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Soybean Seed Matured on Different Dates Affect Seed Quality

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Abstract: Production of quality seed is one of the major problem in soybean (Glycine max. (L) Mell.,) in tropical countries including Pakistan. Seed quality in soybean, as determined by germination, seed weight and infection by seed pathogens is affected by date of maturity. The objective of this research was to evaluate the quality of soybean seed matured at different temperature. Soybean was planted on January 13, January 16, February 19, March 1, July 10, July 20, July 26 and August 25, 1991 at Agricultural Research Institute, Tarnab, Peshawar, Pakistan. Seeds planted in January, February, and March matured during hot weather conditions (June, July), produced heavier seeds, but had lower germination, and higher infection with seed borne pathogens. Seed planted in July and August reached maturity after hot weather conditions in October and November had ended and exhibited higher germination, little infection with seed borne pathogen, but produced smaller seeds. Seed size was inversely related to germination. Conditions that favor production of large seeds also favor infection with seed borne pathogens and lower germination.

Key words: Maturity dates, germination, seed infection, Soybean

Introduction

Soybean seed quality can be reduced by a wide range of environmental factors during seed production both before and after the seed reaches a harvestable moisture content (Rasyad *et al*., 1990; Filho and Ellis *et al*., 1991a, b; Demir and Ellis, 1992a, b; Demir and Ellis, 1993; TeKrony *et al*., 1980). Tropical conditions of high temperature and high relative humidity during the final stages of seed development and maturation are not conducive to the production of quality seed necessary to establish acceptable stands. Deterioration of seed during the preharvest period is a serious production problem where rainfall combined with high temperature, results in rapid loss of viability and vigor of seed in standing crop (Delouche, 1980). Repeated drying and wetting of soybean seed prior to harvest reduces seed quality and results in poor germination. Under extremely moist conditions before harvest, seeds may actually germinate within pods (Banmurthy and Gupta, 1981). Cadwell (1972) made a detailed study of field deterioration in cotton and established a relationship between the viability and vigor of cotton seed and the period of exposure to high temperature, rainfall and relative humidity before harvest. He reported that seed of bottom bolls which exposed to the field environment longest before harvest were lower in quality.

Damage to seed quality can occur early in seed development (Keigly and Mullen, 1986). Mondragon and Potts (1974) studied the deterioration of soybean seed under natural and modified conditions. Seed subjected to ambient environmental conditions in the field declined significantly in germination four weeks after physiological maturity. However, reducing the incident sunlight on plots by 50% reduced temperature and rate of deterioration.

Green *et al*. (1965) found that soybean plants from early planting dates had seeds maturing during hot, dry weather. This produced seed of poor quality. Seeds from later planting dates which reached maturity after hot, dry weather conditions had ended, were high in quality.

Several factors are involved in reducing soybean seed quality, but the combination of susceptability to pathogenic fungi, environmental conditions that favor disease development and field deterioration of seed are respnsible for most seed damage (Jordan *et al*., 1988). The incidence and severity of fungal invasion of seed is increased by high temperature and humidity (Nicholson *et al*., 1972). The pathogens considered to be the major cause of reduction in germination, vigor and emergence of soybean are *Phomopsis longicolla, Diaporthe phaseolorum* and *D. phaseolorum* (Mayhew and Caviness, 1994). *Phomopsis* complex is the most important disease associated with deterioration of soybean seeds in the field and infection with *Phomopsis* increases as moisture increases especially during pod filling and physiological and harvest maturity (Shortt *et al*., 1981). *Phomopsis*-infected seed decay is highest on early maturing cultivars because they mature when temperature and moisture are high (Shortt *et al*., 1981).

Delays in harvesting soybeans result in increased number of seeds infected with species of *Alternaria* and *Phomopsis* (Wilcox *et al*., 1974). Early maturing cultivars are more adversely affected by delayed harvest than late maturing ones (Wilcox *et al*., 1974).

Burdett (1977) concluded that early and mid-season soybean cultivars were more susceptible to seed deterioration than full season cultivars. He added that early and mid season cultivars matured at warmer temperature than full season cultivars.

The importance of planting/ maturity dates in relation to seed quality has long been realized. However, most of the published research work on planting dates was done either using cultivars with different maturity groups, thus confounding environmental factors with genotypic differences (Shortt *et al*., 1982), or the planting dates represented a narrow range of environmental variation. Little information is available regarding planting the same cultivar within broad environmental variation ranging from January to August. Therefore, the present research was conducted to evaluate the effect of exposure of mother plants of the same cultivar to different environmental conditions at the time of seed development and maturation on seed quality.

Materials and Methods

Soybean seeds were planted at Agricultural Research Institute Tarnab, Peshawar, Pakistan. The experimental site i.e. Agricultural Research Farm, is located at 34° latitude, 71.3° longitude and an altitude of 450 meters, while Agricultural Research Institute Tarnab is located at 33° latitude, 70° longitude with an altitude of 440 meters.

Cultivar "SWat 84", which belongs to maturity group 111, was planted on four dates during the Spring 1991 (January 13, January 16, Feb. 19, and March 1) and four dates in the Fall (July 10, July 20, July 26, and Aug. 25). Soybean was planted in open field except January 13, which was planted in young persimon orchards. The rows were spaced 30 cm apart having 50 rows 20 meter long. These planting dates were ready for harvest on June 30, July 2, July 8, July 18, Oct. 26, Nov. 11, Nov. 13, and Nov. 22. Planting dates were manipulated in such a way that the spring planted crop was exposed to low temperature at planting and high temperature during seed development and maturity stage, while fall planted crop was exposed to high temperature at planting and low temperature at seed development and maturity stage (Fig. 1). Seeds from each planting date were harvested, threshed, cleaned and about 20 kg seed from each date was stored in refrigerator at 6 ± 1°C until the seed from the last planting date were processed. Seed from spring crop was germinated in incubator 2 weeks after harvest. The germination was about 1% higher than the germination recorded in experiment 1.

Experiment 1: Seed weight for all dates was determined. Seeds from each harvest date were sown in an incubator at a temperature of 25°C. Twenty seeds were placed in petri dishes (diameter = 14 cm, which had been filled with moistened sand). Each harvest date had 3 replications. Germination counts were made daily until the 9th day; thereafter no germination occurred. Germination was defined as seedlings that emerged through the sand. The data were analyzed according to a completely randomized design (Snedecor and Cochran, 1989) and upon obtaining significant F-value, Least Significant Difference (LSD) test was employed. A linear regression analysis was also conducted for seed weight and germination with temperature during pod filling stage and photoperiod length (Snedecor and Cochran, 1989).

Experiment 2 (Seedborne Pathogens): Seed harvested from three different planting dates [two from the spring crop, i.e. one with high germination (Jan. 13) and one with low germination (Jan. 16), and one from the fall crop (July 10)] were evaluated for seed borne pathogens. The seeds were surface sterilized in a 10% sodium hypochlorite (NaOCl) solution for four minutes, and rinsed twice in distilled water for one minute. One hundred twenty seeds were randomly chosen from each date and were placed in 9 cm plastic culture plates containing potato dextrose agar (Difco) with five seeds per plate. Seeds were incubated at 25 ± 3°C for seven days. After culture development, the seed were analyzed for radicle emergence and seedborne fungal infection. A seed was classified as infected with the pathogen that dominated other pathogens in case of infection with several pathogens. The experimental design was a completly randomized design. Data were statistically analyzed according to SAS Proc (SAS Institute Inc., 1990), and means were compared using approximate pairwise Z test at a = 0.05 analogous to the use of LSD in analysis of variance when chi-square test of dates was significant.

Results

Soybean planted on January 13, January 16, February 19, March 1, July 10, July 20, July 26 and August 25 were exposed to maximum average air temperature of 35.36, 37.41, 37.34, 35.83, 31.00, 29.83, 29.43 and 29.33°C during pod filling stage. The above temperatures are the average of daily maximum temperature in the last 60 days of pod development. The duration of the temperature was 2-3 hours each day (Fig. 1).

Experiment 1

Hundred Seed Weight: Planting dates significantly affected seed weight (Table 1). The heaviest seeds (20.40 g/100) were recorded for seed harvested from March 1 planted crop, followed by January 16, and February 19 planted crop (Fig. 2). Generally spring planted crops produced heavier seeds than fall planted crops. Heavier seeds were recorded from soybean that developed seed at higher temperature (Fig. 3). Seed weight increased by 0.46 g per hundred seed with each 1°C temperature increase and 1.72 g with each 1 hour increase in photoperiod (Fig. 4) during pod filling stage.

Germination: Planting dates significantly affected germination (Table 1). Maximum germination (100%) was observed for seed harvested from July 20, July 26 and August 25 planted crop (Fig. 5), while minimum germination of 5% was recorded for seed harvested from January 16 planted crop. Seed germination was inversely proportional to temperature experienced by mother plant during pod filling stage (Fig. 6). Germination decreased by 10.7% with 1°C temperature increase during pod filling stage. Poor germination was recorded from heavier seeds compared with lighter seeds (Fig. 7). Germination decreased by 20.35% with each 1 g increase in seed weight per hundred seed.

Table 1: Experiment 1. Analysis of variance of seed weight and germination of soybean as affected by different planting dates. Values in parentheses are alpha values for mean squares values above it

Source	D.F.	Mean square	
		100 Seed Weight	Germination (%)
Dates (D)	7	11.17 (<0.01)	213.85 (<0.01)
Error	16	0.409	2.25
C. Total	23		

Table 2: Experiment 2. Caterogical model analysis of germination of soybean as affected by different planting dates. Values in parentheses are P values for chi-square values above it

Source	D.F.	Chi-Square	
		Infection (%)	Germination (%)
Intercept	1	125.08 (<0.01)	570.48 (<0.01)
Source	2	19.60 (<0.01)	19.65 (<0.01)

Experiment 2 (SeedbBorne Pathogen)

Infection: Seeds harvested from two spring planting dates (January 13 and January 16) and one fall planting date (July 10) were evaluated for seed borne pathogens (fungi) and radicle germination. The above dates were selected because

Table 3: Percent infection of soybean with seedborne pathogens as affected by planting dates

Fungi	Planting date						Total
	Jan. 13		Jan. 16		July 10		
	Germinatated	Ungerinated	Germinatated	Ungerinated	Germ inatated	Ungerinated	
Rhizopus	7.6	0	1.7	4.2	0	7.6	21.1
Alternaria	17	3.4	5.9	11.1	5.9	4.2	47.5
Fusarium	2.6	3.4	7.6	11.1	7.6	5.9	38.2
Aspergillius	10.2	15.3	6.8	8.5	7.6	2.6	51.0
Rhizoctonia	0	1.7	2.6	0.8	0	1.7	6.8
Penicillium	0	5.9	3.4	5.1	3.4	1.7	19.5
Curvularia	0.8	0	4.3	0	0	0.8	5.9
Cladiosporium	3.4	4.3	2.6	0.8	1.7	0	12.8
Colletotrichum	0.8	0	1.7	1.7	1.7	0	5.9
Helminthosporium	0	0	2.6	0	0	0.8	3.4
Nigrospora	0	0	0	1.7	0.8	1.7	4.2
Chaetomium	0	0.8	1.7	0	0	0	2.5
Septocylindrium	0	0	0	0	1.7	0	1.7
Bacteria	0.8	0.8	0	0.8	3.4	1.7	7.5
Total	43.2	35.6	40.9	45.8	33.8	28.7	

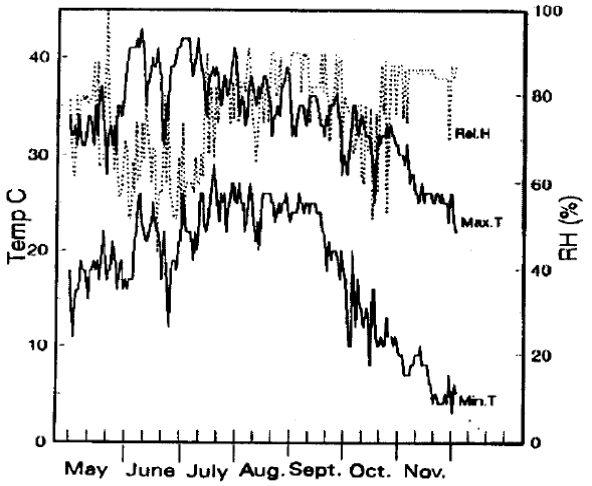

Fig. 1: Daily maximu, minimum temperature (°C) and relative humidity (%) during growing season (1991)

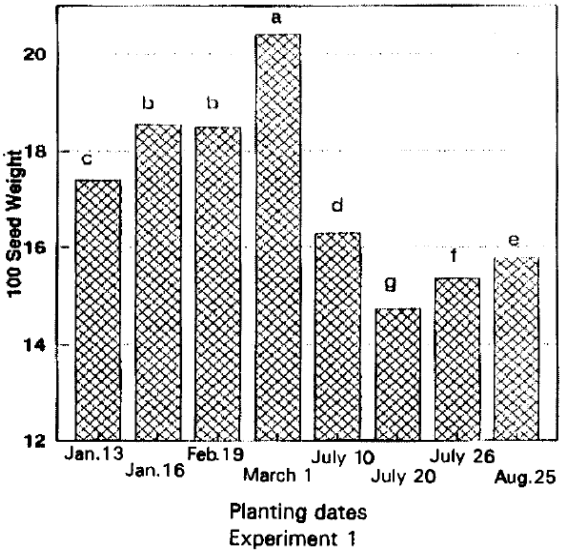

Fig. 2: Hundred seed weight (g) of soybean as affected by planting dates. Bars with similar letters are non significant at alpha =0.05 using LSD

seed harvested from January 13 and July 10 had better germination, while seed from January 16 crop had poor germination. Significant differences in seedborne pathogen were observed due to seed harvested from different planting dates (Table 2). Seeds harvested from January 16 planted soybean were highly infested with seedborne pathogens (Fig. 8), while seed harvested from July 10 planted crop had the least infection with seedbome pathogens.

Seeds were highly infected with *Aspergillius*, *Alternaria*, *Fusarium*, *Rhizopus*, *Penicillium* and *Cladosporium* (Table 3). Seeds harvested from spring crop (January 13 and January 16) germinated poorly when infected with *Aspergelllus*, *Fusarium*, *Rhizopus* and *Penicillium*. However, seed infected with *Alternaria* germinated better except seed harvested from January 16. Generally the spring crop was more infected with seedborne pathogens than fall crop. However, the fall crop was infected more with bacteria.

Germination: Planting dates significantly affected germination (Table 2). Seed harvested from July 10 planted produced 36.7% healthy seeds and 33.3% infected seed that were able to germinate (Fig. 9). However, the percentage of healthy seeds that germinated was quite low (2.5%) in January 16 planted crop.

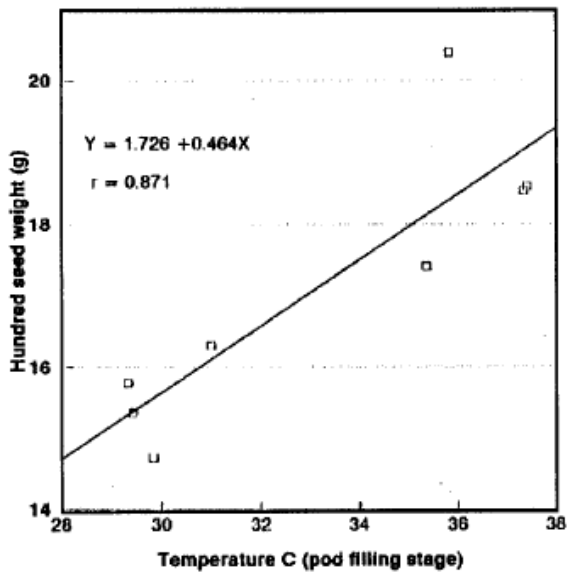

Fig. 3: Hundred seed weight of soybean matured under different temperature

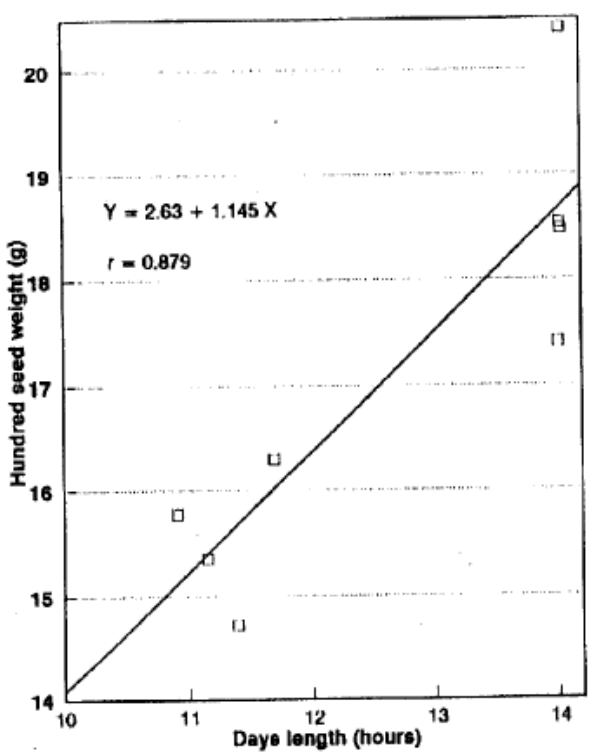

Fig. 4: Hundred seed weight (g) of soybean as affected by photoperiod (hours) during pod filling stage

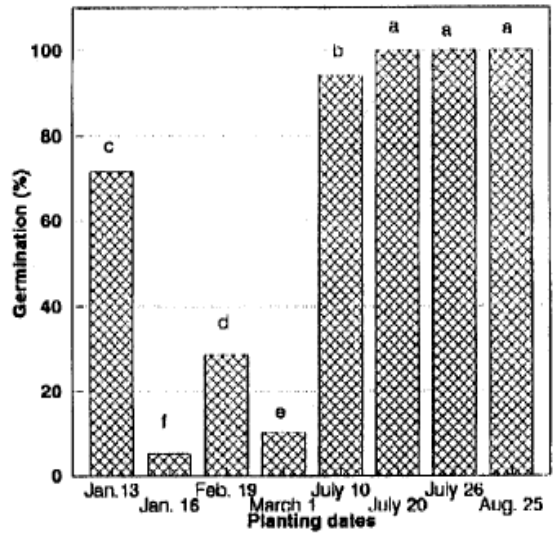

Fig. 5: Germination of soybean as affected by planting dates. Bars with similar letters are non significant at alpha = 0.05 using LSD

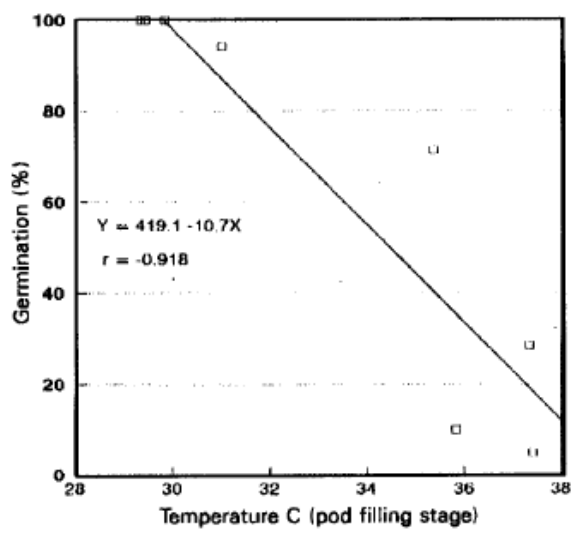

Fig. 6: Germination of soybean seed matured under different temperature

Discussion

Figure 5 indicate that as the planting was delayed from spring to fall, there was an improvement in the quality of seed produced. The germination tests indicate that seed which matured during or shortly after the hot, dry weather period extending from late May to June, and July resulted in poor germination. Seeds which matured after the above described weather period had ended were of better quality. Generally the spring planted crop matured in May and June, during which period the temperature

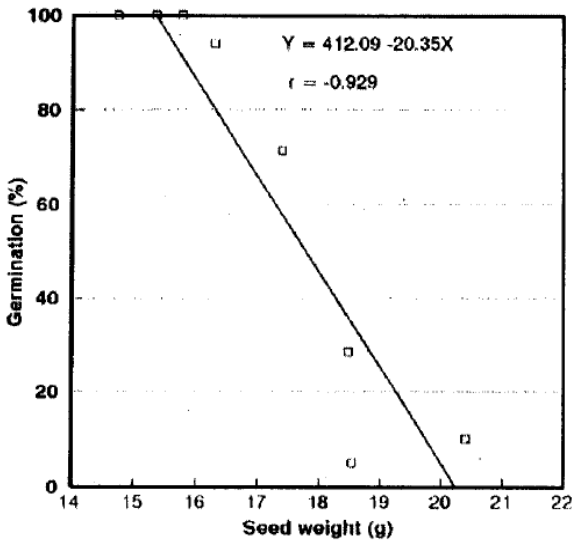

Fig. 7: Relationship between seed weight and germination

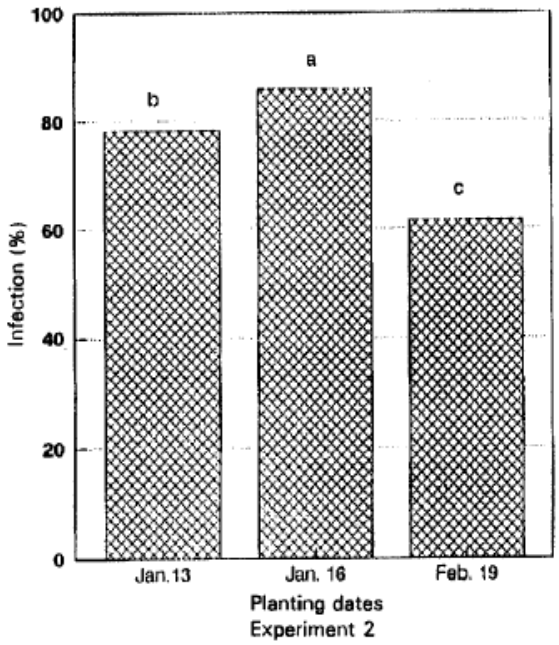

Fig. 8: Seed infection with seedborne pathogens as affected by planting dates. Bars with different letters are significantly different at alpha =0.05 analogous to LSD

was high, and dry weather prevails which ultimately resulted in poor germination. Fall planted crop matured at low temperature and resulted in better germination. These results are consistent with the findings of others (Ellis *et al.*, 1993; Mayhew and Caviness, 1994; Burdett, 1977; Green *et al.*, 1965, 1966) who reported poor quality seed from early

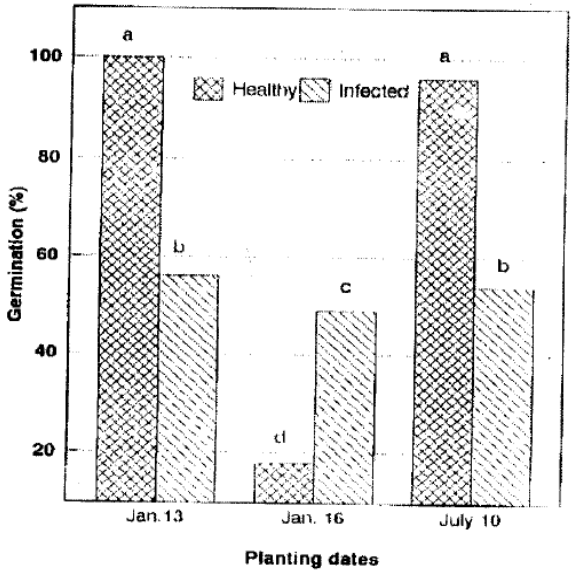

Fig. 9: Seed status as affected by planting dates. Bars with similar letters are significantly different at alpha = 0.05 analogous to LSD

planted rice/soybean that matured usually at high temperature. However, these results contradicts the findings of Zanakis *et al.* (1994) who reported no reduction in soybean seed germination grown in greenhouse. The difference in the work by Zanakis *et al.* (1994) and these results may be due to two reasons: a). They used lower range of temperature (26-32) the critical temperature in these results was temperature above 32°C (Fig. 6) that drastically reduced the germination and b). They used different cultivars that were bred mainly for resistance to drought and high temperature. It appears that soybean seed quality is determined by environmental conditions both before and after the seed reaches maturity (Delouche, 1980). Burton (1982) reported that both high temperature and high relative humidity decreased viability in maize.

The possible cause of high quality seed harvested from January 13 planted crop which matured at high temperature could be due the fact that this crop was planted in a young persimmon orchard and the seed matured under partial shade. This partial shade provided the maturing soybean crop with comparatively lower temperatures that protected the crop, which ultimately resulted in better quality seed. This idea is supported by Mondragon and Potts (1974) who studied the deterioration of soybean seeds in the field under natural and modified conditions and reported that reducing the incident sunlight on the plots by 50% by the use of wire screens reduced the temperature and rate of deterioration.

Early planting dates, that is spring planting, resulted in heavier seeds than late planting, similar to previous findings (Green *et al.*, 1965, 1966; Heatherly, 1988; Singh *et al.*, 1990). It seems apparent that seed size is inversely correlated with seed quality. The data suggests that growing conditions that favors the production of large seed, such as the conditions occurring during the development of

early dates of planting, also favor the production of seed with low germinability. Larger seeds with poor germination from early planting dates could be due to a longer photoperiod that partitioned more photosynthates to seed. However, high temperatures encouraged infection with seed borne pathogens that ultimatly decreased the germination of those large seeds. These findings agree with the results of Green *et al*. (1965, 1966) who reported that early planted soybean produced heavier seeds with poor germinability.

Soybeans were grown under differing field conditions through January to August to ensure expression of seed quality differences. Soybean seed quality varied with planting dates, and was associated with fungal infection. The data indicate that the incidence of seedborne fungi was dependent on weather conditions (Fig. 1, 7). Weather conditions during crop maturation stages affected disease development and resulted in differences among planting dates (Fig. 7). The data shows that seed developing earliest were exposed to high temperature during pod filling (Fig. 1). This high temperature favors development of plant and seed pathogens that reduce seed quality. Similar results were reported by Damicone *et al*. (1987), Vaughan *et al*. (1989), Hepperly and Sinclair (1978), Jordan *et al*. (1988), Shortt *et al*. (1981) and Mayhew and Caviness (1994) who reported high seedborne pathogen infection for seed that matured in late July or August compared with October matured soybean. They further added that the same cultivars had better quality and low seedborne pathogen infection when grown at relatively low temperature and low humidity. Seed harvested from July and August planted crops developed when rainfall and temperature were least favorable for infection, and escaped severe seed infection by seedborne pathogens.

The results indicate that soybean planted early in the season (spring crop) that matured during hot weather conditions produced seed with lower germination. Seed from later dates of planting (fall crop) that reached maturity after hot weather condition had ended generally exhibited higher germination. Small seed size was associated with high germination and later dates of planting. Germination was inversely related to seed size. The conditions that favor production of large seed also favor seed infections with seedborne pathogens and production of poor quality seed.

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