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Influence of varieties and integrated nutrient management on quality parameters of Isabgol (*Plantago ovata* Forsk.) under Northern Dry Zone of Karnataka, India

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A B S T R A C T

The field research was conducted to evaluate the performance of quality 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. Among the varieties the analysis on pooled data exhibited higher value in Vallabh Isabgol-1 Seed yield (12.30 q ha^{-1}),husk yield (3.62q ha^{-1}), harvest index (18.11%), test weight (2.57g), swelling factor (16.08 ccg^{-1}), ash content (2.43), moisture content (8.15 %) and carbohydrate (5.65%) as campared to Gujarat Isabgol-2. The higher value with INM treatments with respect to plant quality parameters *Viz.* were recorded, $\mathbf{N}_{11}$-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}) + $ZnSO_4$ (15kg ha^{-1}) + $FeSO_4$ (7.5 kg ha^{-1}) exhibited higher seed yield (15.34 q ha^{-1}), husk yield (5.38 q ha^{-1}), harvest index (22.13%), test weight (2.57g), swelling factor (17.99 cc g^{-1}), ash content (2.83 %), and carbohydrate (6.69%), further minimum moisture (7.73 %) which was on par with N_{16}, N_6, N_4.Interaction effect higher quality parameters recorded in seed yield Vallabh Isabgol-1 N_{11}, 75 % RD of FYM + 75% RD of NPK +*Azospirillum* + *PSB* + $ZnSO_4$ + $FeSO_4$. exhibited seed yield (15.50 q ha^{-1}), husk yield (5.45 q ha^{-1}), harvest index (22.34 %), test weight (2.75g), swelling factor (18.23 cc g^{-1}), ash content (2.81%), moisture content (7.87%) and carbohydrate (6.95 %) which were all these parameters on par with V_1N_{16}, V_1N_4 and V_1N_6 and lower values quality parameters observed inV_2N_{13}.

Introduction

Isabgol is a stem less annual herb as it belongs to the family Plantaginaceae. The word ‘Isabgol’ is derived from two Persian words, ‘asap’ and ‘ghol’, means “horse ear”, referring to the characteristic boat shape of the seeds. The word *plantago* is a Latin word, meaning sole of the foot. Isabgol is a short duration *rabi* crop and requires cool and dry climate during most of the growing period. The husk is thin, white, membranous, and translucent covers the concave side of seeds (Farooqui and Sreeramu, 2001).

Isabgol husk is a mucilaginous fibre. The mucilage is used as substitute for agar-agar. It serves as stabiliser in ice cream, filler for wheat starch and an ingredient in chocolate, a sizing agent for textiles, in the formation of pharmaceutical tablets and in cosmetics. As the seeds are rich in protein, they are mixed with guar (*Cyamopsis tetragonoloba* L.) for feeding cattle.

The performance of any crop or variety largely depends upon its genetic makeup and response to climatic conditions of the crop zone under which they are grown, the cultivars which perform well in one agroclimatic zone may not perform better in other zones because of varying climatic conditions (Salimath. 2013). Hence, it is very much necessary to collect and evaluate all the available cultivars in order to select suitable and high yielding cultivars for northern dry zone of Karnataka.

India is the only country produce maximum in the international trade, country earns on an average ₹ 1168.34 crores annually from its exporter (Department of commerce), it is widely cultivated in north Gujarat (₹1,504 Lakhs), adjoining Rajasthan (₹ 25,107 Lakhs) and Madya Pradesh over an area of about 1,50,000 ha (Anonymous 2015a) both States-out put values wise estimates of output from ₹ 26,611 corers of Isabgol crop (Anonymous 2015b).

Isabgol farmers faced many problems like unseasonal rains leading to loss of crops at harvest period, less price for produce, less quality of seed, lack of suitable varieties to farmers leads to less productivity, lack of high yielding Isabgol seeds tested for farmers' field. Chandra *et al.,* (2009) have reported that this crop is less responsive to chemical fertilizers. Several trials were conducted in India and abroad but in most of the cases the response to macronutrients in isabgol was reported with low doses so this shows improper use of fertilizers dose and less agronomical experimentation on INM in Isabgol in different agroclimatic zones. This situation leaves the farmers under trouble however; farmers get additional income by growing this Isabgol as a cash crop during winter season, within the period of three to four month of time they will get good produce for their income.

In northern dry zone of 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, with improved INM research in Isabgol has been carried out on development of suitable cultivars with INM techniques this northern dry zone of Karnataka.

Materials and Methods

The experiment was conducted field in the Department of Plantation Spices Medicinal and Aromatic Plants of College Horticulture, Bagalkot at Havaeli farm during the two years of 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, sand (%) 22.60, silt (%) 26.10, clay (%) 52.20, 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 sources of seed collection did on DMAPR Anandh Gujarat states with two varieties Vallabh Isabgol-1 (V_1) and Gujarat Isabgol-2 (V_2) which was sown in 18th November 2015 and 2016 with gross plot size 3.6 m x 1.5 m =

5.40 m^2 in split plot design in two main plot with sixteen INM sub treatments with three replications nutrients listed below.

N_1 -RDF FYM **(**10 t ha^{-1}) + RDF NPK (50:25:30 kg ha^{-1})
N_2-RDF FYM **(**10 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})+$ZnSo_4$ (15kg 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% RD FYM **(**7.5 t ha^{-1}) + 75% RDF NPK (37.5:18.75:22.50 kg ha^{-1})
N_8-75% RD FYM **(**7.5 tha^{-1})+75% RDF NPK (37.5:18.75:22.50 kg ha^{-1})+ *Azotobacter*(5kg ha^{-1})
N_9-75%RD 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% RD 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 **(**7.5t ha^{-1})+75%RDF NPK (37.5:18.75:22.50kg 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%RD 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% RD FYM (5t ha^{-1}) +50% RDF NPK (25:12.5:15 kg ha^{-1}) +*Azospirillum* (5kg ha^{-1})
N_{15}-50% RD 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}) were applied just after layout 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.

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). Test weight in grain and straw was computed by 1000 number of seeds weight content with soil moisture (Anonymous, 2014b).

As a preliminary step, the husk content (q/ha) 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 husk content, one gram seed of respective sample was taken and was boiled with mild acid (0.1 N 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.
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

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.

Swelling factor (cc/g): Swelling factor in Isabgol seeds was determined by dipping one gram seed in 20 ml of water for overnight and swollen mass was recorded next day (Kalyanasundaram *et al.*, 1982) and was expressed in cubic centimetre per gram.

Ash (%): Total ash content was determined by burning the noodles in pre-weighed crucible in a muffle furnace at 500°C for 6 hours (Rao and Bingren, 2009). After burning the residue ash weight was recorded and ash content was calculated by using the formula and expressed in percentage.

$$\text{Total ash (\%)} = \frac{\text{Weight of the ash (g)}}{\text{Weight of the sample (g)}} \times 100$$

Moisture (%): The Universal (OSAW) digital moisture meters method, consists of a compression unit to compress the sample to predetermined thickness. The thickness setting is very easily read on a vertical and circular scale. The seed material on the test is taken in a test cup and is compressed. Then press the push type switch till the reading comes in the display. Here no temperature reading and correlated dial are required. The computer version of digital moisture meter automatically compensates for temperature corrections (Anon. 2014b)

Carbohydrate (%): Amount of carbohydrate present in 100 mg of the sample of seeds, carbohydrate percent was worked out by using the following formula (Hedge and Hofreiter, 1962).

$$\text{Carbohydrate (\%)} = \frac{\text{mg of glucose}}{\text{Volume of test sample}} \times 100$$

In order to test the significance of variation the data were statically analysed as per procedure described by Panse and Sukhatme (1985). The critical differences were calculated to assess the significance of treatment means ($P< 0.05$).

Results and Discussion

At harvest stage yield and quality parameters were recorded significantly higher values were recorded with Vallabh Isabgol-1 seed yield (12.30q ha^{-1}), husk yield (3.62 q ha^{-1}), straw yield (23.93 q ha^{-1}), harvest index (%) (18.11), test weight (2.55g ha^{-1}), swelling factor (ccg^{-1}) (16.08 cgg^{-1}), ash content (%) (2.43), moisture content (%) (8.15), carbohydrate (%) (5.75) during pooled data respectively. This results due to varietal performance to different agro climatic 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 Seed yield (11.05q ha^{-1}), husk yield (3.33 q ha^{-1}), harvest index (%) (15.53), test weight (2.21g), swelling factor (ccg^{-1}) (14.89), ash content (%) (2.30), moisture content (%) (8.37), carbohydrate (5.65 %) as compared to in Gujarat Isabgol-2 during pooled data.

Integrated nutrient management

Significantly higher seed yield per hectare in pooled analysis were presented 15.34 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_{16} (50 % RD of FYM+ 75% RD of NPK + *Azospirillum* + *PSB* + $ZnSO_4$ + $FeSO_4$)(15.17q ha^{-1}), N_6 (Vermicompost + 50 % RD of NPK + *Azospirillum* + *Azatobacter*) (14.87. q ha^{-1}) and N_4 (RD of FYM + RD of NPK+ $ZnSO_4$ + $FeSO_4$) (14.84 q ha^{-1}),. Further lower seed yield (9.25 q 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 increase towards yield attributing characters 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).

INM effect the significantly higher husk yield was (5.38 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_4 (5.20 q ha^{-1}), N_6 (5.14 q ha^{-1}) and N_{16} (5.01 q ha^{-1}). The lower husk yield (2.38 q ha^{-1}) was recorded in N_{13} might be due to the higher husk yield (q ha^{-1}) 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), Venkatesh (2007).

The significantly higher harvest index (14.87 %) 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_4 (21.54) and N_4 (21.47 q ha^{-1}). Further the lower harvest index N_{13} (13.17 q ha^{-1}).

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_{16}

(2.45), and N_6 (2.42 q ha^{-1}). Further the lower harvest index (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).

The significantly higher swelling factor (17.99 ccg^{-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_4 (17.81), N_{16} (17.68) and N_6 (17.23). Further the lower number of leaves per plant was recorded in N_{13} (12.37). 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 reported same findings by Yadav *et al.,* (2003).

The significantly higher ash content (2.83 %) 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 (2.64), N_{16} (2.64) and N_6 (2.61). Further the lower number of leaves per plant was recorded in N_{13} (1.88)

The significantly lower moisture content (7.73 %) 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_6 (7.80), N_{16} (7.82) and N_4 (7.88). Further the higher moisture content was recorded in N_{13} (8.39).This may be due to qualitative characters of Isabgol varieties and positive effect towards INM treatments because of releases of nutrients at faster rate. However, less moisture content in seeds leads to more storability and enhancement of seed keeping quality (Keer *et al.,* 2015)..

The significantly carbohydrate content (6.69 %) 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_6 (6.68),N_4 (6.64) and N_{16} (6.53). Further the lower carbohydrate was recorded in N_{13} (4.82). This is because of the integrated nutrient management application which helps to make sufficient availability of nutrients to plant hence more absorption of available nutrients enhanced the biosynthesis of photosynthetic pigments by creating favourable cellular environment and providing nutrients to plants directly, by their mechanism like nitrogen is involved in chloroplast development and essential unit of chlorophyll molecule. Further phosphorus and potassium are the major nutrients involved in various vital processes by plant through roots development leading to improvement in the photosynthesis process. Likewise application of inorganic fertilizers and organic manure along with Zinc further release of nutrients at faster rate helps to increased quality parameters like swelling factor (ccg^{-1}) this increased seed mucilage percentage in Isabgol (Majid *et al.,* 2007, Choudhary *et al.,* 2014 and Keer *et al.,* 2015). Least swelling factor was 12.37ccg^{-1} recorded in 50 % RD FYM + 50 % RD of NPK + *Azotobacter* (N_{13}).

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_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_1N_{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 (5.45q 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_1T_{11} (5.45), 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) and Shivran *et al.*, (2015). 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_2N_{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.

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

Varieties / Nutrients	Seed yield (q ha^{-1})									Husk yield (q ha^{-1})								
	2015			2016			Pooled data			2015			2016			Pooled data		
Nutrients	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
N_1	12.05	9.43	**10.74**	12.93	9.62	**11.27**	12.49	9.52	12.05	3.12	2.43	**2.78**	3.60	2.48	**3.04**	3.36	2.46	**2.91**
N_2	12.51	9.49	**11.00**	13.22	9.80	**11.51**	12.86	9.65	12.51	3.70	2.82	**3.26**	3.43	2.92	**3.17**	3.56	2.87	**3.22**
N_3	11.79	11.85	**11.82**	12.43	12.14	**12.28**	12.11	11.99	11.79	2.48	3.68	**3.08**	2.62	3.70	**3.16**	2.55	3.69	**3.12**
N_4	14.84	14.86	**14.85**	15.55	15.22	**15.39**	15.19	15.04	14.84	5.16	5.18	**5.17**	5.48	4.96	**5.22**	5.32	5.07	**5.20**
N_5	10.56	10.49	**10.53**	10.89	10.58	**10.73**	10.72	10.54	10.56	2.49	2.85	**2.67**	2.75	2.87	**2.81**	2.62	2.86	**2.74**
N_6	14.87	14.81	**14.84**	15.29	14.34	**14.82**	15.08	14.57	14.87	5.11	5.02	**5.07**	5.52	4.90	**5.21**	5.31	4.96	**5.14**
N_7	10.33	9.00	**9.66**	10.80	9.14	**9.97**	10.56	9.07	10.33	2.87	2.69	**2.78**	3.02	2.69	**2.85**	2.94	2.69	**2.82**
N_8	10.14	9.38	**9.76**	10.29	8.62	**9.45**	10.21	9.00	10.14	2.73	2.29	**2.51**	2.76	2.10	**2.43**	2.75	2.19	**2.47**
N_9	10.10	9.16	**9.63**	10.03	9.37	**9.70**	10.06	9.27	10.10	2.81	2.73	**2.77**	2.79	2.80	**2.80**	2.80	2.76	**2.78**
N_{10}	10.36	9.50	**9.93**	10.18	9.47	**9.82**	10.27	9.49	10.36	2.75	2.58	**2.66**	2.69	2.57	**2.63**	2.72	2.57	**2.65**
N_{11}	15.34	15.22	**15.28**	15.66	15.53	**15.59**	15.50	15.37	15.34	5.35	5.19	**5.27**	5.55	5.41	**5.48**	5.45	5.30	**5.38**
N_{12}	12.68	9.56	**11.12**	12.67	9.54	**11.10**	12.67	9.55	12.68	3.41	2.69	**3.05**	3.74	2.68	**3.21**	3.57	2.69	**3.13**
N_{13}	9.95	8.37	**9.16**	9.96	8.71	**9.33**	9.95	8.54	9.95	2.36	2.25	**2.31**	2.54	2.35	**2.45**	2.45	2.30	**2.38**
N_{14}	10.05	9.58	**9.82**	10.03	9.83	**9.93**	10.04	9.70	10.05	2.96	2.53	**2.75**	2.96	2.94	**2.95**	2.96	2.74	**2.85**
N_{15}	14.65	10.88	**12.77**	12.70	11.18	**11.94**	13.68	11.03	14.65	4.71	3.17	**3.94**	4.08	3.25	**3.67**	4.40	3.21	**3.80**
N_{16}	15.17	14.78	**14.97**	15.47	14.17	**14.82**	15.32	14.48	15.17	5.03	5.02	**5.02**	5.13	4.84	**4.99**	5.08	4.93	**5.01**
MEAN	**12.21**	**11.02**		**12.38**	**11.08**		**12.30**	**11.05**	**12.21**	**3.57**	**3.32**		**3.67**	**3.34**		**3.62**	**3.33**	
	S.Em ±	C.D at 5%		S.Em ±	C.D at 5%		S.Em ±	C.D at 5%		S.Em ±	C.D at 5%		S.Em ±	C.D at 5%		S.Em ±	C.D at 5%	
Varieties (V)	0.16	**0.49**		0.16	**0.49**		0.16	**0.49**		0.06	**NS**		0.11	**NS**		0.08	**NS**	
Nutrients (N)	0.36	**1.04**		0.36	**1.04**		0.36	**1.04**		0.18	**0.51**		0.17	**0.50**		0.15	**0.45**	
N at same V	0.51	**1.47**		0.51	**1.47**		0.51	**1.47**		0.25	**0.72**		0.25	**0.71**		0.22	**0.63**	
Vat same or different N	0.63	**1.81**		0.63	**1.81**		0.63	**1.81**		0.26	**0.75**		0.46	**1.31**		0.33	**0.94**	

Varieties / Nutrients	Harvest index (HI %)									Test weight (g)								
	2015			2016			Pooled data			2015			2016			Pooled data		
Nutrients	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	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**	2.00	2.19	**2.09**	2.05	2.25	**2.15**	2.03	2.22	**2.12**
N_2	17.56	12.63	**15.09**	18.23	13.47	**15.85**	17.89	13.05	**15.47**	2.19	2.21	**2.20**	2.16	2.19	**2.17**	2.18	2.20	**2.19**
N_3	16.57	14.89	**15.73**	17.04	15.62	**16.33**	16.80	15.26	**16.03**	2.25	2.14	**2.20**	2.22	2.14	**2.18**	2.24	2.14	**2.19**
N_4	21.53	21.38	**21.46**	21.92	21.04	**21.48**	21.72	21.21	**21.47**	2.54	2.50	**2.52**	2.76	2.14	**2.45**	2.65	2.32	**2.49**
N_5	16.91	14.97	**15.94**	17.89	15.65	**16.77**	17.40	15.31	**16.36**	2.49	2.21	**2.35**	2.26	2.19	**2.23**	2.37	2.20	**2.29**
N_6	21.70	21.48	**21.59**	21.84	21.13	**21.49**	21.77	21.31	**21.54**	2.42	2.42	**2.42**	2.47	2.38	**2.42**	2.44	2.40	**2.42**
N_7	16.06	12.60	**14.33**	17.00	12.93	**14.97**	16.53	12.77	**14.65**	2.12	2.08	**2.10**	1.93	2.00	**1.97**	2.02	2.04	**2.03**
N_8	16.53	13.92	**15.23**	16.95	14.17	**15.56**	16.74	14.05	**15.39**	1.98	2.05	**2.02**	2.35	2.23	**2.29**	2.17	2.14	**2.15**
N_9	16.75	12.23	**14.49**	17.26	13.28	**15.27**	17.00	12.76	**14.88**	1.99	1.99	**1.99**	1.98	2.01	**2.00**	1.99	2.00	**1.99**
N_{10}	16.71	12.69	**14.70**	16.93	13.15	**15.04**	16.82	12.92	**14.87**	2.30	2.06	**2.18**	2.28	2.10	**2.19**	2.29	2.08	**2.19**
N_{11}	22.18	21.83	**22.01**	22.49	22.02	**22.25**	22.34	21.92	**22.13**	2.69	2.38	**2.54**	2.82	2.38	**2.60**	2.75	2.38	**2.57**
N_{12}	17.74	12.64	**15.19**	17.40	13.14	**15.27**	17.57	12.89	**15.23**	2.26	2.27	**2.26**	2.29	2.34	**2.31**	2.27	2.30	**2.29**
N_{13}	13.88	11.72	**12.80**	14.90	12.19	**13.55**	14.39	11.96	**13.17**	1.66	1.71	**1.69**	1.73	1.93	**1.83**	1.70	1.82	**1.76**
N_{14}	14.95	12.84	**13.89**	16.60	13.01	**14.80**	15.78	12.92	**14.35**	2.11	2.38	**2.25**	2.07	2.44	**2.25**	2.09	2.41	**2.25**
N_{15}	17.45	13.26	**15.35**	17.65	14.09	**15.87**	17.55	13.67	**15.61**	2.33	2.22	**2.27**	2.38	2.26	**2.32**	2.35	2.24	**2.30**
N_{16}	21.71	21.53	**21.62**	**21.90**	**21.25**	**21.57**	21.80	21.39	**21.60**	2.44	2.45	**2.45**	2.51	2.41	**2.46**	2.48	2.43	**2.45**
MEAN	**17.86**	**15.35**		**18.37**	**15.71**		**18.11**	**15.53**		**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%		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**		0.017	**NS**		0.010	**NS**		0.013	**NS**	
Nutrients (N)	**0.34**	**0.98**		**0.40**	**1.14**		0.29	**0.82**		0.054	**0.15**		0.054	**0.15**		0.043	**0.12**	
N at same V	**0.49**	**1.39**		**0.57**	**1.61**		0.41	**1.16**		0.076	**0.21**		0.076	**0.21**		0.061	**0.17**	
Vat same or different N	**0.51**	**1.44**		**0.35**	**1.00**		0.25	**0.71**		0.068	**0.19**		0.043	**0.12**		0.051	**0.14**	

Table.2 Growth parameters on Swelling factor (%), Ash (%) and Moisture (%) and carbohydrate as influenced by Isabgol varieties and integrated nutrient management

Varieties Nutrients	Swelling factor (ccg^{-1})									Ash (%)								
	2015			2016			Pooled data			2015			2016			Pooled data		
Nutrients	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
N_1	15.47	15.65	**15.56**	15.20	16.07	**15.63**	15.34	15.86	**15.60**	2.36	2.16	**2.26**	2.44	2.55	**2.50**	2.40	2.36	**2.38**
N_2	16.59	14.95	**15.77**	16.40	15.25	**15.83**	16.49	15.10	**15.80**	2.33	2.15	**2.24**	2.50	2.62	**2.56**	2.41	2.39	**2.40**
N_3	14.65	11.97	**13.31**	13.89	12.27	**13.08**	14.27	12.12	**13.20**	2.44	2.19	**2.31**	2.39	2.14	**2.27**	2.41	2.17	**2.29**
N_4	17.67	16.87	**17.27**	18.33	18.37	**18.35**	18.00	17.62	**17.81**	2.76	2.58	**2.67**	2.64	2.57	**2.61**	2.70	2.57	**2.64**
N_5	16.75	15.19	**15.97**	16.40	16.01	**16.21**	16.57	15.60	**16.09**	2.21	2.18	**2.19**	2.55	2.21	**2.38**	2.38	2.20	**2.29**
N_6	17.79	14.79	**16.29**	18.32	18.03	**18.18**	18.06	16.41	**17.23**	2.68	2.52	**2.60**	2.69	2.56	**2.62**	2.68	2.54	**2.61**
N_7	16.60	13.16	**14.88**	16.40	13.82	**15.11**	16.50	13.49	**15.00**	2.12	2.23	**2.17**	2.41	2.21	**2.31**	2.26	2.22	**2.24**
N_8	16.29	13.84	**15.07**	17.00	14.37	**15.69**	16.64	14.11	**15.38**	2.24	2.27	**2.26**	2.33	2.24	**2.29**	2.29	2.26	**2.27**
N_9	14.93	11.22	**13.07**	15.19	11.40	**13.29**	15.06	11.31	**13.18**	2.28	2.61	**2.44**	2.30	2.17	**2.23**	2.29	2.39	**2.34**
N_{10}	15.59	12.48	**14.03**	16.40	12.54	**14.47**	15.99	12.51	**14.25**	2.62	2.05	**2.34**	2.25	2.02	**2.13**	2.43	2.03	**2.23**
N_{11}	17.82	16.99	**17.41**	18.64	18.51	**18.58**	18.23	17.75	**17.99**	2.82	2.81	**2.82**	2.79	2.88	**2.84**	2.81	2.85	**2.83**
N_{12}	15.83	15.63	**15.73**	16.40	15.89	**16.14**	16.11	15.76	**15.94**	2.22	2.29	**2.25**	2.37	2.29	**2.33**	2.30	2.29	**2.29**
N_{13}	12.19	11.77	**11.98**	12.97	12.97	**12.97**	12.58	12.37	**12.48**	2.17	1.55	**1.86**	2.22	1.58	**1.90**	2.20	1.56	**1.88**
N_{14}	13.55	13.66	**13.61**	14.40	15.09	**14.75**	13.98	14.37	**14.18**	2.35	2.15	**2.25**	2.49	2.12	**2.30**	2.42	2.13	**2.28**
N_{15}	15.25	15.49	**15.37**	16.52	16.53	**16.53**	15.88	16.01	**15.95**	2.31	2.26	**2.28**	2.27	2.19	**2.23**	2.29	2.22	**2.26**
N_{16}	16.83	17.51	**17.17**	18.21	18.20	**18.20**	17.52	17.85	**17.68**	2.66	2.70	**2.68**	2.57	2.63	**2.60**	2.61	2.66	**2.64**
MEAN	**15.86**	**14.45**		**16.29**	**15.33**		**16.08**	**14.89**		**2.41**	**2.29**		**2.45**	**2.31**		**2.43**	**2.30**	
	S.Em ±	C.D at 5%		S.Em ±	C.D at 5%		S.Em ±	C.D at 5%		S.Em ±	C.D at 5%		S.Em ±	C.D at 5%		S.Em ±	C.D at 5%	
Varieties (V)	0.091	**0.55**		0.052	**0.31**		0.070	**0.43**		0.034	**NS**		0.049	**NS**		0.041	**NS**	
Nutrients (N)	0.392	**1.11**		0.401	**1.14**		0.383	**1.08**		0.073	**0.21**		0.066	**0.19**		0.060	**0.17**	
N at same V	0.554	**1.57**		0.568	**1.61**		0.542	**1.53**		0.104	**0.29**		0.094	**0.26**		0.086	**0.24**	
Vat same or different N	0.379	**1.07**			0.245		**0.69**	**0.86**		0.135	**0.38**		0.000	**0.00**		0.160	**0.45**	

Varieties Nutrients	Moisture (%)									Carbohydrate (%)								
	2015			2016			Pooled data			2015			2016			Pooled data		
Nutrients	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
N_1	8.31	8.76	**8.54**	8.28	8.69	**8.48**	8.30	8.73	**8.51**	5.30	5.64	**5.47**	5.33	5.50	**5.42**	5.31	5.57	**5.44**
N_2	8.17	8.93	**8.55**	8.16	8.92	**8.54**	8.17	8.93	**8.55**	5.09	5.53	**5.31**	5.32	5.44	**5.38**	5.21	5.49	**5.35**
N_3	8.10	8.72	**8.41**	8.08	9.01	**8.55**	8.09	8.87	**8.48**	5.34	5.55	**5.44**	5.30	5.56	**5.43**	5.32	5.56	**5.44**
N_4	7.87	7.83	**7.85**	7.92	7.90	**7.91**	7.90	7.87	**7.88**	6.73	6.29	**6.51**	6.91	6.63	**6.77**	6.82	6.46	**6.64**
N_5	8.13	8.53	**8.33**	8.12	8.51	**8.31**	8.13	8.52	**8.32**	5.54	5.45	**5.50**	5.47	5.46	**5.46**	5.50	5.46	**5.48**
N_6	7.72	7.80	**7.76**	7.82	7.85	**7.84**	7.77	7.82	**7.80**	6.72	6.47	**6.60**	6.76	6.77	**6.77**	6.74	6.62	**6.68**
N_7	8.26	8.42	**8.34**	8.21	8.40	**8.30**	8.23	8.41	**8.32**	5.58	5.46	**5.52**	5.48	5.54	**5.51**	5.53	5.50	**5.52**
N_8	8.21	8.48	**8.35**	8.18	8.39	**8.29**	8.20	8.44	**8.32**	5.33	5.33	**5.33**	5.30	5.39	**5.35**	5.32	5.36	**5.34**
N_9	8.22	8.48	**8.35**	8.20	8.43	**8.31**	8.21	8.46	**8.33**	5.36	5.29	**5.32**	5.56	5.32	**5.44**	5.46	5.31	**5.38**
N_{10}	8.32	8.58	**8.45**	8.27	8.51	**8.39**	8.30	8.54	**8.42**	5.36	5.25	**5.30**	5.29	5.28	**5.29**	5.33	5.27	**5.30**
N_{11}	7.83	7.54	**7.69**	7.90	7.64	**7.77**	7.87	7.59	**7.73**	6.98	6.21	**6.60**	6.91	6.67	**6.79**	6.95	6.44	**6.69**
N_{12}	8.41	8.51	**8.46**	8.35	8.46	**8.41**	8.38	8.49	**8.43**	5.55	5.43	**5.49**	5.79	5.34	**5.57**	5.67	5.38	**5.53**
N_{13}	8.33	8.65	**8.49**	8.26	8.32	**8.29**	8.29	8.49	**8.39**	4.59	5.53	**5.06**	4.79	4.36	**4.58**	4.69	4.95	**4.82**
N_{14}	8.39	8.56	**8.48**	8.37	8.55	**8.46**	8.38	8.56	**8.47**	5.58	5.47	**5.53**	5.61	5.27	**5.44**	5.59	5.37	**5.48**
N_{15}	8.34	8.35	**8.35**	8.33	8.33	**8.33**	8.34	8.34	**8.34**	5.79	5.59	**5.69**	5.59	5.41	**5.50**	5.69	5.50	**5.59**
N_{16}	7.79	7.82	**7.81**	**7.77**	**7.90**	7.83	7.78	7.86	**7.82**	**6.89**	**5.64**	**6.26**	6.89	6.69	**6.79**	6.89	6.17	**6.53**
MEAN	**8.15**	**8.37**		**8.14**	**8.36**		**8.15**	**8.37**		**5.73**	**5.63**		**5.77**	**5.67**		**5.75**	**5.65**	
	S.Em ±	C.D at 5%		S.Em ±	C.D at 5%		S.Em ±	C.D at 5%		S.Em ±	C.D at 5%		S.Em ±	C.D at 5%		S.Em ±	C.D at 5%	
Varieties (V)	0.030	**0.08**		0.021	**0.05**		0.026	**0.078**		0.014	**0.04**		0.023	**0.07**		0.005	**0.01**	
Nutrients (N)	0.040	**0.11**		0.041	**0.12**		0.038	**0.11**		0.089	**0.25**		0.072	**0.20**		0.064	**0.18**	
N at same V	0.056	**0.16**		0.058	**0.16**		0.054	**0.15**		0.127	**0.36**		0.101	**0.29**		0.090	**0.26**	
Vat same or different N	0.118	**0.33**		0.084	**0.24**		0.100	**0.28**		0.062	**0.18**		0.091	**0.26**		0.029	**0.08**	

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).

The interaction effect on test weight (g) was significantly 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.

The interaction effect significantly swelling factor (18.23) was recorded in (V_1N_{11}) Vallabh Isabgol-1, supplied with (75 % RD of FYM + RD of NPK + *Azospirillum* + *PSB* + $ZnSO_4$ + $FeSO_4$) which was on par with V_1N_6 (18.06), V_1N_4 (18.00), V_1N_{16} (17.52) where as minimum swelling factor (13.98) was recorded in V_1N_{13} during the pooled data. due to Vallabh Isabgol-1 variety and their performance under the agroclimatic condition with This may be due to the application of above doses of nutrients helps to make sufficient availability of nutrients through combined application of integrated nutrient management which could increase the available nutrients for plant roots development and improve photosynthesis process as a result higher seed mucilage percentage can make higher swelling capacity in Isabgol findings are identical with Majid *et al.,* (2007).

The interaction effect at harvest significantly higher ash content (%) (2.85) was recorded $V_2 N_{11}$ (75 % RD of FYM + 75 % RD of NPK + *Azospirillum* + *PSB* + $ZnSO_4$ + $FeSO_4$) which was on par with V_1N_{11} (2.81), V_1N_4 (2.70), V_1N_6 (2.68) and V_1N_{16} (2.61). However the lower dry matter production (1.56) was recorded with V_2N_{13} during the pooled data. Same findings reported by Shivran *et al.,* (2016 b).

Interaction effect on higher carbohydrate (%) were recorded in Vallabh Isabgol-1, with application 75 % RD of FYM + 75 % RD of NPK + *Azospirillum* + *PSB* + $ZnSO_4$ + $FeSO_4$ (V_1N_{11}) 6.95, which was on par with V_1N_{16} (6.89), V_1N_4 (6.82), V_1N_6 (6.74) and lower reproductive parameters were recorded with Vallabh Isabgol-1 application with 50 % RD of FYM + 50 % RD of NPK + *Azotobacter* (V_1N_{13}) (4.69) during the pooled data due to Vallabh Isabgol-1 variety and their performance under the agroclimatic condition with application above 75% RD organic and inorganic NPK fertilizers along secondary nutrients, biofertilizers combined application might resulted plants to more nutrients utilization for plant growth towards production of bio-active substances in soil micro flora, combined use of *Azotobacter* in soil it acts like growth regulators effects supports the hypothesis through the production of phytohormones, which stimulate root growth in Isabgol increased due to synthesis of carbohydrates, further utilized in building up of new cells towards the production of higher plant height and number of leaves increased tillers per plant which had positive effect towards higher growth parameters. Similar results are confirmed by Yadav *et al.,* (2003),

Interaction effect on lower moisture content (%) 7.59 was recorded in Gujarat Isabgol-2, with application 75 % RD of FYM + 75 % RD of NPK + *Azospirillum* + *PSB* + $ZnSO_4$ + $FeSO_4$, which was on par with Vallabh Isabgol-1 N_6(7.77), V_1N_{16} (7.78) and V_2N_6 (7.82) and V_1N_{11}(7.87) lower reproductive parameters were recorded with Vallabh Isabgol-1 application with 50 % RD of FYM + 50 % RD of NPK + *Azotobacter* V_1N_{13} (8.29) during the pooled data. varietal characteristics like higher seed yield, and husk yield, straw yield, these conversion of carbohydrates accumulation in plants resulted higher swelling factor (ccg^{-1}), This increasing growth yield parameters have a positive effect towards which contributed to increase in quality parameters in that variety, however by use of improved variety with application of organic and inorganic along with Zinc and Iron micro nutrients with biofertilizers helps to increase growth and yield towards increasing by faster rate releasing of nutrients to plants, tends study increasing growth and yield characters which have profound effect on improving quality parameters like, swelling factors ash and carbohydrate in Isabgol. Similar findings also reported by Singh *et al.*, (2011), Salmasi *et al.*, (2012) and Keer *et al.*, (2015).

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