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Standardization of protocol for seed pelleting in onion (*Allium cepa*) to improve seed handling

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ABSTRACT

A pelleting method for onion (*Allium cepa* L.) seed has been standardized using locally available cheaper materials, viz. vermicompost, cow dung and clay powders as stuffing materials, and methyl cellulose and polyvinyl alcohol as adhesive materials. The pelleted onion seeds resulted from this method were bold, smooth, round and uniform in size that helped in easy handling. The pellet weight was increased almost 4-5 times of nonpelleted seeds. The quality of pelleted seed was on par with nonpelleted seed in terms of germination and seedling vigour. The germination and seedling vigour index were 87% and 1117, respectively in pelleted seeds and 89% and 1169 in nonpelleted seed. The bulb yield of pelleted seed treatment (31.81tonnes/ha) was better than nonpelleted seed (27.85 tonnes/ha). The pelleted seeds could be stored for 3-4 months even under ambient conditions without decline in viability and vigour.

Key words: Field performance, Onion, Seed pelleting, Seed quality

Coatings are applied for a variety of reasons: improve physical properties of the seed for ease of handling, reduce pesticide dust used on seeds, better protection against diseases, and direct application of nutrients and growth regulators to increase seedling growth (Bennett *et al.* 1992). In the case of direct sowing precision sowing is difficult if seeds are too small and irregular in shape. Seed pelleting makes small and irregular shaped seeds into bold, round with smooth surface that helps in separation of seeds individually and easy handling of seeds during sowing. In crops like onion (*Allium cepa* L.) and carrot, the seed rate can considerably be reduced and thinning and gap filling operations can be eliminated totally by use of pelleted seed provided the seed is of high quality. For crops like onion, precise seed placement is of great advantage as uniform bulb development is assured with equal distance planting (Hill 1999). In recent years, there has been a shift from growing vegetable transplants on raised nursery beds in the open towards value added transplants in specially designed containers such as perforated plastic trays, plug trays, pre-spaced peat pellets etc. Planting of small and irregular shaped seeds individually in special containers is difficult and time-consuming. Pelleted seed helps in the mechanization of seed sowing in the field as well as in the nursery. In addition, bio-fertilizers, bio-active chemicals, seed protectants etc. can be incorporated effectively into the coating and pelleting that will be useful for ensuring better field emergence and crop establishment under sub-optimal conditions. Seed pelleting helps in supply of extra nutrients and provide an establishment medium (Wyk 1983). Techniques of pelleting and coating are not standardized for vegetable seeds in India. Presently available coating and pelleting materials are costly and the technology is a closely guarded secret by few MNC's. Few studies have been reported on seed pelleting in onion in India and abroad. The studies conducted by Srimathi *et al.* (2000) in tomato and Veena *et al.* (2008) in onion were not actually improving the shape and size of seeds but mere encrustation with small quantity of inert materials and only confined to lab and storage aspects. Similarly, Valsicova *et al.* (2012) reported the effect of seed pelleting in onion on lab germination and field emergence only. And these studies have not described the finer details of seed pelleting as to the particle size of the filler materials and the concentration of binding materials used. Hence there is a need for identifying cheaper yet effective pelleting materials. Although onion is grown mainly as a transplanted crop; a large area in many states of India is under direct sown crop. Hence, this study was conducted to find out the suitable low-cost pelleting materials and to standardize the technique of pelleting with bio-fertilizers and micronutrients and to study its effect on seed quality and field performance in onion.

MATERIALS AND METHODS

Fresh seeds of onion cultivar Arka Kalyan were used for this study. The seeds were cleaned and graded to get maximum germination. Initially we tried various materials,

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viz. gypsum, clay, cow dung, vermicompost, clay, red soil, sand, talc powders and leaf powders of neem, and *Pongamia* as filler materials and methylcellulose, polyvinyl alcohol, gelatin, rice gruel, guar gum, gum arabic as adhesives alone or in combination for their suitability as pelleting and coating materials in various concentrations. The pelleting materials were fine ground using flour mill or stone grinder and sieved using 200-micron sieves. The material which passed through 200-micron sieve was used for pelleting. After initial evaluation of all the above pelleting and adhesive materials, we settled down for cow dung, vermicompost, clay soil as pelleting materials and methyl cellulose (1.5%) and polyvinyl alcohol (2.0%) as adhesive materials. Vermicompost, cow dung and clay were used in 3:2:1 ratio by volume basis. Pan type pelletizer fabricated by INCOTEC India Pvt Ltd, Ahmadabad, was used to make pellets. Adhesives were sprayed uniformly on seed surface in very fine droplets using spray gun mounted on the pelletizer, whereas the pelleting material was put manually layer after layer till the desired pellet size was achieved. Care was taken so that each pellet contains single seed only. At the end, pellets were taken out of the pan and dried in shade for one day and then under sunlight till the moisture content of the pellets reduced to < 8 percent. Dried pellets were sieved first using 2.5 mm round sieve to remove pellets without seed and few undersized pellets and then sieved using 3.5 mm round sieve to remove few pellets with double seeds. Further, micronutrients such as zinc sulphate 5% and boric acid 1% and microbial consortium, viz. *Actinomycetes* + *Bacillus aryabhatai* (Microbial consortium I) and *Bacillus subtilis* + *Trichoderma harizianum* (Microbial consortium II) were incorporated concurrently along with pelleting material in following combinations:1) Pelleted only; 2) Pelleted with Zn and B; 3) Pelleted with Zn, B and microbial consortium I; 4) Pelleted with Zn, B and microbial consortium II; 5) Control (non-pelleted). The seeds were soaked in enough quantity of broth containing *Actinomycetes* + *Bacillus aryabhattai* at 10^6cfu/ml for 5 minutes before pelleting. In the case of *Bacillus subtilis* + *Trichoderma harizianum* the seeds were coated with a slurry containing consortium mixed with vermicompost powder and then surface dried before pelleting as described by Mohan Kumar *et al.* (2015). Micronutrients, viz. zinc sulphate and boric acid were ground into fine powder and mixed with the pelleting mixture. The pellets were tested for seed quality, the stability of microorganisms in pelleted seeds and field performance.

Observations on the shape and surface texture were made visually and pellet strength was measured by pressing the pellet between two fingers. The moisture content of pellets was determined by standard oven method by drying at 103 °C for 17 hr.

The pelleted seeds were evaluated for germination and vigour along with control. The pelleted and nonpelleted seeds were stored in cloth bags under ambient for 12 months to study the effect of pelleting on their storage.

Germination and vigour tests were conducted using between paper towel method with 4 replications of 100 seeds each. These seeds were placed in germination chamber maintained at alternate temperature of 20-30 ^{0}C and RH 90%. First count was recorded on 6th day and final germination was recorded on 12th day after incubation.

For estimation of seedling vigour index, the mean seedling length of 10 normal seedlings (cm) obtained randomly at the end of germination test period, was measured and this value was multiplied by germination percentage.

Field performance of pelleted seeds was evaluated in *rabi* 2012 using RCBD with 4 replications. The net plot size was 3.2 m^2 with the row to row spacing of 20cm and seed to seed spacing of 4-5cm. Seedling transplanting was taken as one of the treatments for comparison. The seeds were sown in the nursery bed on the same day when pelleted seeds were sown in the main field leaving the plots meant for seedling transplanting. After 25 days in nursery, the seedlings were transplanted to the main field in the vacant plots where pelleted seeds were sown. Other agronomic practices such as application of fertilizers, irrigation, plant protection measures and weed control were followed as per package of practices. The observations such as crop stand (number of plants/plot), plants with bulbs (%), single bulb weight (g), plot yield (kg) and yield/ha (tonnes) were recorded. The data on seed quality paprameters such as 100 seed weight, first count, final germination, abnormal seedlings, seedling length and vigour index were analyzed by CRD and field data on crop stand, plants with bulbs, yield/plot and estimated yield/ha by RCBD ANOVA. Treatments means were compared using critical difference values at P=0.01 for laboratory data and at P=0.05 for field data.

RESULTS AND DISCUSSION

Preliminary experiment on identification of suitable pelleting and adhesive materials

Among the pelleting materials evaluated gypsum alone or in combination with clay, neem, *Pongamia*, vermicompost or cow dung powders formed round pellets in onion. Among the adhesive materials tried such as methylcellulose, polyvinyl alcohol, gelatin, rice gruel, guar gum, gum Arabic, only methylcellulose (1-1.5%) and polyvinyl alcohol (1.5-2.0%) were found suitable for forming firm pellets. The pellets formed with gypsum alone were fragile, whereas the pellets with gypsum in combination with any of clay, neem, *Pongamia*, vermicompost or cow dung powders formed relatively firm pellets. The pellet weight was increased almost 3-4 times of nonpelleted seeds. The seed quality assessment showed that gypsum had an inhibitory effect on germination (16%) but in combination with clay, neem or cow dung powders (1:1 v/v) the germination was as good as control (72%). Field emergence of pelleted seeds except for gypsum and gypsum with *Pongamia* was as good as nonpelleted seeds (~63%). Seed pelleting technology is new to India and this technology has been developed and commercialized by few MNC's and hence remained as a highly guarded secret. Few studies published in the

literature have not given finer details of pelleting as to the exact filler materials used, their proportion, particle size of filler materials and the concentration of binding materials used (Valsicova *et al.*2012). Studies on seed coating in India are limited to film coating or at the most to seed encrustation with very little work on seed pelleting (Srimathi *et al.* 2000 and Veena *et al.* 2008). Basic studies such as selection of suitable stuffing and adhesive materials, steps to be followed during pelleting, particle size of stuffing material and concentration of adhesives to be used are very limited. Stuffing material is the major portion of a seed pellet and it must be an inert material, water soluble with fine and uniform particles and able to form enough pore to avoid restriction of gas exchange between germinating seed and the environment outside the pellet (Halmer 1987). Poor germination in seed pellets formed with gypsum as stuffing material in this preliminary study may be due to high pH created by it.

Refinement of seed pelleting technique and evaluation of seed pellets for seed quality and field performance

Further refinement of pelleting technique was made by totally eliminating gypsum as it was found to affect seed germination in the preliminary study and also it was found highly hygroscopic that might make drying seed pellets to reasonably low moisture level difficult. The combination of vermicompost, cow dung and clay powders as filler material and the combination of methyl cellulose (1-1.5%) and polyvinyl alcohol (1.5-2.0%) as adhesive material were used to get firm, smooth and round pellets of onion seeds. Further, micronutrients such as zinc sulphate 5% and boric acid 1% and bio-agents consortium, viz, *Actinomycetes* + *Bacillus aryabhattai* and *Bacillus subtilis* + *Trichoderma harizianum* were incorporated along with pelleting material in various combinations (Table 1). The size and weight of pellets were increased to 4-5 times of non-pelleted seeds (Table 1 and Fig 1) as a result separation of individual seeds was easy during sowing. Locally available cheaper materials such as vermicompost, cow dung and clay soil in a combination of 3:2:1 by volume basis used in the present study could meet the specifications of ideal stuffing materials as described by Hill (1999). Clay alone as stuffing material could restrict the gas exchange because of very fine particle size (Sooter and Miller 1978, Sachs *et al.* 1981, Silva and Nakagawa 1998). But in combination with vermicompost and cow dung powders, this problem could be eliminated as these materials are highly porous with higher bulk density. The addition of clay in small proportion could help in forming smooth pellets because of its fine particles. The other important aspect in seed pelleting is the use of right adhesives which bind the stuffing material firmly on seed surface and at the same time dissolves easily on contact with moisture. Many different compounds have been used as binders, including various starches, sugars, gum arabic, clay, cellulose, vinyl polymers (Halmer 1987). In the present study we tried many adhesives both natural and synthetic and found that

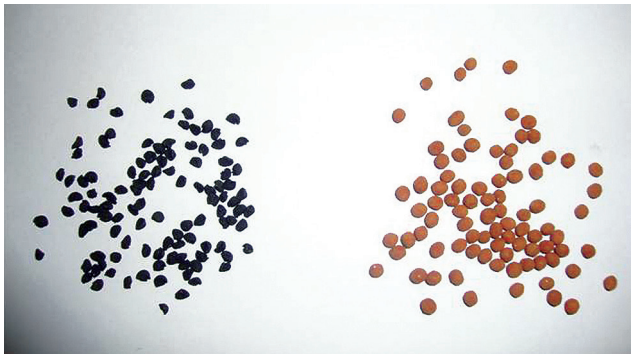

Fig 1 Nonpelleted (left) and pelleted (right) onion seed

methyl cellulose and polyvinyl alcohol in combination are suitable as adhesive materials as they formed round and firm pellets which dissolved easily when came in contact with moisture and they are effective at very low concentration, as a result, the cost of these adhesives is very meagre. In a similar study, Peske and Novembre (2011) reported that among the materials used to form the pearl millet pellet, the most efficient binders were the polyvinyl acetate and the methyl cellulose, and as coaters, the vermiculite and the microcellulose.

Seed quality evaluation under laboratory conditions showed no difference in final germination between pelleted and nonpelleted seeds except in seeds pelleted with microbial consortium II (*Bacillus subtilis* + *Trichoderma harizianum*) where the germination was significantly lower than other (Table 1). The speed of germination was slower in pelleted seeds as reflected in the first count. The seedling vigour index was same in both pelleted and non-pelleted seeds. Similarly, Olivera *et al.* (2003) observed slow germination of green pepper pelleted seeds but final germination was not affected. There was no additional benefit of combining microbial consortia and micronutrients along with filler material as for as total germination percentage was concerned; may be because of the low quantity of these things supplied through pelleting. Significant improvement in seed germination and field emergence was noticed in tomato seeds pelleted with zinc sulfate (Srimathi *et al.* 2000). Tomato seeds coated with microbial consortium II resulted in better germination and seedling vigour (Mohan Kumar *et al.* 2015).

Survival of microbes in dry seed pellets was found to be the limiting factor as the spore count decreased markedly from 10^6 to 10^4 within three months of storage under ambient conditions (Table 2) which were below the optimal count required for effective colonization. Reduced spore count and low vigour of spores in dry seed pellet may be the reasons far no additional benefit from microbial consortium either on seed quality or on field performance. These microbes are known to survive better in moist condition than at dry condition (Bushby and Marshall 1977, Mohan Kumar *et al.* 2015). As seed pellets need to be stored till the sowing time, pellets with high moisture cannot be stored even for few days unless they are dried to suitable moisture level. Hence, there is a need to find out microbial strains which

Table 1 Seed quality of pelleted onion seeds

Treatment	100 seed wt. (g)	First count (%)	Germn. (%)	Abnormal seedling (%)	Seedling length (cm)	Vigour index
Pelleted only	1.667	65.3	87.0	5.0	12.83	1117
Pelleted with Zn and B	1.633	63.7	84.7	5.0	12.60	1066
Pelleted with Zn, B and Microbial consortium I	1.588	62.7	87.0	4.0	11.57	1007
Pelleted with Zn, B and Microbial consortium II	1.698	62.0	76.0	3.3	12.97	985
Control (non- pelleted)	0.376	82.7	89.0	5.7	13.13	1169
SEm±	0. 15	2.9	1.6	0.8	0.60	55
CD (P=0.01)	0. 42	8.6	4.6	NS	1.74	159

Table 2 Survival of microorganisms in pelleted onion seeds (3 month old pelleted seeds)

Type of onion pellets	Cfu $\times 10^4$/ 50 pelleted seeds
Pelleted only-Control	0.6
Pelleted +*B. subtilis* + micro nutrients	4.3
Pelleted + *Actinomycetes* + micro nutrients	1.3
Pelleted + *B. aryabhattai* + micro nutrients	2.9
Pelleted +*T.harizianum* + micro nutrients	2.1

can withstand moisture levels to incorporate them through pelleting materials.

The pelleted onion seeds were sown during *rabi* 2012 along with non-pelleted seed. Seedling transplanting was taken as one of the treatments for comparison. The crop stand in pelleted seed was good and comparable with non-pelleted seeds (Table 3). There was not much difference with respect to the percentage of plants without bulbs. The bulb weight was significantly better in pellets with micronutrients than nonpelleted seed and transplanted crop but on par with other pelleted treatments. The bulb yield was significantly higher than non-pelleted and transplanted ones in some of the pelleted treatments; the highest being in Pelleted +Zn+B+ microbial consortium I (32.5 tonnes/ha). Dogan and Zeybek (2009) reported that the pelleted sesame seeds improved the yield significantly compared to the normal seeds. Contrary to this, Parashuraman (2001) reported that in cowpea seed pelleting with DAP and KH_3PO_4 did not influence seed quality and yield parameters appreciably. The recommended seed rate for onion is 4-5 kg/ha. By use of pelleted seed, the seed rate could be reduced markedly. In the present study pelleted seeds were sown at the rate of 10 kg/ha that works out to 2.3-2.5 kg in terms of nonpelleted seed. Hence, there is a reduction in seed rate at least by 1/3rd. Apart from saving the seed it also helps in avoiding thinning and gap filling operations because of precision planting and uniform crop stand. Because of these, we can expect higher marketable bulb yield as reflected in better bulb size in pelleted seeds than nonpelleted seeds. Very low yield in transplanted crop may be due to delay in maturity by 25 days compared to direct sown treatments which resulted in build up of purple blotch disease at bulb development stage resulting in lower bulb size and yield. The total cost of pelleting 1 kg of onion seed worked out to ₹ 150/ (approximately) as the main component of pellet, i.e. stuffing material used was locally available and cheaper also. The extra cost of pelleted seeds can be totally compensated by reduced seed rate of pelleted seeds. One kg of onion seeds after pelleting

Table 3 Field performance of pelleted onion seeds

Treatment	Crop stand /plot (no. of plants)	Plants with bulbs (%)	Bulb wt. (g)	Yield/plot (kg)	Estimated yield (tonnes/ha)
Pelleted only	131	95.4	58.25	7.63	31.81
Pelleted with Zn and B	120	94.4	61.77	7.32	30.49
Pelleted with Zn, B and Microbial consortium I	138	94.5	56.52	7.80	32.50
Pelleted with Zn, B and Microbial consortium II	122	96.1	59.94	7.32	30.49
Control (non-pelleted)	122	91.6	55.47	6.68	27.85
Transplanted	118	93.3	45.04	5.10	20.83
SEm±	7.2	2.6	3.4	0.44	1.86
CD (P=0.05)	NS	NS	6.84	0.89	3.71

Table 4 Seed quality of pelleted onion seeds after 3 and 6 months of storage under ambient conditions

Treatment	First count (%)		Germn. (%)		Seedling length (cm)		Vigour index	
	3 mon.	6 mon.	3 mon.	6 mon.	3 mon.	6 mon.	3 mon.	6 mon
Pelleted only	62.0	48.0	83.3	76.0	14.7	11.77	1193	889
Pelleted with Zn and B	76.7	55.3	79.3	70.7	14.9	12.63	1177	890
Pelleted with Zn, B and Microbial consortium I	76.7	52.0	84.0	77.3	15.0	12.47	1258	957
Pelleted with Zn, B and Microbial consortium II	61.3	30.7	78.7	72.0	14.5	12.03	1141	864
Control (non-pelleted)	82.0	58.0	86.0	78.7	14.9	12.83	1280	1006
SEm±	2.9	2.7	2.3	2.9	0.6	0.8	48	57
CD (P=0.01)	8.2	7.8	6.5	8.2	NS	NS	NS	NS

Table 5 Quality of pelleted onion seeds packed in moisture proof containers after 11 months of storage under ambient condition

Treatment	First count (%)	Germn. (%)	Seedling length (cm)	Vigour index
Pelleted only	83.5	90	12.5	1130
Pelleted with Zn and B	67.5	82	13.5	1105
Pelleted with Zn, B and Microbial consortium I	63	74.5	12.5	934
Pelleted with Zn, B and Microbial consortium II	29.5	65	11.7	760
Control (non- pelleted)	86.5	89.5	13.6	1220
SEm±	2.8	2.6	0.5	43
CD (P=0.01)	8.1	7.5	NS	124

weighs 3.5-4.0 kg depending on the size of the pellet, and weight and volume are the drawbacks of pellets as it requires more space during storage and transportation.

Evaluation of pelleted onion seeds for storage

Pelleted as well as non-pelleted seeds showed no reduction in germination and vigour up to 3 months of storage under ambient conditions compared to initial germination. When tested after 6 months of storage 5 to 10% reduction in germination was noticed in both pelleted and non-pelleted seed (Table 1 and 4). When pelleted seeds were dried to <8% and packed in moisture proof containers they could store up to 11 months (Table 5). However, pelleted seeds with microbial consortia showed a decline in germination and vigour even in moisture vapour proof containers after 11 months storage. The viability of pelleted seeds in storage is an important issue as not all pelleted seed are used immediately for sowing. Onion seed pellets could maintain its original viability and vigour till 3-4 months under ambient conditions. Similar observations were made by Srimathi *et al.* (2000) in pelleted tomato seeds. If a longer period of storage is required then seed pellets should be dried to less than 8% and stored in moisture vapour proof containers as revealed in the present study. Oliveira *et al.* (2003) observed the faster deterioration of pelleted green pepper seeds when stored in moisture permeable containers than in impermeable containers.

It can be concluded that combination of vermicompost, clay and cow dung powders as stuffing materials and the combination of methyl cellulose and polyvinyl alcohol as the adhesive were found suitable to get firm, round and smooth seed pellets in onion. The recommended seed rate for onion is 4-5 kg/ha. By use of pelleted seed, this seed rate could be reduced to 2.3-2.5 kg/ha. This works out to 10 kg/ha in terms of pelleted seed. The germination was not affected by pelleting. Pelleted seeds with bio-fertilizers failed to improve the germination. Field performance of pelleted onion seeds was found to be better than non-pelleted seeds with better bulb size and bulb yield. The microbial population in pelleted seeds declined significantly after 3 months storage. Pelleted onion seeds could be stored up to 3 months beyond that decline in germination and vigour was observed. Dried pelleted seeds packed in moisture proof containers could be stored up to 11 months. The cost of pelleting one kg of seed worked out to be ₹ 150.

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