Studies on post-harvest seed handling techniques on grain amaranth
(Amaranthus hypochondriacus L.) cv. Suvarna

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ABSTRACT

Grain Amaranth is the leafy vegetable rich in lysine and having commercial value in culinary industries. Seeds of amaranth are tiny in nature and fetches much importance as crop is propagated through seeds and the economic product is both leaves and grains. Quality seed requires pre and post-harvest management techniques for assured productivity. In post-harvest handling, heterogeneous seeds are homogenized based on physical characters using mechanical and manual grading techniques. Such techniques are scanty in grain amaranth. Hence, studies were conducted to evaluate the influence of grading techniques on seed quality characters. Bulk seeds after extraction were size graded using two sieve sizes viz., BSS 20 x 20 and BSS 22 x 22 square wire mesh and density graded with specific gravity separator as heavier, medium and lighter seeds and with seed blower as retained and blown seeds. The results revealed that in size grading seeds retained in BSS 22 x 22 sieve recorded 87 per cent recovery with higher germination (96 %) and vigour index (883). The seeds graded (based on weight) with specific gravity separator with the machine setting of 0.5, 1.5 and 3.0 VHA revealed that collection of seeds from heaviest fraction recorded higher seed recovery (75 %) germination (98 %) and vigour index (1029). The studies on density grading with seed blower revealed that seed retained at bottom with 0.30 water pressure, improved the seed germination, seedling vigour in terms of root length (5.5 cm) shoot length (3.7 cm) and dry matter production (5.0 mg).

KEY WORDS: Density grading, grain amaranth, seed quality, size grading, specific gravity grading

INTRODUCTION

Grain amaranth native of Central America, (Stallknecht and Schulz-Schaeffer, 1993) belongs to the family of Amaranthaceae. Pale-seeded, highly nutritive grain amaranth is rich in lysine (5%) and sulphur aminoacid (4.4%) which are the limiting amino acids in plant kingdom but required for balanced human diet (Sounders and Becker, 1983). It is termed as “Poor man's spinach” and is recommended for combating malnutrition of the population in many parts of the world. Hence, it is considered as an alternative to cereal and this leafy vegetable propagated only through seeds. Good quality seed play a vital role in successful seed or crop production as the end product depends on the quality of seed used for sowing. In seed production programs, implication of post-harvest management techniques occupies a pivot role as the results of production techniques is value added only during this process. The major operation at post-harvest handling is the grading of
seeds, which assures improvement in physical purity by eliminating non seed material and foreign seed from the seed lot. Further the seed lot is homogenized using the physical characters of seed, which assures uniform germination and higher seedling vigour. The positive influence of size on higher seedling vigour was reported by Kalakanavar et al., (1989) in wheat and by Jerlin and Vadivelu, (2004) in pungam. The betterment of heavier seed weight, on germination, and field emergence compared to lighter seeds was also reported by Gowda and Gowda, (1996) in sorghum. Information on the influence of seed grading techniques of grain amaranth is scanty, hence studies were carried out in grain amaranth cv. Suvarna to evaluate the upgrading ability of physical grading on seed quality characters.

MATERIALS AND METHODS

The experiment was conducted at Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore. Freshly harvested seeds of grain amaranth (Amaranthus hypochondriacus L.) cv. Suvarna were graded based on size and density as following techniques.

MANUAL GRADING - Size grading

Based on size seeds were graded and separated with different sieves. Seeds were passed through the sieves, sequentially arranged based on size in reducing order as BSS 20 x 20 (bigger size) and BSS 22 x 22 square wire mesh sieves manually. The seeds retained and passed in the above sieves were weighed separately and were evaluated for seed recovery in percentage based on seeds retained on each of the sieves compared to bulk.

MECHANICAL GRADING

Specific gravity separator

Based on density, seeds were graded by using a laboratory model of specific gravity separator the seeds were separated into different grades with the machine setting of vertical slope (0.5), horizontal slope (1.5), air blow rate (3.0 / 3.5) and 500 RPM, which were separated in to five grades. The density graded seeds were designated as heaviest, heavy, medium, light and lightest. The seeds separated in each of the grades were evaluated for seed recovery in percentage based on the initial weight of bulk seed used for grading.

Seed blower

Based on specific gravity, the bulk seeds were graded by using South Dakota air blower highly used in seed testing laboratory is used to separate the light weight inert material from the heavy seeds. Using Seed blower, bulk seeds of amaranth were blown with different water pressures viz., 0.35 (P), 0.30(P) and 0.25(P) to separate the seed based on density and were collected at the top and the bottom mesh, which were designated as blown and retained seed respectively and evaluated for seed recovery (%) in each of the grades based on total weight of bulk seed used for blowing.

Seed and seedling quality evaluation

The seeds obtained through all grading techniques as well as the control (not graded) were evaluated for the seed and seedling quality characters viz., 100 seed weight, seed germination, seedling length and drymatter production were observed as per ISTA (1999). The seeds size graded with sieves were also evaluated for protein...
content as per (Alikhan and Youngs, 1973) and vigour index values were computed as per Abdul baki and Anderson (1973) adopting the following formula as it is the totality of seed quality characters.

Vigour index = Germination (%) x Total seedling length (cm)

Statistical analysis

The data collected for the various parameters of the grading experiments were subjected to statistical analysis in a IBM PC compatible, HCL computer using Agrostatistical format for evaluating the analysis of variance and tested for significance according to Panse and Sukhatme, (1967).

RESULTS AND DISCUSSION

The purpose of grading is to improve the homogeneity of the seed lot by eliminating the seeds of the same species with low quality. During size grading, the small seeds are discarded which are believed to be empty, underdeveloped and low vigour seeds. The importance of seed size has been reported by Ramesh (1996) and Menaka and Balamurugan (2008) in carrot and amaranthus seeds respectively. The results on size grading (Table 1) revealed that among the three grades of seeds retained by BSS 20 x 20 and BSS 22 x 22 the maximum and minimum seed recovery were obtained in the 22 x 22 sieve (87%) and 20 x 20 sieve (5 %) respectively. Maximum and minimum 100 seed weight were obtained from the sieve size 20 x 20 (86 mg) and 22 x 22 passed (53 mg) respectively. The 1000 seed weight increased with the increase in seed size and was in accordance with the findings of Sabir-Ahamed (1989) in soybean. Seed size and seed weight was also to have

positive influence in sunflower by Balamurugan (1993) and in amaranthus by Menaka (2000) and in palak by Chakravarthy (2004).

Germination capacity is an important indicator of seed quality. Seeds retained in each of the sieve size viz., BSS 20 x 20, BSS 22 x 22 and that passed through BSS 22 x 22 sieve recorded a germination of 97, 96 and 70 per cent respectively highlighting the reduction in germination with higher sieve size retaining smaller seeds. Large and medium size seeds recorded a higher germination than bulk seeds, while the reject recorded 26 per cent lower germination than bulk seeds. Thus a positive association between seed size and germination was exerted in grain amaranth. Ashby (1936) in his initial capital theory expressed that initial stamina of the seed is expressed during regeneration, based on the availability of quantum of nutrient available within the seed. Similar positive influence between seed size and germination was reported by Sokolowska et al. (1997) in carrot. The higher germination in large seeds might also be due to the increased activity of the redox enzyme in large seeds helping in the breaking down of the complex reserve food materials into simple soluble sugars (Gurbanov and Berth, 1970).

The seed vigour, as measured through root and shoot length and dry matter production of seedlings, showed the superiority of larger sized seeds. The large size seeds from BSS 20 x 20 recorded maximum shoot length, root length and dry matter production of 5.4 cm, 4.0 cm and 8.0 mg/10 seedlings, respectively. The seeds from 22 x 22 BSS retained sieve also had higher germination, root length, shoot length, dry matter production and vigour index followed by BSS 20 x 20. The smaller
seed recorded minimum values of 3.2 cm, 2.7 cm and 5.0 mg 10/seedlings, respectively, for the above parameters. The computed vigour index values were higher for seeds retained in BSS 20 x 20 sieves (921) and it decreased by 4 per cent with the seeds retained in the sieve size of BSS 22 x 22. The vigour index values of bulk seeds were 10 per cent lesser than seeds retained in BSS 20 x 20 sieve. All the evaluated vigour parameters exhibited a rhythmic reduction with large, medium, smaller sized seeds and rejects. Pollack and Roos, (1972) reported that larger seeds possessed more vigour than smaller seeds due to the presence of more of food material. Jayasheere (1996) in cotton and Rajasekaran (2001) in niger also observed that seedling vigour characteristics were positively correlated with seed size and seed weight. The nutrient content of the graded seed measured in terms of Protein content was also higher in larger sized seed retained in (15.5 %) and was followed by (14.0 %). Thus the study highlighted that amaranth seed exerted a positive association between seed size seed weight and seed quality characters and the seeds retained on BSS 22 x 22 sieve could be selected for commercial purpose as seeds had higher seed quality characters than bulk along with higher recovery. Hence the amaranth cv. Suvarna could be graded with BSS 22 x 22 for obtaining high quality seeds.

In this modern era, combined grading of seeds with continuous set up of machineries is recommended for preparation of seed for precision sowing either based on one or two physical characters is becoming popular with post harvest handling of seeds in agricultural crops (Anon, 2002; 2003; NSP Crop Report) Specific gravity grading is one of the mechanical methods of seed grading using specific gravity separator. Hence, an attempt was made in grain amaranth to homogenize the seed based on specific gravity. The specific gravity separator got the adjustmentsviz., horizontal slope, vertical slope and air flow rate and works on the principle of floatation. A combination of shaking and air flow up through the deck causes the seeds to stratify according to the specific gravity, producing a layering effect. The heavier particle move to the top and lighter particles to the bottom and the lightest seeds float down under gravity and are discharged at the lower end, while the heaviest ones are kicked up by the slope by its contact with the oscillating deck and discharged at the upper end. Before resorting to actual separation of seeds, the optimization of the machine setting was made in order to obtain perfection in seed separation. Accordingly the slopes of the deck were fixed at (V) vertical (0.5) and (H) horizontal (1.5) slope with the (A) air blow rate adjustments of 3.0. On grading with bulk seeds, the recovery of seed varied significantly with grades which separated into five different fractions. Among the five grades, the heaviest seeds recorded higher recovery and it was followed by heavy, medium, light and lightest weight fractions while the recovery of seeds under light and lightest were the lowest ranging as 4.0 and 1.0 per cent respectively highlighting the uniformity maintained with the seed in this small seeded crop. However the highest recoveries of seeds were observed with the heaviest seed (75%) and was followed by heavier seeds (14%), highlighting the homogeneity maintained by the crop on seed weight basis where the seed and seed coat is closely attached.

The physical seed quality factor, the 100 seed weight observed a positive association with specific gravity grading indicating the separation of seeds based on
weight. Patil and Sarode (1988) and Gowda and Gowda, 1996 in Agricultural crops also obtained the highest 100 seed weight with the heaviest and heavier seeds received from the spout levels of the specific gravity separator and recorded higher germination with those seeds compared to lower spout levels of the mechanical separator. The germination of the seeds of heaviest fraction recorded the highest value of 98 per cent and was followed by heavier (95 %) and medium (93 %) lighter (70%) and the Lightest (40%) seeds. Dharmalingam (1989) and Anon (1998) in Eucalyptus; Srimathi (1997) in Amla; Umarani (1999) in Casuarina reported similar positive influence between seed weight and sequential sample grades of specific gravity grading.

Physiological characters in terms of vigour parameters evaluated through root and shoot length, dry matter production and vigour index also exerted a positive association with seed weight and seed germination (Table 2). The heavier seed recorded the maximum root length (6.3 cm) shoot length (4.2 cm), drymatter production (8.0 mg) and vigour index (1029). Similar results were reported by Menaka, 2000 in amaranthus and Balamurugan (1993) in sunflower. Thus the study highlighted that collection of heaviest and heavy seeds after specific gravity separation with the setting of 0.5, 1.5 and 3.0 VHA would be beneficial for selection of quality seed as the recovery (89%) and the seed quality characters (97% Germination) were the maximum.

Seeds are graded based on specific gravity adopting different methodologies viz., salt water floatation (Anon, 1999), water floatation (Srimathi, 1997) and organic solvent floatation technique (Natarajan, 2000) as an alternative to mechanical specific gravity separation. Seed blower is the seed testing equipment, works with the principle of specific gravity separation, used for separation of inert material using differential air flow rate from small seed species (Tunwar and Singh, 1985). Since the amaranthus seeds are tiny in nature an attempt was made to separate the seeds using seed blower and to evaluate the seed quality characters of blown and retained seeds as this could be helpful in conditions where the specific gravity separator is not available. Hence an attempt was made to separate the illfilled seeds of grain amaranth using seed blower. The experiment conducted with 3 different water pressures viz., 0.35 (P), 0.30 (P) and 0.25 (P) using bulk produce revealed that as the water pressure increased the recovery of blown seeds were higher. During blowing 95, 87 and 80 per cent of seeds were retained at the bottom of the blowing container with increase in water pressures as 0.35 (P), 0.30 (P) and 0.25 (P) respectively that where adjusted with air blow rate. Harakumar (1997) in gymnema and Suma (2005) in sesame also revealed that water pressure in terms of air blown velocity decides the recovery of seeds at the bottom portion which are known for their higher density.

Evaluation of pure seed fraction of blown and retained seed expressed that irrespective of water pressures the retained seeds recorded cent per cent pure seed. But in blown seed the pure seed content increased with water pressure as 0.35 (P), 0.30 (P) and 0.25 (P) as the illfilled and immatured seed also lifted along with inert matter and settled at top portion leaving the good seed at bottom. The analysis on seed quality characters in terms of 100 seed weight, germination and vigour expressed that the retained seeds irrespective of water
pressure recorded higher seed quality characters than the blown seeds (Table 3). But considering the seed recovery and the quality characters of retained seeds, seed retained after blowing at 0.30 water pressure could be selected for seed purpose as this would increase the amount of seed gained for sale of quality seed though the germination was lesser by 2 per cent which was on par with seed blown at 0.25 water pressures. The seedling vigour characters measured through root length (5.5 cm), shoot length (4.0 cm), dry matter production (5.0 mg) and vigour index (865) values were also higher with the retained seeds. The principle behind the separation might be the relationship between the seed weight and seed quality characters (Jacqueline and Ramaswamy, 1988). But in stringent basis, for maintenance and carryover of seed for longer duration of seeds retained after blowing with 0.30 water pressure could be selected as it recorded the highest seed and seedling quality characters with the higher recovery of 8 per cent than the seeds retained with 0.25 water pressure. Thus the study expressed that grading of seed with seed blower using 0.30 water pressure and selection of retained seed could improve the seed and seedling quality characters of grain amaranth seed.

**CONCLUSION**

Thus the study expressed the following as the suitable post-harvest grading techniques for grain amaranth and recommended the use of anyone of this technique for upgrading the quality of harvested seed.

- Size grading of seeds with BSS 22 x 22 sieve and selection of retained seed for higher recovery of quality seeds.
- Grading with specific gravity separator with the machine setting of 0.5, 1.5 and 3.0 VHA collection of heaviest and heavy seeds of aided in selection of quality seed.
- Grading with seed blower at 0.30 water pressure and selection of seeds retained at bottom for improved the seed and seedling quality characters.

### Table 1: Influence of size grading on seed quality characters of grain amaranth

<table>
<thead>
<tr>
<th>Size of sieves / Characters</th>
<th>Sieve sizes</th>
<th>BSS 20X20 Retained</th>
<th>BSS 22X22 Retained</th>
<th>BSS 22X22 Passed</th>
<th>Bulk seed</th>
<th>SEd</th>
<th>CD(P=0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed Recovery (%)</td>
<td></td>
<td>5</td>
<td>87</td>
<td>8</td>
<td>-</td>
<td>0.745</td>
<td>1.522</td>
</tr>
<tr>
<td>100 Seed weight (mg)</td>
<td></td>
<td>86</td>
<td>84</td>
<td>53</td>
<td>84</td>
<td>0.805</td>
<td>1.650</td>
</tr>
<tr>
<td>Germination (%)</td>
<td></td>
<td>97</td>
<td>96</td>
<td>70</td>
<td>93</td>
<td>1.363</td>
<td>2.8144</td>
</tr>
<tr>
<td>Root length (cm)</td>
<td></td>
<td>5.4</td>
<td>5.2</td>
<td>3.2</td>
<td>5.0</td>
<td>0.049</td>
<td>0.100</td>
</tr>
<tr>
<td>Shoot length (cm)</td>
<td></td>
<td>4.0</td>
<td>4.0</td>
<td>2.7</td>
<td>4.0</td>
<td>0.039</td>
<td>0.080</td>
</tr>
<tr>
<td>Dry matter production 10 seedling⁻¹ (mg)</td>
<td></td>
<td>8.0</td>
<td>7.7</td>
<td>5.0</td>
<td>7.0</td>
<td>0.073</td>
<td>0.151</td>
</tr>
<tr>
<td>Vigour Index</td>
<td></td>
<td>921</td>
<td>883</td>
<td>413</td>
<td>837</td>
<td>8.049</td>
<td>16.489</td>
</tr>
<tr>
<td>Protein content (%)</td>
<td></td>
<td>15.60</td>
<td>15.54</td>
<td>14.00</td>
<td>15.42</td>
<td>0.168</td>
<td>0.344</td>
</tr>
</tbody>
</table>

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Table 2: Influence of density grading using specific gravity separator on seed quality of grain amaranthus

<table>
<thead>
<tr>
<th>Characters</th>
<th>Heaviest</th>
<th>Heavy</th>
<th>Medium</th>
<th>Light</th>
<th>Lightest</th>
<th>Ungraded</th>
<th>SEd</th>
<th>CD (P=0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed recovery (%)</td>
<td>75</td>
<td>14</td>
<td>6</td>
<td>4</td>
<td>1</td>
<td>-</td>
<td>0.98</td>
<td>2.079</td>
</tr>
<tr>
<td>100 Seed Weight (mg)</td>
<td>90</td>
<td>87</td>
<td>78</td>
<td>56</td>
<td>30</td>
<td>85</td>
<td>1.55</td>
<td>3.248</td>
</tr>
<tr>
<td>Germination (%)</td>
<td>98</td>
<td>95</td>
<td>93</td>
<td>70</td>
<td>40</td>
<td>90</td>
<td>2.02</td>
<td>4.250</td>
</tr>
<tr>
<td>Root length(cm)</td>
<td>6.3</td>
<td>6.0</td>
<td>5.5</td>
<td>4.2</td>
<td>3.5</td>
<td>5.4</td>
<td>0.11</td>
<td>0.232</td>
</tr>
<tr>
<td>Shoot length(cm)</td>
<td>4.2</td>
<td>4.0</td>
<td>3.7</td>
<td>3.0</td>
<td>2.5</td>
<td>4.0</td>
<td>0.08</td>
<td>0.158</td>
</tr>
<tr>
<td>Drymatter production 10 seedling^-1(mg)</td>
<td>8.0</td>
<td>7.7</td>
<td>7.0</td>
<td>5.5</td>
<td>4.0</td>
<td>7.5</td>
<td>0.14</td>
<td>0.295</td>
</tr>
<tr>
<td>Vigour Index</td>
<td>1029</td>
<td>950</td>
<td>856</td>
<td>504</td>
<td>240</td>
<td>864</td>
<td>16.94</td>
<td>35.597</td>
</tr>
</tbody>
</table>

Table 3: Influence of density grading using seed blower on seed quality

<table>
<thead>
<tr>
<th>Water pressure (P)</th>
<th>Seed recovery (%)</th>
<th>100 seed wt (mg)</th>
<th>Pure seed (%)</th>
<th>Germination (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Blown</td>
<td>Retained</td>
<td>Mean</td>
<td>Blown</td>
</tr>
<tr>
<td>0.35</td>
<td>5</td>
<td>95</td>
<td>50</td>
<td>35</td>
</tr>
<tr>
<td>0.30</td>
<td>13</td>
<td>87</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>0.25</td>
<td>20</td>
<td>80</td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>Mean</td>
<td>13</td>
<td>87</td>
<td>50</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>W</td>
<td>BXW</td>
<td>B</td>
</tr>
<tr>
<td>SEd</td>
<td>0.649</td>
<td>0.795</td>
<td>1.125</td>
<td>0.602</td>
</tr>
<tr>
<td>CD (P=.05)</td>
<td>1.341</td>
<td>NS</td>
<td>2.322</td>
<td>1.244</td>
</tr>
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Table 3 Contd..

<table>
<thead>
<tr>
<th>Water pressure (P)</th>
<th>Root length (cm)</th>
<th>Shoot length (cm)</th>
<th>Dry matter production 10 seedling -1 (mg)</th>
<th>Vigour index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Blown</td>
<td>Retained</td>
<td>Mean</td>
<td>Blown</td>
</tr>
<tr>
<td>0.35</td>
<td>4.0</td>
<td>4.5</td>
<td>4.2</td>
<td>2.5</td>
</tr>
<tr>
<td>0.30</td>
<td>4.5</td>
<td>5.5</td>
<td>5.0</td>
<td>3.5</td>
</tr>
<tr>
<td>0.25</td>
<td>5.0</td>
<td>6.0</td>
<td>5.5</td>
<td>4.0</td>
</tr>
<tr>
<td>Mean</td>
<td>4.5</td>
<td>5.3</td>
<td>5.0</td>
<td>3.3</td>
</tr>
<tr>
<td>SEd</td>
<td>0.055</td>
<td>0.067</td>
<td>0.095</td>
<td>0.035</td>
</tr>
<tr>
<td>CD (P =.05)</td>
<td>0.113</td>
<td>0.139</td>
<td>NS</td>
<td>0.073</td>
</tr>
</tbody>
</table>

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