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Optimisation of Sieve Size for Grading Seeds of Pole Type French Bean cv. Arka Sukomal

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Abstract

An experiment was conducted to study the effect of different seed size on quality and field performance in pole type French bean cv. Arka Sukomal. Bulk seed lot was subjected to processing by using six different slotted bottom screens of aperture size *viz*., 4.75, 4.50, 4.25, 4.00, 3.75 and 3.50 mm. Except for total dehydrogenase activity of seed, all the quality parameters significantly differed among the seed grades. Among the six sieves used, seed size ranging from <4.75 - 4.50 mm recorded the highest proportion of seed grade (29.95 %), germination (96.65 %) and for other seed quality parameters like root length (15.74 cm), shoot length (20.74 cm), mean seedling length (36.48 cm) and seedling vigour index-I (3446) were recorded highest in seed size ranging from <4.50 - 4.25 mm. Significantly higher seed weight (28.20 g), mean seedling dry weight (64.78 mg), seedling vigour index-II (6057) and total soluble protein (24.23 %) were recorded in seeds with >4.75 mm size. The lowest quality parameters were recorded in seeds ranging from <3.75 - 3.50 mm size. As seed size decreased the EC value and seed coat splitting percentage also decreased. Higher field emergence and green pod yield were recorded highest (97.45 % and 18.02 t ha^{-1}) with seed size having lesser than 4.75 mm to greater than 4.50 mm followed by seeds with size ranging from 4.25 - <4.50 and seed size of >4.75. Hence, sieve size of 4.25 mm for grading screen in Air Screen Cleaner can be recommended for seed processing of Arka Sukomal, a pole type French bean variety as it resulted in lower rejection level with higher seed quality and yield.

Keywords : French bean, Seed size, Bulk seed, Quality parameter

French bean [*Phaseolus vulgaris* (L.)] is an important legume vegetable crop cultivated in tropics, subtropics and temperate regions. It is nutritionally rich in proteins, fat, carbohydrates, vitamins and minerals. In recent times, the farmers are interested in cultivating pole type French bean due its indeterminate growth habit and production of more pods than bush type. Arka Sukomal is newly bred pole type French bean variety developed at ICAR - Indian Institute of Horticultural Research, Bengaluru. It is resistant to rust, pods are stringless and attractive and it has more yield potential than any commercially available pole type French bean varieties. As a result, demand for this variety is increasing among the farmers and there is growing demand for quality seeds. The production of good quality seed has got immense role in the seed industry. Seed size is one of the most important components that decide final yield and quality during crop production. In pole beans, the harvested seed lot has variation in seed size and densities. The deterioration of seed quality may be due to poor handling of seed after harvest that leads to poor and erratic field emergence and failure of seedling establishment in the field which subsequently results into lower productivity (Ganiger *et al.,* 2018).

Biotic and a biotic factor affect the physiological and biochemical processes during the growth and reproductive cycle of the plant that leads to variation in seed size and shape. Also, the seed harvested from different plants and at different positions within the plant exhibit size and shape variations which might be due to the variation in source-sink relationship and partly due to differences among seeds borne at different times on the same plant. Seed size, to some extent is an inherited character; it is also influenced by mother plant nutrition, moisture availability to the developing seed and its position in the plant (Angadi and Kumar, 2016). The sieve sizes recommended for processing different crop seeds under the minimum seed certification standard appear more general and not appropriate for all the newer varieties resulting in poor seed recovery. Hence the present study was taken up to determine the optimum sieve size for grading of seed, in order to improve the seed quality, recovery percentage and uniform field establishment of the crop.

Material and Methods

The laboratory and field experiments were carried out to optimise the suitable sieve size for grading in pole type French bean cv. Arka Sukomal. Harvested bulk seed lot obtained from *Rabi* season was processed through two screen air screen cleaner machine in which six slotted bottom screens of aperture size *viz*., 4.75 mm, 4.50 mm, 4.25 mm, 4.00 mm, 3.75 mm and 3.50 mm with one common top screen of 11.00 mm round were used for grading seeds into various sizes. Each individual graded seed lot was subjected for quality analysis at seed quality control lab, vegetable seed production unit, ICAR - Indian Institute of Horticulture Research, Hesaraghatta Lake post, Bengaluru. The laboratory experiment was conducted by adopting Completely Randomised Design (CRD) with seven treatments *viz*., T_1 : bulk seed, T_2 : > 4.75 mm, T_3 : 4.50-<4.75 mm, T_4 : 4.25-<4.50 mm, T_5 : 4.00-<4.25mm, T_6 : 3.75-<4.00 mm and T_7 : 3.50-3.75 mm, each treatment having four replications. These seven seed grades were evaluated in the field for growth and yield by adopting Randomised Complete Block Design (RCBD) with four replications. The raised beds of size one meter width were lined with drip lines and covered with mulch sheet. The seeds were sown on raised bed at a spacing of 1.5 meter between rows and 30 cm from plant to plant. The vines were supported to the twines that were tied to the poles. Other standard agronomic practices were followed for raising the crop. The following observations were recorded from laboratory and field experiments.

For seed coat splitting percentage one hundred seeds in four replicates were randomly collected from each treatment and the number of seeds having seed coat splits were counted and expressed in percentage. The seed germination percentage was worked out as per the procedure given by ISTA (Anonymous, 2011), seedling vigour index was worked out as per the formula given by Abdul-Baki and Anderson (1973), electrical conductivity of seed leachate by Presley (1958), total dehydrogenase activity test by perl *et al*. (1978) and total soluble protein was estimated as per the method prescribed by Lowry *et al*. (1951). Proportion of each seed grade in bulk is calculated by using the following formula and expressed in percentage.

$$\text{Proportion (\%)} = \frac{\text{Weight of seeds retained on each sieve}}{\text{Weight of raw seed}} \times 100$$

In field experiment seedling emergence was recorded after final establishment in each plot and percentage emergence was calculated. Ten plants from each plot were randomly selected and data recorded on plant height, number of branches, number of inflorescences, pod number and pod yield. Number of flowers within inflorescence was recorded from each five randomly selected plants from each plot. The pod yield per ha was calculated by using plot yield.

Statistical Analysis

The data obtained from lab and field experiments were analysed using analysis of variance for Completely Randomized Design and Randomised Complete Block Design (Gomez and Gomez 1984). The critical differences were calculated at 1 and 5 per cent level of probability wherever 'F' test was found significant.

Results and Discussion

The data on effect of different seed size on proportion of seed grade, test weight, seed coat splitting percentage and seed quality parameters are presented in Table 1 & Fig.1. Seed size significantly influenced on proportion of seed grade

TABLE 1

Influence of different sieve size for grading on proportion of seed grade, seed coat splitting, test weight and seed germination in pole type french bean cv. Arka Sukomal

Treatments	Proportion of seed grade (%)	Seed coat splitting (%)	Test weight (gm)	Seed germination (%)
T_1	100	28.82	20.05	91.18
T_2	29.95	48.75	28.20	93.50
T_3	33.18	30.58	24.25	96.65
T_4	19.95	24.48	21.08	94.45
T_5	9.98	21.02	18.10	90.18
T_6	3.13	17.55	17.80	87.94
T_7	1.43	16.40	17.04	85.37
S.Em±		0.78	0.18	0.52
CD (P=0.01)		2.29	0.52	1.53
CV (%)		5.82	1.70	1.14

T_1 : bulk seed; T_2 : > 4.75mm; T_3 : 4.50- <4.75 mm; T_4 : 4.25- <4.50 mm ; T_5 : 4.00- <4.25 mm ; T_6 : 3.75- <4.00 mm ; T_7 : 3.50- <3.75mm.

and treatment T_3 (4.50 - < 4.75 mm) showed the highest (29.95%) seed proportion because of less rejection due to high retaining of seeds over the sieve and this was significantly different from other treatments. The lowest (1.43%) seed proportion was recorded with T_7 (3.50-< 3.75 mm) due to higher rejection of seeds. This is because of undersized seeds dropped through perforations and only over sized seeds retained on the screens which have more food materials and bolder has high recovery than undersized seeds (Fatima Banu Sutar, 2018).

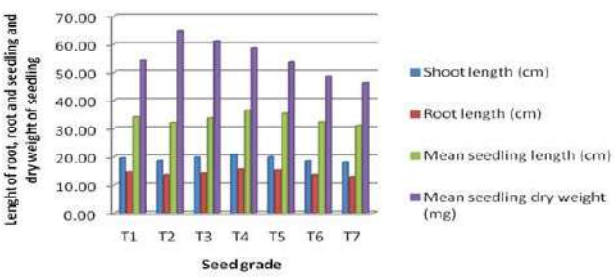

Fig. 1 : Influence of different sieve size for grading on root and shoot length, mean seedling length & mean seedling dryweight (T_1: bulk seed; T_2: > 4.75mm; T_3: 4.50- <4.50 mm; T_4: 4.25- <4.50 mm; T_5: 4.00- <4.25 mm; T_6: : 3.75- <4.00 mm; T_7: 3.50- <3.75mm

During processing the bigger sized seeds are highly subjected to mechanical damage than the smaller ones has less recovery (Vishwanth *et al.*, 2006). The results are in agreement with the findings of Vishwanath *et al.* (2006) in French bean cv. Arka Komal that had shown the highest seed recovery with 4.50 mm than 4.75 mm and 5.00 mm. Vishwanath and Ravi hunji, (2018) in soyabean reported that seeds retained on the screen of 4.50 mm sieve size had shown higher mechanical damage of seeds during processing. Fatima Banu Sutar (2018) in redgram resulted highest seed recovery in 4.50 mm than 4.75 and 6.00 mm

Seed coat splitting percentage was significantly influenced by seed size. As seed size decreased the seed coat splitting percentage also decreased. The lowest (16.40 %) seed coat splitting was recorded in T_7 and the highest in T_2 (48.75 %). Seed coat splitting is an issue in white seeded French bean varieties. Arka Sukomal being white seeded type exhibits seed coat splitting adjacent to hilum region upon maturity and drying. The insufficient supply of nutrients or moisture during seed development that leads to cracking of seed coat as studied in soyabean high germination lines with high boron and lignin content in seed coat resulted with reduction of cracking in seed coat as boron maintains the integrity of cell membrane (Bellaloui *et al.*, 2017). Test weight of the seed varied significantly among the seed grades and was found to be maximum (28.20 g) with T_2 followed by T_3 (24.25 g) and T_4 (21.08 g) which were on par with each other and significantly different from other seed grades. The lowest was noticed in T_7 (17.04 g). Test weight of seed increased with increase in seed size.

Germination which is an important quality parameter of seed was significantly influenced by different seed grades. Significantly highest germination (96.65%) was recorded in T3 followed by T4 (94.45 %) and T2 (93.50 %) whereas, the lowest (85.37 %) was registered by T7. Seed germination percentage was found to be lower in bigger seeds with >4.75 mm size and also in seeds with below

4.50 mm size. According to Negi et al. (1988) as larger seeds had more breaks in embryonic axis and other important seed parts than the smaller seeds and therefore showed poor germination and viability. Whereas in smaller seeds immature embryo and endosperm development leads to insufficient supply of reserve materials during germination. Similar findings were reported by Fatima Banu Sutar (2018) in redgram, Vishwanath and Ravi Hunji, (2018) in soyabean.

With respect to the seedling parameters, mean length of the root, shoot and seedling were found to be higher in T_4 (4.25 - < 4.50 mm) and differed significantly from other treatments whereas, the lowest was recorded in T_7 (3.50 - < 3.75 mm) (Fig. 1). Similarly, the highest seedling vigour index-I (3446) was recorded in T_4 followed by T_3 (3273), T_5 (3195) and $T\text{-}_1$ (3128). However, the lowest (2658) was registered with T_7 (Table 2). This increase in seedling vigour index-I was correlated with increase in germination and seedling length. Pollock and Roos (1972) reported that larger seeds possessed more vigour than smaller seeds due to the presence of more food material. Seedling vigour characteristics were positively correlated with seed size and seed weight. In contrast, Jose *et al.* (2016) in soyabean revealed that medium sized seeds had shown better seedling vigour than bigger and smaller ones. Vishwanath and Ravi hunji, (2018) in soyabean observed increased vigour index- I in smaller seeds than larger ones.

Significantly maximum mean seedling dry weight and vigour index-II were recorded with T_2 (64.78 mg and 6057) which was statistically on par with T_3 (61.12 mg and 5905) and T_4 (58.71 mg and 5546) but significantly different as compared to rest of the

TABLE 2

Influence of different sieve size for grading on seedling vigour index I and II, Electrical conductivity of seed leachate, total dehydrogenase and total soluble protein in pole type french bean cv. Arka Sukomal

Treatments	Seedling vigour index-I	Seedling vigour index-II	Electrical conductivity of seed leachate (iS cm^{-1})	Total dehydrogenase (A480 nm)	Total soluble protein (%)
T_1	3128	4945	656.15	1.28	20.50
T_2	3022	6057	764.65	1.67	24.23
T_3	3273	5905	662.50	1.93	22.95
T_4	3446	5546	582.13	1.56	20.80
T_5	3195	4829	519.68	1.45	19.30
T_6	2837	4286	472.75	1.17	19.02
T_7	2658	3957	469.00	1.16	18.60
S.Em±	39.02	113.54	15.92	0.21	0.24
CD (P=0.01)	114.75	333.93	46.83	NS	0.72
CV (%)	2.53	4.47	5.40	29.04	2.34

T_1 : bulk seed ; T_2 : > 4.75mm ; T_3 : 4.50- <4.75 mm ; T_4 : 4.25- <4.50 mm ; T_5 : 4.00- <4.25 mm ; T_6 : 3.75- <4.00 mm and T_7 : 3.50- <3.75mm.

treatments whereas, minimum (46.35 mg and 3957) was noticed with T_7 (Fig. 1 and Table 2). The increase in seedling dry weight and vigour index-II were correlated with the increase in seedling length. Larger seeds contained more number of cells per cotyledon in the form of reserve food material and thus had greater rates of dry matter accumulation and final dry weights (Guldan and Brun, 1985). Similar findings were reported by Vishwanath *et al.* (2011) in French bean cv. Arka Komal, Ali and Idris (2015) in faba bean, Fatima Banu Sutar (2018) in redgram, Vishwanath and Ravi hunji, (2018) in soyabean and Thakur *et al.* (2019) in chilli.

Graded seeds had shown significant difference in electrical conductivity (EC) of seed leachate. Lower (469.0 μScm^{-1}) seed leachate was observed in T_7 which was on par with T_6 (472.75 μScm^{-1}) and higher (764.65 μScm^{-1}) was noticed in T_2 (Table 2). There is a positive correlation between the seed leachate and seed size, as larger seeds with more stored food materials and thin seed coat would readily imbibe the water and leach out the stored food materials than the smaller ones. McDonald (1985) revealed that seed size may influence electrical conductivity results because larger seed leak more electrolytes due to more mechanical damage than smaller seeds of equivalent quality which results in lower electrical conductivity. Similar findings were reported by Vishwanath *et al.* (2006) in French bean cv. Arka Komal and Vishwanath and Ravi hunji, (2018) in soyabean. Seed size did not influence significantly total dehydrogenase activity. Maximum (24.23 %) total soluble protein was registered with T_2 followed by T_3 (22.95 %), T_4 (20.80 %) and T_1 (20.50 %), respectively. However, minimum (18.60 %) total soluble protein was recorded in T_7 (Table 2). Protein percentage is directly proportional to the seed size. Seed storage proteins which serve as nitrogen source to the growing seedling were found abundant in bigger sized seeds than smaller ones. This is in conformity with the study in potato seeds by Bhatt *et al.*, 1989 as large seeds contained higher levels (% dry weight) of total proteins, ethanol soluble proteins and alkali soluble proteins than small seeds.

The data on the effect of seed size on growth and pod yield are presented in Table 3 and 4. Significant difference in field emergence was observed among the different seed grades and was noticed the highest (97.45 %) emergence of seedlings in T_3 which was on par with T_4 (97.35 %) but significantly different from other treatments. The lowest field emergence (84.95 %) was recorded in T_7 (Table 3). The smaller

TABLE 3

Effect of seed size on field emergence, plant height, number of branches per plant, number of inflorescences per plant, number of flowers per inflorescence French bean cv. Arka Sukomal

Treatments	Field emergence (%)	Plant height (m)	Number of branches	No. of inflorescence per plant	No. of flowers per inflorescence
T1	95.33	3.38	4.30	74.25	8.41
T2	94.47	3.92	4.43	82.20	8.90
T3	97.45	3.53	4.87	80.95	8.78
T4	97.35	3.49	4.40	78.00	8.33
T5	92.70	2.92	4.08	73.68	8.38
T6	87.60	2.94	3.99	66.90	8.06
T7	84.95	2.68	3.86	64.60	8.01
S.Em±	0.45	0.09	0.20	1.64	0.28
CD (P=0.01)	1.32	0.27	NS	4.83	NS
CV (%)	0.97	5.66	9.51	4.41	6.60

T_1 : bulk seed ; T_2 : > 4.75 mm ; T_3 : 4.50 - <4.75 mm ; T_4 : 4.25 - <4.50 mm ; T_5 : 4.00 - < 4.25 mm ; T_6 : 3.75- <4.00 mm and T_7 : 3.50- <3.75 mm.

TABLE 4

Effect of seed size on number of pods per plant and green pod yield per plant, green pod yield per plot and green pod yield per hectare. french bean cv. Arka Sukomal

Treatments	No. of pods per plant	Green pod yield per plant (kg)	Green pod yield per plot (kg)	Green pod yield per hectare (t)
T1	73.75	4.22	19.22	16.02
T2	75.00	4.35	20.86	17.38
T3	77.00	4.63	21.62	18.02
T4	74.25	4.45	21.44	17.87
T5	68.50	4.15	18.03	15.02
T6	61.83	3.54	17.87	14.89
T7	50.43	2.20	16.39	13.66
S.Em±	0.71	0.08	0.18	0.15
CD (P = 0.05)	2.10	0.25	0.54	0.45
CV (%)	2.08	4.30	1.89	1.89

T_1 : bulk seed ; T_2 : > 4.75 mm ; T_3 : 4.50- <4.75 mm ; T_4 : 4.25- <4.50 mm ; T_5 : 4.00- <4.25 mm ; T_6 : 3.75- <3.75 mm ; T_7 : 3.50- <3.75 mm.

sized seeds had shown lower field emergence than the larger and medium sized seeds as was the case in seed germination percentage. Lower field emergence (94.47 %) in seeds larger than 4.75 mm size could be due to more mechanical. The results are in support of the results obtained by Vishwanath and Ravi hunji, 2018 in soyabean.

Significantly highest plant height (3.92 m) was observed in T_2 followed by T_3 (3.53 m), T_4 (3.49 m) and T_1 (3.38 m) whereas; the lowest (2.68 m) was noticed in T_7 (Table 3). These results are in support of the findings reported by Verma and Bajapai (2002) in pigeon pea where higher performance for plant height was noticed in larger seeds than smaller ones. There was no significant difference observed with respect to number of branches and number of flowers per inflorescence. More number of inflorescences were recorded with T_2 (82.20) which were statistically on par with T_3 (80.95) and T_4 (78.00) but significantly different from other seed grades (Table 3). These results are positively correlated with the plant height. Number of flowers per inflorescence did not differ significantly among different seed grades.

Pod numbers per plant and pod yield are presented in table 4. Number of pods per plant varied significantly among the seed grades. Maximum number of pods was observed in T_3 (77.00) which was statistically on par with T_2 (75.00) but significantly varied from other treatments. The lowest (50.43) pod number was recorded with T_7. Green pod yield per plot and per hectare varied significantly among seed grades and was found maximum (21.62 kg and 18.02 t) in T_3 which was statistically on par with T_4 (21.44 kg and 17.87 t) but significantly different from rest of the treatments. The lowest green pod yield per plot and per hectare (16.39 kg and 13.66 t) was recorded with T_7. The results are positively correlated with plant height, number of branches and number of inflorescences per plant. The results are in agreement with the findings of Lima *et al*. (2005) in common bean, Charles and Patience (2020) in groundnut who recorded more number of pods and yield in larger sized seeds than smaller ones.

From the study it could be inferred that seed size of 4.25 mm and above recorded higher values for seed quality, and yield and yield attributes with minimum percentage of seed rejection. Hence, grading screen of sieve size 4.25 mm for in Air Screen Cleaner can be recommended for seed processing of Arka Sukomal, a pole type of French bean variety.

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