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Effect of nitrogen application and weed management schedules on growth, yields and economics of forage pearl millet (*Pennisetum glaucum* L.)

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Abstract
A field experiment was carried out during *Kharif* 2015 at ICAR-NDRI, Karnal to assess the efficacy of nitrogen application and weed management scheduling on growth, yields and economics of pearlmillet. The experiment consisting of four nitrogen levels (0, 50, 100 and 150 kg N ha^{-1}) and six weed management practices in split plot design replicated thrice. The pre-emergence (PE) herbicides *viz.* atrazine and pendimethalin were combined either with hand weeding (HW) or with post-emergence (POE) herbicide halosulfuron to evolve integrated weed management. The major weed flora at experiment site was constituted *Digera arvensis*, *Cyperus rotundus*, *Commelina benghalensis*, *Dactyloctenium aegyptium*, *Trianthema monogyna* and *Echinochloa colonum*. The results indicated that maximum plant height and number of tillers (221.5 cm and 5.1, respectively), stem diameter (4.75 cm), number of leaf (10.0) at harvest, green (505.6 kg ha^{-1}) and dry fodder yield (120 kg ha^{-1}), stover yield (10.85 t ha^{-1}) and biological yield (13.1 t ha^{-1}), were recorded with 150 kg N ha^{-1} whereas 100 kg N ha^{-1} recorded highest seed yield (2.3 t ha^{-1}) which were significantly higher over control. Among weed management schedules, besides weed free, higher values of plant height (215.2 cm), number of leaves (10.0), stem diameter (4.69 cm) and leaf stem ratio (0.19) at harvest, stover (10.61 t ha^{-1}) and green fodder yield (444.4 kg ha^{-1}) were recorded with pendimethalin PE fb 1 HW at 25 DAS whereas higher values of dry fodder yield (108.7 kg ha^{-1}) were obtained with atrazine PE fb 1 HW 25 DAS which were at par with other treatments besides weedy check. Higher number of tillers at harvest (5.3) was recorded with atrazine PE fb 1 HW at 25 DAS which was at par with pendimethalin PE fb 1 HW at 25 DAS whereas maximum seed yield (2.3 t ha^{-1}) was recorded with pendimethalin PE fb 1 HW 25 DAS which were at par with atrazine PE fb 1 HW 25 DAS and significantly differ than other treatments. Highest gross, net returns and B: C ratio were observed with 100 kg N ha^{-1} and pendimethalin (PE) fb 1 HW 25 DAS. The highest grain yield (2304.5 kg N ha^{-1}) was obtained at 126.5 kg N ha^{-1} which was considered as optimum economic dose.

Keywords: Atrazine, bajra, green fodder yield, halosulfuron, pendimethalin

Introduction
Livestock production is backbone of Indian agriculture contributing 4% to national GDP besides source of employment and ultimate support livelihood for 70% population in rural areas. India is gifted with the largest livestock population in the world with about 57.3% of the world's buffalo population and 14.7% of the cattle population (Anonymous, 2013) [2]. The country has only 4.9% of the cultivated area under fodder crops with an annual total forage production of 978.7 MT (525.5 and 453.2 MT green and dry fodder, respectively). Whereas, the annual forage requirement is 1325.7 MT (816.8 and 508.9 MT green and dry fodder, respectively) to support the existing livestock population. So at present, the country faces a net deficit of 35.6% green, 10.95% dry fodder and 44% concentrate feed ingredients (Anonymous, 2013) [2]. Among several factors causing low productivity, lack of suitable seed production agronomy is considered as most crucial aspect in success of bajra forage crop. Current demand for seeds of cultivated fodder is estimated to be 3.6 lakh tonnes $annum^{-1}$ based on the area under cultivation (8.3 m ha) and the availability of quality seed is 15-20% for fodder crops (Anonymous, 2013) [2]. The various constraints being fused in providing adequate quantity of quality seed includes lack of breeder seed production, lack of improved variety of fodder for seed production and lack of seed production agronomy for particular crops/variety.

Pearl millet (*Pennisetum glaucum* L.) commonly known as bajra it grown about 0.9 m ha area out of total fodder crops area of 8.47 M ha (Anonymous, 2011) [1]. The cultivation of pearl millet for forage purpose has been recently emphasized due to its profuse tillering habit, multicut nature, resistance to serious diseases and pests, drought tolerance, absence of poison 'Prussic acid' and better performance even on poor fertility soils. Nitrogen (N) is the key element and major constituents of protein and nucleic acid which favours the synthesis of protoplasm in plant body, promotes photosynthesis, size of plant, yield contributing characters and yield of crops (Meena *et al.*, 2012) [12]. Black (1957) reported that plant growth is affected more due to deficiency of nitrogen than that of any other nutrient. Weed management is an important factor for enhancing the productivity of pearl millet, as weeds compete for nutrients, water, light and space with crop plants during early growth period (Bahadur *et al*., 2015) [3]. Banga *et al*. (2000) [4] reported that on an average, 55% yield reduction was observed due to heavy weed infestation in pearl millet crop. Presence of mixed flora and to control the later flushes of weeds in bajra, post-emergence herbicides are required to be tested for broader spectrum control of weeds. Use of only pre emergence herbicides (Atrazine and pendimethalin) give rise to some weeds which are not controlled by these herbicides as these herbicides are effective only for initial 35-40 days which results in serious infestation of late emerging weeds. So, there is a need to make a comparative study on economic N levels and weed management techniques in bajra to develop an integrated weed management approach for higher yield.

Materials and Methods

The field experiment was carried out during *Kharif* season of 2015 at Forage Research and Management Centre, ICAR-National Dairy Research Institute, Karnal, located in North Western Zone of Haryana at 29º45' North latitude, 76º58' East longitudes and at an altitude of 245 m above mean sea level. Karnal has sub-tropical climate characterized by hot and dry summer and severe cold during winter season. The mean annual rainfall is about 707 mm of which major portion (about 574 mm) is received during the monsoon season (July to September) and rest during winter and spring seasons. The soil of the experimental field was clay loam in texture and low in available nitrogen (136.3 kg N ha^{-1}), medium in available phosphorus (20.0 kg P_2O_5 ha^{-1}), available potassium (260 kg K_2O ha^{-1}) and organic carbon (0.57%) and nearly neutral in reaction (pH-7.47). Half of the nitrogen was applied as basal in the form of urea and remaining half was top dressed at 30 DAS. Pre emergence herbicides were applied next day of sowing and post emergence herbicide was sprayed at 25 DAS as per the treatment with knapsack sprayer keeping spray volume 600 l ha^{-1}. The crop was harvested at 94 DAS. Yield attributes and seed yield were recorded at harvest of the crop. A 500 g sample of fresh fodder yield was taken from each plot at 60 DAS, dried at a temperature of 70°C till constant weight in an electric hot air oven. Dry fodder yield was calculated on the basis of dry matter content of these samples and expressed as dry fodder yield in quintal per hectare

$$\text{Dry matter (\%)} = \frac{\text{Weight of oven dry sample}}{\text{Weight of sample before drying}} \text{ X } 100$$

$$\text{Dry fodder yield (q/ha)} = \frac{\text{Fresh fodder yield X Dry matter content (\%)}}{100} \text{ X } 100$$

The total weight of produce harvested from each plot after excluding boarder rows was recorded after sun drying and expressed as biological yield and stover yield (t ha^{-1}) after ear removal. The economic optimum dose of nitrogen is a relationship between yield and fertilizer dosage which is defined by the quadratic regression equation.

Quadratic model:

$Y = a + bx + cx^2$

Where,

Y = Seed yield (kg/ ha)

X = the dosage of the nitrogen applied (kg/ ha), a is intercept and b and c are the regression coefficient.

The economic analysis in terms of gross and net returns and benefit: cost (B: C) ratio was worked out on the basis of existing rate of inputs, outputs and rental value of land. Fisher's method of analysis of variance was applied for the statistical analysis. The data collected from the experiment at different growth stages and at harvest were subjected to statistical analysis by software of O. P. Sheoran and interpretation of data as given by Gomez and Gomez (1984) [6]. Critical difference was calculated wherever 'F' test was significant.

Result and Discussion

Effect of nitrogen application and weed management schedules on growth parameters

The data on effect of nitrogen application and weed management schedules on growth parameters are presented in table 1. Nitrogen is an essential primary nutrient for profuse plant growth. Among different nitrogen levels 150 kg N ha^{-1} recorded the maximum plant height (221.5 cm) and stem diameter (4.75 cm) at harvest which were significantly higher than control and at par with 50 and 100 kg ha^{-1}. Highest number of tillers (5.1) and number of leaves (10.0) at harvest recorded with 150 kg N ha^{-1} which was at par with 100 kg N ha^{-1} and significantly higher than control and 50 kg N ha^{-1} (Table 1). Higher values of growth parameters at higher nitrogen levels might be attributed due to adequate supply of nitrogen resulted in better shoot development, high photosynthetic rate, better utilization of carbohydrate in the synthesis of more protoplasm resulted higher accumulation of dry matter. The results are in consistent with the result of Kumar and Ram (2010) [9] and Ibrahim *et al*. (2014) [7].

Among weed management schedules, besides weed free, higher values of plant height (215.2 cm), number of leaves (10.0), stem diameter (4.69 cm) and leaf stem ratio (0.19) at harvest, were recorded with pendimethalin PE fb 1 HW at 25 DAS which were at par with other treatments besides weedy check whereas higher number of tillers at harvest (5.3) were recorded with atrazine PE fb 1 HW at 25 DAS which was at par with pendimethalin PE fb 1 HW at 25 DAS and significantly differ than other treatments (Table 1). These results are in agreement to results reported by Silva *et al*. (2014) [15] and Dhage *et al.*, (2008) [5].

Table 1: Effect of nitrogen application and weed management schedule on yield attributes at harvest of forage Pearlmillet

Treatments	Plant height (cm)	Number of tillers	Number of leaves	Stem diameter (cm)	Leaf stem ratio
Nitrogen levels					
No (Control)	193.8	3.5	9.2	4.41	0.16
50 kg N ha^{-1}	203.3	4.6	9.6	4.61	0.18
100 kg N ha^{-1}	217.2	5.1	9.9	4.70	0.18
150 kg N ha^{-1}	221.5	5.1	10.0	4.75	0.18
S.Em±	5.7	0.1	0.13	0.07	0.01
C.D. (P=0.05)	19.6	0.4	0.5	0.17	N.S.
Weed Management					
PE Pendimethalin fb 1 HW	215.2	5.1	10.0	4.69	0.19
PE Atrazine fb 1 HW	209.8	5.3	9.8	4.67	0.18
PE Pendimethalin fb POE Halosulfuron	207.5	4.1	9.6	4.61	0.17
PE Atrazine fb POE Halosulfuron	209.1	4.3	9.5	4.53	0.17
Weedy check	196.9	2.9	9.2	4.33	0.16
Weed free	215.1	5.8	10.0	4.86	0.20
S.Em±	4.0	0.1	0.18	0.11	0.008
C.D. (P=0.05)	11.5	0.4	0.5	0.21	0.02

Effect of nitrogen application and weed management schedules on yields

The data on effect of nitrogen and weed management schedules on yields are presented in table 2. Results indicated that higher values of stover (10.9 t ha^{-1}), biological (13.1 t ha^{-1}), green 505.6 (kg ha^{-1}) and dry fodder yield (120 kg ha^{-1}) were obtained with 150 kg N ha^{-1} which remained at par with 100 kg N ha^{-1} and significantly higher than control and 50 kg N ha^{-1}. Increase in yield due to higher nitrogen application might be due to positive integrated effect of nitrogen on growth contributing characters *viz*. plant height, number of leaves, leaf area and dry matter content. The results get confirmation from the findings of Kumawat *et al*. (2014) [8], Pathan *et al*. (2010) [14] and Meena and Jain (2013) [13].

Among weed management schedules, besides weed free, pendimethalin PE fb 1 HW at 25 DAS recorded higher values of seed yield (2.3 t ha^{-1}) which was at par with atrazine PE fb 1 HW 25 at DAS and significantly higher than other weed management schedules (Table 2). Similarly, higher stover (10.6 t ha^{-1}) and green fodder yield (444.4 kg ha^{-1}) were found with pendimethalin PE fb 1 HW at 25 DAS which was significantly higher than weedy check and remained at par with other weed management schedules. Pendimethalin PE fb 1 HW at 25 DAS, recorded higher biological yield (13.1 t ha^{-1}) which remained at par with atrazine PE fb 1 HW 25 at DAS and atrazine PE fb halosulfuron at 25 DAS and significantly higher than other treatments. Significantly higher yield of pearlmillet in these treatments may be due to less competition with weeds resulting into better utilization of resources viz., nutrients, moisture, light and space etc. The results were conformity with those of Virkar *et al*. (2007) [16] and Kumar *et al*. (2012) [10].

Table 2: Effect of nitrogen application and weed management schedule on yields of forage Pearlmillet

Treatments	Green fodder yield (kg ha^{-1})	Dry fodder yield (kg ha^{-1})	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Test weight (g)
Nitrogen levels						
No (Control)	321.0	72.6	1.5	8.7	10.3	9.8
50 kg N ha^{-1}	407.4	93.6	1.9	8.9	10.8	9.6
100 kg N ha^{-1}	450.6	110.5	2.3	10.5	12.8	9.6
150 kg N ha^{-1}	505.6	120.0	2.3	10.9	13.1	9.7
S.Em±	24.9	7.1	0.034	0.3	0.4	0.2
C.D. (P=0.05)	85.8	24.4	0.12	1.1	1.3	N.S.
Weed Management						
PE Pendimethalin fb 1 HW	444.4	105	2.3	10.6	13.1	9.8
PE Atrazine fb 1 HW	435.2	108.7	2.2	10.5	12.7	9.6
PE Pendimethalin fb POE Halosulfuron	416.7	94.2	1.9	9.2	11.1	9.8
PE Atrazine fb POE Halosulfuron	439.8	102.0	2.0	10.0	11.9	9.8
Weedy check	310.2	76.2	1.3	7.2	8.5	9.6
Weed free	480.6	109.0	2.4	10.9	13.3	9.8
S.Em±	25.5	6.6	0.06	0.6	0.6	0.2
C.D. (P=0.05)	72.9	18.9	0.2	1.6	1.6	N.S.

Effect of nitrogen application and weed management schedules on economics

The data, effect of nitrogen and weed management schedules on economics are presented in table 3. Nitrogen application at 100 kg ha^{-1} recorded higher values of gross, net returns and B: C ratio. Among weed management schedules, maximum values of gross, net returns and B: C ratio were observed with pendimethalin (PE) fb 1 HW at 25 DAS. Though weed free treatment gave maximum gross returns however it recorded lower net returns and B:C ratio than pendimethalin (PE) fb 1 HW at 25 DAS due to higher cost involved in manual weeding. The results are according as reported by Meena and Jain (2013) [13] and Mathukia *et al*. (2015) [11].

The economic optimum dose of nitrogen was recorded with the application of 126.5 kg N ha^{-1}, where highest grain yield (2304.5 kg N/ha) was recorded it was increase over control

(811.3 kg N ha^{-1}) resulted additional gross returns (48678 □/ha**)** was obtained as compared to control which was considered as optimum economic dose (Table 4 and Fig.1). Highest response of pearlmillet seed kg^{-1} N was obtained at 50 kg N ha^{-1} which was decreased as nitrogen levels were increasing. The response of pearlmillet seed kg^{-1} N at optimum economic dose (126.5 kg N ha^{-1}) was higher than 150 kg N/ha (25.5).

Table 3: Effect of nitrogen and weed management schedule on cost of cultivation, gross returns, net returns and B:C ratio of forage Pearlmillet

Treatments	Cost of cultivation (variable cost) (ha^{-1})	Gross returns (ha^{-1})	Net Returns (ha^{-1})	B:C ratio
Nitrogen levels				
No (Control)	17750	104468	86718	4.9
50 kg N/ha	18621	129590	110969	6.0
100 kg N/ha	19237	156415	137178	7.1
150 kg N/ha	19858	152032	132174	6.6
Weed management				
PE Pendimethalin fb 1 HW	21698	155172	133474	6.2
PE Atrazine fb 1 HW	20875	147340	126465	6.1
PE Pendimethalin fb POE Halosulfuron	23698	126115	102417	4.3
PE Atrazine fb POE Halosulfuron	22875	132201	109326	4.8
Weedy check	17750	92008	74258	4.2
Weed free	30250	160988	130738	4.3

The Cost of seed – 60 /kg and cost of stover – 155 /q

Table 4: Economics of nitrogen fertilization on the basis of optimum yield

Nitrogen (kg ha^{-1})	Optimum yield (kg ha^{-1})	Increase in yield over control(kg ha^{-1})	Cost of Nitrogen (kg)	Response of pearlmillet seed kg^{-1} nitrogen	Additional returns over control (ha^{-1})
No (Control)	1493.2	—	—	—	—
50 kg N/ha	2001.4	508.2	620	49.2	30492
100 kg N/ha	2264.6	771.4	1239	37.4	46284
150 kg N/ha	2282.8	789.6	1859	25.5	47376
Optimum economic dose					
126.5	2304.5	811.3	1567	31.1	48678

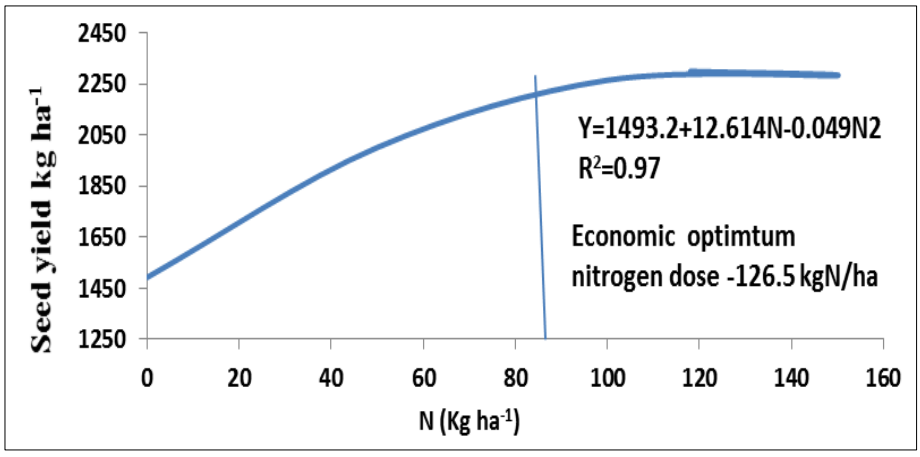

Fig 1: Optimum economic dose and response of nitrogen to seed yield of Forage Pearlmillet

Conclusion

On the basis of result obtained from present field study, it can be concluded that application of 126.5 kg N ha^{-1} with pendimethalin (PE) fb 1 HW at 25 DAS or atrazine (PE) fb 1 HW at 25 DAS was recommended for effective management of weeds with profitable fodder and seed yield of HC-20 variety of forage pearl millet. However, in the areas of *Cyprus rotundus*, dominance the application of pendimethalin (PE) fb halosulfuron (POE) at 25 DAS or atrazine (PE) fb halosulfuron (POE) at 25 DAS would be the better option.

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