# Relationship of Hull Mesocarp Color to Seed Germination and Vigor in Large-Seeded Virginia-Type Peanuts

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**ABSTRACT**

Classification of peanuts (*Arachis hypogaea* L.) based on pod mesocarp color has become a popular means of estimating maturity of runner peanuts. This study was initiated to determine if the hull mesocarp color is related to seed maturity of virginia-type peanuts and to evaluate changes in quality as seed mature. Cultivars NC 7 and NC 9 peanuts were harvested by hand in 1990, 1991, and 1992. Pods were separated according to mesocarp color. Seed moisture content and dry weight within a maturity class varied with cultivar and production year. Germination of NC 7 seed grown in 1990 and 1992 increased as seed approached maturity. Immature NC 9 seed grown in 1991 and 1992 had substantially lower germination than seed from mature pods. There was no increase in germination during maturation of NC 7 seed harvested in 1991 or NC 9 from 1990. Seed leakage during imbibition, measured by electrical conductivity, decreased as seed matured. The lowest leakage levels occurred when seed had reached physiological maturity. Germination following accelerated aging (AA) increased as seed matured. Maximum AA germination of NC 7 occurred when seed had reached 77, 84, and 100% of their final dry weight in 1990, 1991, and 1992, respectively. NC 9 seed achieved maximum germination following AA after the seed amassed at least 90% of their final dry weight.

Key Words: Germination, vigor, maturity.

The indeterminate growth habit of peanuts (*Arachis hypogaea* L.) presents numerous challenges to peanut producers, particularly determining when to dig. Pods and seed on a single plant at digging time will vary in maturity and seed size. Additionally, the maturation pattern of peanuts will vary from year to year and from cultivar to cultivar (Sullivan, 1994). These characteristics, along with the lack of above-ground indicators of pod and seed maturity, make it difficult to determine the optimum digging date for obtaining maximum yields and quality.

The maturity level of an individual kernel is important to peanut seed germination and vigor potential. Studies have shown that peanut seed, like seed of most agronomic crops, reach maximum seed quality at or just prior to physiological maturity (PM) (Sombatsiri and Nuanon, 1987). However, unlike producers of most agronomic crops, peanut growers usually do not delay harvest past PM. Delayed harvests past PM often result in reduced yields and poor peanut quality.

Peanuts in Virginia and North Carolina are dug when a majority of the pods are close to or at PM and seed moisture content of the crop averages approximately 35%. The plants are inverted, placed in windrows, and allowed to dry to a seed moisture content of 20 to 25% before combining. Producers of large-seeded virginia-type peanuts typically harvest a seed crop a week earlier than normal when seed moisture content is approximately 38 to 40% (Sullivan and Reusche, 1983). This reduces the number of extra large seed, which are more susceptible to mechanical damage during combining and conditioning. These large seed are also slow to germinate and emerge in the field.

Several techniques have been developed to measure peanut maturity. Pattee *et al.* (1977) developed a seed-to-hull maturity index based on the weight ratio between

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the two components. The index was highly correlated with the physiological stage of peanut development. In their study, peanut seed reached maximum dry weight at or near PM and lost dry weight if allowed to remain on the plant past PM.

Arginine maturity index (AMI) was shown to be a reliable measure of maturity of runner-type peanuts (Young and Mason, 1972). AMI is based on the free arginine content of peanut seed. Johnson *et al.* (1976), however, found this technique less reliable for use on large-seeded virginia-type peanuts.

The most widely used method today for estimating pod maturity is the hull scrape method described by Williams and Drexler (1981). The pod epidermis (exocarp) is removed to expose the mesocarp which changes color from white to yellow to orange to brown and finally to black as the pod matures. This technique is nondestructive to the seed and thus offers an opportunity to study changes in peanut seed development. Though this technique was developed for small-seeded runner peanuts, it has been adopted by many peanut farmers in the Virginia-North Carolina area to estimate digging date for large-seeded virginia-type peanuts (Sullivan, 1994).

The objectives of this study were to (a) determine if pod mesocarp color is related to seed maturity, germination, and vigor for large-seeded virginia-type peanuts and (b) determine when during development peanut seed reach maximum quality potential.

## Materials and Methods

Cultivars NC 7 and NC 9 peanuts were produced at the Peanut Belt Research Station near Lewiston, NC in 1990, 1991, and 1992. Plots were established in the spring of each year and standard production practices were followed. Two replications were established for each cultivar, with one replicate consisting of two 15.2-m rows. Pods were removed by hand immediately after digging and processed through a wet pod blaster to remove the hull exocarp. Approximately 1300 g of freshly dug pods were placed the a perforated cylinder of the blaster. The cylinder rotated slowly as peanut pods were abraded for approximately 4 min with a high pressure stream of water containing glass beads (soda lime glass, chemical abstract service number 65997-17-3). This process removed the exocarp from the pods, exposing the mesocarp. Each pod was then placed in a maturity category based on hull mesocarp color; maturity classes included yellow 1 (Y1), yellow 2 (Y2), orange (OR), brown (BR), and black (BL), with black being the most mature (Williams and Drexler, 1981).

Moisture (wet weight basis) and dry weight for seed of each maturity class was determined by placing five 10-seed subsamples in 105 C for 24 hr. Percent final dry weight was calculated by dividing the average seed dry weight for a maturity class by the dry weight at PM (maximum dry weight) for each individual cultivar and production year.

Following the removal of hull exocarp, pods from the various maturity classes were placed in mesh bags and dried over forced air (no heat) to approximately 8% seed moisture content. Pods were shelled and the seed stored at 10 C until tested for quality.

Seed quality evaluations included standard germination (SG), accelerated aging (AA) and electrical conductivity (EC) of seed soak water. Seed used for SG and AA were treated with Gustafson 4-Way [18% captan (*N*-trichloromethylthio-4cyclohexene-1,2 dicarboximide), 18.75% maneb (manganese ethylenebisdithiocarbamate), 10% PCNB (pentachloronitrobenzene), 2.5% 5-ethoxy-3-trichloromethyl-1,2,4-thiadiazole] in 1990 and 1991 and with Vitavax PC [45% captan, 15% PCNB, 10% carboxin (5,6-dihydro-2-methyl-*N*-phenyl-1,4-oxathiin-3-carboxamide)] in 1992. SG tests were performed on eight 25-seed subsamples in rolled towels at alternating 20/30 C with 16 hr at 20 C. Seedlings were counted at 3 and 7 d, according to the Association of Official Seed Analysts, Rules for Testing Seed (AOSA, 1993). Only those seedlings with normal development were considered as germinated.

For AA, 200 g of seed were placed on wire-mesh screens and suspended over 150 mL of water inside plastic boxes. The boxes were placed in a water jacketed incubator and held at 41 C (±0.1 C) and near 100% relative humidity for 96 hr (AOSA, 1987). Eight 25-seed subsamples were then tested for germination as described previously for the SG test. Evaluations for normal seedling development were made 4 and 7 d.

EC of the leachate from seed was measured using a Cole-Palmer Conductivity Meter, model 1481-60 (Cole-Palmer Instrument Company, Niles, IL). Ten 10-seed subsamples were weighed and placed in 125-mL erlenmeyer flasks containing 75 mL of 25 C distilled water. Flasks were covered and held at 25 C for 24 hr. Conductivity is reported as mmhos $g^{-1}$ of seed.

All laboratory tests were analyzed as completely randomized experiments with two replications and the data were subjected to analysis of variance. Means were separated using Duncan's Multiple Range test (LSD = 0.05).

## Results and Discussion

Moisture content of NC 7 and NC 9 peanuts decreased significantly ($P \leq 0.05$) as seed matured and hull color changed from yellow to black (Table 1). Though absolute moisture content varied from year to year and between the two cultivars, trends for decreasing moisture content were similar. NC 9 seed produced in 1990 had considerably lower moisture content during the early stages of kernel development (Y1, Y2, and OR pod) than seed produced in 1991 or 1992. NC 7 seed appear to be slightly lower in moisture content at BL pod (32 to 35%) than NC 9 seed (36 to 37%).

Dry weight accumulation of peanut seed is similar to that of most crops. Accumulation rate is more rapid during the early stages of development (Y1, Y2, and OR pod), followed by slower weight gain as seed near PM (BR and BL pod). NC 7 dry weight accumulation patterns were similar in all three production years (Table 1). Though physiological maturity (100% of final dry weight) was generally observed in seed from BL pods, there was no significant weight gain between BR and BL maturity classes, with the exception of the 1992 NC 9 seed.

NC 9 seed produced in 1990 expressed a different pattern of development than those produced in 1991 or 1992; there was no significant difference between the dry weight of seed from OR, BR or BL pods. Seed from BL pods in the NC 9 cultivar produced in 1990 were actually lower in dry weight than seed from BR pods. Peanut seed have been shown to lose dry weight if allowed to remain on the plant beyond full maturity

**Table 1. Moisture content, dry weight and percent of final dry weight of NC 7 and NC 9 seed harvested in 1990, 1991 and 1992.**

| Maturity class | Seed moisture[a] | | | Seed dry weight | | | Final dry weight[b] | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 1991 | 1992 | 1990 | 1991 | 1992 | 1990 | 1991 | 1992 |
| | % | | | mg/seed | | | % | | |
| | | | | **NC 7** | | | | | |
| Y1 | 56a[c] | 68a | 60a | 454d | 194d | 448c | 45 | 27 | 43 |
| Y2 | 48b | 51b | 54b | 602c | 658c | 582c | 62 | 61 | 56 |
| OR | 41c | 42c | 45c | 748b | 912b | 775b | 77 | 84 | 74 |
| BR | 38c | 36d | 39d | 970a | 1044a | 971a | 99 | 96 | 93 |
| BL | 32d | 33d | 36d | 976a | 1085a | 1048a | 100 | 100 | 100 |
| | | | | **NC 9** | | | | | |
| Y1 | 49a | 63a | | 537c | 378d | | 61 | 37 | |
| Y2 | 43b | 57b | 52a | 729b | 574c | 541d | 86 | 56 | 53 |
| OR | 40bc | 51c | 47b | 847ab | 717b | 684c | 96 | 70 | 67 |
| BR | 37c | 43d | 40c | 875a | 960a | 898b | 100 | 94 | 87 |
| BL | 36c | 38e | 37d | 846ab | 1015a | 1027a | 96 | 100 | 100 |

[a]% Seed moisture = [(Fresh seed weight - Dry seed weight)/Fresh seed weight] x 100.

[b]% Final dry weight = (Dry weight of a specific maturity class/Maximum dry weight of that cultivar for that year) x 100.

[c]Means in the same column followed by the same letter are not significantly different at P = 0.05.

(Pattee *et al.*, 1977).

NC 9 seed produced in 1992 developed slower and did not reach maxiumum dry weight until the BL pod stage. Seed from BR pods in 1992 were less mature (87% of final dry weight) than seed from the same hull color in 1990 (100%) and 1991 (94%).

Though differences in seed dry weight accumulation did occur, seed maturation patterns of NC 7 and NC 9 are in agreement with previous studies (Williams and Drexler, 1981). The magnitude of the increase in dry weight was less between maturity classes BR and BL than between other stages of development.

Environmental conditions during the three peanut production seasons of this study varied considerably. 1990 was considered dry and warm while 1992 was wetter and cooler than normal. Conditions for 1991 were considered more normal for the peanut belt of North Carolina. The difference in NC 9 moisture content and dry weight accumulation patterns for the 3 yr would indicate that NC 9 was more susceptible to inclement weather conditions than NC 7. NC 9 vine growth in fields throughout North Carolina was more extensive than normal in 1990 and pod numbers were generally reduced. This resulted in larger seed that were further along in development at harvest. Both cultivars were somewhat slower to develop in 1992 when conditions were wet and cool, as noted by the reduction in percent final dry weight for seed from Y2, OR, and BR pods (Table 1).

Seed moisture and dry weight are frequently used to describe stages of peanut seed development or kernel maturity. These parameters, however, can vary greatly depending on the environmental conditions during seed development and the cultivar being described. Miles *et al.* (1988) used percentage of final dry weight to describe changes in seed maturity for soybean. This approach appears to be useful in describing peanut seed development. Dry weight of peanut seed within a hull scrape based maturity class varied substantially with cultivar and production year in this study (Table 1). Therefore, seed dry weight was not a useful tool in describing peanut maturity. There was, however, a significant linear relationship ($r^2 = 0.94$) between seed moisture and percent of final dry weight for both cultivars and all three production years (Fig. 1).

Germination potential of seed from different maturity classes varied considerably for the two cultivars from year to year (Table 2). SG of NC 7 and NC 9 seed produced in 1990 was 80% or greater regardless of the

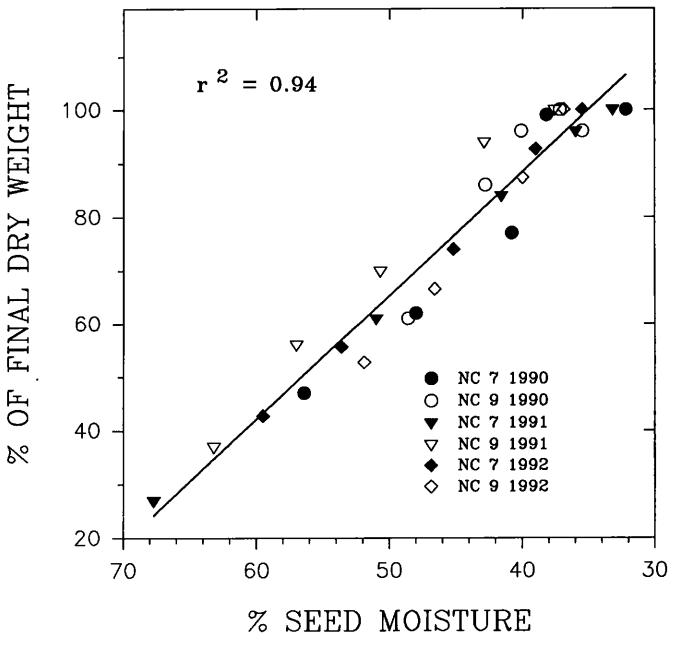


**Figure 1. Relationship between seed moisture content and percentage of final dry weight of NC 7 and NC 9 peanuts produced in 1990, 1991, and 1992.**

**Table 2. Standard germination (SG), accelerated aging (AA) and electrical conductivity of seed soak water (EC) of peanuts harvested in 1990, 1991 and 1992.**

| Maturity class | Final dry weight | | | SG | | | AA | | | EC | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 1991 | 1992 | 1990 | 1991 | 1992 | 1990 | 1991 | 1992 | 1990 | 1991 | 1992 |
| | % | | | | | | | | | μmhos $cm^{-1}g^{-1}$ | | |
| | | | | | | NC 7 | | | | | | |
| Y1 | 45 | 27 | 43 | 80c[a] | 94a | 49d | — | 78c | — | 80a | 62a | 234a |
| Y2 | 62 | 61 | 56 | 88b | 94a | 58c | 74b | 86bc | 3 c | 38b | 33b | 192a |
| OR | 77 | 84 | 74 | 94ab | 98a | 84b | 89a | 94ab | 14 c | 18c | 13bc | 94b |
| BR | 99 | 96 | 93 | 95ab | 92a | 96a | 92a | 92ab | 73 b | 16c | 16bc | 36bc |
| BL | 100 | 100 | 100 | 98a | 97a | 99a | 94a | 96a | 96 a | 9c | 7c | 26c |
| | | | | | | NC 9 | | | | | | |
| Y1 | 61 | 37 | — | 92a | 57c | — | 75b | 13d | — | 36a | 81a | — |
| Y2 | 86 | 56 | 53 | 90a | 76b | 60c | 74b | 31c | 3d | 19a | 58b | 150a |
| OR | 96 | 70 | 67 | 92a | 93a | 83b | 78ab | 75b | 20c | 17a | 12c | 100b |
| BR | 100 | 94 | 87 | 92a | 96a | 96a | 83ab | 93a | 63b | 19a | 8c | 57c |
| BL | 96 | 100 | 100 | 91a | 98a | 100a | 89a | 96a | 92a | 12a | 5c | 36d |

[a]Means in the same column followed by the same letter are not significantly different at P = 0.05.

level of seed maturity. In 1990, NC 7 seed reached maximum SG when pods reached OR stage, whereas no differences were observed in SG of seed from immature Y1 pods or mature BL pods for NC 9.

Germination of immature NC 7 seed was higher in 1991 than in 1990 or 1992. SG was over 90% for seed from Y1 pods in 1991 even though these seed had accumulated only 27% of their final potential dry weight. Germination percentage of immature NC 7 seed was very low in 1992. Seed that had accumulated 43 and 56% of their final dry weight (Y1 and Y2) germinated 49 and 58%, respectively (Table 2). Maximum SG in 1992 seed did not occur until the BR pod stage of development, when seed had amassed 93% of their potential final dry weight.

Germination of NC 9 seed in 1990 was 90% or greater, regardless of maturity at harvest (Table 2). In 1991 and 1992, SG of seed from Y1 and Y2 pods was considerably lower than that of seed from more mature pods. High levels of SG (greater than 90%) occurred when seed had accumulated 70% of their final dry weight in 1991, but not until they reached 87% of their final dry weight in 1992.

The germination test is the standard means of measuring seed quality. The test is used for labeling purposes and is conducted in a laboratory under ideal germination conditions. Growers know that conditions in the field at planting can be harsh and less than ideal for seed germination and seedling growth. Vigor tests, though not official or regulatory, are frequently used to determine if a seed lot is likely to perform well in the field when conditions can be stressful to the seed or seedling (AOSA, 1983). The two vigor tests used in this study are AA and EC.

Seed vigor, as measured by AA, increased significantly ($P \leq 0.05$) as the seed approached maturity. Maximum germination following AA did not occur in NC 7 seed produced in 1990 and 1991, until seed had reached OR pod or 77 and 84% of their final dry weight, respectively (Table 2). In 1992, high levels of germination following AA did not occur until seed had reached BL pod stage.

Similar patterns were seen in NC 9 seed. Germination following AA of immature NC 9 seed grown in 1990 were higher than those of 1991 or 1992 (Table 2). It was not until seeds reached 94% of their final dry weight (BR pod) in 1991 that high germination values following AA were seen. As with the NC 7 seed grown in 1992, NC 9 seed did not achieve a high level of germination following AA until the seed had reached physiological maturity (100% final dry weight).

The second vigor test, EC, is a measure of the amount of leakage that occurs from seed during the first few hours of imbibition. Cells of poor quality seed are often characterized as having excessive leakage during the initial stage of imbibition (AOSA, 1983; ISTA, 1987). Immature NC 7 seed had significantly higher EC values than mature seed, regardless of the year of production (Table 2). Low levels of leakage from seed grown in 1990 and 1991 occurred in seed from OR, BR, and BL pods, which had accumulated at least 77% of their final dry weight.

Significant differences were not observed in EC during 1990 for NC 9 seed regardless of maturity level. EC values of NC 9 seed decreased significantly in 1991 as pods matured; low levels of leakage occurred when seed had reached approximately 70% of their final dry weight (OR pod stage of development).

EC of NC 7 and NC 9 seed produced in 1992 was considerably higher than seed produced in 1990 or 1991 for all maturity classes (Table 2). The increased amount of leakage from 1992 seed is a reflection of the lower overall quality of the peanuts produced that year. There was a significant decline in EC as the 1992 seed approached maturity. Low levels of leakage were seen when NC 7 seed had reached 93% of their final dry weight (BR pod), but not until NC 9 seed had fully matured (BL pod or 100% of the final dry weight).

## Summary

This investigation shows that hull mesocarp color can

be used to estimate maturity of large-seeded, virginia-type peanuts. Seed from Y1, Y2, and OR pods of both cultivars varied considerably in moisture, maturity level (percent of final dry weight), germination, and vigor. Growers, however, are generally interested in pods of the BR and BL categories as an indicator of when to dig. Hull mesocarp color of the more mature NC 7 pods (BR and BL) corresponded to relative maturity of the crop for all three production years. Seed moisture content and percent final dry weight of NC 9 peanuts grown in 1990, however, differed considerably from those produced in 1991 or 1992. It is clear from this data that the relationship between hull mesocarp color and peanut maturity is responsive to the cultivar being grown and the environmental conditions during peanut seed development and maturation. The three very different years of production prompted varying responses from NC 7 and NC 9 cultivars.

This study also shows that germination and vigor of peanut seed is related to stage of development, cultivar, and environmental conditions during seed development. In years when weather conditions may adversely affect peanut seed growth and development, for example the 1992 season of this study, seed producers should avoid harvesting too early to assure adequate seed growth and maturity.

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