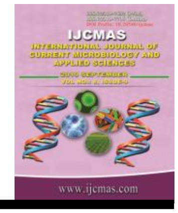
Int.J.Curr.Microbiol.App.Sci (2019) *8*(9): 2031-2041

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 8 Number 09 (2019)**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2019.809.235

Influence of Varieties and Integrated Nutrient Management on Yield Parameters of Isabgol (*Plantago ovata* Forsk.) under Northern Dry Zone of Karnataka, India

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Keywords

Vallabh Isabgol-1 and Gujarat Isabgol-2, Varieties, INM treatments, varieties with INM, Growth, Yield

Article Info

Accepted:
20 August 2019
Available Online:
10 September 2019

A B S T R A C T

The field research was conducted to evaluate the performance of yield parameters of two Isabgol cultivars for commercial production in northern dry zone of Karnataka during two years 2015-16 and 2016-17. The experiment was laid out in split plot design (SPD) with sixteen INM treatment combinations at the College of Horticulture, Bagalkot. Analysis of both years with pooled data exhibited higher value was recorded in Vallabh Isabgol-1in growth parameters *viz.*, number of seeds per spike (60.33), seed yield per plot (442.23 g $plot^{-1}$), seed yield (12.30 q ha^{-1}), husk yield (3.62 q ha^{-1}), straw yield (23.93q ha^{-1}), harvest index (23.93 %), test weight (2.25 g) as compared to Gujarat Isabgol-2. Whereas the higher values with INM treatments with respect to plant growth parameters were observed in *Viz.* $\mathbf{N_{11}}$-75 % RD of FYM **(**7.5 t ha^{-1}) + 75% RD of NPK (37.5:18.75:22.50 kg ha^{-1}) +*Azospirillum* (5kg ha^{-1}) + *PSB* (3kg ha^{-1}) + $ZnSO_4$ (15 kg ha^{-1}) + $FeSO_4$ (7.5 kg ha^{-1}) *viz.*, and number of seeds per spike (71.79), seed yield per plot (555.66g), seed yield (15.43 q ha^{-1}), husk yield (5.38q ha^{-1}), straw yield (28.83 q ha^{-1}), harvest index (22.13) and test weight (2.57g). Higher values for interaction effect on growth parameters were recorded in V_1N_{11}.*viz*, number of seeds per spike (72.50), seed yield per plot (557.97 g), seed yield (15.50 q ha^{-1}), husk yield (5.45q ha^{-1}) straw yield (29.30 q ha^{-1}), harvest index (22.34) and test weight (2.75 g).

Introduction

Isabgol is a sub-caulescent softy hairy or woolly annual herb it growing to a height of 30 to 50 cm. Leaves are narrowly linear and distinctly toothed. Flowers are bisexual and favour out crossing due to protruding stigma, 45 to 70 in cylindric or ovoid, 2 to 4 cm long and about 0.5 cm broad spikes, capsules ellipsoidal about 8 mm long, obtuse, the upper half coming off as against blunt conical lid, membranous, glabrous, seeds ovoid-oblong, about 3 mm long, boat shaped, smooth, yellowish brown, contain a membranous cover and provide the husk on mechanical milling which constitutes the drug. The seeds are minute and 1000 seeds weighing about two grams. The husk is thin, white, membranous, and translucent covers the concave side of seeds (Farooqui and Sreeramu, 2001).

In India, Isabgol occupies an area of 80,000 ha with the total production of 45,000 tonnes and productivity of 0.56 MT ha^{-1}. India is the only country with monopoly in Isabgol production and marketing in the international trade. Thus, with average export volume of 29,000 MT and it earns on an average of ₹ 520 crores annually which contribute to about 80 per cent of the Psyllium traded in the world market. So, it is called as dollar earning medicinal plant of India. Among all the countries in the world, the United States of America is the single major buyer of Psyllium husk from India, accounting for about 75 per cent of the total exports of the material from India (Goraya and Ved, 2019) with annual trade of more than 60,000 MT.

In Karnataka, Isabgol cultivation is very meager and only local cultivars are grown with poor yield. There is a wide yield gap between local cultivars and high yielding varieties. Performance of any crop or variety depends upon inherent genetic potential make up, of variety and response to climatic condition of the zone. To attain increased productivity, studies on INM have been carried out with an aim to identify suitable cultivar.

Materials and Methods

The experiment was conducted in the field at Department of Plantation Spices Medicinal and Aromatic Plants, College of Horticulture, Bagalkot at Haveli farm during the years 2015-16 and 2016-17. Geographically, this experimental site lies in Northern Dry Zone (Zone-3) of Karnataka state in the agro-climatic zone of Karnataka, situated at 16° North latitude and 74°59’ East longitude and at an altitude of 533.0 m above mean sea level

The soil of experimental field was red clay loamy in texture, with percentages of sand 22.60, silt 26.10 and clay52.20 bulk density 1.25, EC 0.24 dS m^{-1} and pH 8.22 (alkaline in reaction) with organic carbon 1.63 and available 268.02, 34.80, 273.69 NPK kg ha^{-1}. The source of seed collection was DMAPR Anandh Gujarat *i.e.* Vallabh Isabgol-1(V_1) and Gujarat Isabgol-2 (V_2). Seed were sown in 18 November 2015 and 2016 with gross plot size of 3.6 m x 1.5 m = 5.40 m^2 in split plot design in sixteen INM sub treatments with three replications as subplot listed below.

N_1 **-**RDF FYM **(**10 t ha^{-1}) + RDF NPK (50:25:30 kg ha^{-1})
N_2-RDF FYM **(**0 t ha^{-1}) + RDF NPK (50:25:30 kg ha^{-1}) +$ZnSo_4$ (15 kg ha^{-1})
N_3-RDF FYM **(**10 t ha^{-1}) + RDF NPK (50:25:30 kg ha^{-1}) +$FeSo_4$ (7.5 kg ha^{-1})
N_4-RDF FYM **(**10 t ha^{-1}) + RDF NPK (50:25:30 kg ha^{-1}) +$FeSo_4$ (7.5 kg ha^{-1}) + $ZnSo_4$ (15 kg ha^{-1})
N_5-Vermicompost (1t ha^{-1}) + RDF NPK (50:25:30 kg ha^{-1})
N_6-Vermicompost (1t ha^{-1}) +50% RDF NPK (50:25:30 kg ha^{-1})+*Azospirillum*(5kg ha^{-1}) + *Azotobacter* (5kg ha^{-1})
N_7-75% RDF FYM **(**7.5 t ha^{-1}) + 75% RDF NPK (37.5:18.75:22.50 kg ha^{-1})
N_8-75% RDF FYM **(**7.5 t ha^{-1}) +75% RDF NPK (37.5:18.75:22.50 kg ha^{-1}) + *Azotobacter* (5kg ha^{-1})
N_9-75% RDF FYM **(**7.5 t ha^{-1}) +75% RDF NPK (37.5:18.75:22.50 kg ha^{-1})+ *Azospirillum* (5kg ha^{-1})
N_{10}-75% RDF FYM **(**7.5 t ha^{-1}) +75% RDF NPK (37.5:18.75:22.50 kg ha^{-1}) + *PSB* (3kg ha^{-1})
N_{11}-75%RDF FYM **(**7.5tha^{-1}) + 75% RDF NPK (37.5:18.75:22.50 kg ha^{-1})+ *Azospirillum*(5kg ha^{-1})+ *PSB* (3kg ha-

^{1})+ZnSo$_4$(15kg ha^{-1}) + FeSo$_4$ (7.5 kg ha^{-1})
N$_{12}$-50%RDF FYM (5t ha^{-1}) + 50% RDF NPK (25:12.5:15 NPK kg ha^{-1})
N$_{13}$-50% RD FYM (5t ha^{-1}) +50% RDF NPK (25:12.5:15 kg ha^{-1}) +*Azotobacter* (5kg ha^{-1})
N$_{14}$-50% RDF FYM (5t ha^{-1}) +50% RDF NPK (25:12.5:15 kg ha^{-1}) +*Azospirillum* (5kg ha^{-1})
N$_{15}$-50% RDF FYM (5t ha^{-1}) +50% RDF NPK (25:12.5:15 kg ha^{-1}) +*PSB* (3kg ha^{-1})
N$_{16}$-50%RD FYM (5t ha^{-1}) +75% RDF NPK (37.5:18.75:22.50 kg ha^{-1}) + *Azospirillum* (5kg ha^{-1}) +*PSB* (3kg ha^{-1})+Znso$_4$ (15kg ha^{-1})+FeSo$_4$(7.5 kg ha^{-1}).

The experiment after layout then treatments were applied as per above nutrient combination, then mixed thoroughly in plots before imposing the treatments. Zinc was applied in the form of ZnSo$_4$ at the time of sowing half dose of N was applied as a basal and remaining half was applied one month after sowing as top dressing full dose of P and K were applied at the time of sowing below the seed in furrows made with the help of land hoe. Manual thinning weeding and hoeing were done at one month after sowing to provide an ideal environment to the crop a light irrigation was given immediately before sowing, however six and seven irrigation were given as pet requirement of the crop with the help of sprinkler.

Five plants were selected randomly in each plot, were recorded dry matter of plants per meter row length growth parameter were recorded at the time of harvest in each plot at all the stages of crop however the yield parameters were recorded at harvest stages values were discussed here. The grain and straw samples were collected separately from each plot, dried at 60 ^{0} C for 48 hours. Dry mass was ground in a stainless steel ball mill for nutrient analysis. N concentration in both seed and straw was estimated by modified Kjeldahal's method (Piper,1966). The P content was determined using the vanado molybdo phosphoric acid yellow colour method (Jackson 1973), K content was estimated with diacid mixture by using Flame photometer (Stanford, S. and English., 1963).

Number of seeds per spike: The seed number was recorded for five spikes from each of five labelled plants from each plot and their average value was taken for the analysis.

Seed yield per plot (g): The net plot was harvested and threshed. The weight of the seeds of net plot was recorded in gram per plot yield.

Seed yield (q ha^{-1}): The net plot was harvested and threshed and weight of the seeds of net plot was recorded and was converted into seed yield quintal per hectare.

Husk yield (q ha^{-1}): As a preliminary step, the husk content (%) of the seeds of the samples belonging to different nutrient treatments was determined as per the procedure given by Patel *et al.*, (2005). To determine the husk content, one gram seed of respective sample was taken and was boiled with mild acid (0.1N HCl) for two minutes and subsequently washed nine times with hot (80°C) distilled water, each time using 10 ml. Total removal of mucilage was judged by the non-stickiness of the seeds. The husk yield per hectare was worked out by multiplying the total unhusked seed yield per hectare with the husk content in the seeds.

Straw yield (q ha^{-1}): The crop of the net plot was harvested and threshed after separating from the seeds; the straw was dried under shade and then converted into straw yield as quintals per hectare.

Harvest Index (%): The harvest index was calculated by dividing economic yield (seed yield) per hectare by total biological yield per hectare on dry weight basis and it was expressed in percentage.

Test weight (g): The observations on the weight of 1000 seeds (g) were recorded after harvest in each of the treatment combination.

The pooled data was subjected to statistical analysis of split-plot design by the Fischer's method of analysis of variance technique as given by Panse and Sukhatme (1983). The level of significance used in 'F' and 't' test was p=0.05, critical values were calculated wherever the 'F' test was significant.

Results and Discussion

At harvest stage yield parameters were recorded significantly higher values were recorded with Vallabh Isabgol-1, number of seeds per spike (60.33), seed yield per plot (442.23g), seed yield (12.30 q ha^{-1}), husk yield (3.62 q ha^{-1}), straw yield (23.93 q ha^{-1}), harvest index (18.11%) and test weight (2.57g) during pooled data respectively. This results due to varietal performance to different agroclimatic conditions and genetical characteristics of particular variety and their difference in genotypic factor and adaptability of particular variety to soil and climatic conditions and the increased number of leaves, leaf area and number of tillers helped in better synthesis of carbohydrates and their utilization for build up of new cells, apart from better absorption of nutrients resulting in increased dry matter production were reported by several workers (Kumar *et al.,* 2009, Shirvan *et al.,* 2016a and Tyagi *et al.,* 2016) and also quality parameters this may be due to genotypic factor same findings was reported by Raissi *et al.,* (2013).The lower number of seeds per spike (58.03), seed yield per plot (397.85),seed yield (11.05q ha^{-1}), husk yield (3.33 q ha^{-1}), straw yield (20.00 q ha^{-1}), harvest index (15.53%), test weight (2.21g) as campared to in Gujarat Isabgol-2 during pooled data.

Integrated nutrient management

The significantly higher number of seeds per plant, at harvest (71.79) was recorded in N_{11}which was on par with N_6 (66.95), N_{16} (66.70) and N_4 (65.76). The significantly lower number of tillers per plant was recorded in N_{13} (47.72). This has been the consequence as a result of higher nutrient availability with application of organic manure (FYM, VC and biofertilizers) along with inorganic fertilizers which had profound influence in mobilizing the nutrients from the unavailable form of nutrients to available source and also enhanced improvement of soil physical, chemical and biological properties. The micro nutrient zinc application along with organics it acts as a component of carbonic anhydrase, as well as several dehydrogenases and required for auxin production which in turn enhance plant growth.

Iron was necessary for the biosynthesis of chlorophyll and cytochrome, leading to increase in photosynthesis processes, respiration, other biochemical physiological activities of the plants. Similar results observed by Yadav *et al.,* (2003) Salmasi *et al.,* (2012) and Tripathi *et al.,* (2013).

Significantly higher seed yield per plot and seed yield per plot and hectare in pooled analysis were presented 555.66g $plot^{-1}$, 15.43 q ha^{-1} was recorded in N_{11} (75 % RD of FYM + 75 % RD of NPK + *Azospirillum* + *PSB* + $ZnSO_4$ + $FeSO_4$), which were on par with N_6 (Vermicompost + 50 % RD of NPK + *Azospirillum* + *Azatobacter*) (533.81 g,14.83 q ha^{-1}) and N_4 (RD of FYM + RD of NPK+ $ZnSO_4$ + $FeSO_4$) (540.91g, 15.12 q ha^{-1}), N_{16} (50 % RD of FYM+ 75% RD of NPK + *Azospirillum* + *PSB* + $ZnSO_4$ + $FeSO_4$)

(536.34 g, 14.90 q ha^{-1}). Further lower seed yield (332.92g and 9.25 q ha^{-1}) seed yield $plot^{-1}$ and seed yield $ha^{-1}$was recorded in N_{13} (50 % RD of FYM + 50% RD of NPK+ *Azatobacter*) during pooled data, which could be due to the increased seed yield consequence with application of balanced nutrient RD of FYM 75 % + RD of NPK micro nutrients mixed with bio fertilizers like *azospirillum* mechanism through phosphate dissolution and in the biosynthesis of bio-active in soil. The biofertilizers help in fixation of atmospheric nitrogen, better root proliferation, better availability and absorption of nutrients by the plants, which might have resulted in better growth in plant further N P K nutrients available form would attributed to more uptake of nutrients in faster rate in plant, *PSB* helps in reducing phosphorus fixation by its chelating effect and also solubilized the fixed phosphorus accelerated increase in growth of parameters towards reproductive parameters with accelerating tillers, dry matter production, number of spikes per plant, spikelets per plant, spike length, increase towards yield attributing characters *viz*. number of seeds per spike, ultimately all these growth and reproductive and yield attributes helped to increase seed yield, Similar findings observed by Repsiene (2001), Yadav *et al.*, (2003), Nadim *et al.*, (2011), Singh *et al.*, (2011), Tripati *et al.,* (2013), Choudhary *et al.*, (2014), Nadukeri *et al.,* (2014) and Shivran *et al.*, (2015).

Higher husk yield (q ha^{-1}) was significantly influenced by integrated nutrient management (5.38 q ha^{-1}) was recorded in $N_{11,}$ which was on par with N_4 (5.20), N_6 (5.14), and N_{16} (5.01). Further the lower number of leaves per plant was recorded in N_{13} (2.38). This is because of combined application of nutrients resulted creation of favourable environment for uptake of nutrients for plants by use organic and inorganic nutrients along with *Azospirillum* and *PSB* around rhizosphere which attributed to the enhanced the availability nutrients at appropriate time leads to the production of growth promoting substances, further that might have caused cell elongation and multiplication then to increase in the chlorophyll content of leaves resulted in increased synthesis of carbohydrates Yadav *et al.,* (2003).

Significantly higher straw yield, (28.83 q ha^{-1}) was recorded in N_{11} (75 % RD of FYM + 75 % RD of NPK + *Azospirillum* + *PSB* + $ZnSO_4$ + $FeSO_4$) which was on par with N_{16} (28.29), N_6 (28.25) and N_6 (27.77).Whereas the lower (17.10) straw yield recorded in N_{13} during pooled data same findings reported by Patel and Saravanan (2010) and Shivran *et al.*, (2016 a).

The significantly higher harvest index (22.13 %) was recorded in N_{11} (75 % RD of FYM + 75% RD of NPK + *Azospirillum* + *PSB* + $ZnSO_4$ + $FeSO_4$) which was on par with N_{16} (21.60), N_6 (21.54) and N_4 (21.47 q ha^{-1}). Further the lower harvest index N_{13} (13.17 q ha^{-1}). The PSB helps in reducing phosphorus fixation by its chelating effect and also solubilized the fixed phosphorus leading to more uptakes of nutrients and reflected in better yield attributes like higher seed and straw yield. Higher economic and biological yield contributed towards increase harvest index these findings are in line with (Nadim *et al.*, 2011).

The significantly higher test weight (2.57 %) was recorded in N_{11} (75 % RD of FYM + 75% RD of NPK + *Azospirillum* + *PSB* + $ZnSO_4$ + $FeSO_4$) which was on par with N_4 (2.49), N_6 (2.49 q ha^{-1}) and N_{16} (2.45). Further the lower harvest index N_{13} (1.76 q ha^{-1}) because of higher seed weight due to higher doses of nutrients use, leads to increase higher functional photosynthetic accumulation, which in turn have resulted in increased seed size and seed filling further then the higher husk yield same findings reported by Nadim *et al.,* (2011), Singh *et al.,* (2011) and Tripati *et al.,* (2013).

Interaction effect

Interaction effect significantly higher seed yield (15.50 q ha^{-1}) was recorded in Vallabh Isabgol-1 supplied of N_{11} (75 % RD of FYM + 75% of RD NPK + *Azospirillum* + *PSB* + $ZnSO_4$ + $FeSO_4$), which was on par with V_2N_{16} (15.32 q ha^{-1}), V_1N_{16} (15.32 q ha^{-1}), V_1N_4 (15.19 q ha^{-1}) and V_1N_6 (15.08 q ha^{-1}). The lower seed yield (8.54 q ha^{-1}) was recorded in V_2N_{13} during pooled data This was attributed to genotypic variation of that variety and proper vegetative development by plants and differences in soil, agroclimatic condition then suitability of variety to that region and balanced application of 75 percentage of fertilizer doses with organics and micro nutrients application leads to plant to take adequate nutrition at optimum growth stage helps for plant more available NPK plant at faster rate, which leads to plant to absorb optimum nutrients, leads to increased in number of tillers and spikes per plant and spike length these findings leads to more longer period of vegetative growth parameters resulting in enhanced photosynthetic and metabolic activities then consequently enabling the plants to bear more spikes of longer size, and spike length with application organics along with *PSB* treatments, which in turn played an important role in rapid cell-division and elongation in the meristamatic regions, root development and proliferation of enhancing early and more flowering, results increase, in number spikes, spikelets per plant same findings observed by Hindiholi (2006), Kumar *et al.,* (2015) and Shivran *et al.,* (2016 b). Interaction effect significant higher husk yield (5.45 q ha^{-1}) was recorded with V_1 supplied with N_{11} (75 % RD of FYM + 75 % RD of NPK + *Azospirillum* + *PSB* + $ZnSO_4$ + $FeSO_4$) which was on par with V_1N_4 (5.32 q ha^{-1}), V_1N_6 (5.31 q ha^{-1}), V_2T_{11} (5.30), and V_1N_{16} (5.08 q ha^{-1}).Whereas lower husk yield (2.30q ha^{-1}) was recorded in V_2N_{13} during pooled data. This increased yield parameters due to use of improved variety because of genotypic character and increased the growth parameters conversion towards yield parameters with integrated use of chemical fertilizer, manures like FYM enhances the uptake of N, P and K by process releasing humus forming microbes. *Azotobacter* has nitrogen fixing potential as *Nitrogenase* activity of rhizosphere in soils by releasing some growth regulators IAA, results in the production of more vegetative growth parameters conversion towards physiological then reproductive. This relationship helped to increase the yield attributes, these characters had positive beneficial effect towards higher seed yield and husk yield same findings revealed by Hindiholi *et al.,* (2006), Chaudhary and Shivran *et al.,* (2009), Saxena and Rao (2000), Shivran *et al.,* (2015) and Shivran *et al.,* (2016b). INM effect significantly number of straw yield (29.30 kg ha^{-1}) was recorded in Vallabh Isabgol-1 supplied of N_{11} (75 % RD of FYM + 75% of RD NPK + *Azospirillum* + *PSB* + $ZnSO_4$ + $FeSO_4$), which was on par with V_2N_{11} (28.35), V_1N_6 (28.46), V_1N_{16} (28.29) and V_1N_4 (28.16). The lower harvest index (15.37) was recorded in V_1N_{13} during pooled data.. This might be due to use of improved variety with its genotypic character and a balance way of Integrated Nutrient Management leading to increased growth, physiological, reproductive parameters leads to more uptake of NPK, source to sink. This relationships helped to increase the seed yield of identical characters reported by Shivran *et al.,* (2016b). This was increased due to use of improved variety with integrated use of chemical fertilizer, manures helps to increase the straw yield and biological yield of Isabgol FYM enhances the uptake of N, P and K by releasing humus forming microbes.

Table.1 Yield parameters on number of seeds spike and seed yield plot $^{-1}$ (g) as influenced by Isabgol varieties and integrated nutrient management

Varieties Nutrients	Number of seeds spike								
	2015			2016			Pooled data		
Nutrients	V_1	V_1	Mean	V_1	V_1	Mean	V_1	V_1	Mean
N_1	61.07	61.07	61.07	61.67	60.00	60.83	61.37	59.75	60.56
N_2	62.08	62.08	62.08	63.33	47.67	55.50	62.71	47.42	55.06
N_3	68.12	68.12	68.12	68.67	41.33	55.00	68.40	41.20	54.80
N_4	66.10	66.10	66.10	68.67	67.67	68.17	67.39	64.13	65.76
N_5	55.95	55.95	55.95	55.33	56.67	56.00	55.64	56.42	56.03
N_6	66.93	66.93	66.93	68.00	66.67	67.33	67.47	66.44	66.95
N_7	65.67	65.67	65.67	56.00	63.00	59.50	60.83	62.82	61.83
N_8	58.80	58.80	58.80	57.67	59.67	58.67	58.23	59.36	58.79
N_9	49.00	49.00	49.00	48.00	61.33	54.67	48.50	60.99	54.74
N_{10}	50.37	50.37	50.37	57.33	48.33	52.83	53.85	48.10	50.98
N_{11}	71.33	71.33	71.33	73.67	71.67	72.67	72.50	71.08	71.79
N_{12}	60.40	60.40	60.40	61.00	55.00	58.00	60.70	54.67	57.68
N_{13}	44.17	44.17	44.17	44.00	51.50	47.75	44.08	51.35	47.72
N_{14}	54.50	54.50	54.50	55.00	58.33	56.67	54.75	58.15	56.45
N_{15}	59.50	59.50	59.50	60.00	62.67	61.33	59.75	62.25	61.00
N_{16}	68.77	68.77	68.77	69.33	67.33	68.33	69.05	64.36	66.70
MEAN	60.17	60.17	60.17	60.48	58.68		60.33	58.03	
	S.Em ±	CD at 5%		S.Em ±	CD at 5%		S.Em ±	CD at 5%	
Varieties (V)	0.76	NS		0.48	NS		0.53	NS	
Nutrients (N)	2.53	6.59		2.32	6.59		2.27	6.42	
N at same V	3.57	9.32		3.29	9.32		3.21	9.08	
Vat same or different N	3.09	5.81		2.05	5.81		2.22	6.29	

Varieties Nutrients	seed yield per plot (g)								
	2015			2016			Pooled data		
Nutrients	V_1	V_1	Mean	V_1	V_1	Mean	V_1	V_1	Mean
N_1	465.33	346.33	405.83	449.48	342.90	396.19	465.33	346.33	405.83
N_2	476.03	352.97	414.50	463.13	347.35	405.24	476.03	352.97	414.50
N_3	447.52	436.97	442.24	436.01	431.70	433.86	447.52	436.97	442.24
N_4	546.55	548.09	547.32	540.32	541.49	540.91	546.55	548.09	547.32
N_5	391.89	381.03	386.46	386.04	379.34	382.69	391.89	381.03	386.46
N_6	550.59	516.13	533.36	543.00	524.61	533.81	550.59	516.13	533.36
N_7	388.69	329.00	358.84	380.26	326.43	353.35	388.69	329.00	358.84
N_8	370.39	310.33	340.36	367.66	324.06	345.86	370.39	310.33	340.36
N_9	361.13	337.30	349.21	362.32	333.61	347.97	361.13	337.30	349.21
N_{10}	366.37	340.99	353.68	369.70	341.54	355.62	366.37	340.99	353.68
N_{11}	563.61	558.93	561.27	557.97	553.34	555.66	563.61	558.93	561.27
N_{12}	455.96	343.56	399.76	456.26	343.93	400.09	455.96	343.56	399.76
N_{13}	358.40	313.67	336.03	358.28	307.55	332.92	358.40	313.67	336.03
N_{14}	360.93	353.73	357.33	361.37	349.38	355.38	360.93	353.73	357.33
N_{15}	457.33	402.47	429.90	492.34	397.12	444.73	457.33	402.47	429.90
N_{16}	557.00	510.16	533.58	551.48	521.19	536.34	557.00	510.16	533.58
MEAN	444.86	398.85		442.23	397.85		444.86	398.85	
	S.Em ±	CD at 5%		S.Em ±	CD at 5%		S.Em ±	CD at 5%	
Varieties (V)	2.81	8.56		3.62	11.03		2.81	8.56	
Nutrients (N)	12.52	35.42		10.10	28.58		12.52	35.42	
N at same V	17.70	50.09		14.28	40.41		17.70	50.09	
Vat same or different N	11.76	33.27		14.48	40.98		11.76	33.27	

Varieties Nutrients	Seed yield (q ha^{-1})								
	2015			2016			Pooled data		
Nutrients	V_1	V_1	Mean	V_1	V_2	Mean	V_1	V_2	Mean
N_1	12.05	9.43	61.07	12.93	9.62	11.27	12.49	9.52	11.01
N_2	12.51	9.49	62.08	13.22	9.80	11.51	12.86	9.65	11.26
N_3	11.79	11.85	68.12	12.43	12.14	12.28	12.11	11.99	12.05
N_4	14.84	14.86	66.10	15.55	15.22	15.39	15.19	15.04	15.12
N_5	10.56	10.49	55.95	10.89	10.58	10.73	10.72	10.54	10.63
N_6	14.87	14.81	66.93	15.29	14.34	14.82	15.08	14.57	14.83
N_7	10.33	9.00	65.67	10.80	9.14	9.97	10.56	9.07	9.82
N_8	10.14	9.38	58.80	10.29	8.62	9.45	10.21	9.00	9.61
N_9	10.10	9.16	49.00	10.03	9.37	9.70	10.06	9.27	9.67
N_{10}	10.36	9.50	50.37	10.18	9.47	9.82	10.27	9.49	9.88
N_{11}	15.34	15.22	71.33	15.66	15.53	15.59	15.50	15.37	15.43
N_{12}	12.68	9.56	60.40	12.67	9.54	11.10	12.67	9.55	11.11
N_{13}	9.95	8.37	44.17	9.96	8.71	9.33	9.95	8.54	9.25
N_{14}	10.05	9.58	54.50	10.03	9.83	9.93	10.04	9.70	9.87
N_{15}	14.65	10.88	59.50	12.70	11.18	11.94	13.68	11.03	12.35
N_{16}	15.17	14.78	68.77	15.47	14.17	14.82	15.32	14.48	14.90
MEAN	12.21	11.02	60.17	12.38	11.08		12.30	11.05	
	S.Em ±	S.Em ±		S.Em ±	S.Em ±		S.Em ±	C.D at 5%	
Varieties (V)	0.16	0.49		0.08	0.24		0.09	0.29	
Nutrients (N)	0.36	1.04		0.35	1.00		0.28	0.79	
N at same V	0.51	1.47		0.50	1.41		0.39	1.12	
Vat same or different N	0.63	1.81		0.33	0.94		0.38	1.07	

Varieties Nutrients	Husk yield (q ha^{-1})								
	2015			2015			Pooled data		
Nutrients	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
N_1	3.12	2.43	2.78	3.60	2.48	3.04	3.36	2.46	2.91
N_2	3.70	2.82	3.26	3.43	2.92	3.17	3.56	2.87	3.22
N_3	2.48	3.68	3.08	2.62	3.70	3.16	2.55	3.69	3.12
N_4	5.16	5.18	5.17	5.48	4.96	5.22	5.32	5.07	5.20
N_5	2.49	2.85	2.67	2.75	2.87	2.81	2.62	2.86	2.74
N_6	5.11	5.02	5.07	5.52	4.90	5.21	5.31	4.96	5.14
N_7	2.87	2.69	2.78	3.02	2.69	2.85	2.94	2.69	2.82
N_8	2.73	2.29	2.51	2.76	2.10	2.43	2.75	2.19	2.47
N_9	2.81	2.73	2.77	2.79	2.80	2.80	2.80	2.76	2.78
N_{10}	2.75	2.58	2.66	2.69	2.57	2.63	2.72	2.57	2.65
N_{11}	5.35	5.19	5.27	5.55	5.41	5.48	5.45	5.30	5.38
N_{12}	3.41	2.69	3.05	3.74	2.68	3.21	3.57	2.69	3.13
N_{13}	2.36	2.25	2.31	2.54	2.35	2.45	2.45	2.30	2.38
N_{14}	2.96	2.53	2.75	2.96	2.94	2.95	2.96	2.74	2.85
N_{15}	4.71	3.17	3.94	4.08	3.25	3.67	4.40	3.21	3.80
N_{16}	5.03	5.02	5.02	5.13	4.84	4.99	5.08	4.93	5.01
MEAN	3.57	3.32		3.67	3.34		3.62	3.33	
	S.Em ±	S.Em ±		S.Em ±	S.Em ±		S.Em ±	C.D at 5%	
Varieties (V)	0.06	NS		0.11	NS		0.08	NS	
Nutrients (N)	0.18	0.51		0.17	0.50		0.15	0.45	
N at same V	0.25	0.72		0.25	0.71		0.22	0.63	
Vat same or different N	0.26	0.75		0.46	1.31		0.33	0.94	

Table.2 Yield parameters on straw yield (q ha^{-1}), harvest index (HI %) and Test weight (g) as influenced by Isabgol varieties and integrated nutrient management

Varieties Nutrients	Straw yield (q ha^{-1})								
	2015			2016			Pooled data		
Nutrients	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
N_1	22.89	20.53	**21.71**	22.97	20.92	**21.95**	22.93	20.72	**21.83**
N_2	22.61	15.76	**19.18**	23.24	17.13	**20.18**	22.92	16.45	**19.68**
N_3	21.34	17.94	**19.64**	21.66	19.10	**20.38**	21.50	18.52	**20.01**
N_4	28.23	27.91	**28.07**	28.09	26.86	**27.47**	28.16	27.38	**27.77**
N_5	23.26	19.45	**21.36**	24.89	20.72	**22.81**	24.08	20.08	**22.08**
N_6	28.53	28.14	**28.34**	28.39	27.93	**28.16**	28.46	28.04	**28.25**
N_7	21.78	16.20	**18.99**	23.20	16.73	**19.96**	22.49	16.47	**19.48**
N_8	22.93	18.46	**20.70**	23.61	19.73	**21.67**	23.27	19.09	**21.18**
N_9	23.41	15.30	**19.35**	24.48	17.19	**20.84**	23.95	16.24	**20.09**
N_{10}	23.05	15.88	**19.46**	23.68	16.82	**20.25**	23.36	16.35	**19.86**
N_{11}	29.15	28.32	**28.73**	29.46	28.38	**28.92**	29.30	28.35	**28.83**
N_{12}	22.80	15.72	**19.26**	22.14	16.74	**19.44**	22.47	16.23	**19.35**
N_{13}	17.81	15.06	**16.43**	19.84	15.68	**17.76**	18.82	15.37	**17.10**
N_{14}	19.85	16.09	**17.97**	19.84	16.19	**18.02**	21.51	16.14	**18.83**
N_{15}	18.91	15.63	**17.27**	19.59	17.00	**18.30**	21.42	16.32	**18.87**
N_{16}	28.25	28.27	**28.26**	28.32	28.33	**28.33**	28.29	28.30	**28.29**
MEAN	**23.42**	**19.67**		**23.96**	**20.34**		**23.93**	**20.00**	
	S.Em ±	**C.D at 5%**		**S.Em ±**	**C.D at 5%**		**S.Em ±**	**C.D at 5%**	
Varieties (V)	**0.17**	**1.06**		**0.22**	**1.38**		**0.09**	**0.55**	
Nutrients (N)	**0.55**	**1.56**		**0.71**	**2.03**		**0.52**	**1.47**	
N at same V	**0.78**	**2.21**		**1.01**	**2.88**		**0.73**	**2.09**	
Vat same or different N	**0.70**	**1.99**		**0.91**	**2.58**		**0.39**	**1.12**	

Varieties Nutrients	Harvest index (HI %)								
	2015			2016			Pooled data		
Nutrients	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
N_1	17.47	14.98	**16.22**	17.95	15.27	**16.61**	17.71	15.12	**16.42**
N_2	17.56	12.63	**15.09**	18.23	13.47	**15.85**	17.89	13.05	**15.47**
N_3	16.57	14.89	**15.73**	17.04	15.62	**16.33**	16.80	15.26	**16.03**
N_4	21.53	21.38	**21.46**	21.92	21.04	**21.48**	21.72	21.21	**21.47**
N_5	16.91	14.97	**15.94**	17.89	15.65	**16.77**	17.40	15.31	**16.36**
N_6	21.70	21.48	**21.59**	21.84	21.13	**21.49**	21.77	21.31	**21.54**
N_7	16.06	12.60	**14.33**	17.00	12.93	**14.97**	16.53	12.77	**14.65**
N_8	16.53	13.92	**15.23**	16.95	14.17	**15.56**	16.74	14.05	**15.39**
N_9	16.75	12.23	**14.49**	17.26	13.28	**15.27**	17.00	12.76	**14.88**
N_{10}	16.71	12.69	**14.70**	16.93	13.15	**15.04**	16.82	12.92	**14.87**
N_{11}	22.18	21.83	**22.01**	22.49	22.02	**22.25**	22.34	21.92	**22.13**
N_{12}	17.74	12.64	**15.19**	17.40	13.14	**15.27**	17.57	12.89	**15.23**
N_{13}	13.88	11.72	**12.80**	14.90	12.19	**13.55**	14.39	11.96	**13.17**
N_{14}	14.95	12.84	**13.89**	16.60	13.01	**14.80**	15.78	12.92	**14.35**
N_{15}	17.45	13.26	**15.35**	17.65	14.09	**15.87**	17.55	13.67	**15.61**
N_{16}	21.71	21.53	**21.62**	**21.90**	**21.25**	**21.57**	21.80	21.39	**21.60**
MEAN	**17.86**	**15.35**		**18.37**	**15.71**		**18.11**	**15.53**	
	S.Em ±	**C.D at 5%**		**S.Em ±**	**C.D at 5%**		**S.Em ±**	**C.D at 5%**	
Varieties (V)	**0.12**	**0.78**		**0.08**	**0.51**		0.05	**0.36**	
Nutrients (N)	**0.34**	**0.98**		**0.40**	**1.14**		0.29	**0.82**	
N at same V	**0.49**	**1.39**		**0.57**	**1.61**		0.41	**1.16**	
Vat same or different N	**0.51**	**1.44**		**0.35**	**1.00**		0.25	**0.71**	

Varieties Nutrients	Test weight (g)								
	2015			2016			Pooled data		
Nutrients	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
N_1	2.00	2.19	**2.09**	2.05	2.25	**2.15**	2.03	2.22	**2.12**
N_2	2.19	2.21	**2.20**	2.16	2.19	**2.17**	2.18	2.20	**2.19**
N_3	2.25	2.14	**2.20**	2.22	2.14	**2.18**	2.24	2.14	**2.19**
N_4	2.54	2.50	**2.52**	2.76	2.14	**2.45**	2.65	2.32	**2.49**
N_5	2.49	2.21	**2.35**	2.26	2.19	**2.23**	2.37	2.20	**2.29**
N_6	2.42	2.42	**2.42**	2.47	2.38	**2.42**	2.44	2.40	**2.42**
N_7	2.12	2.08	**2.10**	1.93	2.00	**1.97**	2.02	2.04	**2.03**
N_8	1.98	2.05	**2.02**	2.35	2.23	**2.29**	2.17	2.14	**2.15**
N_9	1.99	1.99	**1.99**	1.98	2.01	**2.00**	1.99	2.00	**1.99**
N_{10}	2.30	2.06	**2.18**	2.28	2.10	**2.19**	2.29	2.08	**2.19**
N_{11}	2.69	2.38	**2.54**	2.82	2.38	**2.60**	2.75	2.38	**2.57**
N_{12}	2.26	2.27	**2.26**	2.29	2.34	**2.31**	2.27	2.30	**2.29**
N_{13}	1.66	1.71	**1.69**	1.73	1.93	**1.83**	1.70	1.82	**1.76**
N_{14}	2.11	2.38	**2.25**	2.07	2.44	**2.25**	2.09	2.41	**2.25**
N_{15}	2.33	2.22	**2.27**	2.38	2.26	**2.32**	2.35	2.24	**2.30**
N_{16}	2.44	2.45	**2.45**	2.51	2.41	**2.46**	2.48	2.43	**2.45**
MEAN	**2.24**	**2.20**		**2.27**	**2.21**		**2.25**	**2.21**	
	S.Em ±	**C.D at 5%**		**S.Em ±**	**C.D at 5%**		**S.Em ±**	**C.D at 5%**	
Varieties (V)	0.017	**NS**		0.010	**NS**		0.013	**NS**	
Nutrients (N)	0.054	**0.15**		0.054	**0.15**		0.043	**0.12**	
N at same V	0.076	**0.21**		0.076	**0.21**		0.061	**0.17**	
Vat same or different N	0.068	**0.19**		0.043	**0.12**		0.051	**0.14**	

Azotobacter has nitrogen fixing potential as *Nitrogenase* activity of rhizosphere soils on different treatments Isabgol rhizosphere (Saxena and Rao, 2000).

Significantly higher harvest index (22.34) was recorded with Vallabh Isabgol-1 supplied with 75 % RD of FYM + 75 % RD of NPK + *Azospirillum* + *PSB*+ $ZnSO_4$+ $FeSO_4$ (N_{11}), which was on par with V_2N_{11} (21.92), V_1N_{16} (21.80),V_1N_4(21.72), V_1N_6(21.77). The lower harvest index (11.96) was recorded in V_1N_{13} during the pooled data. This increased yield parameters due the increased seed yield consequence with application of balanced nutrient RD of FYM 75 % + RD of NPK micro nutrients mixed with bio fertilizers like *azospirillum* mechanism through phosphate dissolution and in the biosynthesis of bio-active in soil. The biofertilizers help in fixation of atmospheric nitrogen, better root proliferation, better availability and absorption of nutrients by the plants, which might have resulted in better growth in plant towards reproductive parameters with accelerating tillers, dry matter production, number of spikes per plant, spikelets per plant, spike length, increase towards yield attributing characters *viz*. number of seeds per spike and more straw yield production, ultimately all these growth and reproductive yield attributes helped to increase seed yield, husk yield, further the higher economic and biological yield contributed towards increase harvest index. However because of higher seed weight due to higher doses of nutrients use, leads to increase higher functional photosynthetic accumulation, which in turn have resulted in increased seed size and seed filling. Similar findings observed by Repsiene (2001), Yadav *et al.,* (2003), Nadim *et al.,* (2011), Singh *et al.,* (2011), Tripati *et al.,* (2013), Choudhary *et al.,* (2014), Nadukeri *et al.,* (2014), Shirvan *et al.,* (2014) and Shivran *et al.,* (2015). The number of test weight (g) was significantly at harvest stage of crop higher (2.75) was recorded with Vallabh Isabgol-1 supplied with 75 % RD of FYM + 75 % RD of NPK + *Azospirillum* + *PSB*+ $ZnSO_4$ + $FeSO_4$ (V_1N_{11}) which was on par with V_1N_4 (2.65), Further the lowest test weight (g) was recorded in V_1N_{13} (1.70) during the pooled data. However because of higher seed test weight due to higher doses of nutrients use, leads to increase higher functional photosynthetic accumulation, which in turn have resulted in increased seed size and seed filling. Similar findings observed by Repsiene (2001).

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How to cite this article:

Siddalingayya V. Salimath, K. N. Kattimani Y. K. Kotikal, Md Jameel Jhalegar, J. Venkatesh, D. R. Patile and Nagarja, N. S. 2019. Influence of Varieties and Integrated Nutrient Management on Yield Parameters of Isabgol (Plantago ovata Forsk.) under Northern Dry Zone of Karnataka, India. *Int.J.Curr.Microbiol.App.Sci.* 8(09): 2031-2041.
doi: https://doi.org/10.20546/ijcmas.2019.809.235