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Ramakrushna Bastia
Odisha University of Agriculure and Technology, Bhubaneswar, Odisha, India

Saroj Kumar Mohanty
Odisha University of Agriculure and Technology, Bhubaneswar, Odisha, India

Ashirbachan Mahapatra
Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Corresponding Author:
Ashirbachan Mahapatra
Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Effect of different doses of N, P and K fertilisers on seed storability of Indian mustard (*Brassica juncea* L.)

Ramakrushna Bastia, Saroj Kumar Mohanty and Ashirbachan Mahapatra

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Abstract
The present investigation was carried out with the objective to study the effects of different doses of fertilisers on seed storability of the Indian mustard variety NRCHB-101. The field experiment was conducted during 2016-17 at the Agronomy Main Research Station, OUAT, Bhubaneswar laid out in a Factorial Randomized Block Design with three replications and twelve treatments i.e. three levels of nitrogen (N_1=80, N_2=100 and N_3=120 kg/ha), two levels of phosphorus (P_1=20 and P_2=40 kg/ha) and two levels of potassium (K_1=0 and K_2=30 kg/ha). The freshly harvested dried seeds were subjected to accelerated aging process and the seed storability parameters *viz*. germination percentage, seedling length and vigour index were studied. Seed storability was found to be significantly affected by NPK fertiliser doses. After accelerated aging test, highest level of germination percentage, seedling length and vigour index were observed at N_2 which was significantly higher than N_3 and N_1. Lower level of phosphorus (P_1) showed higher germination percentage and lower seedling length, whereas the effect of phosphorus was non-significant on vigour index. Higher level of potassium (K_2) showed high germination percentage, seedling length and vigour index. The combined interaction of N-P-K revealed that highest germination percentage, seedling length and vigour index were observed under $N_2P_1K_2$, whereas lowest values were obtained at $N_3P_1K_1$.

Keywords: Indian mustard, doses of fertiliser, seed vigour, seed storability

Introduction
Among the seven edible oilseeds cultivated in India, rapeseed-mustard ranks second after groundnut contributing 28.6% of the total oilseed production and sharing 27.8% in the India's oilseed economy [11]. The average annual production of rapeseed-mustard is about 8.17 Mt from an area of about 6.51 Mha with a total productivity of 12.57 q/ha [3]. Indian mustard (*Brassica juncea*) is an important winter season *rabi* crop. Out of total cropped area in India, oilseeds account for 14.1% out of which rapeseed-mustard shares 3% [10]. India's total rapeseed-mustard seed output i.e. 7.6 Mt in 2020 which is nearly 25% lower than 2019, while the Ministry of Agriculture in its third advanced estimated projected total output at 8.7 Mt for the recently ended *rabi* harvesting season from 9.2 Mt in the same season of the last year [2]. The gap between the production and demand of mustard is progressively increasing and the situation warrants to increase the production. Among different production factors seed and its storage play an important role. The storability of Indian mustard seed has not been adequately studied yet.
Balanced fertilizer application helps in better yield and quality seed production. In oil seed crops, protein levels are increased upon nitrogen fertilization, whereas oil concentration is decreased. N input increases the rate of conversion of carbohydrates in to protein which in turn important in the structure of protoplasm producing vigorous [9]. Potassium is responsible for the transport mechanisms in the plant whereby materials made by photosynthesis in the leaf can be moved to other parts of the plant for growth, formation of seed and deposition of oil. This nutrient is nevertheless vital for vigorous, healthy crop growth and profitable yields. Phosphorus plays an important role for improved crop establishment, winter hardiness, and yield in oilseeds.

From various research conducted on oilseed crops *viz*. groundnut, soybean and safflower, it has been reported that balanced fertilizer application of N, P, K increases not only the seed yield but also the seed quality parameters. Soybean plants grown without potassium fertilization matured later than those receiving adequate potassium and K fertilization almost always decreased seed pathogen levels [6]. Seed viability and vigour of soybean seed lots grown with high levels of potassium fertilization remained high for first few months in poor storage conditions which are consequently followed by a rapid decrease in vigour levels [7]. Sesamum seeds produced from 60:20:30 kg NPK/ha + sulphur (10 kg/ha) fertilizer level maintained lower seed infestation at the end of six month of storage period as compared to control [12]. However the information on effect of NPK on seed storability in Indian mustard is very scanty.

Taking in to considerations the above facts, the present investigation on Indian mustard hybrid NRCHB-101 was conducted with an objective to study the seed storability of the variety under different fertility levels.

Materials and Methods

The field experiment was conducted during *rabi* 2016-17 at the Agronomy Main Research Station, Odisha University of Agriculture and Technology, Bhubaneswar (20026'N, 85081'E, 25.9m above MSL), Odisha. The soil of the experimental field was sandy loam acidic (pH 5.4) medium in organic carbon (0.628%) and available nitrogen, phosphorus and potassium were 1673.3, 64.5 and 123.4 kg/ha respectively. The experiment was laid out in a Factorial Randomized Block Design with three replications. Twelve treatment combinations comprising three nitrogen levels (80, 100, 120 kg N/ha), two phosphorus levels (20, 40 kg P_2O_5/ha) and two potassium levels (0, 30 kg K_2O/ha) were tested in the experiment. Indian mustard variety 'NRCHB-101' was sown 30 cm row spacing. Thinning was done as 15 DAS to maintain plant to plant distance of 10 cm. All the recommended agronomic practices were done throughout the crop season. The crop was sown on 20th November and harvesting was done manually during last week of February.

The storability of mustard seeds produced under different treatments was studied by accelerated aging test. Seeds belonging to different treatments were exposed to 100% RH and 40±^{0}C temperature in the accelerated chamber for 7 days. The treated seeds were brought out of the chamber and kept under laboratory condition for assessment of germination percentage, seedling dry weight and vigour. After accelerated aging, germination test was conducted by T.P. method [5] expressed in percentage. 10 numbers of normal seedlings from aged seeds were selected randomly from each treatment and the shoot & root portion of the seedlings were measured separately with the help of centimeter scale and average length of both root and shoot was calculated. Vigour index values of seeds produced under different treatments were calculated as per the formula developed by Abdul Baki and Anderson [1] using the following formula.

Vigour Index = Seedling length (cm) × Germination percentage

Data collected on various observations on Indian mustard were analyzed statistically by following standard analysis of variance technique (ANOVA) as described by Gomez and Gomez [4]. Test of significance of the treatment differences was done on the basis of 'F' test. The differences between treatments were compared with critical difference at 5 per cent level of significance (P= 0.05).

Results and Discussions

The seed storability parameters like germination percentage, seedling growth and vigour index of aged seeds of all the seed lots harvested from all the different levels of NPK treatments and their interactions were studied by exposing the seeds to accelerated ageing process. Accelerated aging caused by exposing the seeds to an unfavourable hot and moist atmosphere is representative of natural ageing. The performance of seeds in form of germinability after accelerated aging of seeds indicates storage potential of seed lots.

Data on effects of sole application of N, P & K, their interaction effects *viz*. N-P, P-K & N-K and the combined interaction effects i.e. N-P-K on germination percentage, seedling length and vigour index of Indian mustard are presented in Table 1, 2 and 3 respectively. The germination percentage of different seed lots receiving accelerated ageing reduced to variable extent.

From the experiment it was observed that the 3 nutrients have different effects on the germination percentage of accelerated aged seeds. Numerically higher germination (59.33%) was found at N_2 which significantly differed from N_1 (57.83%) and N_3 (57.50%). Here it was observed that at highest dose of nitrogen the germination percentage decreased whereas, different results were observed in phosphorus and potassium. Seeds obtained from lower level of phosphorus (P_1) and higher level of potassium (K_2) showed high germination percentage i.e. 60.05% and 65.94% respectively. Among the P-K interactions, significantly higher germination (71.7%) was witnessed in case of P_1K_2.

Among all interactions significantly highest germination is observed (73.2%) at N_2K_2. Out of the N-P-K interactions, significantly higher germination (76.33%) was found in $N_2P_1K_2$. Significantly lowest germination was witnessed with $N_3P_1K_1$ (40.0%). The storability of seeds decreased with high level of phosphorus has been founded in onion [8] and in soybean [7].

Among the sole effects of N, P & K, lower seedling length (6.31 cm) was observed under the highest level of N (N_3) and higher seedling lengths i.e. 7.15 cm and 8.03 cm were observed under higher levels of P (P_2) and K (K_2) respectively. Among the P-K interactions, significantly higher seedling length (8.1 cm) was witnessed in case of P_2K_2 which was similar with that of N_2P_2 interaction. Significantly the highest seedling length (10.4 cm) was observed at N_2K_2. Among combined N-P-K interactions, significantly highest seedling length (11.10cm) was found in $N_2P_2K_2$. Significantly lowest seedling length was witnessed with $N_3P_1K_1$ (2.77cm). The treatment which maintained to occupy top ranking in respect of germination also exhibited comparatively greater seedling growth.Sole application of N, P and K exhibited significant influence on vigour index. Significantly higher vigour index was observed under N_2 (455.69) followed by N_1 (412.80) and N_3 (400.25). There was no significant effect of sole P levels on vigour index, whereas K_2 had significantly higher vigour index (533.57) than the control or K_1 (312.25). Among all the two factor interactions, significantly highest vigour index was found at N_2K_2 (661.9).

As far as the combined NPK interactions are concerned, significantly highest and lowest vigour index were recorded at $N_2P_1K_2$ (780.87) and $N_3P_1K_1$ (116.60) respectively. Similar results were also observed in soybean [7].

Table 1: Germination percentage, Seedling length and Vigour Index after accelerated ageing as influenced by different N, P and K levels

Treatment	Germination (%)	Seedling length (cm)	Vigour index
N-levels			
N_1	57.83	6.95	412.80
N_2	59.33	7.63	455.69
N_3	57.50	6.31	400.25
SE(m)±	1.896	0.017	14.805
CD(P=0.05)	4.611	0.042	36.008
P-levels			
P_1	60.05	6.76	435.24
P_2	56.38	7.15	410.57
SE(m)±	1.548	0.014	12.088
CD(P=0.05)	3.765	0.034	NS
K-levels			
K_1	50.50	5.90	312.25
K_2	65.94	8.03	533.57
SE(m)±	1.548	0.014	12.088
CD((P=0.05)	3.743	0.034	29.230

*N_1 = 80 kg/ha, N_2 = 100 kg/ha, N_3 = 120 kg/ha, P_1 = 20 kg P_2O_5/ha, P_2 = 40 kg P_2O_5/ha, K_1 = 0 K_2O/ha and K_2 = 30 kg K_2O/ha

Table 2: Germination percentage, seedling length and vigour index after accelerated ageing as influenced by different N-P, P-K and N-K interactions

	Germination (%)		Seedling length		Vigour index	
N-levels	**P-levels**					
	P_1	**P_2**	**P_1**	**P_2**	**P_1**	**P_2**
N_1	66.0	52.7	7.3	6.6	390.9	409.6
N_2	58.2	57.5	7.2	8.1	478.6	347.0
N_3	56.0	59.0	5.8	6.8	436.2	475.2
SE(m)±	2.681		0.024		20.938	
CD(P=0.05)	6.522		0.059		50.924	
P-levels Kg ha^{-1}	**K-levels**					
	K_1	K_2	K_1	K_2	K_1	K_2
P_1	48.4	71.7	5.6	7.9	299.9	570.6
P_2	52.6	60.2	6.2	8.1	324.6	496.6
SE(m)±	2.189		0.020		17.096	
CD(P=0.05)	5.294		0.048		41.337	
N-levels	**K-levels**					
	K_1	K_2	K_1	K_2	K_1	K_2
N_1	58.3	60.3	8.7	5.2	178.8	317.1
N_2	42.5	73.2	4.9	10.4	508.5	661.9
N_3	50.7	64.3	4.1	8.5	249.5	621.7
SE(m)±	2.681		0.024		20.938	
CD(P=0.05)	6.522		0.059		50.924	

*N_1 = 80 kg/ha, N_2 = 100 kg/ha, N_3 = 120 kg/ha, P_1 = 20 kg P_2O_5/ha, P_2 = 40 kg P_2O_5/ha, K_1 = 0 K_2O/ha and K_2 = 30 kg K_2O/ha

Table 3: Combined interaction effects of N-P-K on Germination percentage, Seedling length and Vigour Index after accelerated aging

Levels of N	Germination (%)				Seedling Length (cm)				Vigour Index			
	Levels of P & K											
	P_1		P_2		P_1		P_2		P_1		P_2	
	K_1	**K_2**	**K_1**	**K_2**	**K_1**	**K_2**	**K_1**	**K_2**	**K_1**	**K_2**	**K_1**	**K_2**
N_1	42.00	68.67	53.33	52.00	9.30	5.36	8.03	5.11	368.33	588.90	428.07	265.89
N_2	63.33	76.33	45.00	70.00	4.77	9.60	5.04	11.10	190.60	780.87	226.65	777.37
N_3	40.00	70.00	59.33	58.67	2.77	8.79	5.49	8.17	116.20	615.53	325.52	479.61
	N×P	P×K	N×K	N×P×K	N×P	P×K	N×K	N×P×K	N×P	P×K	N×K	N×P×K
SE(m)±	2.681	2.189	2.681	3.792	0.024	0.020	0.024	0.034	20.938	17.096	20.938	29.611
CD(P=0.05)	6.522	5.294	6.522	9.223	0.0598	0.048	0.059	0.084	59.924	41.337	50.924	72.017

*N_1 = 80 kg/ha, N_2 = 100 kg/ha, N_3 = 120 kg/ha, P_1 = 20 kg P_2O_5/ha, P_2 = 40 kg P_2O_5/ha, K_1 = 0 K_2O/ha and K_2 = 30 kg K_2O/ha

Conclusion

Considering all the facts and observations obtained from the experiment, it may be concluded that N, P and K fertilisers had different effects on seed storability of Indian mustard. With increase in doses of nitrogen fertilizers, the seed storability increased up to 100 kg/ha, whereas phosphorus has shown no significance in seed vigour with increase in dose, rather lower level of phosphorus showed better vigour index and increase in potassium dose resulted in better seed storability.

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