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Effect of establishment techniques, levels and time of application of nitrogen on growth attribute, yield attribute and yield of finger millet (*Eleusine coracana* L. Gaertn.)

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Abstract:

A field experiment was conducted to study the effect of establishment techniques, levels and time of application of nitrogen on growth, yield and quality of finger millet (*Eleusine coracana* L. Gaertn). The field experiment was laid out in split-split plot design with 48 treatments and three replications. Total number of 48 treatments consist of four techniques of establishment as main plot (T_1-Recommended transplanting at 20X15 cm, T_2-Random transplanting, T_3-Random broadcasting of 30 days old seedling (*Awatni*), T_4-Random broadcasting of 20 days old seedling (*Awatni*)), three nitrogen levels in sub plot (F_1-60 kg N ha^{-1}, F_2-80 kg N ha^{-1}, F3-100 kg N ha^{-1}) and four times of nitrogen application as sub-sub plot (**S_0**-Basal- (half dose through suphala (15:15:15)), S_1-2 Split- TP, 30 DAT, S_2-3 Split- TP, 30 DAT, 60 DAT, **S_3**-4 Split- TP, 20 DAT, 40 DAT, 60 DAT). Results revealed that to obtain higher grain and straw yield per ha the finger millet crop should be established by recommended transplanting at 20x15 cm and supplied with 100 kg nitrogen per ha along with three equal splits of nitrogen (at transplanting, 30 and 60 DAT).

Keywords: Establishment techniques, Nitrogen levels, Time of application, Finger millet.

INTRODUCTION

Millets are the most important cereals of the semi-arid zones of the world. Among millet crops, finger millet ranks fourth in importance after sorghum, pearl millet and foxtail millet. It is an important staple crop in many parts of Eastern and Southern Africa, as well as in South Asia. It has outstanding attributes as a subsistence food crop. It is grown globally on more than 4 million hectares and is the primary food source for millions of people in tropical dryland regions. With a total production of 5 million tonnes of grains, of which India alone produces about 2.2 million tonnes and Africa about 2 million tonnes. The rest comes from other countries in South Asia. Finger millet contributes nearly 40 per cent of small millets of India, occupying an area of 1.27 million ha with average annual production 1.89 million tonnes with productivity 1489 kg ha^{-1} in 2009-10 (Rajendra Prasad, 2012).

In Maharashtra, finger millet occupies an area of about 120 thousand ha with an annual grain production of 109 thousand tonnes with productivity 908 kg ha^{-1} in 2009-10 (Rajendra Prasad, 2012). It is mainly cultivated in Thane, Raigad, Ratnagiri, Sindhudurg, Dhule, Jalgaon, Nashik, Ahmednagar, Pune, Satara and Kolhapur districts. The finger millet is cultivated during *Kharif* on hill slopes and uplands, which are less fertile and productive. The main reasons of low productivity and profitability are mainly viz., vagaries of nature, lower fertilizer dose, poor crop management, less fertilizer use efficiency and adherence of farmers to traditional crop management practices.

To get higher yield of finger millet, new high yielding fertilizer responsive varieties should be adopted with proper nutrient management practices. The productivity is low due to delay in nursery sowing and late transplanting, faulty methods of cultivation and little or no use of fertilizers. The secret of boosting its yields mainly lies in timely transplanting and properly fertilizing the crop. Transplanted finger millet gives higher yield over random transplanting and *awatni* method because of suppression of weeds by early establishing, proper plant spacing and optimum plant population as well as less losses of applied fertilizers, easy to intercultural operation, optimum space for plant for growth and development and also vigorous growth of crop. The key to enhance fertilizer use efficiency is to synchronize the time of fertilizer application with the growth need of the crop and period of high root activity. It is useful to increase the number of split applications provided the cost of application is not prohibited. In cereal crops, it is best to apply fertilizers prior to flowering that helps for increasing fertilizer use efficiency and reduces fertilizer losses. Top dressing can be done in several stages to reduce nutrient losses. Therefore, it is usually best to divide the total fertilizer N into a series of applications, called split applications. Split application allows us to apply nutrients as and when needed. *Konkan* is major finger millet growing tract of Maharashtra. There is wide scope to increase the yield potential of *nagli* by using appropriate production technology. Therefore, such technologies are to be developed which are possible to use even by the poor farmers to improve their crops yield. In view of the above, the investigation "Effect of establishment techniques, levels and time of application of nitrogen on growth, yield and quality of finger millet (*Eleusine coracana* L. Gaertn.)" was planned, keeping four techniques of establishment i.e. recommended transplanting, random transplanting and random broadcasting of 20 and 30 days old seedlings with three levels of nitrogen i.e., 60, 80 and 100 kg N per hectare and four times of nitrogen application i.e. basal dose, two split, three split and four split of nitrogen application under high rainfall area of South *Konkan*.

MATERIALS AND METHODS

A field experiment was conducted during Kharif season 2011 and 2012 at Research farm, Department of Agronomy, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.) to study the effect of establishment techniques, levels and time of application of nitrogen on growth and yield of finger millet (*Eleusine coracana* L. Gaertn). The field experiment was laid out in split-split plot design with 48 treatments and three replications. Total number of 48 treatments consist of four techniques of establishment as main plot (T_1-Recommended transplanting at 20X15 cm, T_2-Random transplanting, T_3-Random broadcasting of 30 days old seedling (*Awatni*), T_4-Random broadcasting of 20 days old seedling (*Awatni*)), three nitrogen levels in sub plot (F_1-60 kg N ha^{-1}, F_2-80 kg N ha^{-1}, F3-100 kg N ha^{-1}) and four times of nitrogen application as sub-sub plot (S_0-Basal- (half dose through suphala (15:15:15))**,** S_1-2 Split- TP, 30 DAT, **S_2**-3 Split- TP, 30 DAT, 60 DAT, **S_3**-4 Split- TP, 20 DAT, 40 DAT, 60 DAT). Plant geometry was maintained with 20X15 cm^2 spacing. The all biometrical and phenological observations were recorded at different stages of crop growth. Quantity of nitrogen applied is for Basal-100 %, 2 split – 50%, 50%, 3 split -33.3%, 33.3% & 33.3%, 4 split- 25%, 25%, 25% & 25%.

The nursery was manured with farmyard manure and it was mixed thoroughly in soil at the time of seedbed preparation. Fertilizers *viz*., urea and single super phosphate at the time of sowing. Later it was top dressed with urea 0.5 kg per 100 m^2 at 15 DAS. Spraying of COC was carried out before transplanting. For sowing of finger millet crop different methods were adopted in this region that are as follows. 1. Recommended Transplanting of crop at 20X15 cm (Transplanting of *nagli* was done, when seedlings were 30 days old. The field was prepared for transplanting by ploughing. Transplanting of the seedlings was done across the slope. Whereas, in transplanting two seedlings $hill^{-1}$ was transplanted at 20x15 cm^2 spacing. Transplanting was done by using *thomba*). 2. Random transplanting (Transplanting of seedlings was carried out like recommended transplanting method except keeping the line spacing and mostly adopted by farmers in this region. Farmers generally use half dose of fertilizer as a basal dose in the form of mixed fertilizers and other management practices are used as par the other methods of crop establishment). 3. Random broadcasting of 20 and 30 days old seedlings (*Awatni*) (In *awatni* methods, 20 and 30 days old, healthy and vigorous seedlings were uprooted and thereafter, seedlings were transplanted by broadcasting randomly in *awatni* method as per the treatments in the experimental field. Here, 20 days old seedlings were taken for transplanting on the basis of SRI methods used in rice. To get the benefits of early age seedlings to reduce the life span of seedlings in nursery as well as early aged seedlings establish easily than old once as well as mature early).

Fertilizer application was done as per the recommended dose of the crop. The RDF for finger millet is 80:40:00 kg NPK ha^{-1}, as per the treatments. Nitrogen was applied in the form of urea (46% N as per treatments while phosphorus through single super phosphate (16% P_2O_5). In random transplanting (Farmers practice), basal dose of fertilizer was used in half quantity in the form of mixed fertilizers.

Different biometrical and phonological observations were recorded at different growth stages of crop as follows.

RESULTS AND DISCUSSION

Effect establishment techniques

Crop establishment techniques *viz*., recommended transplanting, random transplanting, random broadcasting of 30 days old seedlings and 20 days old seedlings showed their varying effect on growth and yield contributing characters of *nagli*. The effect of recommended transplanting technique was more prominent than remaining three techniques of establishment in respect of periodical growth observations, yield contributing characters and yield of *nagli*. The other establishment techniques were studied which is locally known as *awatni*, in which transplanting is done by throwing the seedlings randomly. There having an age of 20 and 30 days old seedlings. This technique of planting early age (12 to 14 days old) seedlings was used in rice i.e. system of rice intensification (SRI) which is the best alternative to other techniques by producing higher yield by reducing the life period by 15 days and also cost of cultivation incurred on crop. The height of plant was significantly influenced due to different crop establishment techniques. At harvest of the crop plant height recorded maximum values in case of recommended transplanting of *nagli* at 20x15 cm (T_1) followed by treatment random transplanting (T_2) which was also found to be significantly superior over random broadcasting of 30 days old seedlings and random broadcasting of 20 days old seedlings during both the years. However, random broadcasting of 30 days old seedlings (T_3) was significantly superior to the treatment random broadcasting of 20 days old seedlings (T_4). During the year 2011, random broadcasting of 20 days old seedlings (T_4) recorded the lowest plant height, but in case of 2012 the treatment random broadcasting of 30 days old seedlings (T_3) recorded the lowest plant height. This is because of less infestation of transplanted crop with weeds due to early establishment of transplanted crop, maximum availability of sunlight, easiness for intercultural operation, proper plant spacing and maintaining maintain optimum plant population than rest of the treatments. Profuse root growth that takes large amount of nutrients from soil at faster rate. The results collaborates the findings of Ghadage (1982), Laulanie (1993), Namara *et al*. (2004) and Jagtap (2011).

The number of functional leaves in the treatment receiving recommended transplanting techniques produced significantly the more number of functional leaves per hill that ultimately reflected in significantly maximum leaf area per hill and also LAI over the remaining treatments. At harvest of the crop the number of functional leaves per hill recorded significantly higher values in recommended transplanting (T_1) followed by treatment random transplanting (T_2) whereas, it was also found to be significantly superior over random broadcasting of 30 days old seedlings (T_3) and random broadcasting of 20 days old seedlings (T_4). The lowest value with respect of number of leaves per hill was recorded in random broadcasting of 20 days old seedlings (T_4) and random broadcasting of 30 days old seedlings (T_3) during the year 2011 and 2012, respectively. Data presented in Table 1 revealed that the leaf area per hill was significantly influenced by the different establishment techniques during both the years. Recommended transplanting techniques of *nagli* (T_1) recorded significantly more leaf area than all other establishment treatments *viz*., random transplanting (T_2), random broadcasting of 30 days old seedlings (T_3) and random broadcasting of 20 days old seedlings (T_4) at harvesting of crop, during both the years of experimentation. The treatments random transplanting recorded significantly more leaf area over the random broadcasting of 30 days old seedlings (T_3) and random broadcasting of 20 days old seedlings (T_4) during both the years. Thereafter, treatment random broadcasting of 30 days old seedlings (T_3) was found significantly superior over random broadcasting of 20 days old seedlings (T_4), during both the years. The increased leaf area in recommended transplanting might be due to better absorption of nutrients because of more fibrous roots of crop and maximum area covered for absorption of sunlight that ultimately produced higher food materials. These results are in agreement with the results reported by Islam *et al*. (2005) and Jagtap (2011).

Data presented in Table 1 revealed that the leaf area per hill was significantly influenced by the different establishment techniques during both the years. Recommended transplanting techniques of *nagli* (T_1) recorded significantly more leaf area than all other establishment treatments *viz*., random transplanting (T_2), random broadcasting of 30 days old seedlings (T_3) and random broadcasting of 20 days old seedlings (T_4) at harvesting of crop, during both the years of experimentation. The treatments random transplanting recorded significantly more leaf area over the random broadcasting of 30 days old seedlings (T_3) and random broadcasting of 20 days old seedlings (T_4) during both the years. Thereafter, treatment random broadcasting of 30 days old seedlings (T_3) was found significantly superior over random broadcasting of 20 days old seedlings (T_4), during both the years. The increased leaf area and LAI per hill in recommended transplanting might be due to better absorption of nutrients as a result of more fibrous roots which might have absorbed more nutrients available in soil that ultimately led to higher dry matter accumulation. The other reason of high dry matter accumulation in recommended transplanting techniques may be due to the significant increase in morphological parameters, which are responsible for the photosynthetic capacity of the plant thereby increasing the biological yield. These results are in conformity with the results reported by Jagtap (2011) and Tippanagoudar *et al*. (2012).

At harvest, dry matter production in leaves attained its maximum value in case of recommended transplanting technique of crop establishment (T_1) followed by treatment random transplanting (T_2), which recorded significantly maximum dry matter in leaves over random broadcasting of 20 days old seedlings (T_4) and random broadcasting of 30 days old seedlings (T_3). Random broadcasting of 20 days old seedlings (T_4) and random broadcasting of 30 days old seedlings (T_3) recorded the lowest dry matter accumulation in leaves per hill during 2011 and 2012, respectively. At harvest, recommended transplanting (T_1) recorded significantly maximum stem dry matter production per hill over rest of the establishment techniques during both the years. Whereas, treatment random transplanting (T_2) recorded significantly higher stem dry matter per hill over random broadcasting of 30 days old seedling (T_3) and random broadcasting of 20 days old seedling (T_4). Random broadcasting of 20 days old seedlings and random broadcasting of 30 days old seedlings recorded the lowest stem dry matter accumulation per hill during the year 2011 and 2012, respectively. Crop raised by recommended transplanting (T_1) technique recorded significantly higher mean dry matter of earheads than the crop raised by random transplanting, random broadcasting of 30 days old seedlings and random broadcasting of 20 days old seedlings techniques. However, treatments random transplanting technique of crop establishment (T_2) recorded significantly maximum mean earhead dry matter per hill over random broadcasting of 30 days old seedlings (T_3) and random broadcasting of 20 days old seedlings (T_4) during both the years. Whereas, random broadcasting of 20 days old seedlings (T_4) and random broadcasting of 30 days old seedlings (T_3) were at par to each other with respect of earhead dry matter per hill during both the years.

The maximum number of tillers per hill was also associated with the treatment recommended transplanting techniques during harvesting of crop. At harvest of the finger millet crop recommended transplanting (T_1) recorded significantly higher number of tillers per hill than random transplanting (T_2), random broadcasting of 30 days old seedlings (T_3) and random broadcasting of 20 days old seedlings (T_4) during all the growth stages of crop during both the years. However, random transplanting (T_2) showed significantly more number of tillers per hill than random broadcasting of 30 days old seedlings (T_3) and random broadcasting of 20 days old seedlings (T_4) during both the years. Among all the establishment techniques, random broadcasting of 30 days old seedlings and random broadcasting of 20 days old seedlings recorded the lowest number of tillers per hill during the year 2011 and 2012, respectively. The higher tiller production in transplanting might be due to better inducement of root growth for anchorage. It leads to better nutrient and water uptake and ultimately leads to higher number of tillers. Plants get optimum space for tiller development. These results are in agreement with the results reported by Singh *et al*. (2006), Awan *et al*. (2007) and Tippanagoudar (2012). This showed that wider spacing supports plant growth when there is adequate nutrient supply. This suggest that during the active tillering stage, tillering was profuse in wider spacing (20x15 cm) compared to other treatments. The manner in which dry matter accumulation distributed among different plant parts will determine the magnitude of the economic yield.

It revealed that the tillering count was significantly low in 20 and 30 DAT by random broadcasting of seedlings as compared to the tiller count at recommended transplanting. All the observations are minimum in 20 and 30 days old seedlings because of that these treatments required maximum energy for establishment and also some timespan lost for its own establishment due to that plant put forth less number of tillers and leaf area. Due to *awatni* method, roots of crop was very compact and covered less area as compared to former methods. The beneficial effect of recommended transplanting techniques in enhancing the growth through increased height, leaves, number of tillers, leaf area, LAI and dry matter production ultimately reflected in higher yield attributing characters *viz*., the average number of earheads per hill, weight per earhead, weight of earhead per hill, grain weight per earhead, test weight, length of fingers, number of finger per earhead, length of earhead, grain and straw weight per hill and ultimately the grain yield obtained from the plant. Grain yield is a manifestation of growth components like dry matter production, number of tillers at maturity and yield contributing characters like 1000-grain weight. Crop yields depends upon the dry matter production per unit area therefore, high production of total dry matter was first prerequisite for high yield. It showed the progressive increase in total dry matter accumulation as crop attained maturity.

Recommended transplanting was significantly superior over rest of the treatments which recorded significantly higher grain yields per ha followed by random transplanting, random broadcasting of 30 days old seedlings and random broadcasting of

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20 days old seedlings in the descending order. Increase in the yield due to recommended transplanting technique was to the tune of 12.65%, 26.85% and 30.50% over random transplanting, random broadcasting of 30 days old seedlings and random broadcasting of 20 days old seedlings, respectively. Similar trend was also observed in case of straw yield and biological yield (Table 3). This may be ascribed to the beneficial effect of recommended transplanting technique on yield attributes which might have contributed to increased growth and development parameters, which finally enhanced the grain yield of finger millet. These results corroborated the findings of Newase *et al.* (1995), Singh *et al*. (2006) and Jagtap (2011).

Effect of nitrogen levels

Nitrogen nutrition is supposed to be important constituent of finger millet. Perusal of the data presented on growth parameters of finger millet indicated that, nitrogen element plays an important role in improving all the growth parameters *viz*., plant height, number of leaves, number of tillers and dry matter per hill. Similarly, different levels of nitrogen had also influenced crop growth. The highest plant height was attained at 100 kg N per ha than rest of the treatments. Thus, it revealed that plant height responded to levels of nitrogen as compared to lower levels from initial growth stages. At harvest of the crop F_3 levels of nitrogen (100 kg N per ha) produced significantly taller plants followed by treatment 80 kg N per ha level (F_2) which was also found significantly superior to the F_1 nitrogen level i.e. 60 kg N per ha during both the years. The lowest plant height was recorded with 60 kg nitrogen per hectare (F_1) during both the years of experimentation. The role of nitrogen in protein synthesis, which is primary absorber of light energy, needed for photosynthesis resulted in to increased values of growth parameters. These results are in full conformity with the results reported by Subramanian and Rajgopalan (1979), Om *et al*. (1997), Panda and Das (1997) and Camara *et al.* (2003).

Data presented in Table 2 indicated that, all the yield contributing characters viz., number of earhead, number of fingers per earhead, length of finger, grain weight per earhead and weight of grains per plant, except 1000 grain weight were significantly higher in the case of nitrogen application at the rate of 100 kg N ha^{-1} followed by 80 and 60 kg N ha^{-1}. Similarly, grain and straw yields of finger millet were significantly influenced by the 100 kg nitrogen application. 100 kg N application increased the N uptake, leading to greater dry matter production and its translocation towards sink. Similar results have been reported by Panda and Das (1997). Absorption of more nutrients in the treatment 100 kg N per ha resulted into vigorous growth through more number of leaves at all the growth stages of crop which ultimately resulted in to higher photosynthetic activity and the synthesis of higher amount of food by crop. Every increase in the nitrogen level significantly increased grain and straw yield of finger millet. These results corroborated the findings of Singh (1997) and Camara *et al.* (2003).

Nitrogen is the major nutrient added to increase crop yield. At a cellular level, N increases the cell number and cell volume; at the leaf level, it increases the photosynthetic rate and efficiency. Similar results were reported by Lawlor (1995). Increases in crop growth rate are largely produced through an increase in leaf area index and by an increase in radiation use efficiency (dry matter produced per unit of either incident radiation or intercepted radiation). Similar results were reported by Lawlor, (1995) and Camara *et al.* (2003).

It is well emphasized that increasing rates of nitrogen, markedly improved overall growth of the crop in terms of dry matter production per plant by virtue of its impact on morphological and photosynthetic components along with accumulation of nutrients. This suggests greater availability of nutrients and metabolites for growth and development of reproductive structure, which ultimately led to realization of higher productivity of individual plants.

As far as mean plant height was concerned the 100 kg N per ha level recorded significantly more plant height than rest of the treatments. The enhancement in growth parameters could be due to the better and proper nourishment of the crop when fertilized through 100 kg N per ha.

It could be revealed that 100 kg N per ha level significantly increased the dry matter production compared to 60 kg N per ha. The observed data are in agreement with those of Khanda *et al*. (1997) and Om *et al*. (1997), who noted more dry matter production with application of higher dose of nitrogen in lateritic soil of *Konkan*.

The higher leaf area and dry matter accumulation at 100 kg N per ha might have ultimately resulted into more transformations in the sink resulting into significantly higher yield attributes *viz*., the average number of earheads per hill, weight per earhead, weight of earhead per hill, grain weight per earhead, test weight, length of fingers, number of finger per earhead, length of earhead, grain and straw weight per hill as compared to other treatments. This might be due to the sufficient availability and uptake of nitrogen by crop which ultimately resulted in better crop growth. Similar results in respect of more yield attributes due to 100 kg nitrogen per ha were reported by Panda and Das (1997), De Datta, (1986) and Tisdale *et al*. (2002).

The grain yield of *nagli* is contributed by yield attributes viz., the average number of earheads per hill, weight per earhead, weight of earhead per hill, grain weight per earhead, test weight, length of fingers, number of finger per earhead, length of earhead, grain and straw weight per hill. The results revealed that all the yield attributes of *nagli* were influenced significantly due to nitrogen levels. The marked improvement in yield attributes was due to the significant improvement in growth parameters due to application of 100 kg N per ha (Table 1).

Higher yield attributes under 100 kg N per ha level might be due to fulfillment of crop need with increased nitrogen levels. The higher value of growth and yield attributes under 100 kg N per ha reflected in significantly higher grain and straw yield of nagli compared to rest of the treatments. Similar results were also obtained by De Datta, (1986) and Om *et al.* (1997).

This increase in grain yield with increase in N dose was due to more number of productive tillers. These findings confirm the results of Sharma and Rajat (1975), Om *et al.* (1997) and Parshuramkar *et al*. (2012).

Application of 100 kg N per ha recorded maximum and significantly higher grain, straw and biological yield over rest of the treatments (Table 3). The increase was due to 100 kg N per ha was to the tune of 17.43 and 28.43 percent and straw yield was 20.02 and 33.31 percent, respectively. These results are in the line with those reported by Parshuramkar *et al*. (2012). Khanda and Dixit (1996) has suggested that higher yield with higher levels of nitrogen might be due to better N uptake leading to greater dry matter production and its translocation to the sink, Thakur (1993) also reported similar results.

Effect of time of nitrogen application

It was observed that all the growth attributes *viz*., Plant height, functional leaves, number of tillers per hill, leaf area, LAI and partitioning of dry matter of finger millet showed significantly higher values due to 3 splits (at transplanting, 30 and 60 DAT) of nitrogen application at all the stages. However, there was no definite trend due to four splits of nitrogen (at transplanting, 20, 40 and 60 DAT) and two splits of nitrogen (at transplanting and 60 DAT). Both of the latter treatments were at par to each other. Basal dose of nitrogen (S_0) recorded significantly the lowest growth parameters over other split application of nitrogen. Yield of finger millet have been declined mainly due to lack of improved management practices among many constraints. Application of nitrogen at right time is perhaps the simplest agronomic solution for improving the nitrogen use efficiency. Nitrogen supplemented by split application should be designed in such a way that it should be given at such a stage when crop critically requires it. Finger millet differs in its requirement by either total or proportion in the different stages of crop. Finger millet is grown in high rainfall and slopy land of hills that leaches the nitrogen easily. Hence, at critical stages of N requirement the hunger can be better met with split applications of nitrogen.

Three splits of nitrogen application (at transplanting, 30 and 60 DAT) was superior over other treatments in respect of growth and development characters like plant height, number of tillers per hill, leaf area index, dry matter of leaves, stem and earhead per hill at all the crop growth stages. With respect of split application of nitrogen that was available to plant mostly at critical stages of crop growth that causes maximum utilization of nutrients from soil and less losses through leaching compared to basal dose of nitrogen application.

Higher yield attributes under this treatment might be due to split application of nitrogen, which also increased the availability of nitrogen. The maximum and significantly higher value of growth attributes as well as yield contributing characters under the treatment three split of nitrogen reflected higher grain and straw yield of finger millet as compared to other splits of nitrogen as well as basal application of nitrogen.

The yield contributing characters *viz*., as number of fingers per earhead, length of fingers, length of earhead, grain weight per earhead per hill and grain, straw yield as well as biological yield per ha were higher in three splits of nitrogen (at transplanting, 30 and 60 DAT) which was superior over rest of the split application. Four splits of nitrogen (at transplanting, 20, 40 and 60 DAT) was also found significantly superior than two splits of nitrogen (at transplanting and 30 DAT) and these are comparable most of time to each other, both are significantly superior than basal dose of nitrogen application. The basal dose of nitrogen recorded significantly the lowest performance than the remaining treatments throughout the life period. Application of nitrogen at different stages of crop growth also significantly influenced the yield attributes and helped for reduction in loss of nitrogen but also increased the nitrogen absorption, consequently better utilization of applied nitrogen leads to higher yield attributes and finally resulted in higher grain and straw yield similar results have been reported by Sahar *et al.* (2012).

Higher leaching and overflow losses resulted in significantly lower yield with four splits (S_3) than with three split application of nitrogen (S_2) and also it was adjusted to tillering and earhead initiation stages of crop growth. To exploit the high yield potential of the crop, quantity of nitrogenous fertilizer with split application directly involves in enhancing crop productivity as earlier reported by Satyanarayanan *et al*., (2004).

Interaction effect of establishment techniques, nitrogen levels and time of nitrogen application

The effect on increased yield can be better quantified in the light of interaction effects of establishment techniques, nitrogen levels and time of nitrogen application. Recommended transplanted crop of finger millet recorded the maximum values of number of leaves per hill, leaf area per hill, leaf dry weight, total dry weight, grain and straw yield per ha, uptake as well as gross and net returns due to recommended transplanting and 100 kg nitrogen per hectare which was followed by treatment 80 kg nitrogen per ha. This may be ascribed to the better utilization of nitrogen in case of recommended transplanted finger millet as compared to random transplanting, random broadcasting of 30 days old seedlings and random broadcasting of 20 days old seedlings i.e. *awatni.* The results are in conformity with the results reported by Newase *et al.* (1995) and Ganga Devi *et al*. (2011).The interaction effect was significant in case of nitrogen uptake by grain 27.26 kg ha^{-1}, total N uptake 43.45 kg ha^{-1}, grain protein yield 170.41 kg ha^{-1} and total protein yield 271.56 kg ha^{-1} during the year 2012. Effect of establishment techniques and time of nitrogen application was more favorably interacted to each other in nitrogen uptake and protein yield. Significantly, higher uptake of nitrogen was recorded with recommended transplanting and three splits of nitrogen application than other treatment combinations. This was due to the split application of nitrogen that helped to the crop at critical growth stages and reduced loss due to leaching in high rainfall area. Interaction effect due to nitrogen levels and time of nitrogen application was remarkable in case of number of grass weeds and dry weight of grass and broadleaf weeds. The application of 100 kg N per ha as a basal dose was maximum density and dry weight of weeds than all other treatment combinations. Splitting was observed to be helpful to reduce the number of weeds which helps for maximum utilization of nutrients by the crop at their phenological stages. These results corroborate the findings of Avasthe (2009).

The interaction effects were significant in plant height, number of functional leaves per hill, leaf area per hill, grain yield, straw yield and total produce per ha due to establishment techniques and nitrogen levels. This might be due to mutual interaction of one upon another that helps increased in different parameters.

None of the interaction effect was found significant with respect of establishment techniques, levels and time of nitrogen application during both the years of experimentation. Similarly, grain and straw yield were not influenced significantly due to interaction effect of establishment techniques, nitrogen levels and time of nitrogen application in finger millet during both the years of study also similar line with Avasthe (2009).

From the investigation it can be conclude that to obtain higher grain and straw yield per ha the finger millet crop should be established by recommended transplanting at 20x15 cm and supplied with 100 kg nitrogen per ha along with three equal splits of nitrogen (at transplanting, 30 and 60 DAT).

REFERENCES

1. Avasthe Ravikant, A. 2009. Nitrogen management in transplanted rice in mid hill acidic soils of Sikkim Himalayas. Indian Journal of Agronomy 54(1): 47-51.
2. Camara, K. M., W. A. Payne and P. E. Rasmussen. 2003. Long-term effects of tillage, nitrogen, and rainfall on winter wheat yields in the Pacific Northwest. Agron. J. 95: 828-835.
3. De Datta, S. K. 1986. Availability and management of N in low land rice in relation to soil characteristics. Workshop on "Characterization, classification and utilization of wetland soils" manual. IRRI, Manila. Philippines.
4. Ganga Devi, M., Gowada,R. and V. Sumthi 2011. Effect of nitrogen management on growth, yield and quality of scented rice under aerobic conditions. J.ANGARU 39(3)81-83.
5. Ghadage, H.L. 1982. Effect of age of seedlings at transplanting, levels of spacing and nitrogen fertilization on growth, yield, quality of nitrogen by Nagli (Eleusine coracana G.) variety B-11. A thesis submitted to the Konkan Krishi Vidyapeeth, Dapoli.
6. Islam, M. S., G. J. U. Ahmed and A. W. Julfiquar. 2005. Effect of System Rice Intensification on Hybrid Rice Performance and Yield. International Rice Research notes published by International Rice Research Institute.
7. Jagtap, D. N. 2011. Studies on the response of hybrid Rice to different crop establishment methods and sources of fertilizer application under Konkan upland situation. Ph.D. Thesis submitted to Dr.B.S.K.K.V.,Dapoli.
8. Khanda, C. N., Dixit, L. and Panda, S.C. 1997. Effect of zinc and graded levels of N on growth, yield and nutrient uptake of rice. Oryza 34:43-46.
9. Laulanie, H. 1993. Le systéme de riziculture intensive malgache. Tropicultura (Brussels), (11): Pp110-114.
10. Lawlor, D. W.1995. Nitrate nutrition and temperature effects on wheat: a synthesis of plant growth and nitrogen uptake in relation to metabolic and physiological processes. J. Exp. Botany 39: 329-243.
11. Namara, R. E., P. Weligamage, and R. Barker. 2004. Prospects for Adopting System of Rice Intensification in Sri Lanka: A Socioeconomic Assessment. Research Report 75. Colombo: International Water Management Institute.
12. Newase,V.B.; Thorat, S.T. and Chavan, S.A. 1995. Effect of methods of planting and fertilizer application on the yield of kharif ragi. J. Indian Soc. Agric. Res., 13(2): 151-152.
13. Om Hari, Katyal, S.K. and Dahiman, S.D. 1997. Effect of nitrogen and seed rate in nursery on growth and yield of hybrid rice. Indian J.Agron.42(2):275-277.
14. Panda,S.C. and K.C. Das. 1997. Nitrogen for rice. Indian journal of Agronomy. 24 (2): 173-174.
15. Parshuramkar, P.H., S.O. Pawar, D. N. Gokhale and A.S.Chavan. 2012. Effect of nitrogen levels and weed control methods on yield of rice under upland condition. (E.S.) RIC-3, Souvenir and abstract, Akola chapter of Indian Society,249.
16. Rajendra Prasad. 2012. Text book of field crops production, food grain crops. Vol.I. Indian Council of Agricultural Research, New Delhi. Second edn.
17. Sahar Youseftabar, Allahyar Fallah, Jahanfar Daneshiyan (2012). Effect of Split Application of Nitrogen Fertilizer on Growth and Yield of Hybrid Rice (GRH1). Australian Journal of Basic and Applied Sciences, 6(6): 1-5.
18. Satyanarayana, A., T. M. Thiyagarajan, and N. Uphoff. 2004. Abstract on opportunities for water saving with higher yield using the system of rice intensification. Acharya A. N. Ranga Agricultural University, Hyderabad, India; Tamil Nadu Agricultural University, Killikulam, India; and Cornell University, USA.
19. Sharma, S.K. and D. Rajat. 1975. Effect of water regimes, levels and methods of nitrogen application on growth and yield of rice. Indian journal of Agronomy. 20 (4): 299-300.
20. Singh, Parmeet and S.S.Singh. 2006. Effect of establishment method, fertility level and weed management practices on aromatic rice, Department of Agronomy, Allahabad Agricultural Institute- Deemed University, Allahabad, Uttar Prasesh. Indian Journal of Agronomy 51(4):288-292.
21. Singh, M. V., H. N. Tripathi and H. P. Tripathi. 1997. Effect of nitrogen and planting date yield and quality of scented rice (Oryza sativa). Indian Journal of Agronomy 42 (1): 74-76.
22. Subramanian, S. and K. Rajgopalan.1979. Effect of water management and nitrogen levels on nutrient uptake in rice. Indian journal of Agronomy. 25 (1): 77-80.
23. Thakur, R.B. 1993. Performance of summer rice (Oryza sativa) to varying level of nitrogen. Indian Journal of Agronomy 38 (2): 187-190.
24. Tippanagoudar, P.G., M.B. Roodgi and A.C. Jnanesha. 2012. Effect of sowing and weed management practices on nutrient uptake by crops and weeds on prosomillet. Adv. Res. J. of Crop Improvement, Vol.3,Issue 1(June):40-43.
25. Tisdale, S. L., J. L. Havlin, J. D. Beaton and W.L. Nelson. 2002. Soil fertility and fertilizers an introduction to nutrient management.5th ed. Pearson Education (Singapore) Pvt. Ltd, Indian Branch, 482 F. I. E. Patparganj, Delhi, India.

Table1. Effect of establishment techniques, levels and time of nitrogen application on Plant height (cm), number of functional leaves per hill, number of tillers per hill, leaf area (cm^2) per hill, mean dry matter production (g) per hill of finger millet

Treatments	Plant height (cm)		number of functional leaves per hill		number of tillers per hill		leaf area (cm^2) per hill		mean dry matter production (g) per hill (Leaves)		mean dry matter production (g) per hill (Stem)		mean dry matter production (g) per hill (Grain)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
A. Establishment techniques														
T_1: Recommended Transplanting	117.83	124.01	18.08	19.80	4.86	5.67	546.21	681.26	16.58	19.81	30.36	32.41	25.01	26.67
T_2: Random Transplanting	110.02	118.00	14.69	17.04	4.55	5.29	450.54	557.60	12.93	16.13	29.03	30.52	23.96	24.89
T_3: Random Broadcasting of 30 Days Old Seedlings	101.14	108.67	12.30	14.20	3.61	3.81	410.25	451.28	10.17	10.96	25.67	26.23	22.33	22.83
T_4: Random Broadcasting of 20 Days Old Seedlings	97.81	112.38	10.37	15.99	3.29	4.21	345.35	477.18	8.58	13.34	23.98	27.86	20.61	23.47
S.E (m)±	0.20	0.25	0.27	0.20	0.08	0.04	2.01	2.79	0.22	0.23	0.09	0.08	0.08	0.13
C.D. at 5 %	0.68	0.88	0.95	0.68	0.29	0.14	6.95	9.65	0.74	0.79	0.32	0.28	0.28	0.44
B. Nitrogen levels														
F_1: 60 kg ha^{-1}	103.10	112.65	11.89	15.28	3.97	4.37	304.27	410.87	9.70	12.71	26.93	28.51	22.69	24.19
F_2: 80 kg ha^{-1}	106.38	115.65	13.99	16.95	4.05	4.74	411.78	505.12	12.30	15.27	27.37	29.09	22.94	24.46
F_3: 100 kg ha^{-1}	110.62	119.00	16.07	18.05	4.21	5.13	598.21	709.49	14.19	17.20	27.48	30.15	23.30	24.74
S.E (m)±	0.22	0.15	0.24	0.18	0.05	0.05	3.20	2.81	0.19	0.21	0.08	0.09	0.08	0.07
C.D. at 5 %	0.67	0.45	0.71	0.54	0.15	0.15	9.58	8.43	0.58	0.63	0.25	0.28	0.24	0.21
C. Time of nitrogen application														
S_0 : Basal dose (half dose through suphala (15:15:15))	103.54	112.25	11.71	14.56	3.81	4.48	413.78	519.50	9.66	12.88	26.86	28.85	22.41	23.89
S_1 : 2 Split- TP, 30 DAT	109.80	119.31	13.63	16.53	4.02	4.72	430.05	535.49	11.45	14.36	27.18	29.14	22.90	24.33
S_2: 3 Split- TP, 30, 60 DAT	107.73	116.64	15.96	18.41	4.35	4.98	462.14	562.47	14.60	17.52	27.64	29.69	23.47	24.99
S_3 : 4 Split- TP, 20, 40, 60 DAT	105.65	114.85	14.64	17.53	4.11	4.80	446.37	549.86	12.56	15.48	27.36	29.33	23.15	24.65
S.E(m) ±	0.19	0.22	0.23	0.16	0.07	0.06	4.28	3.85	0.19	0.20	0.07	0.08	0.10	0.10
C.D. at 5 %	0.54	0.63	0.68	0.45	0.18	0.18	12.08	10.85	0.55	0.55	0.19	0.22	0.29	0.28
Interaction effect														
							AXB	AXB						
S.E (m)±	-	-	-	-	-	-	6.39	5.62	--	--	--	--	--	--
C.D. at 5 %	NS	NS	NS	NS	NS	NS	19.16	16.86	--	--	--	--	--	--
General Mean	106.70	115.76	13.98	16.76	**4.07**	**4.74**	**438.09**	**541.83**	12.07	15.06	27.26	29.25	22.98	24.47

Table 2. Effect of establishment techniques, levels and time of nitrogen application on mean number of earhead per hill, weight per earhead (g), weight of earheads per hill (g), grain weight per earhead (g) and test weight (g) of finger millet

Treatments	Mean no. of earhead per hill		Weight per earhead (g)		Weight of earheads per hill (g)		Grain weight per earhead (g)		Test weight (g)		Mean number of fingers per earhead		Mean length of fingers (cm)		Mean length of earheads (cm)		Grain weight per hill (g)		Straw weight per hill (g)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
A.Establishment techniques																				
T_1: Recommended Transplanting	4.59	5.10	6.22	6.56	29.12	30.23	4.40	5.40	3.05	3.09	6.92	8.16	9.00	9.50	14.81	17.28	25.01	26.67	28.66	29.72
T_2: Random Transplanting	3.96	4.42	5.94	6.27	27.14	28.02	4.15	4.31	3.00	3.07	6.78	8.04	8.69	8.90	14.33	16.96	23.96	24.89	26.68	27.51
T_3: Random Broadcasting of 30 Days Old Seedlings	3.09	3.10	5.31	5.48	25.14	25.42	3.53	3.58	2.95	2.97	6.59	7.71	7.98	8.04	13.46	15.24	22.33	22.83	24.68	24.91
T_4: Random Broadcasting of 20 Days Old Seedlings	2.82	3.50	2.14	5.73	24.42	26.24	3.43	3.68	2.92	2.98	6.50	7.82	7.73	8.22	13.23	15.48	20.61	23.47	23.96	25.73
S.E (m)±	0.06	0.07	0.07	0.05	0.04	0.13	0.05	0.08	0.05	0.03	0.10	0.09	0.05	0.10	0.06	0.07	0.08	0.13	0.06	0.13
C.D. at 5 %	0.22	0.25	0.24	0.18	0.13	0.44	0.17	0.29	NS	NS	NS	NS	0.18	0.33	0.22	0.23	0.28	0.44	0.20	0.44
B.Nitrogen levels																				
F_1: 60 kg ha^{-1}	3.35	3.62	5.42	5.62	25.59	27.15	3.73	4.00	2.79	2.84	6.54	7.75	8.10	8.26	13.67	15.67	22.69	24.19	25.13	26.64
F_2: 80 kg ha^{-1}	3.55	3.94	5.68	5.95	26.71	27.49	3.87	4.23	2.98	3.03	6.71	7.94	8.37	8.57	13.98	16.40	22.94	24.46	26.25	26.98
F_3: 100 kg ha^{-1}	3.89	4.46	5.86	6.44	27.07	27.79	4.03	4.50	3.16	3.22	6.85	8.10	8.58	9.15	14.23	16.66	23.30	24.74	26.61	27.28
S.E(m) ±	0.05	0.05	0.08	0.08	0.08	0.10	0.04	0.06	0.04	0.04	0.04	0.04	0.05	0.07	0.04	0.08	0.08	0.07	0.08	0.10
C.D. at 5 %	0.16	0.15	0.23	0.24	0.24	0.30	0.13	0.18	0.13	0.12	0.12	0.13	0.14	0.20	0.13	0.24	0.24	0.21	0.24	0.31
C.Time of nitrogen application																				
S_0 : Basal (half dose through suphala (15:15:15))	3.30	3.69	5.35	5.66	26.02	26.92	3.68	3.88	2.74	2.73	6.62	7.81	8.07	8.37	13.68	15.93	22.41	23.89	25.56	26.41
S_1 : 2 Split- TP, 30 DAT	3.55	3.94	5.59	5.96	26.31	27.21	3.84	4.14	2.91	2.90	6.65	7.90	8.27	8.57	13.86	16.17	22.90	24.33	25.85	26.70
S_2: 3 Split- TP, 30, 60 DAT	3.93	4.38	5.95	6.30	26.89	28.12	4.07	4.60	3.21	3.22	6.79	8.04	8.62	8.97	14.25	16.55	23.47	24.99	26.43	27.61
S_3 : 4 Split- TP, 20, 40, 60 DAT	3.67	4.10	5.71	6.04	26.60	27.66	3.91	4.36	3.05	3.16	6.73	7.97	8.44	8.74	14.04	16.32	23.15	24.65	26.14	27.15
S.E(m) ±	0.09	0.08	0.08	0.09	0.10	0.10	0.05	0.07	0.05	0.05	0.06	0.05	0.05	0.06	0.06	0.07	0.10	0.10	0.10	0.09
C.D. at 5 %	0.24	0.23	0.22	0.24	0.27	0.28	0.14	0.19	0.13	0.14	NS	NS	0.15	0.16	0.16	0.18	0.29	0.28	0.27	0.26
Interaction effect																				
S.E(m) ±	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C.D. at 5 %	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-	--	--	--	--	--
General Mean	**3.61**	**4.02**	**5.62**	**6.01**	**26.46**	**27.48**	**3.88**	**4.24**	**2.98**	**3.02**	6.70	7.23	8.35	8.66	13.95	16.24	22.98	24.47	26.00	26.96

Table 3. Effect of establishment techniques, levels and time of nitrogen application on mean yield of grain and straw, total produce (q ha^{-1}), grain to straw ratio and harvest index of finger millet

Treatments	Grain yield (q/ha)			Straw yield (q/ha)			Total produce (q/ha)			Grain to straw ratio			Harvest index (%)		
	2011	2012	Pooled	2011	2012	Pooled	2011	2012	Pooled	2011	2012	Pooled	2011	2012	Pooled
A.Establishment techniques															
T_1: Recommended Transplanting	25.11	27.55	26.33	31.80	36.31	34.05	56.91	63.85	60.38	1.26	1.32	1.29	44.32	43.16	43.74
T_2: Random Transplanting	21.94	24.05	23.00	27.25	30.70	28.98	49.19	54.75	51.97	1.24	1.28	1.26	44.77	43.98	44.38
T_3: Random Broadcasting of 30 Days Old Seedlings	18.47	20.04	19.26	22.47	24.26	23.36	40.94	44.32	42.63	1.21	1.22	1.21	45.25	45.66	45.45
T_4: Random Broadcasting of 20 Days Old Seedlings	16.45	20.15	18.30	19.78	25.22	22.50	36.23	45.36	40.79	1.20	1.25	1.22	45.62	44.46	45.04
S.E (m)±	0.10	0.11	0.07	0.25	0.31	0.24	0.27	0.34	0.28	--	--	--	--	--	--
C.D. at 5 %	0.36	0.39	0.25	0.87	1.06	0.84	0.94	1.17	0.98	--	--	--	--	--	--
B.Nitrogen levels															
F_1: 60 kg ha^{-1}	17.54	19.17	18.35	20.50	23.66	22.08	38.04	42.83	40.44	1.17	1.23	1.20	46.19	45.04	45.62
F_2: 80 kg ha^{-1}	19.97	22.37	21.17	24.43	28.52	26.48	44.40	50.84	47.65	1.22	1.27	1.24	45.11	44.15	44.63
F_3: 100 kg ha^{-1}	23.97	27.31	25.64	31.04	35.18	33.11	55.01	62.49	58.75	1.29	1.29	1.29	43.67	43.75	43.71
S.E (m)±	0.16	0.15	0.10	0.19	0.12	0.09	0.27	0.23	0.14	--	--	--	--	--	--
C.D. at 5 %	0.48	0.45	0.30	0.57	0.36	0.28	0.80	0.67	0.41	--	--	--	--	--	--
C.Time of nitrogen application															
S_0 : Basal dose (half dose through suphala(15:15:15))	17.49	19.56	18.52	21.40	24.88	23.14	38.89	44.43	41.66	1.21	1.26	1.24	45.31	44.82	45.06
S_1 : 2 Split- TP, 30 DAT	19.30	21.80	20.55	24.02	27.49	25.76	43.32	49.29	46.30	1.24	1.25	1.24	44.78	44.51	44.64
S_2 : 3 Split- TP, 30, 60 DAT	23.49	26.10	24.80	29.28	33.74	31.51	52.77	59.84	56.30	1.24	1.29	1.26	44.73	43.68	44.21
S_3 : 4 Split-TP, 20, 40, 60 DAT	21.70	24.34	23.02	26.60	30.38	28.49	48.29	54.72	51.51	1.22	1.24	1.23	45.15	44.64	44.89
S.E(m) ±	0.18	0.15	0.11	0.20	0.20	0.12	0.29	0.25	0.17	--	--	--	--	--	--
C.D. at 5 %	0.51	0.43	0.32	0.56	0.58	0.35	0.81	0.70	0.49	--	--	--	--	--	--
Interaction effect															
		AXB	AXB	AXB	AXB	AXB	AXB	AXB	AXB						
S.E (m)±		0.30	0.20	0.38	0.24	0.19	0.54	0.45	0.28	--	--	--	--	--	--
C.D. at 5 %		0.90	0.59	1.15	0.73	0.56	1.61	1.35	0.83	--	--	--	--	--	--
General Mean	20.49	22.95	21.72	25.32	29.12	27.22	45.82	52.07	48.94	1.23	1.26	1.24	44.99	44.31	44.45