

## NUTRIENT MANAGEMENT FOR SUSTAINABLE OAT PRODUCTION - A REVIEW

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### SUMMARY

Land fragmentation and industrialization pulling back the agricultural output and have a tremendous pressure on nation's food security. Oat is an emerging dual purpose crop which provides high quality grains for human consumption and nutritious fodder for cattle feeding. To feed the world's largest cattle population, it is the present duty to increase productivity of oat with agronomic optimization in pre-exist cultivars. Optimization of nutrient management is always a daunting task among the agronomic practices because it is a complex phenomenon to estimate the nutrient balance to get efficient fertilization promising sustainability of the system. Biofertilizers, which are the living cell inoculums fixing atmospheric N and solubilize fixed P, K and other micronutrients can be a great option when applied judiciously with other nutrient sources to achieve the goal. Therefore, there is a need for an efficient nutrient management for sustainable oat production.

**Key words :** Oat, biofertilizer, integrated nutrient management, food security

Oat (*Avena sativa* L.) belongs to family *Poaceae*, is an important annual *rabi* crop in India, and is also known as *Jai* or *Javi* in Indian subcontinent. It has significance contribution in human nutrition and medicines even long before current use as food (Whole Grains Bureau, 2014). The dietary fibre complex of oat grain with its antioxidants, minerals,  $\beta$ -glucan, vitamin E, polyunsaturated fatty acids and other phytochemicals is effective against different chronic diseases and disorders in humans. With all these bio-significant substances oat in human diet considered as beneficial for human health (Sterna *et al.*, 2016). Oat grain not only considered a good source for human nutrition but also makes a good and balanced concentrate on the ration for poultry, cattle, sheep and other animals. Oste *et al.* (2000) reported that oat milk was developed as a base for the making of different milk free dairy products. Beside this, it contains 2.31% ether extract, 9.33% total ash, 0.47% calcium, 0.22% phosphorus, 0.22% magnesium, 0.52% sodium and 2.84% potassium (SELF nutrition data, 2015).

Though Oat is a dual-purpose crop, its value both as a grain and fodder crop cannot be neglected. Being a shy seeder, the productivity as well as availability of oat seeds considered very much important now a day. India is the home for about 16% cattle and 5.5% buffalo from 512.05 million livestock (DAHD&F,

2012) and it is also facing net deficit of 35% of green fodders and 11% of dry fodders (Meena *et al.*, 2019) which demands the fodder production enhancement. Seed production of oats will mitigate the deficiency of green fodder production in our country. From the nutrient management point of view, more fertilizer application may increase the yield of fertile oat grain significantly but its excess use may result adverse impacts on environment that includes ground water pollution and soil degradation (Miransari and Mackenzie, 2011a, b). Thus, a suitable fertilization method needs in place that supplies necessary quantity of nutrients to the plants (Miransari, 2011c). There is no complete substitute of chemicals fertilizers and the integration of organic and inorganic sources of nutrients not only supplies essential nutrients but also have some positive interaction with chemical fertilizers to increase their efficiency and thereby reduce environment hazards *i. e.* decline in soil fertility, ground water pollution and increasing greenhouse gas emission etc.

### NUTRIENT MANAGEMENT IN OAT

#### a. Nitrogen management in oat

Nitrogen is one of the important constituents of the chlorophyll pigment and N fertilization not only

increases the chlorophyll content but also increases the leaf area in plants which are responsible for maximizing radiation load and the rate of photosynthesis leading to increasing biomass accumulation (Azeez, 2009; Wortman *et al.*, 2011; Diacono *et al.*, 2013). Hazra and Sinha (1996) stated that different nutrients i.e. N, P, K, B, Zn have specific role in developing potential flower and seed setting mechanism of crop plants while, crops requiring higher N failed to produce potential flower and seed set due to shortage of N during reproductive phase since at that period N is involved in amino acid synthesis, a substrate for seed set or flower development.

Patel *et al.* (2007) reported that seed yield of oat was significantly influenced due to nitrogen levels and application of 80 kg N ha<sup>-1</sup> gave significantly higher seed yield (18.5 q ha<sup>-1</sup>) than that with 40 kg N ha<sup>-1</sup> (16.2 q ha<sup>-1</sup>). He also reported that successive increase in nitrogen application increased the nutrient uptake and the forage yield of oat application of 120 kg N ha<sup>-1</sup> gave significantly higher N, P and K uptake as well as the green forage and dry matter yields of oat in total of two cuts (Patel *et al.*, 2008).

Bhat *et al.* (2000) proposed that early sowing resulted in high nutrient uptake and yield components. Increasing N rates from 0 to 90 kg ha<sup>-1</sup> resulted to an increase in grain yield, while crop lodging resulted beyond 90 kg ha<sup>-1</sup>. However, straw yield increased significantly up to 150 kg N ha<sup>-1</sup>. In contrast, Kakol *et al.* (2003) found that the total green forage and dry matter yields from both harvests increased significantly with successive increase in nitrogen level up to 150 kg ha<sup>-1</sup>. Zhou *et al.* (1998) found that N and late sowing caused an increase in protein content and a decrease in moisture content, whereas other grain qualities were little affected. Monem *et al.* (2015) showed that cover crops had significant effects on biomass, test weight, seed yield and harvest index. Nitrogen fertilizer had significant effects on biomass, number of grains cob<sup>-1</sup>, number of grains row<sup>-1</sup>, test weight and seed yield so that these traits increased when higher rates of nitrogen were applied. Mohr *et al.* (2007) reported that low to moderate N rates significantly increased yield, with optimum relative yield achieved with a plant available N supply of approximately 100 kg N ha<sup>-1</sup>. Increasing N rate reduced test weight, kernel weight and kernel plumpness, suggesting that optimal N management must balance yield improvement against reductions in grain quality. Joshi *et al.* (2015) found higher oat production with the application of 90 kg N/ha in three splits i. e. basal (50%), 30DAS (25%) and

45 DAS (25%). Godara *et al.* (2016) reported growth parameters, green and dry matter production when N level increased from 40 to 120 kg/ha, tillers/meter length of row and leaf:stem ratio were increased up to 80 kg N/ha.

## **b. Phosphorous management in oat**

Hazra and Sinha (1996) reported that a supply of P is essential to plants at early stage and during seed formation, the latter because P is found in phytin seed reserves and P is found in organic form in younger tissue and inorganic form in older tissue while K is essential for efficient water relationship in plants, formation and translocation of carbohydrates and activation of some enzyme. It is also reported that concentration of P in seeds had greater influence in good growth and seed yield of various forage crops. Higher P concentration in seeds of various plants had been found to increase yield of seedlings and plant grown from seeds of high P irrespective of soil P condition. Tripathi (2003) reported that the green and dry fodder yield of oats + Indian clover significantly increased with 80 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> on low P soil and 40 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> in medium to high P soils over their respective control. However, the yield increase was highest with highest level of P application (120 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>). Hussain *et al.* (2016) reported that phosphatic fertilizer to wheat crop under arid condition and result can be concluded that application of phosphatic fertilizer at 5 cm apart side dressing of the rows at a depth of 5 cm not only increase the plant vigor but also produced better yield under arid condition.

## **c. NPK management in oat**

Mohr *et al.* (2007) reported phosphorus application increased yield in 2 of 6 site-years, but had no overall effect on quality. Application of KCl resulted in small increases in yield (88 kg ha<sup>-1</sup>), kernel weight and kernel plumpness on moderate to high K soils, which were not likely to provide a significant economic benefit. N, P and K have specific role in developing potential flower and seed setting mechanism of crop plants.

Verma *et al.* (2016) reported significant increase in grain yield (4.99 t/ha), straw yield (10.66 t/ha), NPK uptake by both seed and grain on application of FYM@ 10 t/ha over control.

To study the effect of increasing doses of nitrogen fertilizers at 50%, 100% and 175% balance

of phosphorus and potassium with yield investigation was conducted by Shakovets (2003) and reported that the application of  $N_{(60+30)} P_{(40)} K_{(80)}$ , following use of organic fertilizers at  $70 \text{ t ha}^{-1}$ , resulted in the highest yield and grain quality. Kubresh and Bezsilko (1990) reported that oats grown after barley were given no fertilizers or various combinations of 0, 40, 60, 80 or  $100 \text{ kg N ha}^{-1}$ , 0, 45, 60, 70 or  $80 \text{ kg P}_2\text{O}_5$  and 0, 90, 120, 140 or  $160 \text{ kg K}_2\text{O ha}^{-1}$ . Average grain yields ranged from  $4.17 \text{ t ha}^{-1}$  with no fertilizers to  $5.56 \text{ t ha}^{-1}$  with  $60 \text{ kg N} + 45 \text{ kg P}_2\text{O}_5 + 90 \text{ kg K}_2\text{O ha}^{-1}$ . Grain protein content ranged from 10.3% with  $45 \text{ kg P}_2\text{O}_5 + 90 \text{ kg K}_2\text{O}$  to 12.5% with  $80 \text{ kg N} + 70 \text{ kg P}_2\text{O}_5 + 140 \text{ kg K}_2\text{O}$ . N application increased N content in grain and straw. P application did not affect the contents of the elements tested and K application increased straw K content. Ahmad et al. (2011) reported higher plant height, leaf area, number of leaves per plant, number of tillers per plant and per  $\text{m}^2$  and green fodder yield in 100% RDF from inorganic fertilizer sources in contrast to organic manure.

Malakar et al. (2009) reported that fodder yield attributes i.e. DFY and CPY were the maximum when nitrogen was applied @  $80 \text{ kg ha}^{-1}$ . Similarly, in case of phosphate, the different yield attributes were the maximum when applied @  $60 \text{ kg ha}^{-1}$ . The result concluded that  $N_{80}$  and  $P_{60}$  proved to be the best, which were statistically at par with  $N_{120}$  and  $P_{80}$  respectively. Kumar and Sood (1995) reported that crude protein content in oats increased up to  $60 \text{ kg N ha}^{-1}$  and  $75 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ . Whereas, crude fiber content increased with nitrogen rate and decreased with phosphorus rate. The results obtained from multi location study, Malik and Paynter (2010) suggested that adequate levels of N and K were important to optimize yield and quality of oat hay and grain. Highest hay and grain yields were obtained with combined application of  $80 \text{ kg ha}^{-1} \text{ N}$  and  $100 \text{ kg ha}^{-1} \text{ K}$ . There was no evidence that higher rates of N or K decreased hay or grain quality. The effect of K in improving grain weight and reducing screenings levels was more reflective at higher N level.

#### d. NPKZn management in oat

Arshad et al. (2016) also got the significant influence of combined P and Zn application in cereals. Hazra and Sinha (1996) reported Zinc regulates the synthesis of RNA and transcript the synthesis of substrate required in the development of seed. Arora and Singh (2004) also reported that the combined application of zinc @  $5 \text{ kg ha}^{-1}$  and N @  $60 \text{ kg ha}^{-1}$

increased the yield components like effective tillers, ear length, per ear test weight significantly as compared to lower levels. Higher doses of Zn and N increase yield and yield components non-significantly. According to Joshi et al. (2007), growth attributes viz. plant height, number of tillers and leaves  $\text{m}^{-1}$  row length were recorded higher with application of 100% recommended dose of NPK along with along with  $20 \text{ kg ZnSO}_4 \text{ ha}^{-1}$  and took minimum days to attain 50% flowering. Based on the DTPA method, the critical soil levels were found to be 4.3 ppm of Fe and Mn and 0.9 ppm for Zn and Cu as mentioned by Ziaieian and Malakouti (2001). Rana et al. (2013) found maximum green fodder yield of 59.33 and 48.83 t/ha, dry matter yield of 17.16 and 14.16 t/ha in 0.5%  $\text{ZnSO}_4$  foliar spray at 35 and 45 DAS+RDF during 2009 and 2010, respectively. Khanday et al. (2009) revealed that increase in phosphorous up to  $40 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$  recorded significantly higher seed and straw yields. Significantly higher yield was observed with Zn @  $10 \text{ kg ha}^{-1}$ . Higher panicle length, grains/panicle, test weight was recorded with the application of zinc, FYM and phosphorous up to  $10 \text{ kg ha}^{-1}$ ,  $15 \text{ t ha}^{-1}$  and  $40 \text{ kg ha}^{-1}$  respectively.

#### e. NPK and bio-fertilizer management in oat

Abbasi and Yousra (2012) reported that biofertilizer has been acknowledged as a substitute to chemical fertilizer to increase soil fertility and crop production in sustainable farming. Most of the farmers assume that chemical fertilizer gives more yield than the biofertilizer, ignoring environmental and long-term losses. So he conducted an experiment to study efficiency and efficacy of the biofertilizer in opposition to the chemical fertilizer and in additions to this comparison also done among the four species of *Azotobacter* for their aid in increase in yield and biomass of wheat crop and found the increase in growth attributes and also yield significantly in treated plots than controlled and higher than only chemical source applied plot which gives the same result as concluded by Autade et al. (2011). Moghadam et al. (2012) suggested that biofertilizer application can substitute 25% of chemical fertilizer. Improved vegetative growth in multi-cut fodder oat was recorded higher in  $150 \text{ kg N ha}^{-1}$  along with  $40 \text{ kg P ha}^{-1}$  and dual inoculation of seed with *Azotobacter chroococcum* + *Pseudomonas striata* (Jayanthi et al., 2002).

Researches with biofertilizer application in

oats are limited hence some reviews are presented here of other winter crops and cereals to highlight the effect of biofertilizers on their sole application or integrated application to cereals. Wheat (*Triticum aestivum*) inoculated with *Azotobacter chroococcum* showed the positive impacts on both grain yield and nitrogen content of grain in *Azotobacter* treated plot than untreated (Kizilkaya, 2008). PSB inoculated with *Oryza sativa*, increased significantly the protein content by 41.21% as compared to control (Ravikumar *et al.*, 2014). Integrated application of 100% RDF with biofertilizers (*Azotobacter*+PSB) recorded highest dry fodder and green fodder yield as well as highest net return and B : C in oat production (Deva *et al.*, 2014).

Poureidi *et al.* (2015) experimented to evaluate the effect of plant growth promoting bacteria (*Azospirillum*, *Azotobacter*, *Pseudomonas*) as one factor and four levels of urea nitrogen fertilizer (0, 100, 200, 300 kg ha<sup>-1</sup>) on growth and yield of wheat and result revealed as comparison of interaction between nitrogen (300 kg ha<sup>-1</sup>) with PGPR giving highest grain yield (5151 kg ha<sup>-1</sup>) and control treatments having lowest yield (2943 kg ha<sup>-1</sup>). Enhancement of protein content up to 18.6% in wheat with inoculation of biofertilizer was reported by Sary *et al.* (2009), Abedi *et al.* (2010) and Rana *et al.* (2012) independently.

Saber *et al.* (2012) found that application of biofertilizers could increase grain yield and harvest index as much as 46.6% and 48.8% respectively compared to control. Integrated treatments (synthetic + biofertilizers) showed better performance in terms of grain numbers spike<sup>-1</sup>, tiller number and shoot length by 35.6, 35.1 and 31.9% compared to separate treatments respectively. Mirshekari *et al.* (2012) in order to study the effects of PGPR at various levels of nitrogen and phosphorus fertilizers on yield and dry matter accumulation of barley, resulted that maximum test weight, grain yield, biological yield and harvest index were obtained in the plots which was applied the highest levels of nitrogen and phosphorus fertilizers in seed priming with both *Azospirillum* + *Azotobacter* compared to control treatment.

Farnia and Gudiny (2014) showed that *brady Rhizobium japonicum* biofertilizer inoculation significantly giving higher responses towards growth parameters and yield parameters than the control plot with only chemical sources of nutrients. Non-application of each N and P biofertilizers has a lowest pod length and application of any biofertilizers had high pod length. Khan *et al.* (2007) reported positive

influence of nitrogen fertilization on grain yield of wheat and it was also reported that the grain yield further enhanced by biofertilizer inoculation over control (Sary *et al.*, 2009; Wortman *et al.*, 2011; Scursoni *et al.*, 2012; Namvar *et al.*, 2012). *Azotobacter* inoculation had pronounced effect under no nitrogen or at lower levels of nitrogen than higher levels Devi *et al.* (2014).

### **RDF, FYM and bio-fertilizer management in oat**

Singh *et al.* (2005) reported that *Azotobacter* in combination with RDF gives better response than only FYM treated plots and FYM in combination with RDF treated plots. The result is in conformity with the findings of Sheoran *et al.* (2000). The higher yield in *Azotobacter* + RDF fertility level might be due to increased number of shoots, panicle length, grains panicle<sup>-1</sup> and test weight. Karwasra *et al.* (2007) repeating the experiment of Singh *et al.* (2005) reported that the increase in seed yield with *Azotobacter* + RDF fertility level was 42.2% and 16.21% higher over only FYM and FYM + RDF fertility combination. However, Jan *et al.* (2014) found that combination of liquid manure (Jinong) + Farmyard induced better growth than biofertilizer + Jinong or biofertilizer + farm yard manure. Kumar and Shivadhar (2006) reported higher sustainable and quality fodder with 50% RDF, vermicompost 5 t/ha and FYM 5 t/ha from single cut oat. Amanullah *et al.* (2012) reported application of biofertilizer in combination with 45 kg N ha<sup>-1</sup> and 30 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> increased fresh yield from 11% to 59% and suggested increases in grain yield of 20–46% as compared with control treatment. Fallahi *et al.* (2013) in wheat seeds under salinity stress reported that nitrogen application increased seed nitrogen content in parent plants. Application of middle levels of N fertilizer (55 and 110 kg ha<sup>-1</sup> N) on parent plants combined with seed priming with *Nitragin* biofertilizer improved the germination indices of wheat under salinity stress.

Esmailpour *et al.* (2013) showed that treatment with livestock manure, *Azotobacter* and chemical nitrogen increased plant height, biological and grain yield. Using livestock manure and *Azotobacter* increased biological yield through increase in plant height which cause to increase in grain yield without any significant changes in harvest index and other yield components, but chemical N increase plant height and test weight so concluded for combined application of biofertilizers and chemical

fertilizers. Seed biofertilization increased grain yield of wheat up to 15% compared with control. It showed to reduce the urea application upto 33% when seeds treated with biofertilizers (Mirshekari and Kouchebagh, 2013). Khanday *et al.* (2009) reported improved yield attributes viz., length of panicle, grains/panicle and thousand grain weight with the application of FYM, phosphorus and zinc up to 15 t/ha, 40 kg P<sub>2</sub>O<sub>5</sub>/ha and 10 kg Zn, respectively.

Abdelraouf *et al.* (2013) showed significant increase in water use efficiency, nutrient use efficiency, growth parameters and quality of the produce found in biofertilizer treated plots. Esmailpour *et al.* (2013) found that treatment with livestock manure, *Azotobacter* and chemical nitrogen increased plant height, biological and grain yield. Using livestock manure and *Azotobacter* increased biologic yield through increase in plant height which cause to increase in grain yield without any significant changes in harvest index and other yield components and finally he concluded that using livestock manure and chemical nitrogen fertilizer together with the *Azotobacter* had the maximum impact on yield.

#### **Comparative study of chemical fertilizer and bio-fertilizer application in cereals**

Biofertilizers with chemical fertilizers is more productive as well as economical Ghaderi *et al.* (2012). Azimzadeh *et al.* (2012) in order to study the replacement probability of biofertilizer with chemical fertilizer in bread wheat, taking 4 levels of biofertilizers and seven levels of chemical N fertilizers and the results showed that biofertilizer application increased the growth parameters viz, plant height, LAI, fertile seeds ear<sup>-1</sup>, biomass accumulation and yield significantly when applied combinedly with chemical sources. Similar trend was also observed by Abdel-Razzak and El-Sheshtawy (2013). Mohammed *et al.* (2012) found combined application of organic and biofertilizer increased number of reproductive tillers plant<sup>-1</sup>, number of seeds head<sup>-1</sup>, number of seeds tiller<sup>-1</sup>, number of seeds plant<sup>-1</sup>, plant yield (g plant<sup>-1</sup>), test weight (g) and yield. Organic manure and effective micro organism (EM) increased the yield by 36% in the first season and 34% in the second season. Interaction effect between biofertilizer × nitrogen chemical fertilizer levels had significantly increased fertile tillers, number of grains per plant, grain yield, starch grain, gluten grain, protein grain and flag leaf area. The result also concluded that applying biofertilizer can substitute 25% of chemical source of

nutrients (Moghadam *et al.* 2012). Biofertilizers in combination with micronutrients have significant positive impact on growth, physiological parameters and nutrients content of wheat plants and found that the treated plot showed higher IAA content and protein content than untreated one. Also, the treatment resulted in highest grain and straw yield as well nutrient concentration than the untreated one (Eleiwa *et al.* 2012). However, Agamy *et al.* (2012) observed that the application of Bio and/or FYM in combination with NPK significantly increased all growth characters i.e., plant height, number of spikes plant<sup>-1</sup>, leaf area and fresh and dry weights of both shoot and spikes plant<sup>-1</sup>. Omran *et al.* (2009) reported that the interaction effect between FYM with 50% of the recommended dose of N and biofertilizer inoculation induced significant increase in growth parameters, seed quality and seed chemical compositions of flax seeds grown on sandy soil.

Singh *et al.* (2000) concluded from his experiment that *Azotobacter* inoculation increased the forage yield by 78% compared with no inoculation. The yield response to N decreased with *Azotobacter* inoculation, but the decrease was less at lower N levels compared with that at higher levels. The nitrogen utilization efficiency (NUE) decreased with *Azotobacter* inoculation as well as with increasing level of N. Optimum dose of N gave higher NUE compared with maximum dose. The optimum rates of N for oat were 95.3 and 112.6 kg ha<sup>-1</sup> with and without *Azotobacter*. In *Azotobacter* inoculated oat, N fertilization at optimum rate was economically superior to the maximum rate. Bilal *et al.* (2017) reported that seed inoculation of biofertilizers (*Azotobacter* + *Azospirillum*) produced 9.58%, 6.58%, 2.51%, 16.94%, 10.26%, 17.59%, 14.02%, 33.81% and 66.18% more plant height, number of tillers, leaf : stem ratio, dry matter yield, mineral matter contents, crude fibre, crude protein, crude protein yield and total digestible crude protein yield, respectively over uninoculated seeds. He also propounded that inoculation alone without nitrogen application produced 19.16% and 6.87% more dry matter yield and crude protein (%), respectively. The enhancing effects of biofertilizers on growth and dry matter of oat was gradually decreased at higher nitrogen levels but it was more at intermediate level of inorganic nitrogen combined with seed inoculation.

#### **CONCLUSION**

Recently emerged oat crop cultivation in India

largely needs optimization in management practices to explore the productive potential of cultivars and to achieve food security and environmental sustainability. Though synthetic fertilizers having quick response on crop nutrition, but it has negative impacts *i.e.* lowering partial factor productivity, emergence of multi-nutrient deficiency, water body contamination, environment pollution etc. which can be improved by judicious application of synthetic and organic sources. Among organic sources of plant nutrients, biofertilizers are emerging options which consists of living strains of microbial culture enhancing soil health, fix and enrich soil N status and avail the fixed nutrients to plants by solubilizing them. It is more important to feed the soil rather than plants for long term sustenance of soil productivity, which can be achieved by judicious application of biofertilizers, organic manures and synthetic fertilizers rather than their solo application.

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