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Standardization of optimum pellet size for improving seedling vigour in Amaranthus (*Amaranthus tricolor*)

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Abstract
The experiment was conducted at Department of Seed Science and Technology, TNAU, Coimbatore during 2020-2021 to standardize the pellet size for easy handling in Amaranthus var. CO_2. The seeds of *Amaranthus tricolor* were circumscribed by small amount of filler materials and adhesive to produce a globular unit of size and also supply nutrient to the plant. Pellet size in terms of seed size has been standardized by using TNAU pelleting powder as filler material and gum acacia as adhesive to suite the requirement of precision sowing with minimum seed rate. Results showed that the pellet size of 3.2 mm was found to be optimum for mechanized sowing and 14 layers of coating with filler material increases the seed size from 1.3 to 3.2 mm. The seeds coated to 14 layers have recorded maximum germination (79%), root length (4.9cm), Shoot length (5.7cm), vigour index (2978) with speed of germination (5.4) at laboratory condition.

Keywords: *Amaranthus*, nutrient supply, pellet size, seed pelleting, seed quality

1. Introduction
Leafy vegetables play a major role in food security and human nutrition by providing minerals and vitamins. Amaranthus (*Amaranthus tricolor*) is one of the important leafy vegetable mostly cultivated in some regions of Asia and other parts of the world. Greens of *Amaranthus* cv. Co 2 have ascorbic acid (29.4 mg), Crude fibre (14.2 g), proteins (12.43 g), phosphorus (0.49 g), potassium (4.12 g), calcium (2.13 g), iron (19.40 mg), carotenoids (12.58 mg) and oxalate (737.15 mg). It is also known as poor man's spinach. The main problem in *Amaranthus* is their seed size; because of small size, a large quantity of seeds are being wasted during sowing and also needs a substantial number of labourers for sowing and thinning. These problems can be addressed by mechanized sowing. Hence, Seed pelleting is one of the seed enhancement techniques in which the seeds are coated with inert/nutrient material with the help of adhesive which will increase the seed size to the required level. Pelleting is mostly practiced in small (Halmer, 2003) [5] and irregular shaped seeds for easy handling and also helps in mechanized sowing. The pelleting material serves as an appropriate carrier for biofertilizers, insecticides, fungicides and nutrients (Dunning *et al*., 1985 and Chaya Devi., 2017) [4]. Pelleting is also helps to provide uniform plant spacing by mechanized sowing. Sowing of pelleted seed offers protection from rodents, birds and insects (Manjunath *et al*. 2009) [7]. Seeds pelleted with nutrients improve the initial growth and emergence of the seedling (Roos *et al*., 1979) [9]. With the objective of optimization of seed pellet size in *Amaranthus* for mechanized sowing, a study was taken up at Department of Seed Science and Technology, Coimbatore during 2019-20.

2. Material and Methods
2.1 Materials
Amaranthus CO_2 seeds with minimum of 70 per cent germination was obtained from Vegetable research station, palur. For pelleting the seeds, TNAU Pelleting mixture was used as inert material and gum acacia @ 4% was used as adhesive. The gum acacia 4% was prepared by mixing 40 g powder in 1 litre of water.

2.2 Methods
While pelleting, the seeds were spreaded in a thin layer and sprayed with adhesive (4%) over the seeds. Wet seeds were transferred to a container and measured quantity of pelleting mixture was added for each layer of pellet as detailed below (Flow chart 1) and the seeds were pelleted up to 12 layers (S_1), 14 layers (S_2) and 16 layers (S_3).

Between each step, gum was sprayed for effective coating of pelleting mixture while pelleting, the container was rotated vigorously to avoid the multi and pseudo pellets and to facilitate uniform distribution of pelleting mixture. After completion of pelleting process, the pelleted seeds were dried in hot air oven maintained at 40 °C for 2 hr to increase the compactness. Unpelleted seeds served as control.

The size of pelleted and unpelleted seeds was measured by using vernier calliper. Germination test for pelleted and unpelleted seeds was carried out in paper medium using 400 seeds for each treatment with four replications @ 100 seeds per replication. The paper towels were kept in a germination room maintained at a temperature of 25±1 °C and RH of 96± 2 per cent with diffused light (approx. 10h) during the day. Final count on normal seedlings was recorded on eighth day and percent germination was computed. All normal seedling were measured for root length (between collar region and tip of primary root), shoot length (from collar region to tip of leave) and expressed in cm. The vigour index value was calculated as per Abdul Baki and Anderson, 1973 [1] and expressed in whole number. For determination of dry weight, the seedlings were dried in a hot air oven maintained at 85±1 °C for 24 h and kept in a desiccator for 30 min and weighed in an electronic digital balance and mean dry weight was arrived and expressed as mg 20 seedlings^{-1}.

3.1 Equation

The speed of germination was calculated by the procedure given by Maguire, (1962); the protrusion of plumule from pelleted seeds were counted daily from sowing up to final count day and calculated the speed of germination as per the formula:

$$\text{Speed of germination} = \frac{X1}{Y1} + \frac{X2\text{-}X1}{Y2} + \ldots\ldots + \frac{Xn\text{-}Xn\text{-}1}{Yn} \quad (1)$$

X_1 - Number of seeds germinated at first count.

X_2 - Number of seeds germinated at second count Xn-Number of seeds germinated on nth day.

Y_1 - Number of days from sowing to first count.

Y_2 - Number of days from sowing to second count.

Yn- Number of days from sowing to nth count.

For fragmentation test, 100 pellets in two replications were taken in a plastic bag and vigorous manual shaking was given for one minute. After that, the number of broken and cracked pellets were recorded (Tamilselvi, 2017) [10].

Double pellet i.e., a pellet containing two seeds and pseudo pellet i.e., a pellet without seed were counted using 400 seeds in four replications each with 100 seeds.

Dissolution rate of pelleted seeds was calculated by dropping ten randomly selected pelleted seeds in water and time taken to dissolve the pelleted material was recorded (Dogon *et al*., 2005) [3].

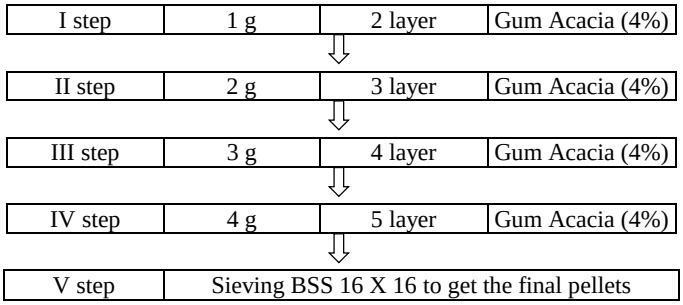
2.3 Statistical analysis and methodology used

The data observed from laboratory experiments were analysed statistically for F test of significance adapting the methods described by Panse and Sukatme (1985) [8] whenever necessary value in the percent data was transformed to angular transformation and at 5% level critical difference was computed.

4 Results and Discussion

4.1 Physical properties of pellet

The seeds pelleted to different layers were examined for their physical properties and suitability for germination under laboratory condition. The results are presented here under.



Flow Chart 1: Details of seed pelleting process (for 15g of seeds)-TNAU pelleting mixture

Table 1: Effect of physical parameters on various layers of TNAU pelleting mixture pelleted seeds

Pellet size	Size of the seed/pellet (mm)	Length of seed/pellet (mm)	Breadth (mm)	1000 seed weight (g)	Fragmentation %	Double seeds (%)	Pseudo pellet (%)	Time taken for dissolution	
								Initial (min)	Final (min)
Control (S_0)	1.1	1.43	1.01	0.91	-	-	-	-	-
12 layers (S_1)	2.6	2.27	2.02	11.07	0.3	0.7	0	2.6	5.7
14 layers (S_2)	3.2	2.42	2.17	12.63	0.2	0.4	0	3.3	6.1
16 layers (S_3)	3.4	3.12	2.97	14.10	0	0.3	0	5.6	7.4
Mean	2.6	2.3	2.05	8.9	0.2	0.5	0	3.8	6.4
S Ed	0.06	0.02	0.03	0.10	0.01	0.01	-	0.01	0.06
CD (P = 0.05)	0.13	0.05	0.05	0.22	0.01	0.01	-	0.02	0.14

The maximum pellet size of (3.4 mm) was noted in 16 layers followed by 14 layers (3.2 mm) and the lowest (12 layers) was observed to be minimum (2.6 mm) which have been lower than the unpelleted seeds. In which the maximum length (3.12 mm) was recorded in S_3 (16 layers) but S_0 (control) recorded minimum length (1.43 cm). The maximum breadth of seed was recorded in S_3 (2.97 mm) followed by S_2 (2.17 mm) and the least breadth was observed in unpelleted control (S_0-1.01 mm). The thousand seed weight of pelleted seeds was maximum than unpelleted seeds because of adding filler materials S_3 (16 layers of pelleting) showed maximum 1000 seed weight (14.10 g) than other two layers (S_1-11.07 g and S_2-12.63 g).

Table 2: Effect of physical parameters on various layers of TNAU pelleting mixture pelleted seeds

Pellet size	Speed of germination	Germination (%)	Root length (cm)	Shoot length (cm)	Vigour index	Dry matter production (mg/20 seedlings)
Control (S_0)	4.7	77	3.9	5.1	2345	31.7
12 layers (S_1)	4.9	78	4.6	5.3	2698	34.9
14 layers (S_2)	5.1	79	4.9	5.7	2978	37.7
16 layers (S_3)	5.4	79	4.2	5.4	3144	39.8
Mean	5.1	78	4.4	5.3	2857	36.0
S Ed	0.06	0.57	0.06	0.08	30.97	0.62
CD (P=0.05)	0.14	1.24	0.13	0.18	67.48	1.35

Different size of pelleted *Amaranthus* seeds in fragmentation test, the maximum broken and cracked pellets was observed in S_1 (0.3%) followed by S_2 (0.2%) and zero percent was observed in S_1. No pseudo pellet was observed in all the three pellets which showed high pelleting efficiency in *Amaranthus*. The maximum double seed per cent in pellet was noticed in S_1 (0.7%) but it was minimum in S_3 (0.3%) (Table 1). Among the three different pellets, S_1 had taken lesser time to dissolute (5.7 min) when compared to S_3 (7.4 min). Due to more number of layers, S_3 might have taken longer duration for dissolution. Dogan *et al*., (2005) [3], reported that massive diameter of pelleted seeds causes the less dissolution rate and imbibition of water and the author opined that the low rate of imbibition might be the reason for longer germination period and less speed of germination.

Irrespective of size of pellets, significant difference was observed in speed of germination due to pelleting over unpelleted seeds. Among the pellet size, S_3 recorded maximum speed of germination (5.4) over S_3 (5.1). In case of seed germination percentage, S_2 (14 layers) and S_3 (16 layers) showed maximum germination (79%) which was on par with each other. The maximum root length (4.9 cm) was observed in S_2 (14 layers) which was on par with S_1 (4.6 cm) and the minimum root length was observed in control (S_0) (3.9 cm) (Table 2).

Fig 1: Pelleted seeds of Amaranthus var. CO_2

Pelleting of seeds with pellet mixture may supplement with nutrients which might have caused the increased emergence and vigour of the seedling (Roos *et al*., 1979) [9]. The TNAU pelleting powder enhances the supply of nutrient to the rhizosphere region. So, the pelleted seeds will attain maximum root length. Shoot length results betrayed that considerable difference was observed in unpelleted and pelleted seeds. The highest vigour index was observed in S_4 (2978) and minimum vigour index was observed in S_0 (2345). The maximum dry matter production was observed in S_4 (39.8 mg) over unpelleted seeds (31.7 mg) (Table 3.4).

5. Conclusion

It is concluded that pellet size of 14 layers (S_2-3.2 mm) recorded maximum germination, seedling quality characteristics, field emergence with high vigour and pelletization efficiency with uniform pellet size. Hence, the pellet size of 3.2 mm with 14 layers can be recommended as the optimum pellet size for mechanized sowing in *Amaranthus* var. CO_2 seeds.

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