**Effect of organic manure and N fertilizer management on yield and Nitrogen use efficiency of kenaf in eastern and south eastern coastal plain zones of Odisha**

**Abstract**

Nitrogen fertilisation in Kenaf helps to increase the vegetative growth, thereby increasing the fibre yield. Hence nitrogen use efficiency is one of the key factor, which determines the ultimate yield of this crop. Keeping this point in view, an experiment was conducted during *kharif* seasons of 2020 and 2021 at Jute Research Station, Kendrapara (190 34’ N latitude and 860 30’ E longitudes) with an objective to study the nitrogen use efficiency (NUE) of Kenaf(*var. JBM 71*) under the combined application of organic manure and application of nitrogen in splits. The experiment was carried out in a split plot design, with treatments viz. with and without FYM application (@5t/ha) in the main plots and five different treatments in sub plots : (i) control(N1), (ii) 40 kg N in equal splits at three and six weeks after sowing(N2), (iii) 60 kg N in equal splits at three and six weeks after sowing (N3), (iv) 40 kg N in three splits as 10 kg N as basal,15 kg at three and remaining 15 kg at six week after sowing(N4), (v) 60 kg N in three equal splits (20kg in each split) as basal, at three and six weeks after sowing (N5) . Nitrogen use efficiency and uptake differed significantly under different treatment combinations. Maximum N uptake (54.6kg/ha) and utilization efficiency(30%) was recorded when the crop was treated with 5t/ha FYM and 60kg of N in three equal splits (N5). In addition, performance of the crop in terms of biological parameter and fibre yield was also higher under the same treatment. Maximum fibre yield of 35.4q/ha was obtained under application of 60kg N/ha, partitioned into three equal splits preceded with application of FYM with B:C ratio of 1.95 For a given dose of fertiliser, better recovery of N and performance of the crop was obtained, under higher number of splits. Application of FYM had a positive impact on N uptake, recovery and use efficiency of kenaf.

**Key words:** Nitrogen,organic manure,Nitrogen use efficiency, N recovery,Kenaf

1. **Introduction:**

 Mesta,a lignocellulosic bast fibre crop, has proved as a major substitute for jute, and is being successfully grown in tropical and subtropical regions. Mesta crop is more adaptive than jute under diverse soil and climate conditions and drought resistant. In particular, mesta is grown for its fibre, which is used in many industrial applications (Ananthi et al., 2019). Among the two types of mesta plants viz. *kenaf* and *roselle,* kenaf is more adaptable to various soil types. Usually, mesta (both species) is grown under marginal soil condition with no fertilizer application or imbalanced fertilization. Only basal application of fertilizers, especially nitrogen is carried out, which led to improper growth and poor efficiency of added fertilisers. Of the nutrients, nitrogen (N) is frequently regarded as the single most important mineral nutrient limiting crop production in many agricultural crops worldwide, and it is needed in large amount, as it constitutes 1–4% of the plant dry matter(Good *et al*,2004)  . Nitrogen is an essential constituent of metabolically active and some non protein compounds in plant tissue. When nitrogen is a limiting factor, the rate and extent of protein synthesis are depressed and as a result vegetative growth is severely affected. Proper N application and rates are critical for meeting plant needs and improving nitrogen use efficiency (NUE). Lowering fertilizer input and breeding plants with better nitrogen use efficiency (NUE) is one of the main goals of research on plant nutrition ([Hirel et al., 2007](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2887065/%22%20%5Cl%20%22MCQ028C42)). It has been estimated that 50–70 % of the nitrogen provided to the soil is lost ([Hodge et al., 2000](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2887065/#MCQ028C45)). Therefore, improving NUE is essential in order to reduce damage due to nitrate leaching, ecosystem saturation and water pollution. NUE in plants is complex and depends on nitrogen availability in the soil and on how plants use nitrogen throughout their life span Timing of fertilizer N application has a significant effect on the uptake of fertilizer N by the crop and resulting partitioning of added ‘N’ between soil and plant (Limaux *et al*., 1999).For fibre crops like mesta, good vegetative growth of the plant is important from economic point of view. Therefore N fertilisation and use efficiency act as key factors for deciding the ultimate fibre yield. Combined application of chemical fertilizers, organic manures and biofertilizers improved roselle fibre production (Saha *et al*,2008). But, the information on nitrogen uptake and use efficiency of kenaf is limited. Keeping the above points in view, an attempt was made, where kenaf was grown under different split doses of ‘N’ for two consecutive years with an objective to study nitrogen utilization efficiency of the crop.

1. **Materials and Methods:**

The experiment was conducted during *kharif* seasons in 2020 and 2021 at Jute Research Station, Kendrapara (190 34’ N latitude and 860 30’ E longitudes) to study the nitrogen use efficiency of mesta under split application of nitrogen. The experiment was carried out in a split plot design, with four replications with two main plot treatments such as without FYM and with FYM application @ 5t/ha and five subplot treatments receiving the different doses of nitrogen such as (i) control(N1), (ii) 40 kg N in equal splits at three and six weeks after sowing(N2), (iii) 60 kg N in equal splits at three and six weeks after sowing (N3), (iv) 40 kg N in three splits as 10 kg N as basal,15 kg at three and 15 kg at six weeks after sowing(N4), (v) 60 kg N in three equal splits as basal and at three and six weeks after sowing (N5). The soil of the experimental field was sandy loam with *pH* 6.6,organic carbon 5.5g/kg and available N,P and K 280, 35 and 170 kg/ha. Average rainfall received during cropping system was 1055mm. Recommended dose of both P and K for Kenaf was 30kg/ha. Sources of nitrogeeous, phosphatic and potassic fertilizers were urea,SSP and MOP respectively. Phosphatic and potassic fertilizers (@30kg/ha each) were applied as basal doses. Well decomposed farmyard manure (0.8%N) was incorporated and mixed well in the soil, 15 days prior to sowing of crop. Kenaf variety JBM 71, was sown in line with a row to row spacing of 30 cm. The crop was sown in the second week of May. Weeding and thinning was done at 21 days crop age. Irrigation was applied as and when necessary. Crop was harvested at 140 days. Plant samples were collected at harvest, oven dried (± 700), processed and mixed thoroughly and analysed following standard procedure (Tandon, 1993). Nitrogen uptake, recovery and use efficiency of kenaf were calculated following the standard formulae after harvest under each treatment.

Percent Recovery of N=

Uptake of N in applied plot (kg/ha)- Uptake of N in control plot(kg/ha) ×100

 Amount of N applied (kg/ha)

Nitrogen use efficiency (kg/ha)=

Fibre yield in fertilised plot (kg/ha)- Fibre yield in control plot(kg/ha)

 Amount of N applied (kg/ha)

1. **Results and Discussions:**

**3.1 Effect of ‘N’ management on uptake, recovery and use efficiency of Nitrogen:**

**3.1.1Nitrogen uptake:**

Result revealed that better uptake of nitrogen was recorded under the treatment, where N was applied @60kg/ha in three equal splits irrespective of application of FYM (Fig 1). This was followed by the treatment, where same dose of N was applied in two splits. It indicated higher availability of ‘N’ to the plants when the given dose of N was partitioned into different splits. In addition, it was observed that application of FYM enhanced ‘N’ uptake of kenaf, under all the treatment combinations. Organic manure coupled with mineral fertilizer

has been generally accepted as an effective means of enhancing microbial activity, soil aggregation, structure, and water retention capacity (Walsh *et al,*2012 and Mahmood *et al*,2017) Accelerated microbial activity in soil with application of FYM, resulted in higher availability of N. Similarly, when 40kg N/ha was considered, more split application of N resulted in higher uptake and recovery of ‘N’. Mehasen *et al*.(2012) stated that the co-applied use of manure and chemical fertilizer sustained soil fertility and improved nutrient uptake and plant growth. This study showed that organic manure and inorganic nutrients significantly increased NUE in all the treatments.

Maximum uptake (54.6kg/ha) of Nitrogen was recorded, in FYM added plots followed by three equal split of N (60kg/ha). Minimum uptake of nitrogen by the crop was found, when no nitrogen was applied to the crop. It was closely followed by N2 treatment, where it was applied in two splits. The ‘N’ uptake was found to be in the order of N5>N3>N4>N2>N1. Hence split application of ‘N’ helped the plant for higher and better uptake of N, irrespective of dose.

**Nitrogen Use Efficiency:**

Mean Nitrogen use efficiency (NUE) of kenaf was highest under N5 treatment (N applied @ 60kg/ha in three equal splits) irrespective of application of FYM (Fig.1). Higher NUE (23kg/kg N) of the crop was obtained with application of FYM @ 5 t/ha as compared to without application of FYM (19.2 kg/kg N) under the said treatment (N5). Application of ‘N’ in higher splits helped the crop to increase the use efficiency, even when the dose decreased to 40kg/ha. Nitrogen use efficiency was found in the order of N5>N4>N3>N2. Further it was seen that performance of the crop was better under all types of nitrogen management, when there was addition of organic matter as compared to the treatments without FYM application and use efficiency of ‘N’ can be enhanced by splitting the application in order to match the nutrient supply with plant need. In addition, the higher use efficiency of nitrogen due to the split application of nitrogen thrice during the growing seasons might be attributed to adequacy of available nitrogen during crop development stage that might have increased the assimilation and redistribution of N.

Liu *et al*(2019), also reported similar findings that application of nitrogen fertilizer in three splits has increased the wheat grain yield and N recovery use efficiency.

**Percent recovery of Nitrogen:**

Similar trend of nitrogen use efficiency was observed for percent recovery of ‘N’. More split application of N resulted in more uptake and recovery of N. Mean percent recovery of N was maximum under N5 treatment (24.7% for FYM treated plots and 22.9% for no FYM treated plots) followed by N4 treatment. The corresponding recoveries for different N treatments were comparatively higher with FYM treated plots than plots without application of FYM (Fig.2). This implies if nitrogenis applied in several small doses during the period of rapid crop growth, rather than as a single large dose at the beginning of rapid crop growth, then losses are minimized and crop recovery is maximized. In line with the current experiment, increase in apparent nitrogen recovery efficiency was reported at the rate of 150 kg N ha−1 for wheat and barley (Delogu *et al*,1998) .

**Growth attributes:**

There was a significant variation in biological parameters like plant height, basal diameter, green biomass yield of kenaf due to variation in dose of N fertilizer, number of splits of N application and application of organic manure(Table 1).

Pooled analysis of two year result revealed that plant height and basal diameter of jute crop showed an increasing trend with increase in the number of splits under a definite dose of nitrogen (Table 1). Besides the crop showed a positive response to the increasing dose of nitrogen upto 60kg/ha irrespective of application of organic manure.

Maximum plant height (368 cm) and basal diameter (2.35cm) and green biomass yield(459.7q/ha) were recorded, when nitrogen was applied @60kg/ha to the crop in three equal splits (N5) preceded by application of FYM (Table 2). This might be due to better uptake and recovery of N under this particular treatment. Lee *et al* (2004)also had similar conclusion in rice crop, which indicated nitrogen use efficiency was positively correlated with dry matter weight of crop. Nitrogen is the main component of the protoplasm which is involved in various metabolic processes *viz.,* photosynthesis (Corsi *et al.,* 1995), stimulation of cell division and elongation (Ali *et al.,* 2010). In addition, for a given dose of nitrogen, higher number of splits helped to increase the height of the crop. It implies, split application of ‘N’ had a positive effect on plant growth as compared to single dose of application. This accelerated the growth of new tissues and the development of new shoots, which might have increased the height and basal girth of the plant and the accumulation of dry matter. The findings of Kumar and Gautam (2004), Lakshmipathi *et al.,* (2012), Thumar *et al.,* (2016) confirm these results. Besides, inclusion of organic matter, along with the nitrogen fertilizer had favourable effect on the crop resulting in better plant growth in terms of height and stem girth. Integration of FYM with fertilizer resulted significant impact on plant growth. Hoever, the interaction effects were non-significant.

**Dry matter accumulation**:

Result showed dry matter partitioning towards leaf and stem varies significantly with application of FYM and application of different level of nitrogen. Significant differences were also seen , when the interaction effect of FYM and N dose was considered (Table 2) .Significantly maximum leaf and stem dry matter accumulation (3.69g of leaf DM/plant and 19.69g of Stem DM/plant) occurred in treatment receiving the application of 60kgN/ha in three equal splits, preceded with application of farm yard manure @5t/ha. Split application of nitrogen combined with farm yard manure had a significant impact on dry matter accumulation in both stem and leaf. Total dry matter production and its greater portioning into stem depend upon photosynthetic capacity of the plant during its vegetative period and translocation of photosynthates from source (leaf and petiole) to ultimate sink(stem). Liu *et al* (2019), also reported the application of N fertilizer in three splits has increased the wheat grain yield and N recovery use efficiency.

. The organic matter serves as a nutrient source to the soil micro organisms, improves the soil physico-chemical properties resulting in good soil health (Puspa *et al*,2013). In addition, initial nutrient supply through fertilizer and availability of nutrients from the decomposition of FYM at later phase of crop growth, might be the reason behind continuous nutrient supply to the crop resulting a better crop stand. Better crop growth under this particular treatment reflected higher green yield of the crop , when compared with other treatments.

**Yield and Economics**

Fibre yield of the crop varied significantly with application of organic manure and different doses of nitrogen in two or three splits. Kenaf, recorded significantly higher yield of 33.9q/ha, when subjected to 60kg N/ha, partitioned into three equal splits (N5) (Table 1). This might be attributed to creating ‘N’ availability in accordance with need of the crop during its growing period. Also, since fibre yield depends on the vegetative growth of individual plants in respect of height and basal girth, better growth of crop in terms of plant height and girth might have contributed for higher fibre yield in this treatment. Addition of FYM favoured the crop for significant increase in the yield up to 27.7q/ha, when compared with the yield obtained with no FYM application (25.4q/ha). The interaction study for fibre yield revealed that, Kenaf recorded significantly maximum fibre yield of 35.4q/ha and B:C ratio of 1.95, when subjected to 60kg N/ha, partitioned into three equal splits and application of FYM. This may be correlated to favourable effect of organic manure in supply of additional nutrients through mineralization and improvement in physico-chemical properties of soil (Saha *et al,* 2008).Probably maximum dry weight of leaves under this particular treatment have resulted in higher photosynthates and its translocation to stem. There was an increase in fibre yield with the increase in number of splits for a definite dose of N. This might be the better matching of Navailability with the crop needs during the growing period.

**Conclusion**

Nitrogen fertilisation in Kenaf induces vegetative growth and finally enhances the fibre yield. Hence utilization efficiency of ‘N’ serves as a key factor for realizing maximum fibre yield. In the present experiment, nitrogen uptake, percent recovery and use efficiency of nitrogen increased with increase in application splits. In addition, organic matter helped to accelerate the above process for higher availability of ‘N’. By increasing the number of splits of a given dose, it was seen that performance of mesta was better, even under lower dose of nitrogen in absence of FYM. Therefore, postponing a portion of nitrogen until the crop is better able to utilize it, may create a congenial situation for mesta to use it more efficiently. It may be concluded that, integrated use of FYM with chemical fertilizers may lead to higher use efficiency of Nitrogen owing to compounding effect.

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**Table 1.Yield and growth parameters and economics of kenaf as influenced by different level of nitrogen management**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Plant height** **(cm)** | **Basal diameter****(cm)** | **Leaf dry weight****(g/plant)** | **Stem dry****weight****(g/plant)** | **Total dry****matter****(g/plant)** | **Green yield** **(q/ha)** | **Fibre yield** **(q/ha)** | **Gross Return****(Rs/ha)** | **B:C Ratio** |
| **FYM** |
| F0 | 308 | 1.8 | 3.2 | 18.2 | 21.4 | 338.7 | 25.4 | 107156 | 1.55 |
| F1 | 337 | 1.96 | 3.5 | 19.04 | 22.6 | 375 | 27.7 | 116800 | 1.56 |
| **CD (FYM)** | **10.6** | **0.09** | **0.009** | **0.13** | **0.13** | **15.6** | **0.69** |  |  |
| **Nitrogen dose** |
| N1 | 268.1 | 1.5 | 2.6 | 16.4 | 16.4 | 215.5 | 17.3 | 73211 | 1.65 |
| N2 | 320.5 | 1.7 | 3.5 | 18.7 | 18.7 | 333.2 | 24.5 | 103763 | 1.45 |
| N3 | 341.1 | 2.25 | 3.53 | 19.4 | 19.4 | 429.5 | 31.2 | 131846 | 1.83 |
| N4 | 326.6 | 1.7 | 3.5 | 18.9 | 18.9 | 366.3 | 25.5 | 107565 | 1.47 |
| N5 | 354.3 | 2.3 | 3.6 | 19.8 | 19.8 | 440 | 33.9 | 143504 | 1.95 |
| **CD (N Dose)** | **14.2** | **0.07** | **0.013** | **0.08** | **0.08** | **19.5** | **0.69** |  |  |

**Table 2.Interaction effect of FYM and nitrogen dose on growth parameters and 1yield of Kenaf**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Plant** **height** **(cm)** | **Basal****Diameter****(cm)** | **Leaf dry weight****(g/plant)** | **Stem dry****weight****(g/plant)** | **Total dry****matter****(g/plant)** | **Green yield** **(q/ha)** | **Fibre Yield****(q/ha)** |
| F0N1 | 251 | 1.47 | 2.31 | 15.34 | 17.64 | 203.0 | 17.2 |
| F0N2 | 310 | 1.62 | 3.36 | 18.55 | 21.90 | 307.6 | 23.3 |
| F0N3 | 326 | 2.16 | 3.42 | 19.10 | 22.52 | 404.8 | 29.5 |
| F0N4 | 312 | 1.73 | 3.40 | 18.72 | 22.12 | 358.1 | 24.1 |
| F0N5 | 341 | 2.31 | 3.44 | 19.63 | 23.07 | 420.1 | 32.6 |
| F1N1 | 285 | 1.53 | 2.88 | 17.43 | 20.31 | 228.0 | 17.3 |
| F1N2 | 335 | 1.77 | 3.56 | 18.83 | 22.39 | 358.8 | 25.8 |
| F1N3 | 356 | 2.34 | 3.65 | 19.79 | 23.43 | 454.4 | 32.9 |
| F1N4 | 341 | 1.82 | 3.60 | 19.21 | 22.80 | 374.7 | 26.8 |
| F1N5 | 368 | 2.35 | 3.69 | 19.96 | 23.65 | 459.7 | 35.4 |
| **FYM×N** | **NS** | **NS** | **0.02** | **0.21** | **0.22** | **NS** | **1.38** |

Fig. 1Nitrogen uptake as influenced by different levels of nitrogen management

Fig. 2 Nitrogen use efficiency as influenced by different levels of nitrogen management

Fig. 3 Percent recovery of Nitrogen as influenced by different levels of nitrogen management