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Upgradation of French bean (*Phaseolus vulgaris* L.) seed production through priming

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Abstract
To obtain the quantity and quality of French bean seed, the seed priming procedure was functional using organic and inorganic compounds in three modes of priming *viz*. hydro-priming, osmo-priming (PEG6000, $CaCl_2$, KNO_3) and halo-priming (Thiourea, GA_3) with control under 6 hours treatment durations. In assessment, the observations allied to eight plant growth and yield attributes including yield for getting the real exposure of qualitative and quantitative parameters. The treatments, T_2 (Thiourea, 750 ppm) was most functioning with significant variation among diverse treatments except in seeds pod^{-1}. In genotypes, V1 showed high significant demarcation predominantly in yield attributes and yield though, V2 was hopeful for a few characters predominantly in days to flower with number of pods and seeds. The treatments interaction with genotypes showed non-significant demarcation only in seeds pod^{-1} but, interacted value T_2V1 was highest considering all parameters. The parameters related to seed weight were pronounced contributor in qualitative and quantitative upgradation in seed where the number of seeds or pods were immaterial. Diverse treatments specified the extent of effects on seed or plant to upgrade the quality. Therefore, the treatment T_2 may be considered for French bean seed production to obtain capable seed for upcoming generation.

Keywords: Seed priming, quality seed, yield attributes, French bean

Introduction
French Bean (*Phaseolus vulgaris* L.) or common bean, an annual plant was grown widespread for use as edible dry seed or unripe whole fruit (green beans). India is leading producer of dry seed followed by Brazil and Myanmar conversely, the production of green beans is extreme in China followed by Indonesia and Turkey [1]. In India, the productivity grain/dry seed is about 2-2.5 tons ha^{-1} by contributing the leading states *viz*. Maharashtra, Punjab and Andhra Pradesh. The high nourishing value of French bean comprises 1.7g protein, 4.5 g carbohydrates, 221 I.U. vitamin A, 11 mg vitamin C, 50 mg calcium [2] etc. considering 100g of green pods though it is not consistent for entire region in India due to developmental variation in plant or seed growth. Moreover, the present seed yield of French bean is 1250-1500 kg ha^{-1} which is lesser in comparison to world average. The production and dissemination of quality seed is one of the indispensable factors to achieve anticipated yields in addition to optimum quality of the cultivar. The quality of seed alone is known to account for at least 10-15% increase in productivity [3]. The unavailability of quality seeds is one of the biggest challenges that need to be dealt with in order to bridge the vast yield gap. The term seed enhancement for quality encompasses 'value-added' techniques including priming, seed coatings, and pre-germination [4]. Seed priming is one of the popular techniques for improving the seed quality where it defines an extensive group of restricted hydration techniques related to seed performance in field predominantly in field emergence. In rapid uniform germination and optimum plant stand in field, seed priming technique is efficaciously operated in various crops. It is also employed in seed invigoration for refining potentiality of germination and vigour as converse to detrimental effects of seed deterioration [5]. In seed priming, the various types explicitly hydro-priming, halo-priming, osmo-priming are commonly used for pulse and vegetable crops. Priming involves soaking of seeds with diverse priming agents to regulate the germination process under constrained condition that can deferral the emergence of the radicle. It accelerates the speed and uniformity in seed germination helpful to make healthy plant population. In this context, the present experiment was appraised the effect of diverse priming for seed quality enhancement of French bean.

Materials and Methods

The study was done in two consecutive years i.e. 2015-16 and 2016-17 at AB Block Seed Farm, Bidhan Chandra Krishi Viswavidyalaya, West Bengal utilizing three (3) French bean genotypes namely RCM-FB-18 (V1), Phyrngop (V2), RCM-FB-62 (V3) which were collected from ICAR Research Complex, NEH, Umiam, Meghalaya. The twelve (12) diverse treatments were measured using various organic and inorganic chemicals for seed priming *viz*. T_1 (500 ppm Thiourea), T_2 (750 ppm Thiourea), T_3 (50 ppm Gibberellic Acid), T_4 (100 ppm Gibberellic Acid), T_5 (0.1 Mpa KNO_3), T_6 (0.2 Mpa KNO_3), T_7 (0.1 Mpa $CaCl_2$), T_8 (0.2 Mpa $CaCl_2$), T_9 (0.1 Mpa PEG 6000), T_{10} (0.2 Mpa PEG 6000), T_{11} (Distilled Water), T_{12} (Control, without treatment). The seeds of dissimilar varieties were soaked separately in above aqueous solutions for 6 hours followed by drying back to its original moisture content except control. After 3 days, the seeds were sown in the field allowing for recommended cultivation practices under randomised block design with 3 replications for analysing the dissimilar eight (8) field parameters related to plant growth and yield attributes. The assessment was done using OPSTAT software in consequence of factorial RBD of 2 factors at 5% level of significance.

Results and Discussion

The three genotypes V1, V2 and V3 of French bean were grown by approaching of 12 different seed treatments (T_1-T_{12}) including control (without treatment) as priming mode on French bean seed. The interpretations were restricted to facilitate the productivity and quality of the seed related to phenotypic expression in two successive years as well as pooled value. The different treatments showed the diversification in different yield attributing characters in a significant mode though non-significant demarcation was observed predominantly on seeds pod^{-1} and for 1st year in pods plant^{-1} only. The observable parameters are grouped into 2 different categories like plant growth parameters, yield attributing parameters. In growth development, the considerable two parameters *viz*., days to 1st flowering and plant height, showed variable significant distinction in application of diverse mode of priming. The reducing value in days to flower can be appropriate to compensate the reproductive phase and seed growth in which most of the treatments showed their prominence over control highlighting the topmost effect in T_2 (thiourea @700ppm). But, it displayed second topmost inducing value next to T_4 through on going non-significant discrimination in between them.

Table 1: Seed priming influence on different field parameters

Treatments	Days to first flowering			Plant height (cm)			Pods plant^{-1}			Seeds pod^{-1}			Seed weight pod^{-1} (g)			100 seed weight (g)			pod yield plant^{-1}			Seed yield sqm^{-1}		
	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P
T1	49.83	49.58	49.71	103.73	116.62	110.18	24.60	19.62	22.11	5.90	5.67	5.79	2.16	1.74	1.95	33.33	29.08	31.22	40.90	41.63	41.27	153.50	146.50	150.00
T2	47.75	45.92	46.83	120.77	112.02	116.39	26.40	23.15	24.78	6.30	6.43	6.37	2.49	2.02	2.26	34.42	31.58	33.01	44.88	50.02	47.45	178.83	165.67	172.25
T3	49.00	46.75	47.88	120.15	106.15	113.15	24.17	19.62	21.89	5.97	5.66	5.81	2.07	1.55	1.82	31.33	31.42	31.39	37.65	44.98	41.32	155.00	147.42	151.21
T4	50.08	48.75	49.42	114.60	121.40	118.00	22.50	19.14	20.82	5.88	6.42	6.15	2.14	1.59	1.87	32.75	28.25	30.51	41.95	50.47	46.21	155.83	141.92	148.88
T5	50.33	51.08	50.71	117.13	109.65	113.39	22.80	19.58	21.19	6.07	6.08	6.08	2.01	1.65	1.83	32.50	28.42	30.46	34.68	46.28	40.48	149.50	149.00	149.25
T6	49.92	51.58	50.75	114.07	109.02	111.55	23.42	17.76	20.59	5.58	6.06	5.82	2.09	1.74	1.92	31.33	28.92	30.13	33.97	47.03	40.50	148.83	141.50	145.17
T7	49.25	47.42	48.33	99.27	107.38	103.33	20.62	19.65	20.13	5.58	6.13	5.86	2.06	1.82	1.94	30.75	30.25	30.52	32.48	48.83	40.66	152.83	138.00	145.42
T8	49.42	50.08	49.75	119.60	110.32	114.96	22.18	18.18	20.18	5.58	6.07	5.83	1.96	1.67	1.82	32.08	30.92	31.51	38.28	47.98	43.13	150.17	144.25	147.21
T9	49.83	48.92	49.38	118.10	112.68	115.39	22.30	15.02	18.66	5.72	6.28	6.00	2.29	1.74	2.02	31.57	29.75	30.66	41.53	44.70	43.12	157.00	149.08	153.04
T10	48.92	48.42	48.67	117.80	122.88	120.34	24.28	15.88	20.08	5.82	6.33	6.08	2.12	1.62	1.87	31.50	31.08	31.31	43.08	45.05	44.07	149.33	123.25	136.29
T11	49.92	49.75	49.83	116.47	112.88	114.68	22.23	17.22	19.73	5.88	6.20	6.04	2.29	1.61	1.95	32.17	30.25	31.22	37.92	47.77	42.84	148.83	128.83	138.83
T12	50.83	50.42	50.63	117.03	105.75	111.39	21.62	16.75	19.18	5.48	5.93	5.71	2.18	1.43	1.81	30.42	29.25	29.84	34.80	41.37	38.08	136.50	133.75	135.13
Mean	49.59	49.06	49.32	114.89	112.23	113.56	23.09	18.46	20.78	5.81	6.11	5.96	2.16	1.68	1.92	32.01	29.93	30.98	38.51	46.34	42.43	153.01	142.43	147.72
SEm (±)	0.34	0.70	0.41	3.03	0.55	1.57	1.29	0.00	0.65	0.27	0.21	0.14	0.07	0.06	0.04	0.39	0.43	0.32	0.25	0.37	0.30	3.71	6.26	3.01
LSD (0.05)	0.97	2.01	1.18	8.74	1.60	4.54	NS	NS	1.87	NS	NS	NS	0.19	0.19	0.12	1.12	1.23	0.93	0.72	1.06	0.87	10.70	18.06	8.68

In plant height, the T_{10} followed by T_4 showed superior effect among applied treatments with significant and non-significant mode though most of them were superior to control. In reflection of yield attributing parameters, the various characters indicated a strong significant differentiation with an exemption in seeds pod^{-1} for both years and pooled analysis. The peak appreciated treatment, T_2 specified its distinct superiority over other treatments in significant mode however non-significant differences were also existing among other treatments. Considering the rest treatments, predominantly T_{10}, T_3 etc. expressing their greater performances in pods plant^{-1} and 100 seed weight, though these were not sustained their consistency for both years as well as pooled data including the parameter seed yield. In seed yield, T_9 showed eminence after T_2 considering discrete significant delineation.

Analysis of variance showed that the early flowering was significantly influenced by the seed priming among genotypes. The earliest flowering trend was seen in V2 (phyrngop) followed by V3 (RCM-FB-62) genotype considering both years and pooled analysis. The priming treatment may have an effect on plant height at maturity where V3 showing highest reading as compared to the other varieties for unlike observations however specific genotypic nature was the most dominant factor. In statement considering pods plant^{-1} and seeds pod^{-1}, the genotype V2 exposed greater number of pods and seeds respectively among various genotypes. But, it was surprising matter that the genotype V1 recorded highest seed yield and 100 seed weight may be due to the effect of seed weight conforming more dry matter accumulation in seed. In seed yield, the early flowering may not be too pronounced influential similar to other yield attributes predominantly in genotype evaluation.

In interacted values of treatment and genotype, the significant demarcation was observed for maximum parameters considering both years as well as pooled analysis but the non-significant trend was followed for seeds pod^{-1} and partially in pods plant^{-1} and seed yield sqm^{-1}. The non-significant interactions were also observed in a few cases for other parameters though all priming treatments interactions were significantly superior over the interacted values with control.

The correlation matrix of the different plant growth and yield contributing characters represented (table 3) the value 0.1659 for R^2 which indicated the significant positive relationship was prevailing for the considerable characters. The negative or positive significant mode was observed for most of the characters though an exception was revealed in plant height under non-significant mode.

Table 2: Deviation in genotypes considering field parameters and the interaction of considerable two factors.

VARIE-TIES	Days to first flowering			Plant height (cm)			Pods plant^{-1}			Seeds pod^{-1}			Seed weight pod^{-1} (g)			100 seed weight (g)			pod yield plant^{-1}			Seed yield sqm^{-1}		
	Y1	Y2	P	Y1	Y2	P	Y1	Y2		Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P
V1	53.88	57	55.44	136.68	138.72	137.7	16.43	20.5	18.47	5.92	5.83	5.88	2.39	1.90	2.15	36.5	35.38	35.94	44.97	65.83	55.40	196	186.21	191.1
V2	40.6	41.83	41.22	36.53	27.24	31.89	36.53	27.24	31.89	5.77	7.21	6.49	2.28	1.82	2.05	33.4	33.58	33.52	34.18	44.78	39.48	95.58	89.19	92.39
V3	54.29	48.33	51.31	171.46	170.73	171.1	16.32	7.65	11.98	5.76	5.28	5.52	1.80	1.32	1.56	26.14	20.83	23.49	36.38	28.43	32.41	167.46	151.9	159.68
Mean	49.59	49.05	49.32	114.89	112.23	113.56	23.09	18.46	20.78	5.82	6.11	5.96	2.16	1.68	1.92	32.01	29.93	30.98	38.51	46.34	42.43	153.01	142.43	147.72
SEm (±)	0.17	0.35	0.2	1.52	0.28	0.79	0.65	0.00	0.32	0.13	0.11	0.07	0.07	0.03	0.02	0.19	0.21	0.16	0.13	0.18	0.15	1.86	3.13	1.51
LSD (0.05)	0.49	1.00	0.59	4.37	0.80	2.27	1.87	NS	0.93	NS	0.31	0.20	0.19	0.09	0.06	0.56	0.62	0.46	0.36	0.53	0.44	5.35	9.03	4.34
Interaction of treatments and genotypes (T x V)																								
	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P
SEm (±)	0.59	1.21	0.71	5.25	0.96	2.72	2.24	0.00	1.12	0.47	0.37	0.24	0.11	0.11	0.07	0.67	0.74	0.56	0.44	0.64	0.53	6.43	10.85	5.22
LSD (0.05)	1.69	3.48	2.04	15.13	2.76	7.85	NS	0.00	NS	NS	NS	NS	0.33	NS	0.21	1.94	2.14	1.60	1.26	1.83	1.51	18.54	NS	15.03

Table 3: Correlation Matrix of different field parameters

	Days to 1st flowering	Plant height	Pods plant^{-1}	Seeds pod^{-1}	Seed wt. pod^{-1}	100 seed wt.	Pod yield plant^{-1}
Plant ht.	-0.058^{NS}						
Pods plant^{-1}	-0.213^{NS}	0.201^{NS}					
Seeds pod^{-1}	-0.369*	0.256^{NS}	-0.185^{NS}				
Seed wt. pod^{-1}	-0.096^{NS}	0.239^{NS}	0.821**	-0.182^{NS}			
100 seed wt.	-0.342*	0.203^{NS}	0.729**	-0.035^{NS}	0.738**		
Pod yield plant^{-1}	-0.407**	0.088^{NS}	-0.322*	0.747**	-0.404**	-0.233^{NS}	
Seed yield sqm^{-1}	-0.375*	0.074^{NS}	0.737**	0.106^{NS}	0.682**	0.595**	-0.013^{NS}

***** Significant; ** Highly significant; ^{NS} Non-significant

The non-significant relationship was also followed in seeds pod^{-1} and pod yield with other attributes though they were highly significant in positive mode within themselves. Days to 1st flowering showed negative correlation with the added traits i.e. lower value indicating earlier flowering advanced the yield parameters. However, the negative correlation was found in pod yield with seed weight and number of pods. The seed yield was very much influenced by seed weight linked attributes instead of their number. Therefore, a direct relationship was found in linking of early flowering, seed weight and seed yield for a genotype that may be beneficial for qualitative and quantitative upgradation of seed in the way of priming.

The effect of primed seeds exposed a positive significant demarcation over control considering most of the traits in current study. It was reported that priming treatments modified the metabolic processes involved in germination and earlier establishment of seedlings as well as plants which may elicit the earlier flowering in comparison to control [6]. The pods plant^{-1} was higher over the control in experiment for both the years. GA_3 application was reported to increase number of fruits per plant in soybean [7] and in tomato [8]. The osmotic potential of the priming solution had a significant effect on the number of seeds pod^{-1} [9]. Many reports have shown the benefits of priming on earliness, yield etc. in beans and cereals [10-15]. Some reports concerning with the beneficial effects of priming may be due to the metabolic repair processes, a build-up of added metabolites or osmotic adjustments during priming [16], or improved membrane integrity and enhanced physiological activities at germination

[17].The effect of priming showed a significant effect on the seed length and breadth over the control that can be recognized for good productivity and quality in seed production. It was reported that priming had a significant effect on seed width and awn length ($p< 0.05$) expansion in wheat cultivar favourable for quality seed production [18].

The present observations indicated considerable improvement of the yield attributes with yield in French bean genotypes as an influence of priming. The treatment T_2 (thiourea@750ppm) displayed its extreme potentiality in field observations and the genotype. V1 (RCM-FB-18) can be utilise that potentiality in cultivation predominantly in seed production programme to facilitate the quality seed production of French bean.

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