun Khwa Agricultural University, Peshawar, Pakistan during 2004 and 2005 growing season. The site is located at 34.01^0 N latitude, 71.35^0 E longitude and at an altitude of 450 meters above sea level, sixteen hundred kilometers away north of Indian Ocean. According to the physiographic zones of the province, the site lies in the agro-ecological zone C, having warm sub humid climate with 450 to 750 mm annual rainfall. The soil of the experimental field was silty clay loam, with montmorilonite clay type, low in nitrogen (0.03-0.04%) and organic matter (0.7-0.8%) and alkaline in nature (pH 8-8.2). Meteorological data for two years (2004-2005) for the site was obtained from the Department of Water Management, Khyber Pakhtun Khwa Agricultural University Peshawar (Table.1). Three indigenous varieties (Kulat brown, Kulat white, Mothi) measuring seed weight of 6.7, 6.7 and 7.2g and two improved varieties (NARC-II, Swat-84) had 14.8 and 15.7g seed weight respectively. Experimental field was irrigated six times, while weeds were eradicated four times. Planting dates were allotted to main, while varieties were allotted to sublots. A subplot size of 3mx3m, having six rows, 3m long and 50 cm apart was used. Each treatment was replicated four times in randomized complete block design with split plot arrangement. A basal recommended dose of 25 kg N and 64 kg P_2O_5 ha^{-1} was applied at the sowing time. After harvest the clean dry seeds of varieties from various planting dates were tested for determing accelerated aging test, Tetrazolium test, Electrical conductivity and Seedling dry weight.

Accelerated Aging Germination Test (%)

Accelerated aging Germination test was conducted; using the jar accelerated aging system. Seeds were placed in muslin cloth bags tied with rubber band and supported with wire mesh stand. Seed was 8 cm above the water surface in the bottom of the jar. Approximately 100% relative humidity was maintained through water. Each treatment consisted of two lots, of 50 seeds each replicated four times, placed in jars and kept in incubator at 40°C for 72 hours. After aging, standard germination test was conducted and the normal seedlings were counted on 7^{th} day as stated in ISTA, (1999).

Tetrazolium Test

Tetrazolium test was used for quick estimate of the viability of seed samples through biochemical reaction. The imbibed chemical in living plant tissues is reduced from a colorless solution to red insoluble compound, which precipitates in live cells, while dead cells remain colorless because of no reaction. Four replications of 100 seeds each from various treatments were preconditioned between folded moist paper towels for 18-20 hours, in order to allow slow water uptake to avoid cotyledon cracking. After preconditioning the seeds were removed and

ISSN: 2186-8476, ISSN: 2186-8468 Print
Vol. 2 No. 3 September 2013

each lot was divided into two halves of 50 seeds each. The seeds were then immersed in 1% solution of 2, 3, 5- triphenyl tetrazolium chloride in one liter distilled water of Ph. 7.0 at 35°C for 3-4 hours to allow staining, according to the procedure adopted by Grabe (1970). After staining, the solution was decanted and the seeds were rinsed several times in tap water, put in glass beaker and refrigerated in moist condition and evaluated immediately. After removing the seed coat, each seed was cut longitudinally through the embryo axis into two halves and evaluated under a dissecting microscope. In addition to completely stained viable seeds and completely unstained non-viable seeds, some were partially stained. However seeds were separated in the viable and non-viable seeds according to ISTA (1999). The number of viable seeds in each treatment was determined and average percentage was calculated.

Electrical Conductivity Test

Electrical conductivity test was satisfactorily used to evaluate the physiological quality of soybean seeds. In a seed soaking solution the electrolytes leached into water were measured with an electrical conductivity meter. Seeds leaching large quantities of electrolytes into the water, exhibit poor field emergence. To conduct electrical conductivity test, samples of 50 seeds each were drawn from each treatment and placed in 250 ml flasks. Each flask was added 200 ml distilled water and stirred to remove air bubbles and floating seeds. Flasks were covered with aluminum foil and kept in incubator at 20^{o}C for 24 hours for proper soaking in water (Association of Official Seed Analysis, 2002). The seeds were then carefully swirled and the conductivity of the soaked water was measured using a dip type cell conductivity meter. Conductivity was expressed as deci-siemens (dsm^{-1}) g^{-1} of seed (ISTA, 1999).

Seedling Axis Dry Weight

Four replications of 50 seeds each of various treatments were allowed to grow at 25^{o}C for 5 days after germination in incubator. The cotyledons were removed and the seedlings were placed in paper bag in oven at 60° C for 24 h for determining seedling axis dry weight (Association of Official Seed Analysis, 2002).

STATISTICAL ANALYSIS

Data and curve fitting were analyzed using Microsoft Excel software and means were separated by least significant difference test at 5% significance level.

Table 1. Climatic data for the experimental area in two growing seasons (2004-05 and 2005-06)

	2004-05				*2005-06*			
Month	*Rainfall (mm)*	*Mean Temperature (ºC)*		*Relative Humidity (%)*	*Rainfall (mm)*	*Mean Temperature (ºC)*		*Relative Humidity (%)*
		Min.	Max.			Min.	Max.	
Jan	55	18	4	73	25	17	3	85
Feb	40	23	6	73	97	16	2	82
Mar	0	28	11	66	109	22	11	79
Apr	37	33	17	65	9	29	13	81
May	0	37	21	59	22	32	17	78
Jun	0	38	27	69	0	39	22	79
Jul	3	37	24	70	6	35	22	75
Aug	24	35	28	71	20	35	24	77
Sep	18	34	21	73	4	34	22	78
Oct	8	28	9	71	0	31	17	81
Nov	11	25	9	70	0	25	7	82
Dec	26	21	6	79	0	21	2	82

ISSN: 2186-8476, ISSN: 2186-8468 Print
Vol. 2 No. 3 September 2013

RESULT AND DISCUSSION

Accelerated Aging Germination Test (%)

Years, planting dates (D), varieties (V), and Planting dates × varieties interaction significantly affected accelerated aging germination. Soybean planted in 2004 had 15% higher accelerated aging germination than 2005 (Table .2). Maximum germination (73.9%) was recorded for seeds from May planted crop. Means for the seeds from April (63.3%) and June (62%) planted crops, though significantly lower than May had no statistical difference among themselves. Minimum germination (49.3%) was recorded for seeds from July planted crop. Accelerated aging germination declined in the seeds from early planted crop than May or late planted crops in June and July. The decline in accelerated aging germination from May planted land races was 4.2% for seeds of early planted crop in April, and 5.4 and 26.8% for late planted crops in June and July respectively. In improved varieties the decline from May planted crop, was 31.8 for early planted crop and 34.8 and 44.3% for June and July planted crops. The findings of Uem and Unioeste (2003) and Rehman *et al*. (2006) supported our results who stated that accelerated aging germination decreased in seeds of delayed planted crop.

Kulat brown, Mothi and Kulat white demonstrated maximum germination of 72.2, 70.9 and 70.4% as a result of accelerated aging test. Minimum accelerated aging germination was noticed in NARC-II (46.8%) and Swat-84 (50.2%). Accelerated aging germination in improved varieties was 46.8% lower than land races. The higher accelerated aging germination in land races was in conformity with the findings of Verma and Ram (1989) that reported that seed size, was negatively correlated with germination after accelerated aging.

Planting dates × varieties interaction revealed that accelerated aging germination of Kulat brown, Kulat white and Mothi was high in seeds from early planted crop and declined in seeds from late planted crop. However, in NARC-II and Swat-84 peak values were recorded in seeds from May planted crop (Fig.1). Similar results were found by Avila *et al*. (2003) early soybean sown seeds which had higher percentage of normal seedlings in the germination and accelerated aging tests while delaying sowing dates had adverse effects on soybean seed production with regard to their sanitary quality.

Table 2. Accelerated aging test of soybean varieties as affected by planting dates over two years

Varieties	*April,2*	*May,2*	*June,2*	*July,2*	*Mean*
Kulat brown	74.8 ab	80.5 a	75.3 ab	58.1 de	72.2 a
Kulat white	75.3 ab	78.5 a	73.5 ab	54.3 ef	70.4 a
Mothi	74.8 ab	76.0 ab	73.5 ab	59.5 de	70.9 a
NARC-II	42.8 ghi	65.3 cd	43.3 ghi	36.0 i	46.8 b
Swat-84	48.8 fg	69.0 bc	44.3 gh	38.8 hi	50.2 b
Means	63.3 b	73.9 a	62.0 b	49.3 c	-
LSD	*Dates (D)*		*Varieties (V)*	*D × V*	
P≤0.05	3.06		3.80	7.60	
		Land races			71.2
		Improved varieties			48.5
		Year-I (2004)			66.4
		Year-II (2005)			57.8

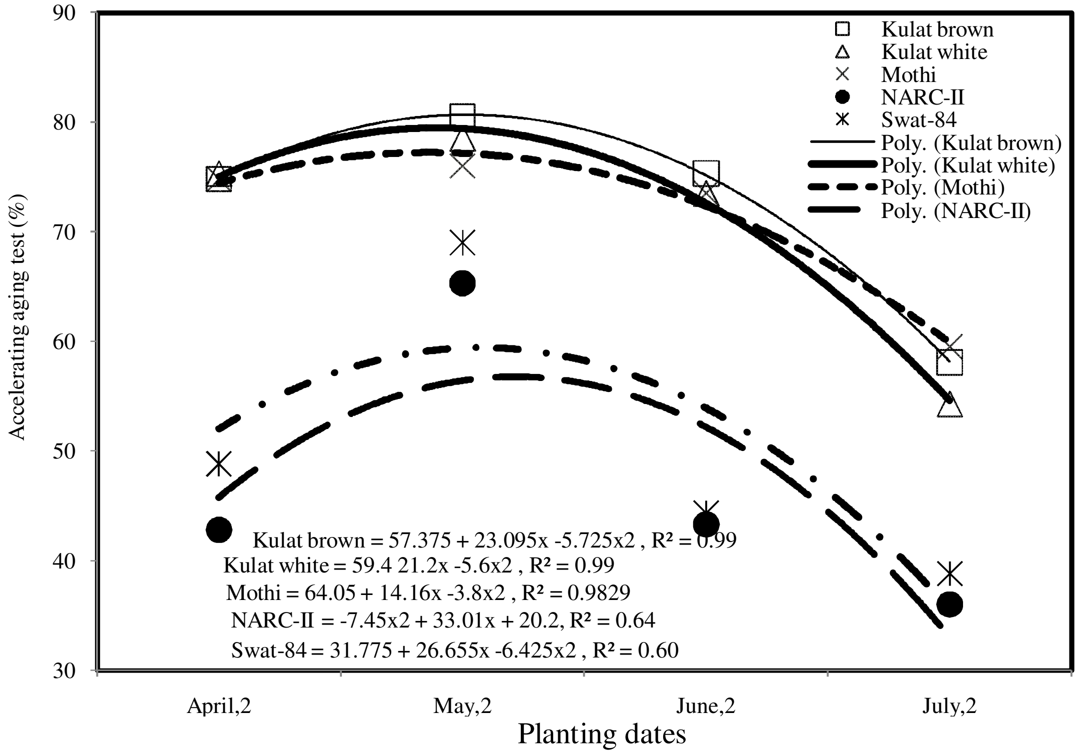

Figure 1. Accelerated aging test (%) of soybean varieties as affected by planting dates over two years average

Tetrazolium Test

Statistical analysis of the data showed that significant variations were observed in the means for years, planting dates (D) and varieties (V) in the average of two years for tetrazolium test. Tetrazolium test indicated more viable seeds during 2004 planted crop. Maximum average percentage of viable seeds (75.3) were noticed in April planted crop, followed by May planting. The percent viable seeds declined significantly, in seeds from June and July planted crops. Minimum percentage of viable seeds (66.3) was recorded in seeds from July planting (Table. 3). Similar results were obtained by Kolasinska *et al.* (2000) they concluded that the viability of seeds was tested by tetrazolium staining and was generally high in very early planting dates.

Maximum percentage of viable seeds (82.4) was recorded for Mothi followed by Kulat brown and minimum percentage (57%) of viable seeds was recorded for NARC-II. In Kulat white percentage of viable seeds (79.1%) was not different than the percentage of viable seeds in Kulat brown. Percentage of viable seeds (58.2%) in Swat-84 was statistically similar to that of NARC-II. Percentage of viable seeds assessed through tetrazolium test in land races was 40% greater than the improved varieties. Seed deterioration in improved varieties was greater than in land races. Similar deterioration was reported by Bakht (1989). Prific *et al.* (1998) believed that standard germination test values were higher than the tetrazolium test values.

Direct relationship was observed between accelerated aging germination, seedling dry weight, and percent viable seeds evaluated through tetrazolium test. This relationship was evident in case of varieties as well as planting dates. The decline in vigour test values in seeds obtained from delayed planted crop was consistent. Seed vigour test determinations proved that land races had better performance than the improved varieties.

ISSN: 2186-8476, ISSN: 2186-8468 Print
Vol. 2 No. 3 September 2013

Table 3. Tetrazolium Chloride test of soybean varieties as affected by planting dates over two years

Varieties	*April,2*	*May,2*	*June,2*	*July,2*	*Mean*
Kulat brown	83.0	83.4	79.9	74.8	80.3 ab
Kulat white	82.4	81.3	77.8	75.0	79.1 b
Mothi	86.3	85.6	79.0	78.8	82.4 a
NARC-II	62.0	58.3	56.9	50.9	57.0 c
Swat-84	63.0	59.6	58.0	52.0	58.2 c
Means	75.3 a	73.6 a	70.3 b	66.3 c	-
LSD	*Dates (D)*		*Varieties (V)*		*D × V*
P≤0.05	3.17		3.24		NS
		Land races			80.6
		Improved varieties			57.6
		Year-I (2004)			69.1
		Year-II (2005)			73.7

Electrical Conductivity

Electrical conductivity values for soybean planted in 2004 were greater than in 2005 planted crop (Table. 4). Electrical conductivity values for the seed leachates from April and May planted crops were minimum and non-significantly different among themselves. Electrical conductivity values for seed leachates of June and July planted crops were largest and statistically similar.

Maximum electrical conductivity values (0.59 dsm^{-1}) were recorded for seed leachates of Swat-84 and lowest (0.18 dsm^{-1}) for seed leachates of Kulat brown. The electrical conductivity values for the seed leachates of Kulat white and Mothi were statistically similar. Seeds of Swat-84 leached large quantities of electrolytes resulting into greater values of electrical conductivity than seeds of NARC-II. The electrical conductivity values for the seeds leachates of improved varieties were more than double the values for seed leachates of land races. Higher electrical conductivity values for improved varieties are in accordance with the results of Horlings *et al.* (1991) who stated that deterioration of seed quality was associated with large seed size and electrical conductivity increased with increase in seed size (Hwang and Sung, 1991).

The interaction between planting dates × varieties revealed that in Swat-84 and NARC-II maximum electrical conductivity values were recorded which increased in seeds from April planted crop to July planted crop. However, in Kulat brown, Kulat white and Mothi electrical conductivity remained static with planting dates (Fig.2).Vieira *et al.* (2004) stated that though there was direct relationship between electrical conductivity and field emergence, yet this relationship could be disturbed under marginal environmental conditions.

ISSN: 2186-8476, ISSN: 2186-8468 Print
Vol. 2 No. 3 September 2013

Table 4. Electrical conductivity (dsm^{-1}) of soybean varieties as affected by planting dates Over two years

Varieties	*April,2*	*May,2*	*June,2*	*July,2*	*Means*
Kulat brown	0.21 ghi	0.15 i	0.23 gh	0.15 i	0.21 ghi
Kulat white	0.24 fgh	0.18 hi	0.31 ef	0.19 hi	0.24 fgh
Mothi	0.28 fg	0.17 hi	0.24 fgh	0.19 hi	0.28 fg
NARC-II	0.28 fg	0.40 d	0.37 de	0.48 c	0.28 fg
Swat-84	0.40 d	0.53 bc	0.58 b	0.85 a	0.40 d
Means	0.28 b	0.29 b	0.35 a	0.37 a	0.28 b
LSD	*Dates (D)*		*Varieties (V)*		*D × V*
P≤0.05	0.03		0.03		0.07
		Land races			0.21
		Improved varieties			0.49
		Year-I (2004)			0.36
		Year-II (2005)			0.27

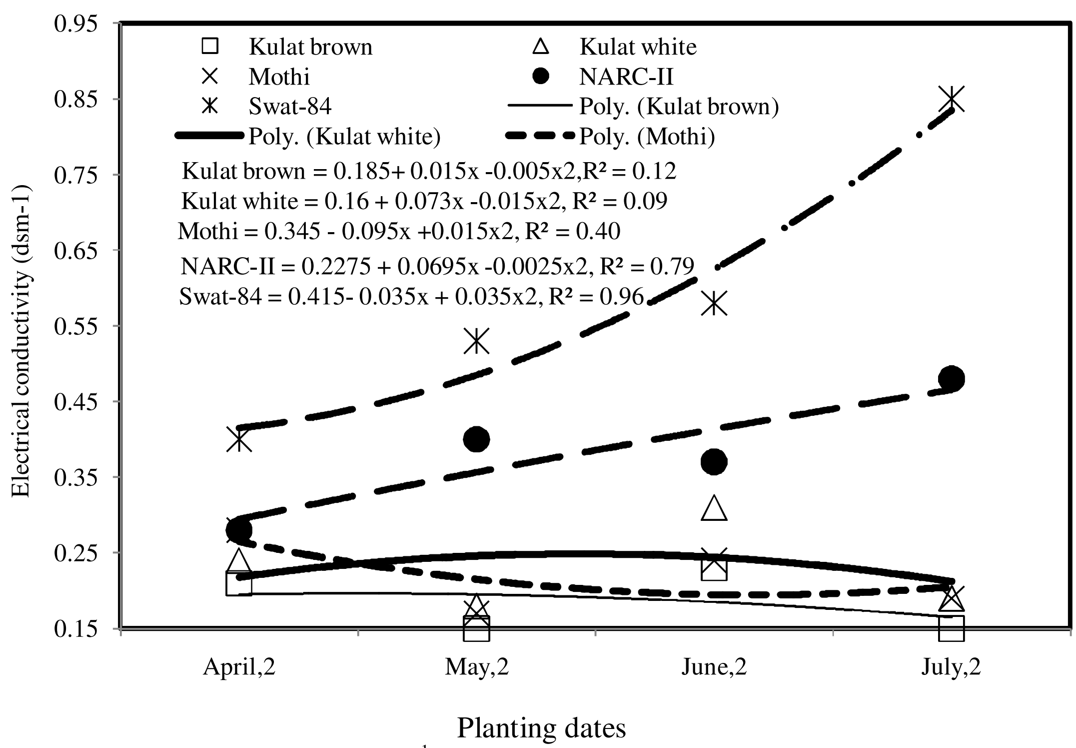

Figure 2. Electrical counductivity (dsm^{-1}) of soybean varieties as affected by planting dates over two years average

ISSN: 2186-8476, ISSN: 2186-8468 Print
Vol. 2 No. 3 September 2013

Seedling Dry Weight

Seedling dry weight recorded in 2004 was 32% higher than 2005. Maximum weight (15.7 mg) was recorded for seedlings from the seeds obtained from June planted crop and minimum (8 mg) from the seeds from July planted crop. Seedling dry weight of seeds from April and May planted crops were similar and intermediate. The results of this research are in conformity with Khan (2001) who reported that seedling dry weight decreased in seeds from delayed planted crop.

Maximum seedling weight (15.9 mg) was recorded for Swat-84 followed by NARC-II (Table. 5). Minimum seedling weight (10.9 mg) was observed in Kulat brown, which was statistically not different than the seedling weight of Kulat white and Mothi. Improved varieties gave greater seedling weight (28% higher) than land races. The reason is that in improved varieties, the seeds were of bigger size, having more stored food material than the land races with seed size of less than half of the improved varieties. Similarly, greater seedling dry weight of improved varieties than land races was supported by Fatima (1999) who reported that dry weight of seedlings increased with increased seed size.

Planting dates × varieties interaction showed that seedling dry weight in NARC-II, Swat-84, Kulat brown and Mothi increased when planting was extended from April to May, thereafter decreased. However, in Kulat white steady decrease was observed when planting was delayed from April to July (Fig.3). Arulnandhy (1988) reported that May and June plantings showed the highest seedling dry weight and seed vigour.

Table 5. Seedling dry weight (mg seedling^{-1}) of soybean varieties as affected by planting dates over two years (2004 to 2005)

Varieties	*April,2*	*May,2*	*June,2*	*July,2*	*Means*
Kulat brown	11.1 ghi	15.0 b-e	10.4 hi	7.0 k	10.9 b
Kulat white	14.0 c-f	11.5 fgh	12.1 fgh	7.5 jk	11.3 b
Mothi	13.3 efg	13.3 efg	13.4 d-g	7.3 jk	11.8 b
NARC-II	16.6 bc	16.0 bcd	21.3 a	8.5 ijk	15.6 a
Swat-84	17.1 b	15.4 b-e	21.3 a	9.8 hij	15.9 a
Means	14.4 b	14.2 b	15.7 a	8.0 c	

LSD	*Dates (D)*	*Varieties (V)*	*D × V*
P≤0.05	1.16	1.37	2.75

Land races	11.3
Improved varieties	15.7
Year-I (2004)	14.9
Year-II (2005)	11.3

ISSN: 2186-8476, ISSN: 2186-8468 Print
Vol. 2 No. 3 September 2013

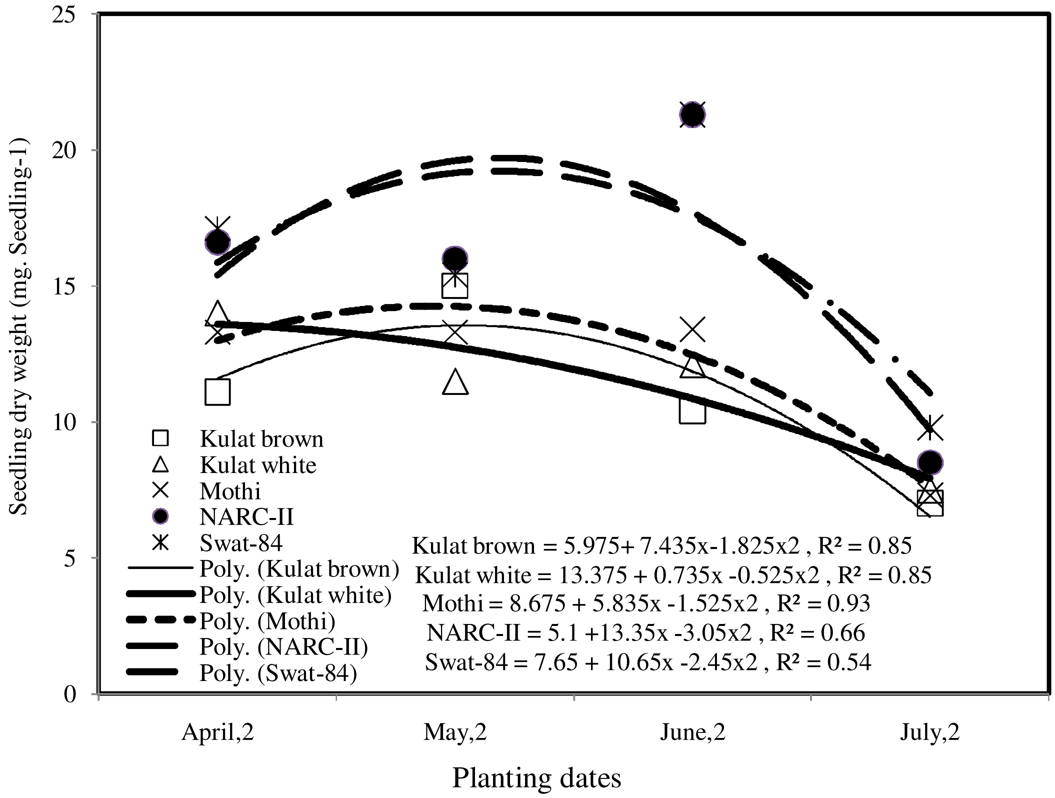

Figure 3. Seedling dry weight (mg. seedling^{-1}) of soybean varieties as affected by planting dates over two years average

CONCLUSIONS

The following conclusions were drawn from the experiments.

Accelerated aging germination, tetrazolium test and seedling dry weight values declined when planting was delayed from April to July, except electrical conductivity. Maximum seed quality and vigour values were determined for land races except seedling dry weight and electrical conductivity values.

REFERENCES

[1] Arulnanadhy, V. (1988). Soybean seed quality as affected by time of planting in the dry zone of Sri Lanka. *J Natn Sci Coun., 16*(1), 1-10.

[2] Association of Official Seed Analysts. (2002). *Seed Vigour Testing hand book.* Lincoln, 105p. (contribution, 32).

[3] Avila, M. R., Bruccini, A. D. L. E., Motta, I. D. S., Scapim, C. A. & Braccini, M. D. C. L (2003). Sowing seasons and quality of soybean seeds. *Scientia Agricola, 60*(2), 245-252.

[4] Bakht, K. (1989). Effect *of environmental factors on the yield, quality and viability of soybean seed.* M.Sc thesis, N.W.F.P. Agri. Uni. Peshawar., Pakistan.

[5] Boersma, M., Law, M. & Adkins, S.W (1996). Assessment of soybean seed vigour tests in eastern Australia. *Aust. J. Exp. Agric., 36*, 99-103.

ISSN: 2186-8476, ISSN: 2186-8468 Print
Vol. 2 No. 3 September 2013

[6] Chattopandhyay, A., Dutta, S. & Chatterjee, S (2011). Seed yield and quality of okra as influenced by sowing dates. *Afr. J. Biot., 10*(28), 5461-5467.

[7] Delouche, J. C. (1982). *Physiological changes during storage that affect soybean quality. Proc.* of conf. for scientists of Asia, Jan 25-31, 1981, Colombo, Srilanka, INTSOY publication., 22:57-66.

[8] Fatima, D. K. (1999). *Effect of Seed Sizes on the Germination and the Emergence Pattern of Eight Soybean Varieties.* M.Sc Thesis, NWFP. Agri. Uni. Peshawar., Pakistan.

[9] Grabe, D. F. (1970). *Tetrazolium Testing Hand Book.* Association of official seed analysis. Hand book No. 29. AOSA. Boise, ID.

[10] Hinson, K. & Hartwig, E. E. (1982). Soybean production in the tropics. Plant production and protection paper First review. *FAO. Rome.* 185-190.

[11] Horlings, G. P., Gamble, E. E. & Shanmugasundaram, S. (1991). The Influence of Seed Size and Seed Coat Characteristics on Seed Quality of Soybean in the Tropics: Field Weathering. *Seed Sci & Tech.,* 19, 665-685.

[12] Hwang, W. D. & Sung, F. J. M (1991). Prevention of Soaking Injury in Edible Soybean Seeds by Ethyl Cellulose Coating. *Seed Sci & Tech.,* 19, 269-278.

[13] ISTA (International Seed Testing Association) International Seed Testing. (1999). *Seed Sci. & Tech., 27*(supl), 1-33.

[14] Johnson, R .R. (1987). Seed production and Technology. In: J.R. Wilcox (editor) Soybeans: Improvement, Production and Uses. American Society of Agronomy Inc., Crop Science Society of America Inc. *Soil Sci. Soc. of Am. Inc.*, 16, 358-383.

[15] Kaya, M., Sanli, A. & Tonguc, M. (2010). Effect of sowing dates and seed treatements on yield, some yield parameters and protein content of chickpea (*Cicer arietinum* L.). *African J. Biot., 9*(25), 3833-3839.

[16] Khan, A. Z., Khan, H., Ghoneim, A., Khan, R. & Ebid, A. (2007). Seed quality and vigour of soybean as influenced by planting date, density and cultivar under temperate environment. *Int. J. Agri. Res., 2*(4), 368-376.

[17] Kolasinska, K., Szyrmer, J. & Dul, S (2000). Relationship between laboratory seed quality tests and filed emergence of common bean seed. *Crop Sci.,* 40, 470-475.

[18] Prific, L., Jovanovic, M. & Glamoc clija, D (1998). Germination and vigour of wrinkled and greenish soybean seed. *Seed Sci. and Tech.,* 26, 377-383.

[19] Rahman, M. M., Hampton, J. G., & Hill, M. J. (2006). Soybean seed yield as affected by time of sowing in a cool temperature environment. *J. of New Seeds,* 7, 1-15.

[20] Uem, Unioeste (2003). Sowing seasons and quality of soybean seeds. *Sci. Agric.,* 60, 245-252.

[21] Verma, V. D. & Ram, H. H. (1989). Relationship between germinability after accelerated aging, laboratory germination and seed size in soybean. *Soybean Genetics Newsletter*, 16, 49-51.

[22] Vieira, R. D., Angelo, S. N., Regira, S., Bittencourt, M. D. & Panobianco, M. (2004). Electrical conductivity of the seed soaking solution and soybean seedling emergence. *Sci. Agric*., 61, 21-30.