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Effect of sowing dates and nutrient sources on nutrient uptake of Indian mustard (*Brassica juncea*)

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ABSTRACT

In India, people facing malnutrition due to soil and environmental problems. Keeping in mind these problems, a field experiment was conducted during *rabi* season of 2015 and 2016 at Agricultural Research Farm, Institute of Agricultural Sciences, BHU, Varanasi. The aim of study was to use the combination of pressmud (PM) as organic source of nutrient and recommended dose of fertilizer (RDF) with different sowing dates on Indian mustard (*Brassica juncea* (L.) Czernj. & Cosson). The experiment laid out in the split-plot design with 24 treatments combinations, *viz*. three sowing dates in main plot treatment–(November 17, November 27, December 7), and eight nutrient sources in sub-plots, *viz*. Control, 100% RDF, 100% RDF + *Azotobacter*, 100% RDF + Phosphorus solubilizing bacteria (PSB), 100% RDF + *Azotobacter* + PSB, 75% RDF + 25% N through PM+ *Azotobacter*, 75% RDF + 25% N through PM + PSB, 75% RDF + 25% N through PM + *Azotobacter* + PSB. The results found that the crop sowing on November 17, total nitrogen uptake was recorded 103.31 kg ha^{-1}. Likewise, total phosphorus, potassium and sulphur uptake was recorded 33.73, 87.38 and 16.83 kg ha^{-1}, respectively on the basis of pooled analysis as compared to other crop sowing on November 27 and December 7. Among the nutrient sources application of 75% RDF + 25% N through PM +*Azotobacter* + PSB maximum total nitrogen, phosphorus, potassium and sulphur uptake was recorded on the basis of pooled analysis as compared with other nutrient sources.

Key words: *Azotobacter*, Indian mustard, Pressmud, PSB, RDF

The Indian mustard (*Brassica juncea* (L.) Czernj. & Cosson) is highly responsive to the inputs than other mustard spp. under varied climatic conditions (Mandal and Sinha 2001). In present conditions, climatic trend has moderately changed in many agricultural regions and this changing trend will continue in the future which raises many questions related growing the crops according to environmental variable (rainfall and temperature) and accordingly shift the sowing time of crops (Gouri *et al*. 2005). A number of environmental factors interact with optimum sowings like soil temperature and moisture level affecting organic cycle and nutrient efficiency to the crop (Qiu *et al*. 2005). The sowing date has to be decided carefully so as to suited to growing conditions in which crop will uptake maximum amount of available nutrients and maximize production without considering adverse environmental effects (Meena and Yadav 2015**).** The environmental temperature effects on the plant growth directly and indirectly influencing the rate of organic matter (OM) decomposition, nutrient availability and other soil chemical reactions (Meena *et al*. 2017).

In the last several years, the productivity of oilseed crops remained almost stagnant or showed a declining trend in India (Tripathi *et al*. 2011). The problem of low yield is associated mainly with depletion of nutrients from the soil (Thaneshwar *et al*. 2017**)**. If mustard crop will sow timely, the soil environmental conditions will help in fast and more nutrient availability and also increase the uptake and efficiency. Otherwise crop is sown late than soil chemical and biological properties will affect adversely and ultimately it will affect crop nutrition and production. Agro biodiversity is directly related to the variety and variability of plants, animals and soil micro-organisms that are necessary to sustain the key functions and processes of the agro-ecosystem and support the production of quality food (Araujo *et al*. 2009). Soil health includes the biological, chemical and physical properties, which sustained capability of a soil to accept, store and recycle nutrients and water, maintain economic yields, as well as environmental quality. Recently mustard growth parameters and yield have been found to be mostly affected by poor management and low soil fertility (Kumar *et al*. 2009).

Pressmud is the waste obtained from sugar mills (Solomon 2005). Recently, it is being used as organic manure in agriculture and for crop production (Kumar *et*

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al. 2017). The pressmud used as manure, it can release the macro and micronutrients required by crop and currently being investigated for their high potential for increase in soil microbial population (Razzaq 2001). Some of the microorganisms like *Azotobacter*, Phosphate-Solubilizing Microorganisms (PSMs) are known to increase nutrient availability in the soil to plants (Asghar *et al*. 2002**)**. The use of biofertilizers play a vital role in integrated plant nutrient supply (IPNS) (Biswas *et al*. 2001). The sound management of fertilization must attempt to ensure both enhanced and safeguarded environment (Yang *et al*. 2013). Balanced fertilization strategy that combines the use of organic and biofertilizers must be developed and evaluated (Dhakal and Meena 2015). Considering these facts in view the present investigation was proposed with the objective that finds out a suitable combination of sowing date and nutrient source to enhance the nutrient uptake by the crop.

MATERIALS AND METHODS

A field research trial was carried out at Agricultural Research Farm of the Institute of Agricultural Sciences during two consecutive *rabi* seasons of 2015 and 2016. The total rainfall of 61.3 mm received during the experimentation crop growth period of the first year was higher than the second year of the experiment (52.1 mm). The soil of the experimental field was sandy clay loam having pH 7.85, 7.62, organic carbon 0.42%, 0.45% (Walkley and Black's method, Jackson 1973), available nitrogen 205.7, 210.3 kg ha^{-1}(Alkaline permanganate method, Subbiah and Asija, 1956), available phosphorus 19.4, 21.1 kg ha^{-1}(0.5 N $NaHCO_3$ extractable, Olsen *et al*. 1954), available potassium 210.2, 219.9 kg ha^{-1} (Ammonium acetate extractable flame photometer, Jackson 1973) and available sulphur 20.8, 22.6 mg kg^{-1} (Williams and Steinberg 1959) during both the years, respectively. The half of N and full doses of P and K were applied in furrows after mixing with moist soil. The sources of NPKS were applied through urea + pressmud compost, DAP, MOP and elemental sulphur, respectively. The rest half of the nitrogen was top-dressed through urea at early vegetative stage after 40 days. Pressmud compost was applied before 15 days of sowing by mixing in soil manually. Biofertilizers applied as seed treatment before sowing with routine procedure. All the agronomic operations were kept uniform in all the plots. Furrows were opened in each plot at a distance of 45×15 cm for the sowing of mustard variety Ashirwad using seed rate of 5 kg ha^{-1}. Pendimethalin 30 EC @ 1 liter ha^{-1} was applied as pre-emergence spray. The maturity days of crop was observed in first (114, 117), second (110, 114), and third (105, 112) sowing during both the years, respectively. The seed and stover samples were analyzed separately for nitrogen concentration (%) by standard (Nessler's reagent) colorimetric method (Gupta 2007). The seed and stover samples were analyzed for phosphorus concentration by Vanadomolybdo phosphoric yellow colour method in sulphuric acid system (Gupta 2007). Potassium concentration in seed and stover was

Table 1 Effect of sowing dates and nutrient sources on nitrogen (N) uptake by Indian mustard

Treatment	N uptake in seed (kg ha^{-1})			N uptake in stover (kg ha^{-1})			Total N uptake (kg ha^{-1})		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Sowing dates									
Sowing I (November 17)	67.26	60.79	64.03	39.97	38.58	39.28	107.24	99.37	103.31
Sowing II (November 27)	60.06	54.27	57.17	30.87	29.74	30.31	90.94	84.02	87.48
Sowing III (December 7)	52.85	47.76	50.30	27.51	26.50	27.00	80.36	74.26	77.31
SEm±	1.57	1.41	1.06	0.73	0.66	0.49	2.27	2.04	1.52
CD (p=0.05)	6.16	5.55	3.44	2.87	2.57	1.60	8.91	7.99	4.97
Nutrients sources									
Control (Zero, NPKS)	28.44	25.73	27.09	14.77	14.26	14.52	43.21	39.99	41.60
100% RDF (NPKS)	49.47	44.70	47.09	27.16	26.16	26.66	76.63	70.87	73.75
100% RDF (NPKS) + *Azotobacter*	57.46	51.92	54.69	32.35	31.18	31.77	89.82	83.11	86.46
100% RDF (NPKS) + PSB	57.37	51.84	54.61	32.12	30.96	31.54	89.50	82.80	86.15
100% RDF (NPKS) + *Azotobacter* + PSB	63.08	57.00	60.04	34.68	33.43	34.06	97.76	90.43	94.10
75% RDF + 25% N through PM+ *Azotobacter*	70.44	63.65	67.05	38.30	37.01	37.65	108.74	100.66	104.70
75% RDF + 25% N through PM + PSB	71.11	64.26	67.69	38.66	37.24	37.95	109.77	101.50	105.64
75% RDF + 25% N through PM + *Azotobacter* + PSB	83.09	75.08	79.08	44.23	42.62	43.43	127.32	117.69	122.51
SEm±	0.97	0.88	0.65	0.37	0.35	0.25	0.99	0.90	0.67
CD (P=0.05)	2.77	2.50	1.84	1.04	0.99	0.71	2.83	2.56	1.88

RDF = Recommended dose of fertilizers; NPKS = Nitrogen, Phosphorus, Potassium and Sulphur; PSB = Phosphorus solubilizing bacteria, PM= Pressmud

Table 2 Effect of sowing dates and nutrient sources on phosphorus (P) uptake of Indian mustard

Treatment	P uptake in seed (kg ha^{-1})			P uptake in stover (kg ha^{-1})			Total P uptake (kg ha^{-1})		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Sowing dates									
Sowing I (November 17)	13.11	11.88	12.49	21.80	20.67	21.24	34.91	32.55	33.73
Sowing II (November 27)	11.70	10.60	11.15	16.82	15.93	16.38	28.53	26.52	27.52
Sowing III (December 7)	10.29	9.32	9.81	14.99	14.19	14.59	25.28	23.51	24.40
SEm±	0.31	0.28	0.21	0.40	0.36	0.27	0.69	0.62	0.47
CD (*P*=0.05)	1.20	1.10	0.68	1.57	1.40	0.87	2.73	2.45	1.52
Nutrients sources									
Control (Zero, NPKS)	5.54	5.03	5.29	8.05	7.64	7.84	13.60	12.67	13.13
100% RDF (NPKS)	9.64	8.73	9.19	14.81	14.02	14.41	24.45	22.75	23.60
100% RDF (NPKS) + *Azotobactor*	11.11	10.06	10.58	17.50	16.57	17.03	28.61	26.63	27.62
100% RDF (NPKS) + PSB	11.26	10.19	10.72	17.64	16.70	17.17	28.89	26.90	27.89
100% RDF (NPKS) + *Azotobactor* + PSB	12.29	11.13	11.71	18.91	17.91	18.41	31.21	29.04	30.12
75% RDF + 25% N through PM+ *Azotobactor*	13.63	12.34	12.99	20.74	19.69	20.22	34.37	32.04	33.20
75% RDF + 25% N through PM + PSB	13.97	12.65	13.31	21.23	20.10	20.66	35.19	32.75	33.97
75% RDF + 25% N through PM + *Azotobactor* + PSB	16.18	14.65	15.42	24.10	22.81	23.46	40.28	37.47	38.87
SEm±	0.20	0.18	0.13	0.19	0.18	0.13	0.26	0.24	0.18
CD (*P*=0.05)	0.56	0.51	0.37	0.54	0.52	0.37	0.74	0.69	0.50

RDF = Recommended dose of fertilizers; NPKS = Nitrogen, Phosphorus, Potassium and Sulphur; PSB = Phosphorus solubilizing bacteria, PM= Pressmud

Table 3 Effect of sowing dates and nutrient sources on potassium (K) uptake by Indian mustard

Treatment	K uptake in seed (kg ha^{-1})			K uptake in stover (kg ha^{-1})			Total K uptake (kg ha^{-1})		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Sowing dates									
Sowing I (November 17)	20.12	17.82	18.97	69.87	66.95	68.41	89.99	84.78	87.38
Sowing II (November 27)	17.96	15.90	16.93	53.92	51.58	52.75	71.88	67.48	69.68
Sowing III (December 7)	15.80	13.99	14.89	48.04	45.95	47.00	63.84	59.94	61.89
SEm±	0.47	0.42	0.31	1.28	1.16	0.86	1.73	1.55	1.16
CD (*P*=0.05)	1.85	1.64	1.03	5.02	4.54	2.81	6.78	6.10	3.79
Nutrients sources									
Control (Zero, NPKS)	8.51	7.54	8.03	25.81	24.75	25.28	34.31	32.30	33.31
100% RDF (NPKS)	14.80	13.10	13.95	47.46	45.40	46.43	62.26	58.50	60.38
100% RDF (NPKS) + *Azotobacter*	17.05	15.10	16.07	56.08	53.66	54.87	73.13	68.76	70.94
100% RDF (NPKS) + PSB	17.27	15.30	16.28	56.53	54.09	55.31	73.80	69.38	71.59
100% RDF (NPKS) + *Azotobacter* + PSB	18.86	16.71	17.79	60.62	58.00	59.31	79.48	74.70	77.09
75% RDF + 25% N through PM+ *Azotobacter*	20.92	18.53	19.72	66.46	63.78	65.12	87.38	82.30	84.84
75% RDF + 25% N through PM + PSB	21.43	18.98	20.21	68.04	65.08	66.56	89.47	84.06	86.77
75% RDF + 25% N through PM + *Azotobacter* + PSB	24.83	21.99	23.41	77.24	73.88	75.56	102.06	95.86	98.96
SEm±	0.30	0.27	0.20	0.61	0.59	0.42	0.65	0.62	0.45
CD (*P*=0.05)	0.86	0.76	0.57	1.73	1.68	1.19	1.85	1.77	1.26

RDF = Recommended dose of fertilizers; NPKS = Nitrogen, Phosphorus, Potassium and Sulphur; PSB = Phosphorus solubilizing bacteria, PM= Pressmud

estimated by flame photometry method (Jackson 1973). Sulphur was estimated by turbidity metric method. The sulphur concentration was calculated and represented in percentage. The data were analyzed as per the standard procedure for "Analysis of Variance" (ANOVA) (Gomez and Gomez 1976).

RESULTS AND DISCUSSION

Effect of sowing dates

The perusal of the data reveals that in all sowing dates, nutrients uptake was recorded significantly different to each other. Among the sowing dates, the maximum uptake of nitrogen (67.26, 60.79, 64.03 in seed, 39.97, 38.58, 39.28 in stover and total uptake 107.24, 99.7, 103.31 kg ha^{-1} in Table no 2), phosphorus (13.11, 11.88, 12.49 in seed, 21.80, 20.67, 21.24 in stover and total uptake 34.91, 32.55, 33.73 kg ha^{-1} in Table 3), potassium (20.12, 17.82, 18.97 in seed, 69.87, 66.95, 68.41 in stover and total uptake 89.99, 84.78, 87.38 kg ha^{-1} in Table 4) and sulphur (7.79, 7.02, 7.40 in seed, 9.57, 9.28, 9.42 in stover and total uptake 17.35, 16.30, 16.83 kg ha^{-1} in table no. 5) by crop was recorded on November 17 sown crop during both the years and in pooled analysis, respectively, followed by November 27 sown crop in terms of nitrogen uptake (60.06, 54.27, 57.17 in seed, 30.87, 29.74, 30.31 in stover and total uptakes 90.94, 84.02, 87.48 kg ha^{-1} in Table 2), phosphorus uptake (11.70, 10.60, 11.15 in seed, 16.82, 15.93, 16.38 in stover and total uptake 28.53, 26.52, 27.52 kg ha^{-1} in Table 3), potassium uptake (17.96, 15.90, 16.93 in seed, 53.92, 51.58,52.75 in stover and total uptake 71.88, 67.48, 69.68 kg ha^{-1} in Table 4) and sulphur uptake (6.95, 6.26, 6.61 in seed, 7.38, 7.15, 7.27 in stover and total uptake 14.33, 13.41, 13.87 kg ha^{-1} in Table 5), during both the years and in pooled analysis, respectively. The lowest uptake of nitrogen (50.30 in seed, 27.0 in stover and total uptake 77.31 kg ha^{-1}), phosphorus (9.81 in seed, 14.59 in stover and total uptake 24.40 kg ha^{-1}), potassium (14.89 in seed, 47.0 in stover and total uptake 61.89 kg ha^{-1}) and sulphur uptake (5.81 in seed, 6.47 in stover and total uptake 12.29 mg kg^{-1}) by crop was observed on December 7 sowing in pooled analysis, respectively. The highest NPKS content and their total uptake were recorded in first sowing. This may be due to more nutrient availability for the crop during more growing days. Hence, the more mineralization of the available nutrient in soil enhance the higher photosynthetic activity in plant as evident from increase in biomass accumulation at successive duration and plant height reveals higher availability of metabolites from shoot to root. This might have promoted growth of root as well as their functional activity resulting in higher extraction of nutrients from soil environment to aerial parts. The nutrient uptake is a function of yield and nutrient concentration in plant. Thus, significant improvement in uptake of NPKS might be attributed to their concentration in seed and stover and associated with higher seed and stover yield (Mondal *et al*. 2011).

Table 4 Effect of sowing dates and nutrient sources on sulphur (S) uptake by Indian mustard

Treatment	S uptake in seed (kg ha^{-1})			S uptake in stover (kg ha^{-1})			Total S uptake (kg ha^{-1})		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Sowing dates									
Sowing I (November 17)	7.79	7.02	7.40	9.57	9.28	9.42	17.35	16.30	16.83
Sowing II (November 27)	6.95	6.26	6.61	7.38	7.15	7.27	14.33	13.41	13.87
Sowing III (December 7)	6.11	5.51	5.81	6.58	6.37	6.47	12.69	11.88	12.29
SEm±	0.18	0.17	0.12	0.17	0.16	0.12	0.35	0.32	0.24
CD (*P*=0.05)	0.72	0.65	0.40	0.69	0.62	0.39	1.38	1.25	0.77
Nutrients sources									
Control (Zero, NPKS)	3.29	2.98	3.13	3.53	3.42	3.48	6.83	6.40	6.61
100% RDF (NPKS)	5.73	5.16	5.44	6.50	6.29	6.40	12.22	11.45	11.84
100% RDF (NPKS) + *Azotobacter*	6.60	5.94	6.27	7.68	7.44	7.56	14.28	13.38	13.83
100% RDF (NPKS) + PSB	6.68	6.02	6.35	7.74	7.50	7.62	14.42	13.52	13.97
100% RDF (NPKS) + *Azotobacter* + PSB	7.30	6.58	6.94	8.30	8.04	8.17	15.60	14.62	15.11
75% RDF + 25% N through PM+ *Azotobacter*	8.10	7.29	7.69	9.10	8.84	8.97	17.20	16.14	16.67
75% RDF + 25% N through PM + PSB	8.29	7.47	7.88	9.32	9.02	9.17	17.61	16.50	17.05
75% RDF + 25% N through PM + *Azotobacter* + PSB	9.61	8.66	9.13	10.58	10.24	10.41	20.18	18.90	19.54
SEm±	0.12	0.10	0.08	0.08	0.08	0.06	0.14	0.13	0.09
CD (*P*=0.05)	0.33	0.30	0.22	0.24	0.23	0.16	0.39	0.36	0.26

RDF = Recommended dose of fertilizers; NPKS = Nitrogen, Phosphorus, Potassium and Sulphur; PSB = Phosphorus solubilizing bacteria, PM= Pressmud

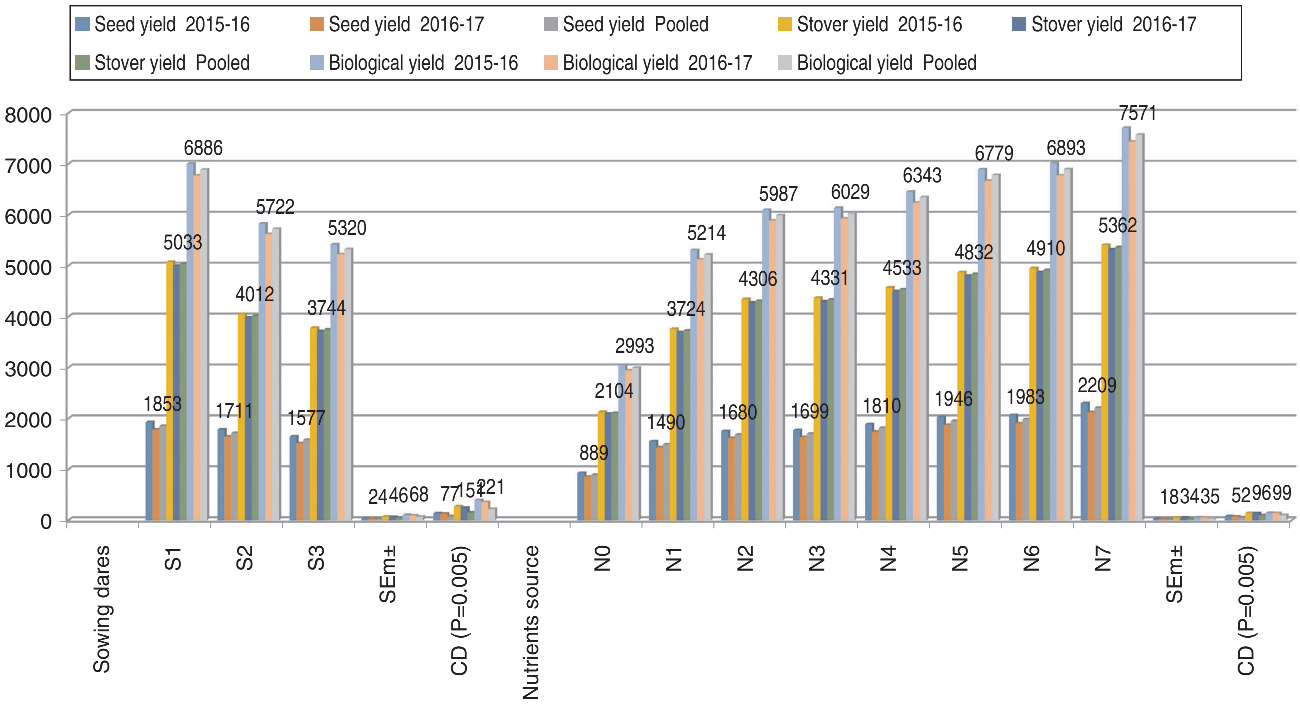

Fig 1 Effect of sowing dates and nutrient sources on yields of Indian mustard.
S1-sowing I, S2-sowing II, S3-sowing III and N0-Control, N1-100% RDF, N2-100% RDF + *Azotobacter*, N3-100% RDF + PSB, N4-100% RDF + *Azotobacter* + PSB, N5-75% RDF + 25% N through Pressmud+ *Azotobacter*, N6-75% RDF + 25% N through PM + PSB, N7-75% RDF + 25% N through PM + *Azotobacter* + PSB.

Effect of nutrient sources

A critical examination of data indicated that all the nutrient sources were significantly improved the nutrient uptake of Indian mustard over control during both the years and in the pooled analysis. Among the nutrient sources, the highest nitrogen uptake (83.09, 75.08, 79.08 in seed, 44.23, 42.62, 43.43 in stover and total uptake 127.32, 117.69, 122.51 kg ha^{-1} in Table 2), phosphorus uptake (16.18, 14.65, 15.42 in seed, 24.10, 22.81, 23.46 in stover and total uptake 40.28, 37.47, 38.87 kg ha^{-1} in Table 3), potassium uptake (24.83, 21.99, 23.41 in seed, 77.24, 73.88, 75.56 in stover and total uptake 102.06, 95.86, 98.96 kg ha^{-1} Table 4) and sulphur uptake (9.61, 8.66, 9.13 in seed, 10.58, 10.24, 10.41 in stover and total uptake 20.18, 18.90, 19.54 kg ha^{-1} Table 5) by crop was observed in 75% RDF + 25% N through pressmud + *Azotobacter* + PSB during both the years and in pooled analysis than other nutrient sources. While, the application of 75% RDF+ 25% N through pressmud+ PSB and 75% RDF + 25% N through pressmud+ *Azotobacter* response on nitrogen uptake (67.69; 67.05 kg ha^{-1} in seed; 37.95; 37.65 kg ha^{-1} in stover and total uptake (105.64; 104.70 kg ha^{-1}), phosphorus uptake (13.31; 12.99 kg ha^{-1} in seed; 20.66; 20.22 kg ha^{-1} in stover and total uptake 33.97; 33.20 kg ha^{-1}), potassium uptake (20.21; 19.72 kg ha^{-1} in seed; 66.56; 65.12 kg ha^{-1} in stover and total uptake 86.77; 84.84 kg ha^{-1}) and sulphur uptake (7.88; 7.69 kg ha^{-1} in seed; 9.17; 8.97 kg ha^{-1} in stover and total uptake (17.05; 16.67 kg ha^{-1}) by crop was found at par to each other in pooled analysis, respectively. Furthermore, minimum nitrogen uptake (28.44, 25.73, 27.09 in seed, 14.77, 14.26, 14.52 in stover and total uptake 43.21, 39.99, 41.60 kg ha^{-1}), phosphorus uptake (5.54, 5.03, 5.29 in seed, 8.05, 7.64, 7.84 in stover and total uptake 13.60, 12.67, 13.13 kg ha^{-1}), potassium uptake (8.51, 7.54, 8.03 in seed, 25.81, 24.75, 25.28 in stover and total uptake 34.31, 32.30, 33.31 kg ha^{-1}) and sulphur uptake (3.29, 2.98, 3.13 in seed, 3.53, 3.42, 3.48 in stover and total uptake by crop 6.83, 6.40, 6.61 kg ha^{-1}) in applied nutrient sources was observed in 100% RDF during both the years and in the pooled analysis, respectively. The application of 75% RDF + 25% N through pressmud + *Azotobacter* + PSB was responded positively on nutrient uptake by the crop. It may be due to improve the initial nutrient content in soil with combination of pressmud and fertilizers. It has promoted slow and long-term availability of nutrients with higher microbial population, which make favorable environment in rhizosphere as well as in plant system (Tummaramatti *et al*. 2014). The adequate supply of balanced nutrients in early crop season resulted in greater availability of macro and micro nutrients in the root zone of the plant. Increased availability of these nutrients coupled with accelerated microbial activities (Yadav *et al*. 2010).

Conclusion

The presented data summarized as the crop sowing on November 17, total nitrogen, phosphorus, potassium and sulphur uptake was recorded 103.31, 33.73, 87.38 and 16.83 kg ha^{-1}, respectively on the basis of pooled analysis as compared to crop sowing on November 27 and December 7. Among the nutrient sources application of 75% RDF + 25% N through PM +*Azotobacter* + PSB maximum total nitrogen, phosphorus, potassium and sulphur uptake was recorded 122.51, 38.87, 98.96 and 19.54 kg ha^{-1} on the basis of pooled analysis as compared with other nutrient sources.

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