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Nutrient management in Isabgol (*Plantago ovata* Forsk) under South Saurashtra Agroclimatic Zone

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Abstract
An experiment was conducted during *Rabi* seasons of 2019-20 to 2021-22 at Instructional Farm, Department of Agronomy, College of Agriculture, JAU, Junagadh entitled "Nutrient management in isabgol (*Plantago ovata* Forsk) under South Saurashtra Agroclimatic Zone". The treatments of the experiment comprised with 3 levels of nitrogen *viz.*, 30, 60 and 90 kg N/ha, two levels of phosphorus *viz.*, 30 and 60 kg P_2O_5/ha and two levels of potash *viz.*, 15 and 30 kg K_2O/ha conducted on factorial randomized block design with three replications The nitrogen was applied in tow splits, half at the time of sowing and the remaining half at 45 DAS. Common application of FYM 5 t/ha was done in all the plots. The results of the experiment revealed that significantly higher growth parameters and yield attributes like plant height, number of tillers per plant, number of spikes per plant, number of seeds per spike and spike length of Isabgol were registered under the application of 90 kg N/ha, 60kg P_2O_5/ha and 30 kg K_2O/ha. However, number of spikes per plant and number of seeds per spike were remained at par with application of 60 kg N/ha. While number of seeds per spike were not affected significantly by levels of phosphorus. Application of 90 kg N/ha (N_3) and 30 kg K_2O/ha (K_3) registered significantly higher seed yield of 1448 and 1439 kg/ha, respectively. However, in case of nitrogen, it was remained at par with application of 60 kg N/ha (N_2). Application of phosphorus did not exert any significant effect on seed yield of Isabgol. The stover yield was differed significantly due to different treatments and significantly higher stover yield was recorded under application of 90 kg N/ha, 60kg P_2O_5/ha and 30 kg K_2O/ha than rest of the levels. Significantly, the highest nutrient content and uptake of seed and stover were registered under application of 90 kg N/ha, 60 kg P_2O_5/ha and 30 kg K_2O/ha. The highest net return and B:C ratio of ` 73504 and 2.58, respectively was obtained under application of 60 kg N, 30 kg P and 30 kg K_2O/ha ($N_2P_1K_2$).

Keywords: Nutrient, isabgol, yield, nitrogen, potash

Introduction
Isabgol (*Plantago ovata* Forsk) is one of the important medicinal plants grown during *rabi* season. The name is derived from two Persian words "Isab" and "Ghol" meaning horse's ear. This derivation fits well with the shape of the seed which resembles the ear of horse. Seeds of isabgol are mainly valued for their mucilaginous rosy white husk. In addition to medicinal uses, it has a place in dyeing, printing, ice-cream, confectionary and cosmetic industries. In India, Isabgol is cultivated commercially in Gujarat, Rajasthan, Haryana, Punjab, Uttar Pradesh, Madhya Pradesh and Bihar. It is a late *rabi* season cash crop. In Gujarat, isabgul is largely grown in Kuchchh, Banaskantha, Patan, Mahesana and Ahmedabad covering 9968 ha. with a total production of 7591 tones and productivity of 761.56 kg/ha. (Anonymous, 2022) [1]. Due to lower production cost and higher market price, it is known as a low volume but high value crop. Though, isabgol does not have heavy soil nutrients demand but application of nutrients regarded as one of the basic factors and judicious use of fertilizers is chief important to get potential production. Among the nutrients, the application of nitrogen, phosphorus and potassium have been found to play significant role in improving the yield potential and quality isabgol under variable range of soil and agro-climatic conditions and their application in proper amount and in proper time will go for higher crop production. NPK are considered as major nutrients for growth and development of plants and its doses greatly varies according to the soil types in the cultivation of isabgol. Keeping these facts in view, the present investigation was conducted to test effect of NPK levels on growth, yield and nutrient uptake by isabgol under South Saurashtra Agro-climatic Zone with a view to find out the effect of NPK on growth and yield of isabgol and to find out the effect of NPK on nutrient content, uptake and soil available nutrients after harvest of the crop.

Materials and Methods

A field experiment was conducted at Instructional Farm, Department of Agronomy, College of Agriculture, JAU, Junagadh (Gujarat) during *Rabi* seasons of 2019 to 2022. The soil of the experimental field was medium black low in available nitrogen (181.6 kg/ha), medium in available phosphorus (31.65 kg/ha) and high in available potash (259.73 kg/ha) with 7.8 pH and EC 0.28 dSm^{-1}. The treatments of the experiment comprised with 3 levels of nitrogen *viz.*, 30, 60 and 90 kg N/ha, two levels of phosphorus *viz.*, 30 and 60 kg P_2O_5/ha and two levels of potash *viz.*, 15 and 30 kg K_2O/ha conducted on factorial randomized block design with three replications The nitrogen was applied in tow splits, half at the time of sowing and the remaining half at 45 DAS. Common application of FYM 5 t/ha was done in all the plots. The Isabgol variety Gujarat Isabgol-3 was sown at 30 cm x 10 cm spacing in the experiment. Data recorded for various growth and yield parameters were statistically analyzed using the method of analysis of variance as described by Panse and Sukhatme (1985) [10].

Results and Discussion

Based on the pooled results of three years it is apparent that significantly higher growth parameters and yield attributes like plant height, number of tillers per plant, number of spikes per plant, number of seeds per spike and spike length of Isabgol were registered under the application of 90 kg N/ha, 60kg P_2O_5/ha and 30 kg K_2O/ha. However, number of spikes per plant and number of seeds per spike were remained at par with application of 60 kg N/ha. While number of seeds per spike were not affected significantly by levels of phosphorus. This could be attributed to better root proliferation, higher root development, increased availability and uptake of nutrients, energy transformation and metabolic processes in plant. These findings are in agreement of Reddy (2014) [6], Jajoria *et al.* (2013) [3], Mor *et al.* (2014) [4], Patel *et al*. (2015) [5] and Sahu *et al*. (2021) [7].

The data advocated that application of 90 kg N/ha (N_3) and 30 kg K_2O/ha (K_3) registered significantly higher seed yield of 1448 and 1439 kg/ha, respectively. However, in case of nitrogen, it was remained at par with application of 60 kg N/ha (N_2). Application of phosphorus did not exert any significant effect on seed yield of Isabgol. Interaction effect was found non-significant with respect to seed yield. Significantly the lowest seed yield was recorded under application of 30 kg N/ha and 15 kg K2O/ha. The stover yield was differed significantly due to different treatments and significantly higher stover yield was recorded under application of 90 kg N/ha, 60kg P_2O_5/ha and 30 kg K_2O/ha than rest of the levels. Significantly the lowest seed yield was recorded under application of 30 kg N/ha and 15 kg K2O/ha. Significant increment in seed yield of isabgol may be due to the increase in the tillers per plant, spikes per plant, seeds per spike, test weight with the fact that N P K is expected to hasten plant development and longer period for movement of photosynthates from source to sink. These reasons are similar with the findings of, Patel *et al.* (2015) [5], Shivran (2016) [8], Sojitra *et al.* (2019) [2], Sahu *et al.* (2021) [7] and Qureshi and Dewangan (2022) [9].

Significantly, the highest nutrient content and uptake of seed and stover were registered under application of 90 kg N/ha, 60 kg P_2O_5/ha and 30 kg K_2O/ha. Application of 30 kg N/ha, 30 kg P_2O_5/ha and 15 kg K_2O/ha recorded significantly lower nutrient content and uptake of seed and stover. The interaction effect of nitrogen and phosphorus in case of nutrient uptake by seed and stover was significant and N_3P_2 level registered significantly the highest NPK uptake by seed and stover. Significantly higher available N, P and K in the soil were noted with application of 90 kg N/ha, 60 kg P_2O_5/ha and 30 kg K_2O, respectively. Interaction effect of nitrogen, phosphorus and potash was found significant in case of available phosphorus. Significantly higher available nitrogen, phosphorus and potash were recorded under application of 90 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha ($N_3P_2K_2$) which was remained at par with $N_2P_2K_1$.

The highest net return and B:C ratio of `73504 and 2.58, respectively was obtained under application of 60 kg N, 30 kg $P_2O_5$ and 30 kg $K_2O$/ha ($N_2P_1K_2$). Comparatively, the lowest gross return, net return and BCR of `88652, `42562 and 1.93, respectively under $N_1P_1K_1$.

Table 1: Effect of NPK levels on plant height and yield attributes (Pooled)

Treatments	Plant height (cm)	No. of tillers per plant	No. of spikes per plant	No. of seeds per spike	Spike length (cm)
N Levels					
N_1: 30 kg/ha	26.67	5.60	43.47	56.99	4.10
N_2: 60 kg/ha	28.20	6.32	47.83	64.82	4.54
N_3: 90 kg/ha	29.70	7.34	50.06	66.56	4.92
S.Em.±	0.36	0.17	0.76	1.03	0.09
C.D. at 5%	1.02	0.48	2.24	2.92	0.27
P Levels					
P_1: 30 kg/ha	27.70	6.15	46.09	62.11	4.36
P_2: 60 kg/ha	28.68	6.69	48.15	63.46	4.68
S.Em.±	0.30	0.14	0.60	0.84	0.08
C.D. at 5%	0.84	0.39	1.70	NS	0.22
K Levels					
K_1: 15 kg/ha	27.50	5.98	45.08	60.16	4.36
K_2: 30 kg/ha	28.88	6.86	49.16	65.41	4.68
S.Em.±	0.30	0.14	0.60	0.84	0.08
C.D. at 5%	0.84	0.39	1.70	2.38	0.22
NxP					
S.Em.±	0.51	0.24	1.04	1.46	0.13
C.D. at 5%	NS	NS	NS	NS	NS
NxK					

S.Em.±	0.51	0.24	1.04	1.46	0.13
C.D. at 5%	NS	NS	NS	NS	NS
PxK					
S.Em.±	0.42	0.20	0.85	1.19	0.11
C.D. at 5%	NS	NS	NS	NS	NS
NxPxK					
S.Em.±	0.73	0.34	1.48	2.07	0.19
C.D. at 5%	NS	NS	NS	NS	NS
C.V. %	7.72	16.01	9.40	9.87	12.58

Table 2: Effect of NPK levels on seed yield of isabgol

Treatments	Seed yield (kg/ha)			
	2019-20	2020-21	2021-22	Pooled
N Levels				
N_1: 30 kg/ha	1421	1352	995	1256
N_2: 60 kg/ha	1548	1402	1088	1346
N_3: 90 kg/ha	1619	1571	1154	1448
S.Em.±	45	59	30	36
C.D. at 5%	131	173	89	105
P Levels				
P_1: 30 kg/ha	1507	1440	1048	1332
P_2: 60 kg/ha	1552	1444	1110	1369
S.Em.±	37	48	25	22
C.D. at 5%	NS	NS	NS	NS
K Levels				
K_1: 15 kg/ha	1448	1308	1028	1261
K_2: 30 kg/ha	1611	1575	1130	1439
S.Em.±	37	48	25	22
C.D. at 5%	107	142	73	62
NxP				
S.Em.±	63	84	43	38
C.D. at 5%	NS	NS	NS	NS
NxK				
S.Em.±	63	84	43	38
C.D. at 5%	NS	NS	NS	NS
PxK				
S.Em.±	52	68	35	31
C.D. at 5%	NS	NS	NS	NS
NxPxK				
S.Em.±	90	118	61	53
C.D. at 5%	NS	NS	NS	NS
C.V. %	10.15	14.21	9.79	11.88
Y				
S.Em.±				26
C.D. at 5%				75
Y x T				NS

Table 3: Effect of NPK levels on stover yield of isabgol

Treatments	Stover yield (kg/ha)			
	2019-20	2020-21	2021-22	Pooled
N Levels				
N_1: 30 kg/ha	2424	2282	1986	2230
N_2: 60 kg/ha	2565	2819	2057	2480
N_3: 90 kg/ha	2706	3334	2223	2754
S.Em.±	72	152	56	59
C.D. at 5%	210	447	163	167
P Levels				
P_1: 30 kg/ha	2532	2675	2048	2418
P_2: 60 kg/ha	2598	2949	2130	2559
S.Em.±	58	124	45	48
C.D. at 5%	NS	NS	NS	136
K Levels				
K_1: 15 kg/ha	2459	2596	2018	2358
K_2: 30 kg/ha	2671	3027	2159	2619
S.Em.±	58	124	45	48
C.D. at 5%	171	365	133	136

NxP				
S.Em.±	101	216	78	84
C.D. at 5%	NS	NS	NS	NS
NxK				
S.Em.±	101	216	78	84
C.D. at 5%	NS	NS	NS	NS
PxK				
S.Em.±	83	176	64	68
C.D. at 5%	NS	NS	NS	NS
NxPxK				
S.Em.±	143	305	111	118
C.D. at 5%	NS	NS	NS	NS
C.V. %	9.66	18.78	9.21	14.25
Y				
S.Em.±				27
C.D. at 5%				76
Y x T				NS

Table 4: Effect of NPK levels on nutrient content of seed and stover of isabgol (Pooled)

Treatments	N content in seed (%)	N content in stover (%)	P content in seed (%)	P content in stover (%)	K content in seed (%)	K content in stover (%)
N Levels						
N_1: 30 kg/ha	0.99	1.36	1.19	1.60	1.18	1.41
N_2: 60 kg/ha	1.21	1.60	1.43	1.88	1.41	1.70
N_3: 90 kg/ha	1.38	1.83	1.64	2.17	1.62	1.93
S.Em.±	0.02	0.03	0.02	0.03	0.02	0.03
C.D. at 5%	0.05	0.07	0.06	0.09	0.06	0.07
P Levels						
P_1: 30 kg/ha	1.12	1.52	1.33	1.79	1.31	1.57
P_2: 60 kg/ha	1.27	1.67	1.51	1.98	1.49	1.79
S.Em.±	0.01	0.02	0.02	0.03	0.02	0.02
C.D. at 5%	0.04	0.06	0.05	0.07	0.05	0.06
K Levels						
K_1: 15 kg/ha	1.15	1.55	1.36	1.83	1.35	1.61
K_2: 30 kg/ha	1.24	1.65	1.47	1.94	1.46	1.75
S.Em.±	0.01	0.02	0.02	0.03	0.02	0.02
C.D. at 5%	0.04	0.06	0.05	0.07	0.05	0.06
NxP						
S.Em.±	0.03	0.04	0.03	0.05	0.03	0.04
C.D. at 5%	NS	NS	NS	NS	NS	NS
NxK						
S.Em.±	0.03	0.04	0.03	0.05	0.03	0.04
C.D. at 5%	NS	NS	NS	NS	NS	NS
PxK						
S.Em.±	0.02	0.03	0.02	0.04	0.02	0.03
C.D. at 5%	NS	NS	NS	NS	NS	NS
NxPxK						
S.Em.±	0.04	0.05	0.04	0.06	0.04	0.05
C.D. at 5%	NS	NS	NS	NS	NS	NS
C.V. %	9.20	9.51	8.51	10.25	8.61	9.01

Table 5: Effect of NPK levels on nutrient uptake by seed and stover of isabgol (Pooled)

Treatments	N uptake by seed (kg/ha)	N uptake by stover (kg/ha)	P uptake by seed (kg/ha)	P uptake by stover (kg/ha)	K uptake by seed (kg/ha)	K uptake by stover (kg/ha)
N Levels						
N_1: 30 kg/ha	12.90	30.62	15.24	35.74	15.27	31.51
N_2: 60 kg/ha	16.94	40.05	19.94	46.64	19.94	42.33
N_3: 90 kg/ha	20.41	50.81	24.02	59.78	24.07	53.57
S.Em.±	0.31	0.76	0.36	1.04	0.37	0.84
C.D. at 5%	0.87	2.14	1.01	2.92	1.04	2.36
P Levels						
P_1: 30 kg/ha	15.32	37.41	18.07	43.57	18.09	38.51
P_2: 60 kg/ha	18.18	43.57	21.40	51.20	21.43	46.43
S.Em.±	0.25	0.62	0.29	0.85	0.30	0.68

C.D. at 5%	0.71	1.75	0.82	2.39	0.85	1.93
K Levels						
K_1: 15 kg/ha	15.16	37.08	17.89	43.55	17.92	38.47
K_2: 30 kg/ha	18.34	43.91	21.57	51.22	21.60	46.47
S.Em.±	0.25	0.62	0.29	0.85	0.30	0.68
C.D. at 5%	0.71	1.75	0.82	2.39	0.85	1.93
NxP						
S.Em.±	0.44	1.07	0.50	1.46	0.52	1.18
C.D. at 5%	1.23	3.02	1.42	4.14	1.47	3.34
NxK						
S.Em.±	0.44	1.07	0.50	1.46	0.52	1.18
C.D. at 5%	NS	NS	NS	NS	NS	NS
PxK						
S.Em.±	0.36	0.87	0.41	1.20	0.43	0.96
C.D. at 5%	NS	NS	NS	NS	NS	NS
NxPxK						
S.Em.±	0.62	1.51	0.71	2.07	0.74	1.67
C.D. at 5%	NS	NS	NS	NS	NS	NS
C.V. %	11.02	11.22	10.84	13.11	11.20	11.81

Table 6: Interaction effect of NPK levels on nitrogen uptake by seed and stover (Pooled)

N / P	Nitrogen uptake by seed (kg/ha)				Nitrogen uptake by stover (kg/ha)			
	N_1	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**
P_1	14.04	19.71	21.68	18.48	33.96	45.37	50.77	43.36
P_2	17.12	20.92	27.12	21.72	40.49	46.60	60.28	49.12
Mean	15.58	20.32	24.40		37.22	45.98	55.52	
S.Em.±	0.44				1.07			
C.D. at 5%	1.23				3.20			

Table 7: Interaction effect of NPK levels on phosphorus uptake by seed and stover (Pooled)

N / P	Nitrogen uptake by seed (kg/ha)				Nitrogen uptake by stover (kg/ha)			
	N_1	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**
P_1	16.15	22.66	24.91	21.24	37.66	50.31	56.30	48.09
P_2	19.69	24.06	31.19	24.98	44.90	51.73	68.58	55.07
Mean	17.92	23.36	28.05		41.28	51.02	62.44	
S.Em.±	0.50				1.46			
C.D. at 5%	1.42				4.14			

Table 8: Interaction effect of NPK levels on potassium uptake by seed and stover (Pooled)

N / P	Nitrogen uptake by seed (kg/ha)				Nitrogen uptake by stover (kg/ha)			
	N_1	**N_2**	**N_3**	**Mean**	**N_1**	**N_2**	**N_3**	**Mean**
P_1	16.85	23.65	26.02	22.17	35.38	49.67	53.36	46.13
P_2	20.55	25.11	32.54	26.07	43.73	51.74	68.39	54.62
Mean	18.70	24.38	29.28		39.55	50.70	60.88	
S.Em.±	0.52				1.18			
C.D. at 5%	1.47				3.34			

Table 9: Effect of NPK levels on available nutrients in soil after harvest (Pooled)

Treatment	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Available Potash (kg/ha)
N			
N_1: 30 kg/ha	224.8	35.8	256.1
N_2: 60 kg/ha	241.7	38.0	257.3
N_3: 90 kg/ha	253.2	38.9	257.4
S.Em.±	2.1	0.6	1.9
C.D. at 5%	5.9	NS	NS
P Levels			
P_1: 30 kg/ha	235.1	35.8	253.9
P_2: 60 kg/ha	244.7	39.3	259.9
S.Em.±	1.7	0.5	1.5
C.D. at 5%	4.8	1.3	4.4
K Levels			
K_1: 15 kg/ha	238.8	37.2	251.9
K_2: 30 kg/ha	241.0	37.9	261.9
S.Em.±	1.7	0.5	1.5

C.D. at 5%	NS	NS	4.4
NxP			
S.Em.±	2.9	0.8	2.7
C.D. at 5%	NS	NS	NS
NxK			
S.Em.±	2.9	0.8	2.7
C.D. at 5%	NS	NS	NS
PxK			
S.Em.±	2.4	0.7	2.2
C.D. at 5%	NS	NS	NS
NxPxK			
S.Em.±	4.1	1.2	3.8
C.D. at 5%	NS	3.3	NS
C.V. %	5.2	9.3	4.4
Initial	181.66	31.65	259.73

Table 10: Interaction effect of N, P and K levels on available phosphorus in soil after harvest

NxPXK	Available Phosphorus (kg/ha)			
	N_1	N_2	N_3	Mean
P_1K_1	36.3	36.7	39.2	37.4
P_1K_2	36.7	37.8	38.3	37.6
P_2K_1	39.0	43.0	39.6	40.5
P_2K_2	38.0	41.7	46.0	41.9
S.Em.±	1.2			
C.D. at 5%	3.3			

Table 11a: Effect of NPK levels on economics of isabgol (Mean of 3 years)

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)	Gross return (₹/ha)	Cost of cultivation (₹/ha)	Net returns (₹/ha)	BCR
N Levels						
N_1: 30 kg/ha	1209	2230	97798	46911	50887	2.09
N_2: 60 kg/ha	1324	2493	107176	47293	59883	2.27
N_3: 90 kg/ha	1430	2754	115764	47681	68083	2.43
P Levels						
P_1: 30 kg/ha	1309	2427	105947	46547	59400	2.28
P_2: 60 kg/ha	1332	2559	107878	48043	59835	2.25
K Levels						
K_1: 15 kg/ha	1227	2358	99313	47223	52090	2.11
K_2: 30 kg/ha	1415	2628	114512	47368	67144	2.42

Table 11b: Interaction effect of NPK levels on economics of isabgol (Mean of 3 years)

S. No	Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)	Gross return (₹/ha)	Cost of cultivation (₹/ha)	Net returns (₹/ha)	BCR
1	$N_1P_1K_1$	1095	2063	88652	46091	42562	1.93
2	$N_1P_1K_2$	1226	2265	99202	46236	52966	2.15
3	$N_1P_2K_1$	1115	2157	90255	47587	42668	1.90
4	$N_1P_2K_2$	1398	2436	113083	47732	65351	2.37
5	$N_2P_1K_1$	1259	2382	101881	46473	55409	2.20
6	$N_2P_1K_2$	1485	2645	120122	46618	73504	2.58
7	$N_2P_2K_1$	1119	2276	90697	47969	42729	1.89
8	$N_2P_2K_2$	1433	2671	116002	48114	67889	2.42
9	$N_3P_1K_1$	1328	2503	107457	46861	60596	2.30
10	$N_3P_1K_2$	1463	2702	118370	47006	71364	2.52
11	$N_3P_2K_1$	1444	2764	116936	48357	68580	2.42
12	$N_3P_2K_2$	1485	3048	120293	48502	71791	2.49

Selling price: Seed ` 80/kg, Stover ` 0.5/kg

Conclusion

On the basis of the experimental results, it could be concluded that different levels of nitrogen, phosphorus and potash significantly affected growth and yield of Isabgol. The application of 30 kg N/ha, 30 kg P_2O_5/ha and 30 kg K_2O/ha along with FYM 5 t/ha at the time of sowing and remaining 30 kg N/ha at as top dressing at 45 DAS performed better in terms of growth parameters, yield attributes, yield and nutrient content and uptake of Isabgol under medium black soils of South Saurashtra Agroclimatic Zone.

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