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Research Article

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Estimation of land and manpower needs for year-round supply of green fodder (Super Napier) to dairy cattle through time studies and crop cutting experiments

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ABSTRACT

The present study was undertaken to determine the land and manpower needed for the production of Super Napier fodder for the year-round feeding of dairy cattle present in Livestock Research Station, Mahanandi, Nandyal district, Andhra Pradesh through time studies and crop cutting experiments. The occasional activities of fodder production such as tillage, planting, irrigation and fertilizer application required 113.97 ± 7.31, 35.81 ± 0.98, 8.45 ± 0.31 and 0.56 ± 0.03 man-hours per acre, respectively, while the daily activities of fodder production such as harvesting of fodder, loading of fodder bundles, transport, chaffing and feeding took 5.64 ± 0.19, 1.86 ± 0.11, 0.24 ± 0.01, 0.93 ± 0.06 and 0.34 ± 0.01 man-hours per ton, respectively. Among the tillage operations, weeding required the most time (105.83 ± 6.90 man-hours per acre) and the application of an adjusted cultivator required the least time (0.64 ± 0.07 man-hours per acre). The cutting of planting material into stem cuttings and the harvesting of the planting material consumed the highest (16.52 ± 0.62 man-hours per acre) and lowest (3.97 ± 0.28 man-hours per acre) time, respectively, among the planting operations. There was a significant difference between two labourers of the same age in the application of adjusted cultivator ($P < 0.01$) and furrow irrigation ($P < 0.05$). The mean fresh yield of fodder in the farm was 16.73 ± 1.62 tons per acre per harvest or 100.40 ± 9.72 tons per acre per annum. Based on the results, it was concluded that one acre of cultivable land managed by a single person is sufficient for ensuring the year-round feeding of seven dairy animals under Super Napier fodder production.

KEYWORDS: Super Napier, Man-hour, Tillage, Yield of fodder

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INTRODUCTION

Feeding is the most important one among the four pillars of livestock management (the remaining three pillars being breeding, weeding/culling and heeding) as the expenditure on feed alone accounts for 57.91% of total costs in a dairy farm (Sathiyabarathi *et al.*, 2015), and the animals should be fed for their maintenance and production. The feed costs can be lowered by measures like on-farm fodder production and reducing feed waste. In the context of the fodder deficit in India as reported by various studies, on-farm fodder production is the key solution to securing feed for our ruminant livestock. The estimates of the green fodder deficit vary greatly among studies, and they ranged from 11.24% (Roy *et al.*, 2019) to 35.6% (IGFRI, 2015). NIANP (2013) projected that the deficit would reach 40.00% by 2025. It is also important to note that the scarcity of green fodder is the most critical constraint in realizing the production potential of our cattle (Birthal & Jha, 2005), and lack of high-quality fodder is one of the basic concerns of the dairy sector in India (Sarkar & Dutta, 2020). Among the available green fodders, Super Napier is a high yielding perennial grass that can be grown round the year under assured irrigation, and contains around 19.48% crude protein (Mohamad *et al.*, 2022).

Apart from the feed, labour is also one of the most critical resources, and hiring efficient and honest labour is the key to

the success of any enterprise. Very few studies, such as those of Reddy (1970) and Sreedhar and Ranganadham (2009), have been reported on fodder production in a dairy farm and they may not align with the present-day context because of increasing mechanisation of farm activities and the invention of more efficient machines. The present study was aimed at estimating land and labour requirements for Super Napier fodder production.

MATERIALS AND METHODS

The present study was carried out at Livestock Research Station, Mahanandi, Nandyal district, Andhra Pradesh for 60 days. The farm had 50 acres of land of loam soil type on which the Super Napier fodder (Pakchong1 variety) was cultivated. About 40 Ongole milch cows were maintained on the farm, and they were fed with chaffed green fodder (40 kg per animal per day) and concentrate (2 kg per animal per day). They were low yielders, with each cow yielding around 3-4 kg of milk per day.

The time studies involved the recording of time taken for various activities such as tillage operations (n = 15 for each activity), planting operations (n = 20 for each activity), irrigation (n = 25), fertilizer application (n = 15), harvesting (n = 25), loading (n = 25), transport (n = 25), chaffing (n = 25) and feeding (n = 40) where, n is the sample size. The tillage operations, planting operations, irrigation and fertilizer application were occasional activities, while the harvesting, loading, transport, chaffing and feeding were done daily. The crop cutting experiments were done by recording the quantity of fodder yield and area of harvesting.

The tillage operations included preparatory tillage, seedbed preparation and inter-tillage or inter-cultivation. The preparatory tillage operations included ploughing with mould board plough, application of a rotavator (Figure 1), levelling with the help of a leveller and application of nine Tyne cultivator. The seedbed preparation involved making bunds with the help of bund former. The inter-tillage or inter-cultivation activities included the application of an adjusted cultivator to work between crop rows (Figure 2) and manual weeding with the help of a sickle. The preparatory tillage operations and seedbed preparation constitute the activities of land preparation which were done before planting. The activities of land preparation and application of adjusted cultivator were done using a tractor of 55 HP capacity and suitable implements.

The Super Napier was propagated through stem cuttings. The various operations of planting included harvesting planting material at 90 bundles per acre, each bundle weighing around 10 kg and yielding 160 stem cuttings, cutting the planting material into stem cuttings each with two nodes, distributing, and planting of stem cuttings (Figure 3) in the field. All these operations were done manually. The required number of stem cuttings was obtained by using the following formula:

Figure 1: Application of Rotavator

Figure 2: Application of adjusted cultivator (inter-cultivation)

Figure 3: Planting of stem cuttings

$$No.\,of\ stem\ cuttings = \frac{Total\ area}{Plant\ to\ plant\ distance\ in\ a\ row \times Row\ to\ row\ distance}$$

The row-to-row distance was one metre, and the distance between two consecutive plants in a row is one foot, in the case of the present study. The requirement for stem cuttings per acre in the present study was found to be 13500.

The farm had adequate irrigation sources in the form of tube wells. The method of irrigation followed in the farm was furrow method. The process of irrigating a field (Figure 4) involved the application of water to one or two consecutive furrows from a head channel using a spade. The fertilizer was

applied at the rate of 40 kg per acre through the top dressing method.

The fodder was harvested manually (Figure 5) with the help of a sickle and made into bundles simultaneously. The fodder bundles were loaded manually (Figure 6) onto a tractor trolley of two tons capacity, and then transported to a chaff cutter. The mean distance from the field to the chaff cutter was 0.96 ± 0.02 km.

The quantity of fodder harvested on a day was determined through two methods: 1) the use of a weigh bridge; and 2) the counting of fodder bundles and weighing of a sample of individual bundles. In the first method, the tractor loaded with fodder bundles was taken to weigh the bridge (Figure 7) located at a distance of five kilometres from the farm. In the second method, the fodder bundles were counted during loading, and a sample of bundles was weighed on the farm itself using an electronic balance (Figure 8). The weight of a bundle was taken when a person held the bundle in his arms and stood on the balance. The quantity of fodder was estimated as a part of the study and it was not a regular activity.

The Chaffing operation (Figure 9) was done with a chaff cutter of 15 HP capacity. The activity of feeding (Figure 10) involved the transport of the chaffed green fodder from the chaff cutter

Figure 4: Furrow irrigation

Figure 5: Harvesting of fodder

Figure 6: Loading of fodder bundles

Figure 7: Weighing of fodder bundles through weigh bridge

Figure 8: Weighing of a fodder bundle through electronic balance

Figure 9: Chaffing

Figure 10: Feeding

to the feed manger through tractor trolley of one ton capacity and its distribution in the manger manually with the help of a rake. The distance from the chaff cutter to the feed manger was 103 meters.

The data obtained from the study was analysed through statistical tools such as mean, standard error and t-test as per Snedecor and Cochran (1989) using IBM SPSS software.

RESULTS

The results of comparison between two labourers of the same age in performing some activities of fodder production were depicted in Table 1.

Tillage Operations

The mean time (man-hours per acre) spent on tillage operations were given in Table 2. The preparatory tillage operations such as ploughing, application of rotavator, levelling and application of cultivator required 2.07 ± 0.13, 0.79 ± 0.04, 2.27 ± 0.06 and 0.81 ± 0.07 man-hours per acre, respectively. The preparatory tillage operations as a whole and seedbed preparation required 5.97 ± 0.22 and 1.72 ± 0.07 man-hours per acre, respectively. The whole land preparation activities took 7.49 ± 0.29 man-hours per acre. The inter-tillage activities such as application of adjusted cultivator and manual weeding took 0.64 ± 0.07 man-hours per acre and 105.83 ± 6.90 man-hours per acre, respectively. A significant difference ($P < 0.01$) was found between two labourers of the same age in the application of the adjusted cultivator. The total tillage operations required 113.97 ± 7.31 man-hours per acre.

Planting Operations

The mean time (man-hours per acre) spent on planting operations was presented in Table 3. The activities of planting, such as harvesting planting material, cutting the planting material into stem cuttings, distributing the stem cuttings on seedbed and planting the stem cuttings took 3.97 ± 0.28, 16.52 ± 0.62, 6.09 ± 0.42 and 10.24 ± 0.63 man-hours per acre, respectively. The planting operations as a whole required 35.81 ± 0.98 man-hours per acre. The mean time taken to cut 100 stem cuttings from the planting material was 7.03 ± 0.24 man-minutes and it did not differ significantly between two labourers of the same age.

Furrow Irrigation and Fertilizer Application

The mean time required for furrow irrigation when one 7.5 HP motor used was 8.45 ± 0.31 man-hours per acre. The mean time taken for the irrigation vary significantly ($P < 0.05$) between two labourers of the same age, and it was non-significantly lower with two motors (7.29 ± 0.58 man-hours per acre) when compared to one motor (8.45 ± 0.31 man-hours per acre). The mean time taken for fertilizer application was 0.56 ± 0.03 man-hours per acre.

Harvesting, Loading, Transport, Chaffing and Feeding

The mean time spent on harvesting, loading, transport, chaffing and feeding of fodder was presented in Table 4. The harvesting of fodder took 5.64 ± 0.19 man-hours per ton or 96.81 ± 9.39 man-hours per acre. The mean time required to harvest a fodder bundle was 2.37 ± 0.13 man-minutes and it did not vary significantly between two labourers of the same age. The loading of fodder bundles took 1.86 ± 0.11 man-hours per ton or 32.45 ± 4.01 man-hours per acre. A mean time of 0.24 ± 0.01 man-hours per ton or 2.03 ± 0.09 man-hours per acre per harvest or 12.52 ± 0.01 man-hours per acre per annum was required for transport of fodder bundles from field to chaff cutter. The chaffing of fodder required 0.93 ± 0.06 man-hours per ton or 16.43 ± 2.36 man-hours per acre. The chaffed green fodder feeding took about 0.34 ± 0.01 man-hours per ton or 5.63 ± 0.12 man-hours per acre.

Estimation of Fodder Yield

When quantities of harvest determined through the weigh bridge method and the counting of bundles method on a day were subjected to a paired t-test, it was found that there was no significant difference ($P = 0.42$) between the two methods. The mean fresh yield of Super Napier in the farm was 16.73 ± 1.62 tons per acre per harvest or 100.40 ± 9.72 tons per acre per annum.

Estimation of Land Requirement

The annual fodder yield from an acre (100.40 tons) is sufficient for the year round feeding of seven animals $\left(\frac{100400}{40\times365}=6.88\approx 7.00\right)$.

Estimation of Manpower Requirement

It took about 312.54 man-hours per acre for performance of both occasional activities (tillage operations, planting operations, irrigation, and fertiliser application) and daily activities (harvesting of fodder, loading of fodder bundles, transport, chaffing and feeding). The daily activities collectively required about 9.01 man-hours per ton or 153.35 man-hours per acre. From these findings, it can be estimated that one person per acre is sufficient to perform the fodder production activities year-round.

Table 1: Comparison between two labourers of the same age in performing some activities of fodder production

Activity	Overall	Labourer 1	Labourer 2	Significance
Application of adjusted cultivator (man-hours per acre)	0.64±0.07	0.45^{a}±0.02	0.77^{b}±0.01	**
Cutting planting material into stem cuttings (man-minutes per 100 stem cuttings)	7.03±0.24	6.84±0.30	7.32±0.39	NS
Furrow irrigation (man-hours per acre)	8.45±0.31	9.10^{b}±0.43	7.81^{a}±0.23	*
Harvesting of fodder (man-minutes per bundle)	2.37±0.13	2.52±0.25	2.23±0.08	NS

NS: Non-significant, *: P<0.05, **: P<0.01. Means bearing different superscripts in a row differ significantly.

Table 2: Mean time (man-hours per acre) spent on tillage operations

Tillage operation	Time required (Mean±S.E.)
A. Preparatory tillage:	
Application of plough	2.07±0.13
Application of rotavator	0.79±0.04
Application of leveller	2.27±0.06
Application of cultivator	0.81±0.07
Total A	5.97±0.22
B. Seedbed preparation:	
Application of bund former	1.72±0.07
Total A+B (Land preparation)	7.49±0.29
C. Inter-tillage or inter-cultivation:	
Application of adjusted cultivator	0.64±0.07
Weeding	105.83±6.90
Total C	106.47±7.50
Total A+B + C	113.97±7.31

Table 3: Mean time (man-hours per acre) spent on planting operations

Planting operation	Time required (Mean±S.E.)
Harvesting planting material	3.97±0.28
Cutting the planting material into stem cuttings	16.52±0.62
Distributing the stem cuttings on seedbed	6.09±0.42
Planting the stem cuttings	10.24±0.63
Total	35.81±0.98

Table 4: Mean time spent on harvesting, loading, transport, chaffing and feeding

Activity	Time spent (Mean±S.E.)	
	Man-hours per ton	Man-hours per acre
Harvesting	5.64±0.19	96.81±9.39
Loading	1.86±0.11	32.45±4.01
Transport	0.24±0.01	2.03±0.09
Chaffing	0.93±0.06	16.43±2.36
Feeding	0.34±0.01	5.63±0.12

DISCUSSION

Tillage Operations

The mean time spent on ploughing (2.07 ± 0.13 man-hours per acre) and application of cultivator (0.81 ± 0.07 man-hours per acre) was similar to that of Singh (2018). The mean time required for the whole land preparation activities (7.49 ± 0.29 man-hours per acre) was lower than that of Baliyan and Kumar (2014) and Mafongoya and Jiri (2015), and higher than that of Sreedhar and Ranganadham (2009). This contradiction was probably due to differences in the type of soil and the capacity of the tractor. The result of the present study regarding the manual weeding (105.83 ± 6.90 man-hours per acre) was similar to that of Ogwuike *et al.* (2014) and Mynavathi *et al.* (2015). About 113.97 ± 7.31 man-hours per acre were spent on the total tillage operations.

Planting Operations

The total time taken for the planting operations (35.81 ± 0.98 man-hours per acre) coincided with that of Baliyan and Kumar (2014). However, Reddy (1970), Obiri *et al.* (2007), Sreedhar and Ranganadham (2009), and Mafongoya and Jiri (2015) reported lower values for planting operations than the present study which might be due to differences in planting density and efficiency of labourers.

Furrow Irrigation and Fertilizer Application

The mean time required for the irrigation (8.45 ± 0.31 man-hours per acre) in the present study was consistent with that of Heitkämper *et al.* (2015). However, Sreedhar and Ranganadham (2009) reported higher value which was probably due to variations in capacity of motor, condition of soil, efficiency of labourers etc. The mean time taken for fertilizer application (0.56 ± 0.03 man-hours per acre) was lower than that reported by Sreedhar and Ranganadham (2009) and Baliyan and Kumar (2014). The reason for this disagreement might be variations in the procedure of application, the quantity applied and efficiency of labourers.

Harvesting, Loading, Transport, Chaffing and Feeding

The mean time spent on harvesting of fodder in the present study (5.64 ± 0.19 man-hours per ton or 96.81 ± 9.39 man-hours per acre) was in agreement to that of Sreedhar and Ranganadham (2009), Sahay *et al.* (2015) and Nandaniya *et al.* (2022). However, the results of the present study were higher than those of CIAE (2004), Singh and Aalam (2017) and Nikam *et al.* (2017), and lower than those of Baliyan and Kumar (2014), which might be due to variations in efficiency of labourers, amount of weed, etc. About 1.86 ± 0.11 man-hours per ton or 32.45 ± 4.01 man-hours per acre was needed for loading of fodder bundles. Sreedhar and Ranganadham (2009) reported higher values which might be due to variation in the process of loading. About 0.24 ± 0.01 man-hours per ton or 2.03 ± 0.09 man-hours per acre per harvest was consumed by transport of fodder. The time spent on chaffing of fodder (0.93 ± 0.06 man-hours per ton or 16.43 ± 2.36 man-hours per acre) was in agreement with that of Gupta and Joshi (2010). The time taken for feeding in the present study (0.34 ± 0.01 man-hours per ton or 5.63 ± 0.12 man-hours per acre) was similar to that of Gupta and Joshi (2010) who reported that loading of berseem fodder into mangers took 21.1 man-minutes per ton.

Estimation of Fodder Yield

It was found through the present study that the counting of bundles method is reliable enough to know the quantity of harvest, and there is no need to go for a weigh bridge. The mean fresh yield of Super Napier in the farm (16.73 ± 1.62 tons per acre per harvest or 100.40 ± 9.72 tons per acre per annum) was similar to that of Pandey and Roy (2011), Getiso and Mijena (2021), Sushma *et al.* (2021) and Triveni *et al.* (2023).

Estimation of Land and Manpower Requirement

From the result regarding fodder yield (100.40 tons per acre per annum), it was found out that one acre of land is needed for

the year round feeding of seven animals. From the results of the time taken for all the activities (312.54 man-hours per acre) and for daily activities (9.01 man-hours per ton or 153.35 man-hours per acre), it was estimated that one person per acre is sufficient to perform the fodder production activities year-round.

CONCLUSION

From the results, it can be concluded that one acre of cultivable land and one person are required for the year-round supply of Super Napier green fodder to seven dairy animals.

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