

RESEARCH PAPER

Effect of nitrogen levels and modified urea on growth and yield of pearl millet (*Pennisetum glaucum* L.) under rainfed condition

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Abstract: A field study was carried out to find out the effect of nitrogen levels and modified urea on growth and yield of rainfed pearl millet during 2016 *kharif* at the Regional Agricultural Research Station, Vijayapur, Northern dry zone of Karnataka (Zone-3). There were 15 treatment combinations involving three nitrogen levels (25, 50 and 75 kg ha⁻¹) and five modified ureas *viz.*, neem coated urea, tar coated urea, sulphur coated urea, vermicompost coated urea and normal urea. The experiment was laid out in a factorial randomised block design with three replications. The results revealed that, application of 75 kg N ha⁻¹ recorded significantly higher grain yield (2878 kg ha⁻¹), stover yield (5.32 t ha⁻¹) and grain weight earhead⁻¹ (42.0 g) compared to 25 kg N ha⁻¹ (2296 kg ha⁻¹, 4.00 t ha⁻¹ and 38.5 g, respectively), however, it was on par with 50 kg N ha⁻¹ (2730 kg ha⁻¹, 5.15 t ha⁻¹ and 40.8 g, respectively). Net income and benefit cost were also higher with 75 and 50 kg N ha⁻¹ compared to 25 kg N ha⁻¹. Among the modified ureas, neem coated urea recorded significantly higher grain yield (2965 kg ha⁻¹), stover yield (6.13 t ha⁻¹) and grain weight earhead⁻¹ (41.4 g) compared to other modified ureas. Similarly, significantly higher net income and benefit cost ratio were recorded with application of neem coated urea (₹ 32316 ha⁻¹ and 3.32, respectively) as compared to application of normal urea (₹ 23317 ha⁻¹ and 2.69, respectively) and other modified ureas.

Key words: Grain yield, Modified urea, Nitrogen, Pearl millet

Introduction

Pearl millet (*Pennisetum glaucum* L.) is one of the fifth most important cereal crop of rainfed areas of Africa and Asia after rice, wheat, maize and sorghum. It is a major crop of arid and semi-arid regions of India and mostly grown as rainfed crop during *kharif* season. The crop sustains the lives of the poorest rural people and will continue to do in the foreseeable future. In addition to its grain consumption as human food and animal feed, it is also used as green fodder in India, Pakistan, Russia, Australia and the USA. India is the largest producer of pearl millet covering about 9.18 million ha (Anon., 2014) of marginal and sub marginal lands of arid and semiarid areas. Primarily, it is cultivated in the states of Rajasthan, Gujarat, Haryana, Uttar Pradesh, Maharashtra and Karnataka. In Karnataka, the pearl millet area, production and productivity are 2.34 lakh ha, 2.48 lakh tonnes and 1117 kg per ha, respectively (Anon., 2015). In Karnataka, among the 10 agro-climatic zones, Northern dry zone (Zone-3) is having the largest area under pearl millet. This zone alone contributes about 76 per cent of the pearl millet area in the state. Pearl millet is grown on a larger scale in rainfed areas of the country mainly due to its drought escaping mechanism coupled with comparatively higher production ability in low fertile soil and high temperature conditions. It is a potential alternative grain crop for dry land areas having low rainfall and short growing seasons. Pearl millet is considered as more efficient in utilization of soil moisture and has a higher level of heat tolerance than sorghum and maize.

Urea is the major commercial N fertilizer used for optimum crop yield in the world. Addition of urea in soil increases soil pH by virtue of its hydrolysis, thereby causing huge

ammonia volatilization losses (Fan and Meckenzie, 1993 and Hamid *et al.*, 1998). And also in field, under alternate wetting and drying, a significant nitrogen loss occurs due to nitrification and denitrification as a result of oxidation and reduction (Burford and Bremner, 1975). Pearl millet is responsive to nitrogen in the form of nitrate than ammonia form. In rainfed condition, applied urea is transformed into ammonia gas through the process of volatilization due to higher soil pH, higher air temperature and lower soil moisture condition. Losses of the applied nitrogen can be reduced through suitable fertilizer management practices (Saad *et al.*, 1996). Keeping these points in view the present study was conducted.

Material and methods

The experiment was conducted at the Regional Agricultural Research Station (RARS), Vijayapura situated in the Northern dry zone of Karnataka (Zone 3), University of Agricultural Sciences, Dharwad (Karnataka) during 2016 rainy season. There were 15 treatment combinations consisting of three nitrogen levels *viz.*, 25, 50 and 75 kg ha⁻¹ and five modified ureas *viz.*, neem coated urea, tar coated urea, sulphur coated urea, vermicompost coated urea and normal urea (control). The experiment was laid out in factorial randomised block design with three replications. The soil of the experimental site belongs to vertisols (medium deep black soils) having alkaline pH (8.5), medium in available nitrogen (252 kg ha⁻¹) and phosphorus (21.2 kg ha⁻¹) and high in potassium content (336 kg ha⁻¹) with soil organic carbon content of 0.51%. Recommended dose of phosphorous (25 kg ha⁻¹) was applied commonly to all the

treatments through single super phosphate. The seeds were sown by hand dibbling at 45 x 15 cm spacing by opening furrows at 45 cm rows manually with the help of hand drawn marker. Initially 2-3 seeds per hill were hand dibbled and 15 days later the plants were thinned by keeping one healthy plant per hill to maintain required plant population per plot. The gross plot size of individual treatments was 4.5 x 5.0 m. Various observations on growth and yield components were recorded on five randomly selected plants in each treatment and means were calculated. The grain and stover yields were recorded on per plot basis and later converted to per hectare. The data collected from the experiment was subjected to statistical analysis as described by Panse and Sukhatme (1967). The level of significance used in "F" and "t" test was P=0.05. Critical difference values were calculated whenever the "F" test was significant. The normal annual rainfall of the station for the past 35 years is 598.6 mm. The highest normal rainfall was received in the month of September (147.6 mm) followed by October (96.3 mm). The rainfall received during the cropping period (July-October) as well as the total rainfall during 2016 (497.7 mm) was lower when compared with past 35 year's average.

Results and discussion

Effect of nitrogen levels on growth, yield and economics

In the present study, significantly higher plant height was observed with 75 kg N ha⁻¹ (146.6 cm), earhead length (22.61 cm), ear head girth (2.90 cm) and total dry matter production plant⁻¹ (32.72 g) as compared to other N levels (Table 1). This might have helped the crop for maximum utilization of available nutrients which enhanced the vegetative growth of pearl millet leading to maximum utilization of solar radiation contributing to the higher rate of photosynthesis which had favourable influence on growth and yield components. The results are in conformity with the findings of Ayub *et al.* (2009) who reported that, forage and dry matter yields of pearl millet were increased significantly with each increased rate of nitrogen. The increase

in yield was mainly due to increase in plant height, stem diameter, number of leaves and leaf area per plant.

Grain yield and yield components of pearl millet varied significantly among different nitrogen levels (Table 2). The grain yield of pearl millet was significantly higher with application of 75 kg N ha⁻¹ (2878 kg ha⁻¹) compared to 25 kg N ha⁻¹ (2296 kg ha⁻¹), however, it was at par with 50 kg N ha⁻¹ (2730 kg ha⁻¹). The increase in grain yield due to application of 50 and 75 kg N ha⁻¹ over 25 kg N ha⁻¹ was to an extent of 18.9 and 25.3 per cent, respectively. The higher grain yield of pearl millet due to application of higher levels of nitrogen *viz.*, 50 and 75 kg N ha⁻¹ is attributed to higher yield contributing characters *viz.*, grain weight ear head⁻¹, ear head length and girth and higher number of productive tillers plant⁻¹ compared to application of 25 kg N ha⁻¹ as a consequence of increased availability of nitrogen throughout the crop growth period.

Similarly, application of 75 kg N ha⁻¹ also resulted in significant increase in stover yield (5.32 t ha⁻¹) as compared to 25 kg N ha⁻¹ (4.00 t ha⁻¹), however, it was at par with 50 kg N ha⁻¹ (5.15 t ha⁻¹). There was 28.8 and 33.0 per cent increased stover yields with application of 50 and 75 N ha⁻¹, respectively compared to 25 kg N ha⁻¹. This increased stover yields due to application of 50 and 75 kg N ha⁻¹ may be attributed to the improvement in growth components *viz.*, plant height, total number of tillers plant⁻¹ and higher total dry matter production per plant. Nitrogen enhances the greater vegetative growth of crop which ultimately leads to higher dry matter accumulation in different plant parts. These results are in conformity with the findings of Sakarvadia *et al.* (2012) who reported higher stover yield as well as improved quality parameters of pearl millet at higher level of applied nitrogen.

Gross and net income were higher with application of 75 kg N ha⁻¹ (₹ 44,061 and 28,815 ha⁻¹, respectively) compared to 25 kg N ha⁻¹ (₹ 34,992 and 21,366 ha⁻¹, respectively), however, they were at par with 50 kg N ha⁻¹ (₹ 42,009 and 27,517 ha⁻¹,

Table 1. Growth and yield attributes of pearl millet as influenced by nitrogen levels and modified urea

Treatments	Plant height (cm)	Ear head length (cm)	Ear head girth (cm)	Total dry matter production plant ⁻¹ (g)	Total number of tillers plant ⁻¹	Number of productive tillers plant ⁻¹
Nitrogen levels (N)						
25 kg ha ⁻¹	135.6	21.41	2.54	28.53	1.1	1.1
50 kg ha ⁻¹	139.7	21.64	2.80	29.70	1.3	1.2
75 kg ha ⁻¹	146.6	22.61	2.90	32.72	1.4	1.2
S.E.m.±	1.93	0.29	0.07	2.06	0.08	0.03
C.D. at 5 %	5.02	0.84	0.19	NS	NS	0.09
Modified urea (U)						
Neem coated urea	150.3	24.22	3.09	42.60	1.9	1.6
Tar coated urea	138.7	21.37	2.61	25.70	1.2	1.1
Sulphur coated urea	142.7	22.17	2.93	33.60	1.4	1.2
Vermicompost coated urea	131.4	20.87	2.65	25.70	1.2	1.0
Normal urea	140.2	20.77	2.47	23.70	1.1	1.0
S.E.m.±	2.23	0.37	0.09	2.66	0.10	0.11
C.D. at 5 %	6.48	1.08	0.25	7.73	NS	NS
Interaction (N×U)						
S.E.m.±	3.87	0.65	0.15	4.61	0.18	0.07
C.D. at 5 %	NS	NS	NS	NS	NS	NS

Table 2. Grain yield and economics of pearl millet as influenced by nitrogen levels and modified urea

Treatments	Grain weight ear head ⁻¹ (g)	Grain yield (kg ha ⁻¹)	Stover yield (t ha ⁻¹)	Gross income (₹ ha ⁻¹)	Net income (₹ ha ⁻¹)	Benefit cost ratio
Nitrogen levels (N)						
25 kg ha ⁻¹	38.5	2296	4.00	34992	21366	2.57
50 kg ha ⁻¹	40.8	2730	5.15	42009	27517	2.90
75 kg ha ⁻¹	42.0	2878	5.32	44061	28815	2.91
S.E.m.±	1.44	78	0.17	1080	1080	0.07
C.D. at 5 %	4.18	226	0.50	3131	3131	0.22
Modified urea (U)						
Neem coated urea	41.4	2965	6.13	46158	32316	3.32
Tar coated urea	39.9	2446	4.24	37261	22625	2.54
Sulphur coated urea	38.8	2686	4.68	40951	27029	2.93
Vermicompost coated urea	44.0	2647	4.60	40332	24211	2.50
Normal urea	38.0	2429	4.45	37068	23317	2.69
S.E.m.±	1.86	101	0.22	1395	1395	1.10
C.D. at 5 %	5.40	292	0.65	4042	4042	0.29
Interaction (N×U)						
S.E.m.±	3.32	175	0.39	2415	2415	0.17
C.D. at 5 %	9.35	NS	NS	NS	NS	NS

respectively). Similarly, higher benefit cost ratio was recorded with 75 kg N ha⁻¹ (2.91) compared to 25 kg N ha⁻¹ (2.57) and which was at par with 50 kg N ha⁻¹ (2.90). The higher gross income, net income and benefit cost ratio with application of 50 and 75 kg N ha⁻¹ are mainly due to higher grain and straw yields of pearl millet obtained with these two N levels compared to 25 kg N ha⁻¹. Similarly, higher gross and net returns as a consequence of higher grain and straw yields at 100 per cent recommended dose of nitrogen in paddy was noticed by Bhanuprakash (2016).

Effect of modified urea on growth, yield and economic returns

Results revealed that, neem coated urea recorded significantly higher grain yield (2965 kg ha⁻¹) compared to other modified ureas *viz.*, normal urea, tar coated urea and vermicompost coated urea (2429, 2446 and 2647 kg ha⁻¹, respectively), however, it was at par with sulphur coated urea (2686 kg/ha⁻¹). The increase in grain yield due to neem and sulphur coated ureas over normal urea was to an extent of 22.1 and 10.6 per cent, respectively. Significantly higher grain yield obtained with neem and sulphur coated ureas is attributed to positive association between yield and yield contributing characters *viz.*, ear head length, ear head girth, grain weight ear head⁻¹ and number of productive tillers plant⁻¹ which might have improved with application of these two modified ureas. The improvement in yield components was also due to improved growth attributes such as plant height, production of tillers and total dry matter per plant. Thus, the improvement in growth and yield components with neem and sulphur coated ureas was a consequence of slow release and continuous availability of nitrogen to pearl millet throughout the entire crop growing period and reduced losses of nitrogen due to nitrification process and volatilization of nitrogen which might have helped for higher availability and uptake of nitrogen by the crop. Similarly, plant height, number of leaves plant⁻¹, leaf area, fresh and dry weight plant⁻¹ were significantly higher with the application of nitrogen through neem coated urea than the granular and prilled urea in maize (Joshi *et al.*, 2014 and Yashbir *et al.*, 2015).

Similarly, stover yield of pearl millet differed significantly due to various modified ureas. Among the different modified ureas, neem coated urea recorded significantly higher stover yield (6.13 t ha⁻¹) compared to other modified ureas including normal urea (4.45 t ha⁻¹). Higher straw yield with neem coated urea might be due to slow release of nitrogen and its higher availability to crop growth throughout the entire cropping period. The increased stover yield was also attributed to the beneficial effect of nitrogen on growth parameters *viz.*, plant height, number of tillers per plant and total dry matter production which were higher with application of neem coated urea compared to normal urea. Similarly, Joshi *et al.* (2014) reported that, application of 100 kg N ha⁻¹ applied through neem coated urea resulted in higher productivity and profitability of maize.

Net income and benefit cost ratio differed significantly due to application of various modified ureas (Table 2). Neem coated urea recorded significantly higher net income (₹ 32,316 ha⁻¹) and benefit cost ratio (3.32) compared to normal urea (₹ 23,317 ha⁻¹ and 2.69, respectively) and other modified ureas. The higher net income and benefit cost ratio with neem coated urea was mainly due to higher grain and stover yields of pearl millet. Lower net income recorded with normal and tar coated ureas was mainly due to lower grain and stover yields of pearl millet. Joshi *et al.* (2014) also reported that, application of 100 kg N ha⁻¹ through neem coated urea resulted in the highest gross income (₹ 87,016, 105,304 and 96,160 per ha) followed by 100 kg N ha⁻¹ through granular urea (₹ 83,846, 106,461 and 95,154 ha⁻¹) during 2009, 2010 and pooled data analysis, respectively.

Conclusion

From the above study, it could be concluded that, application of 50 kg N ha⁻¹ with neem coated urea was found to be optimum for pearl millet crop to achieve higher grain yield, stover yield and economic returns and improving growth and yield components under rainfed condition.

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