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Impact of neem coated urea and Sulphur on growth, yield and economics of pearl millet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz]

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Abstract
Background: Pearl millet {*Pennisetum glaucum* (L.) R. Br. emend Stuntz} is one of the important millet crop of hot and dry areas of arid and semiarid regions. Pearl millet survives in rain-fed area because of its drought escaping mechanisms but still responds well to all inputs including fertilizers. Urea is the major source of fertilizer-N; 83.1 per cent urea offers the most N at the lowest cost, has no storage risks and can be used for all types of crops and soils with little or no harm to the soil. The oil extracted from the seeds of neem and the cake left after oil extraction possess nitrification inhibition properties. Both the oil and the cake can be used to coat urea for escalating urea N use efficiency in cropping systems. Insufficient supply of sulphur can affect yield and quality of the crops, because S is required for synthesis of the three amino acids cysteine, cystine and methionine and in the formation of various enzyme and proteins.
Method: The experiment was laid out in randomized block design with three replications. The experiment was consisting ten treatments *viz*., neem coated urea at 50%, 75% and 100% with sulphur @15, 30 and 45kg/ha respectively.
Result: The experimental results showed that application of neem coated urea 100% + sulphur at 45 kg produced significantly higher plant height and dry matter accumulation at30,60 DAS and at harvest, LAI at 45 DAS, chlorophyll content at 45 DAS, total number of tillers plant^{-1} at harvest, number of effective tillers plant^{-1}, number of grains ear^{-1}, ear length, test weight, grain, stover and biological yield, nutrient (nitrogen, phosphorus, potassium and sulphur) content in grain and stover and their uptake, protein content in grain, gross, net returns and benefit cost ratio over control. However in plant population at 30 DAS and harvest and harvest index of pearl millet application of various levels of neem coated urea + sulphur did not bring significant variation.

Keywords: Pearl millet, neem coated urea, tiller, yield, economics

Introduction
Pearl millet provides staple food for the poor in short period relatively in dry tracts of the country. It is nutritionally better than many cereals as it is a good source of protein having higher digestibility (12.1%), fats (5%), carbohydrates (69.4%) and minerals (2.3%). India is the largest producer of pearl millet having 45.42 lakh hectares area with an annual production of 9.18 million tonnes and productivity of 1198 kg ha^{-1} (Anonymous, 2023). Most of the pearl millet growing areas in country are confined to coarse textured soils having the problem of poor moisture retention capacity and low soil fertility. Cultivation on poor and marginal lands of low fertility and poor and delayed germination due to soil crusting are some of the major constraints responsible for its poor yield.
Urea is the major source of fertilizer-N; 83.1 per cent with record, urea offers the most N at the lowest cost, has no storage risks and can be used for all types of crops and soils with little or no harm to the soil, use competence of urea-N by different crops can be as low as 20 per cent and it rarely exceeds 50 per cent.
The oil extracted from the seeds of neem and the cake left after oil extraction possess nitrification inhibition properties. Both the oil and the cake can be used to coat urea for reducing losses and increase N use efficiency in cropping systems.

Neem cake coated urea (NCU) is manufactured by mixing 0.1–0.2 tonne neem cake per tonne urea by using such coated urea promising results in terms of increased crop yields were attained (Singh, 2016) [2]. Deficiency of sulphur (S) is wide spread in India. The important causes of S deficiency in India are: accelerated removal of sulphur in intensive cropping system, dominance of sulphur free fertilizer use, low native S content, coarse texture soils etc. These causes of S deficiency have widened the ratio of N: P_2O_5:K_2O: S to 14.7:5.1:1.6:1 as against the ideal of 8:4:2:1.

Sulphur availability to crops is influenced by numerous soil factors (available S storage, soil texture, soil pH). The status and distribution of different forms of sulphur in soils varies with soil conditions and soil types. Originally sulphur is present in rocks as sulphide of metals. During weathering, these sulphides are broken down through oxidation to furnish sulphate and other forms through the action of microbes, vegetation and water. (Ye *et al*., 2011) [10].

2. Materials and Methods

The experiment was conducted during kharif 2023 at Research Farm, School of Agriculture, Suresh Gyan Vihar University, Jaipur (Rajasthan) which is situated at an altitude of 432 metres above mean sea level with 26º48'35" N latitude and 75º51'44" E longitude. This region falls under agro-climatic zone IIIa (Semi-arid Eastern Plain Zone) of Rajasthan.

The climate of this region is typically semi-arid, characterized by extremes of temperature during both summers and winters. During summers, the temperature may go as high as 48°C, while in winters, it may fall as low as -1.0°C. The experiment was laid out in randomized block design with three replications. The experiment comprised of 10 treatments of neem coated urea and sulphur. Seeds of pearl millet variety 'RHB-173' were sown manually by 'Kera' method at seed rate of 4 kg ha^{-1} maintaining row distance of 45 cm and plant to plant distance 15 cm placed at depth of 1-2 cm and sowing was done on 10th July 2023. Pearl millet crop was harvested when it reached physiological maturity. The harvested produce of each net plot was tied up in the bundles separately and tagged. The tagged bundles were allowed to sun dry after transferring them to the threshing floor.

3. Results and Discussion

Effect of Neem Coated Urea and Sulphur on Yield Attributes and Yield

The application of neem coated urea and sulphur significantly increased yield attributes *viz*., number of effective tillers $plant^{-1}$, number of grains ear^{-1}, ear length and test weight over control (T_1)., Different doses of neem coated urea significantly affected the yield components. Budhar *et al*. (1991) [3] reported similar results on yield components. Data revealed (Table 1) that the maximum number of effective tillers $plant^{-1}$**,** number of grains ear^{-1}, longest ears and highest test weight was recorded with application of neem coated urea 100% + sulphur 45 kg (T_{10}) which was significantly higher over control (T_1), but remained at par with the application of neem coated urea 75% + sulphur 30 kg (T_6), neem coated urea 100% + sulphur 45 kg (T_7) and neem coated urea 75% + sulphur 45 kg (T_9).

A critical examination of data (Table 2) reveals that grain yield of pearl millet significantly increased due to application of various levels of neem coated urea and sulphur during experimentation. The maximum grain yield, stover yield and biological yield was recorded with application of neem coated urea 100% + sulphur 45 kg (T_{10}) which was significantly higher over control (T_1), but remained at par with the application of neem coated urea 75% + sulphur 30 kg (T_6), neem coated urea 100% + sulphur 30 kg (T_7) and neem coated urea 75% + sulphur 45 kg (T_9). However, harvest index of pearl millet did not affected by application of neem coated urea + sulphur. These results indicated that the increase in grain and stover yield was related to enhanced availability of nutrient mainly nitrogen through neem coated urea helped in reducing the leaching and volatilization losses thereby accelerated the availability Moreover, the higher values of yield attributes viz. number of effective tillers/plant, number of grains/ear, ear length further lend Support to the significant increase in grain yield of pearl millet. The increase in stover yield might be due to significantly higher values of plant height, dry matter accumulation and leaf area index on account of neem coated urea at 100% + Sulphur 45kg/ha application. Nehra and Dhindwal (2010) [7] also obtained the similar results.

An assessment of data (Table 3) confirmed that gross returns and net returns were significantly influenced by application of neem coated urea and sulphur in pearl millet. Maximum gross returns (₹ 86039 ha^{-1}), net returns (₹ 63859 ha^{-1}) and B C ratio were fetched with the application of neem coated urea 100% + sulphur 45 kg (T_{10}), as against the minimum gross returns (₹ 47905 ha^{-1}), net returns (₹ 29356 ha^{-1}) were recorded under control (T_1). These results are in conformity with the findings of Kumar *et al*. (2023).

The cost of cultivation for different treatments varied from 18549rs to 22180rs. The highest gross return (86039), net return (63859) achieved by application of neem coated urea 100% + sulphur 45% (T_{10}). Significantly maximum B C ratio was recorded with the application of neem coated urea 100% + sulphur 45 kg (T_{10}) which was significantly higher over rest of the treatments, which might be due to high return to investment accrued under this treatment.

Table 1: Effect of neem coated urea and sulphur on plant height of pearl millet

Treatments	Plant height (cm)		
	At 30 DAS	At 60 DAS	At harvest
T_1: Control	32.66	108.58	137.60
T_2: Neem Coated Urea 50% + Sulphur 15 kg	38.08	123.27	156.72
T_3: Neem Coated Urea 75% + Sulphur 15 kg	38.82	137.54	175.80
T_4: Neem Coated Urea 100% + Sulphur 15 kg	38.24	145.07	185.21
T_5: Neem Coated Urea 50% + Sulphur 30 kg	39.26	138.34	174.80
T_6: Neem Coated Urea 75% + Sulphur 30 kg	39.56	152.30	195.38
T_7: Neem Coated Urea 100% + Sulphur 30 kg	39.21	160.37	203.13
T_8: Neem Coated Urea 50% + Sulphur 45 kg	39.86	142.70	182.75
T_9: Neem Coated Urea 75% + Sulphur 45 kg	40.32	158.75	205.31
T_{10}: Neem Coated Urea 100% + Sulphur 45 kg	40.45	162.41	212.38
S.Em.±	1.39	4.63	5.78
CD (P=0.05)	4.12	13.74	17.18

Table 2: Effect of neem coated urea and sulphur on Dry matter accumulation, LAI, chlorophyll content and total no. of tillers/plant at 45 DAS of pearl millet

Treatments	Dry matter accumulation (g plant^{-1})			LAI at 45 DAS	Chlorophyll content at 45 DAS	Total number of tillers plant^{-1} at harvest
	At 30 DAS	At 60 DAS	At harvest			
T_1: Control	6.47	20.30	43.53	2.96	1.98	2.53
T_2: Neem Coated Urea 50% + Sulphur 15 kg	7.54	23.61	49.72	3.44	2.43	2.96
T_3: Neem Coated Urea 75% + Sulphur 15 kg	7.69	26.47	55.07	3.85	2.84	3.35
T_4: Neem Coated Urea 100% + Sulphur 15 kg	7.57	27.88	57.70	4.05	3.01	3.50
T_5: Neem Coated Urea 50% + Sulphur 30 kg	7.77	26.62	55.34	3.87	2.83	3.35
T_6: Neem Coated Urea 75% + Sulphur 30 kg	7.83	29.69	61.11	4.32	3.28	3.76
T_7: Neem Coated Urea 100% + Sulphur 30 kg	7.76	30.74	63.05	4.47	3.44	3.90
T_8: Neem Coated Urea 50% + Sulphur 45 kg	7.89	27.43	57.57	4.04	2.99	3.50
T_9: Neem Coated Urea 75% + Sulphur 45 kg	7.98	30.43	63.89	4.53	3.44	3.90
T_{10}: Neem Coated Urea 100% + Sulphur 45 kg	8.01	31.12	65.87	4.68	3.57	4.05
S.Em.±	0.27	0.86	1.62	0.12	0.12	0.13
CD (P=0.05)	0.82	2.57	4.81	0.37	0.35	0.37

Table 3: Effect of neem coated urea and sulphur on yield attributes of pearl millet

Treatments	Yield attributes			
	Number of effective tillers plant^{-1}	Number of grains ear^{-1}	Ear length (cm)	Test weight (g)
T_1: Control	1.14	1106.3	15.9	4.30
T_2: Neem Coated Urea 50% + Sulphur 15 kg	1.37	1246.5	18.9	5.01
T_3: Neem Coated Urea 75% + Sulphur 15 kg	1.57	1375.1	21.8	5.74
T_4: Neem Coated Urea 100% + Sulphur 15 kg	1.65	1410.2	23.0	6.20
T_5: Neem Coated Urea 50% + Sulphur 30 kg	1.57	1372.0	21.8	5.69
T_6: Neem Coated Urea 75% + Sulphur 30 kg	1.79	1503.2	24.7	6.43
T_7: Neem Coated Urea 100% + Sulphur 30 kg	1.87	1535.6	25.8	6.88
T_8: Neem Coated Urea 50% + Sulphur 45 kg	1.65	1423.7	22.8	5.84
T_9: Neem Coated Urea 75% + Sulphur 45 kg	1.86	1562.3	25.8	6.62
T_{10}: Neem Coated Urea 100% + Sulphur 45 kg	1.94	1594.2	26.8	6.96
S.Em.±	0.07	41.4	0.9	0.21
CD (P=0.05)	0.20	123.06	2.7	0.62

Table 4: Effect of neem coated urea and sulphur on yield and harvest index of pearl millet

Treatments	Yield (kg ha^{-1})			Harvest index (%)
	Grain	Stover	Biological	
T_1: Control	1240	3365	4605	26.93
T_2: Neem Coated Urea 50% + Sulphur 15 kg	1585	4286	5871	27.01
T_3: Neem Coated Urea 75% + Sulphur 15 kg	1813	4978	6791	26.70
T_4: Neem Coated Urea 100% + Sulphur 15 kg	1900	5263	7163	26.64
T_5: Neem Coated Urea 50% + Sulphur 30 kg	1822	5006	6829	26.70
T_6: Neem Coated Urea 75% + Sulphur 30 kg	2037	5660	7697	26.47
T_7: Neem Coated Urea 100% + Sulphur 30 kg	2115	5914	8029	26.43
T_8: Neem Coated Urea 50% + Sulphur 45 kg	1912	5243	7155	26.72
T_9: Neem Coated Urea 75% + Sulphur 45 kg	2123	5903	8026	26.50
T_{10}: Neem Coated Urea 100% + Sulphur 45 kg	2201	6127	8328	26.44
S.Em.±	70	240	266	0.92
CD (P=0.05)	209	713	791	NS

Table 5: Effect of neem coated urea and sulphur on economics of pearl millet

Treatments	Economics (₹ ha^{-1})			B: C ratio
	Gross returns	Cost of cultivation	Net returns	
T_1: Control	47905	18549	29356	1.58
T_2: Neem Coated Urea 50% + Sulphur 15 kg	61148	20033	41115	2.05
T_3: Neem Coated Urea 75% + Sulphur 15 kg	70434	20431	50002	2.45
T_4: Neem Coated Urea 100% + Sulphur 15 kg	74117	20830	53287	2.56
T_5: Neem Coated Urea 50% + Sulphur 30 kg	70811	20708	50103	2.42
T_6: Neem Coated Urea 75% + Sulphur 30 kg	79572	21106	58466	2.77
T_7: Neem Coated Urea 100% + Sulphur 30 kg	82862	21505	61357	2.85
T_8: Neem Coated Urea 50% + Sulphur 45 kg	74235	21383	52852	2.47
T_9: Neem Coated Urea 75% + Sulphur 45 kg	82960	21781	61179	2.81
T_{10}: Neem Coated Urea 100% + Sulphur 45 kg	86039	22180	63859	2.88
S.Em.±	2398	-	2398	0.12
CD (P=0.05)	7126	-	7126	0.35

4. Conclusion

Based on results of present investigation, it may be concluded that the maximum grain, stover and biological yield of pearl millet along with the net returns and B:C ratio were achieved with the application of Neem coated urea 100% + 45kg S/ha followed by Neem coated urea 75% + 45kg S/ha and neem coated urea 100% + 30 kg S/ha. Hence, the above treatments may be recommended to obtain higher productivity and profitability of pearl millet in the prevailing conditions of semi-arid eastern plain zone of Rajasthan since these treatments proved superior over rest of the treatments.

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