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Effect of different source of N and insitu Soil moisture conservation practices for the maximization of Maize yield and economic return

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ABSTRACT

Field experiment was conducted during *Kharif* 2022 to find out the effect of different levels and sources of N and in situ soil moisture conservation practices for the maximization of yield attributes, yield and economics of Maize at farmer's field, Solatharam village, Cuddalore, Tamil Nadu, India which is situated between 11° 39 ' N latitude, 79° 50' E longitude with an altitude of +5.79 m above mean sea level (MSL) in the southern part of India. The field experiment was laid out in split plot design with three replications. The details of experiment was control (no mulch plot) (M_1), hydrogel mulch (M_2) and water hyacinth mulch (M_3) were imposed. Whereas, in the sub plot, different levels and sources of nitrogen were applied at two levels viz., 100 and 125 % RDN in the combination of Prilled urea and Nano urea (1:0, 1:1, 2:1, 1:2 and 0:1). The nano urea were foliar sprayed at 20 and 40 DAS. The results indicated that mulching with water hyacinth @ 12 t/ ha registered significantly higher yield attributes, yield and economic returns than other mulching techniques. With regards to different nitrogen management techniques, application of 125% RDN via100% RDN as PU + 25% as NU exhibited higher yield parameters, yield and economic returns than other imposed N treatments. However, the conjoint application of water hyacinth mulch and application of 125% RDN via 100% RDN through prilled urea and 25% RDN through Nano urea significantly outperformed by registering maximum grain yield and economic returns over rest of the treatments.

Key words: *Maize, Mulching, Prilled urea, Nano urea, Yield attributes, Yield and economics, Water hyacinth*

Introduction

The current agriculture system faces several challenges, the most important being the ability to feed ever increasing world population and mitigating climate change. Maize (*Zea mays* L.) is considered as the one of the world's most promising cereal grains for human consumption as well as industrial purpose. In India total area of maize cultivation was 43.78 m ha with a production of 24.51 mt and average productivity of 4.05 t ha^{-1} (USDA report, 2020). In Tamil Nadu, maize is cultivated in an area of 18.04 lakhs hectare with a production of 63.08 lakh metric tonnes and productivity of 2.8 tonnes ha^{-1}.

Maize is an exhaustible crop that demands high nutrition for their growth and development. Efficient use of nitrogen is an important tools for maize production as it increases the yield and maximize economic return with higher nutrient use efficiencies by reducing the environmental pollution (Neha Khardia *et al*., 2022). N application beyond the optimum requirement of maize could not increase yield and may lead to an elevated level of NO_3 in the soil and susceptibility to NO_3 loss by leaching. Now- a-

days, Nano-fertilizer is considered as an effective way to achieving sustainable agriculture and environment and the slow-released fertilizers supply nutrients slowly throughout the growing season which enables the plant to absorb maximum amount of nutrient with maximum nutrient use efficiency (Tajik Khaveh, 2015).

Insitu soil moisture conservation is among the most important factors in modern agriculture to maximize the resource use efficiency and crop yield (Singh *et al*., 2013). Mulching has been considered as an effective way to improve crop growth by maintaining the soil water content and soil temperature in agriculture. It also reduced water evaporation, increased the amount of stored soil water available for plant use and adds organic matter to the soil thus improving soil physical conditions and topsoil fertility and stability (Sarmin *et al*., 2022). Addition of water hyacinth as mulch during and after the mineralization process, increased the nutrient availability to crops and also increased soil fertility especially the N dynamics, and thereby enhanced the crop growth and yield (Widjajanto *et al.*, 2002). As considered as mulching hydrogels or superabsorbers, synthetic compounds that can absorb up to 400 to 1500 g of water per gram of hydrogel (Jaime, 2018) which improves the absorption and retention capacity of water in the soil without affecting its availability to plants. Keeping these in view, the present investigation was noted to find out the effect of different levels and sources of N and insitu mulch practices for the maximization yield and economic returns of maize crop.

Materials and Methods

The field experiment was conducted at Farmer's field, Solatharam village, Cuddalore, Tamil Nadu, India during Kharif, 2022. Geographically this site is situated at 11° 39 ' N latitude, 79° 50' E longitude with an altitude of +5.79 m above mean sea level (MSL) in the southern part of India. The maize hybrid NK 6523 was used as test crop and sowing with a spacing of 60×20 cm. The field experiment was laid out in split plot design with three replications. In main plot, insitu soil moisture conservation techniques were adopted viz., M_1- Control, M_2-Hydrogel at 10 kg ha^{-1} and M_3- Water Hyacinth at 12 t ha^{-1}. In subplot, nutrient management practices were imposed such as N_1 – Control, N_2 - 100% RDN as Prilled Urea (PU), N_3 - 100% RDN as Nano Urea (NU),N_4 - 75% RDN as PU + 25% as NU, N_5 -50% RDN as PU + 50% RDN as NU, N_6 - 25% RDN as PU + 75% NU, N_7-125% RDN as PU, N_8-125% RDN as NU, N_9- 100% RDN as PU + 25% as NU, N_{10}-75% RDN as PU + 50% as NU, N_{11}-50% RDN as PU + 75% as NU and N_{12}-25% RDN as PU + 100% as NU. Nano urea were foliar sprayed at 20 and 40 DAS. Whereas, P_2O_5 and K_2O were supplied uniformly to all the treatmental plots through single super phosphate (P_2O_5) and muriate of potash (60% K_2O) respectively. The data on number of rows cob^{-1} and number of grains cob^{-1} were observed from the five tagged plants and the average values of each treatment were calculated and tabulated. The yield was calculated from the net plot area and the produce was cleaned, weighed and expressed in terms of kg ha^{-1}. Likewise stover yield of maize were also recorded. Cost of cultivation (Rs. ha^{-1}), gross return (Rs. ha^{-1}), net return (Rs.ha^{-1}) and benefit: cost ratio (BCR) were worked out to evaluate the economic benefits of each treatment, based on the existing market prices of inputs and output. The statistical analysis of the field data was done as per the methodology given by Gomez and Gomez (2010). The critical differences were worked out at 5% probability level by using ICAR WASP 2.0 tool, wherever the results were significant.

Results and Discussion

Yield Parameters

The data on number of rows cob^{-1} and number of grains row^{-1} are furnished in Tables 1 and 2. Different insitu soil moisture approaches and different graded levelsand sources of nitrogenexihibited significant effect on number of rowscob^{-1} and number of grains row^{-1} of hybrid maize. Whereas the plot imposed with water hyacinth mulch @ 12 t ha^{-1} (M_3) registered the maximum row number of 15.77cob^{-1} and grain number of 26.81 row^{-1} over rest of the treatments. The least number of rows cob^{-1}(13.72) and grain number row^{-1} (18.67) were recorded in unmulched plot (M_1). Mulch has multiple benefits, including smothering weeds, reducing soil moisture vaporization loss retaining soil moisture and improving the microorganisms and nutrient dynamics in the soil, which eventually increased the crop growth, yield attributing individualities which ultimately resulted in higher yield (Nowroz *et al.*, 2021).

Irrespective of the different levels and sources of

nitrogen management treatments, application of 125% RDN via 100% RDN as Prilled urea (PU) and 25% as Nano urea (NU) (N_9) recorded significantly maximum row number of 15.66 cob^{-1} and grain number of 26.07row^{-1}. The least row number of 13.17cob^{-1} and grain number of 16.93 row^{-1} were recorded in control plot (N_1). The increase in yield parameters was mainly due to high dry matter production and its partition in economic part which in turn gave significantly high yield caused by the application of 125% RDN via prilled urea and nano urea. The nano particles their distinctive, unique behavior and characteristics of smallness, high surface area and ability to increase their absorption speed. Results are in line with those of Neha Khardia *et al*. (2022).

Integration of in situ soil moisture techniques and application different levels and sources of Nfertilizers showed a significant effect on number of rowscob^{-1} and grain number row^{-1} over control. The results revealed that mulching the soil with water hyacinth @12 t ha^{-1} along with the application of 125% RDN via 100% RDN as PU and 25% as NU (M_3 N_9) resulted significantly maximum row number of 17.29 $cob^{-1}$and grain number of 29.95 row^{-1}. The least number of rows 12.76 cob^{-1} and grains 15.23 row^{-1} were recorded in the unmulched and no fertilized plot (M_1F_1). The increased number of rows cob^{-1} and grains row^{-1} in the water hyacinth mulched treatment may be attributed due to the presence of favourable conditions for plant growth as a result of improved soil moisture conservation, availability of nutrients, and the stabilization of soil temperature. Further, the application of N 125% RDN via 100% RDN as PU and 25% as NU (N_9) that make easy absorption of available nutrients to the plant that could promotedhigher rate of photosynthesis, thereby increased plant growth significantly that ultimately leads to the higher yield attributes. Moreover, improvement in soil chemical and biological properties coupled with phyllosphere environment with conjoined application of conventional and nano nutrients resulted in better availability, absorption and utilization of nutrients which resulted enhanced yield attributes. The results are in concurrent with the findings of Middle Sai Kumar *et al.* (2022).

Grain and Stover Yield

Different insitu soil moisture conservation techniques and different levels and sources of nitrogen application exhibited significant effect on grain and stover yields (Tables 3 and 4).

Among the different insitu soil moisture conser-

Table 1. Effect of levels and sources of N and insitu soil moisture conservation on number of rows / cob of maize

	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9	N_{10}	N_{11}	N_{12}	Mean
M_1	12.76	13.42	13.45	13.48	13.46	13.40	14.06	14.04	14.18	14.15	14.10	14.08	13.72
M_2	13.36	14.74	14.80	14.89	14.84	14.20	14.92	14.90	15.52	15.51	15.49	14.99	14.85
M_3	13.38	14.78	15.54	16.15	16.04	14.24	16.30	16.28	17.29	16.52	16.34	16.33	15.77
Mean	13.17	14.31	14.60	14.84	14.78	13.95	15.09	15.07	15.66	15.39	15.31	15.13	
			SE.d							CD (p=0.05)			
M			0.017							0.047			
N			0.036							0.072			
M x N			0.062							0.129			
N x M			0.063							0.126			

Table 2. Effect of levels and sources of N and insitu soil moisture conservation on number of grains / row of maize

	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9	N_{10}	N_{11}	N_{12}	Mean
M_1	15.23	18.34	18.23	18.88	18.91	18.02	19.01	17.98	20.68	20.04	19.57	19.09	18.67
M_2	17.79	24.43	24.91	25.78	25.19	25.91	26.82	25.21	27.57	27.34	27.51	26.56	25.42
M_3	17.77	23.99	27.64	28.29	28.25	23.39	28.35	28.31	29.95	29.05	28.37	28.36	26.81
Mean	16.93	22.25	23.59	24.32	24.12	22.44	24.73	23.83	26.07	25.48	25.15	24.67	
			SE.d							CD (p=0.05)			
M			0.04							0.10			
N			0.08							0.15			
M x N			0.13							0.28			
N x M			0.14							0.27			

vation approaches, the plot receiving water hyacinth mulch @ 12 t ha^{-1} (M_3) registered higher grain yield of 5977 kg ha^{-1} and stover yield of 116308 kg ha^{-1} and performed significantly superior to rest of the treatments. The least grain yield (3332 kg ha^{-1}) and stover yield (100379 kg ha^{-1}) were recorded in control (M_1). Better movement of assimilates from source to sink, improved pollen fertility and grains development are the major role of moisture and nutrient availability in the soil. This hasten the higher values on all the grain yield and stover yields under water hyacinth mulched plot. This result agreed with the results of Chavan *et al*. (2010) and Mechergui *et al*. (2021).

With regards to different nutrient management treatments, application of 125% RDN as 100% RDN through PU + 25% through NU (N_9) registered higher grain yield of 5723 kg ha^{-1} and stover yield of 9639 kg ha^{-1}. The least grain yield of 2851 kg ha^{-1} and stover yield of 8152 kg ha^{-1} were recorded in the unfertilized control plot (N_1). The increased grain yield might be due to the application of conventional urea along with nano fertilizers enhances biogeochemical process such as nitrification which increases the available nitrogen to the plant and also helped in of higher surface area and acted as controlled slow-release of nitrogen that helped to meet the required quantum of nutrients and accelerated the speed of penetration, synthesis, and movement. This leads to an increase in yield contributing traits and enhancedthe yield by activating the photosynthesis process. The results are line with the findings of Middle Sai Kumar *et al.* (2022).

In the conglomeration of insitu soil moisture conservations and nitrogen management showed significant effect on grain and stover yields. Mulching the soil with water hyacinth @ 12 t ha^{-1}and application of 125% RDN via 100% RDN as PU + 25% as NU (M_3 N_9) excelled significantly over rest of the treatments by registering higher grain yield of 7400 kg ha^{-1} and stover yield of 10810 kg ha^{-1}. The least grain yield of 2340 kg ha^{-1} and stover yield of 8152 kg ha^{-1} were recorded in the unmulched and non-fertilized plot (M_1N_1). The use of water hyacinth mulch led to higher moisture retention capacity in the soil due to lesser evaporation, reduced the soil temperature, improved microclimate both above and below the soil surface and the better availability of plant nutrients as per crop needs, since nano nutrition easily penetrates the leaf cuticle and stomata and enters the cells, facilitating easy and rapid utilization of nutrients. These practices were also re-

Table 3. Effect of levels and sources of N and insitu soil moisture conservation on grain yield ofmaize

	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9	N_{10}	N_{11}	N_{12}	**Mean**
M_1	2340	3110	3113	3116	3115	3108	3649	3466	3838	3769	3710	3650	3332
M_2	3105	4854	5004	5197	5132	4472	5439	5200	5930	5840	5770	5440	5115
M_3	3107	4858	5933	6336	6260	4475	6628	6330	7400	7050	6720	6630	5977
Mean	2851	4274	4683	4883	4836	4018	5239	4999	5722	5553	5400	5240	
			SE.d							CD (p=0.05)			
M			85.56							237.56			
N			73.29							146.32			
M x N			148.63							335.16			
N x M			126.94							253.44			

Table 4. Effect of levels and sources of N and insitu soil moisture conservationon stover yield of maize

	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9	N_{10}	N_{11}	N_{12}	Mean
M_1	8152	8155	8157	8159	8158	8154	8572	8571	8578	8576	8574	8573	100379
M_2	8152	8993	8996	8998	8997	8579	9002	9001	9529	9437	9434	9003	108121
M_3	8153	8994	9530	9976	9960	8580	9965	9963	10810	10410	10000	9967	116308
Mean	8152	8714	8894	9044	9038	8438	9180	9178	9639	9474	9336	9181	
			SE.d							CD (p=0.05)			
M			160.56							445.78			
N			137.52							274.57			
M x N			278.90							628.94			
N x M			238.19							475.57			

sponsible for better root development, vigorous growth, leaf production, leaf surface enlargement and drought resistance, and the maize crop have judiciously utilized them effectively and translocated more quantum of assimilates from source to sink, resulting in improved growth and yield contributing characteristics which ultimately produced maximum grain and stoveryields. These interpretations are in consistent with the study of Heba *et al.* (2018), Hyyawi *et al*. (2020), and Gudapati Ashoka Chakravarthy *et al.* (2022).

Table 5. Effect of levels and sources of N and insitu soil moisture conservation on economics in maize

Treatments	Cost of Cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	Benefit : Cost ratio (BCR)
M1N1	40196	51480	11284	1.28
M1N2	45626	66396	20770	1.46
M1N3	43909	66418	22509	1.51
M1N4	45494	68552	23058	1.51
M1N5	44972	68530	23558	1.52
M1N6	44430	64570	20140	1.45
M1N7	46986	80278	33292	1.71
M1N8	44737	76252	31515	1.70
M1N9	46854	84436	37582	1.80
M1N10	46322	82918	36596	1.79
M1N11	45800	81620	35820	1.78
M1N12	45269	80300	35031	1.77
M2N1	50196	64526	14330	1.29
M2N2	55626	106788	51162	1.92
M2N3	53909	110088	56179	2.04
M2N4	55494	114334	58840	2.06
M2N5	54972	112904	57932	2.05
M2N6	54430	98384	43954	1.81
M2N7	56986	119658	62672	2.10
M2N8	54737	114400	59663	2.09
M2N9	56854	130460	73606	2.29
M2N10	56322	128480	72158	2.28
M2N11	55800	126940	71140	2.27
M2N12	55269	119680	64411	2.17
M3N1	45196	64548	17352	1.43
M3N2	50626	106876	54250	2.11
M3N3	48909	130526	79617	2.67
M3N4	50494	139392	86898	2.76
M3N5	49972	137720	85748	2.76
M3N6	49430	98450	47020	1.99
M3N7	51986	145816	91830	2.80
M3N8	49737	139260	87523	2.80
M3N9	51854	162800	108946	3.14
M3N10	51322	155100	101778	3.02
M3N11	50800	147840	95040	2.91
M3N12	50269	145860	93591	2.90

Economics

The economics of different treatments imposed on maize cultivation are furnished in Table 5. The total cost of cultivation varied between Rs. 40196 to Rs. 56986. Among the different insitu soil moisture conservation techniques, the plot receiving water hyacinth mulch at 12 tha^{-1}(M_3) registered higher gross return of Rs. 64548 ha^{-1}, net return of Rs. 17352 ha^{-1} and benefit : cost ratio of 1.43. It was due to very low expenditure on water hyacinth mulch, as it is freely available. In addition, it acted as a good mulches in conserving soil moisture and applied nutrient that helped to record higher growth and development which ultimately resulted in increased grain yield and resulted in higher net return and benefit cost ratio. The findings are with the reports supported by Sarkar and Sarkar (2018). With regards to different levels and sources of N, application of 125% RDN via 100% RDN as PU + 25% RDN as NU (N_9) registered higher gross return of Rs. 84436 ha^{-1}, net return of Rs. 37582$ha^{-1}$and benefit : cost ratio of 1.80. This might be due to the synergistic and cumulative effect of conjoint application of prilled and nano urea at higher levels of 125% RDN. These are in agreement with the findings of (Kumar *et al.*, 2020)

With regards to interaction effect, adoption of soil mulch with water hyacinth @12 t ha^{-1} and application of 125% RDN via 100% RDN as PU + 25% as NU (M_3 N_9) recorded numerically higher gross return of Rs. 162800 ha^{-1}, net return of Rs. 108946 ha^{-1} and benefit: cost ratio of 3.14. Whereas the minimum gross return of Rs. 51480 ha^{-1}, net return of Rs. 11284 ha^{-1} and benefit: cost ratio of 1.28 were observed under unmulched and unfertilized plot (M_1N_1). The significant influence of *in-situ* moisture conservation and conjoint application of prilled urea and nano urea favoured the maize crop by effectively utilizing all the available resources below and above ground, resulting in a higher grain yield, which directly reflected on higher net return and the B:C ratio. These results are in conformity with the results of Sarkar and Sarkar (2018).

Conclusion

From the results of present field experiment, it can be concluded that mulching the soil with water hyacinth @12t/ha and application of 125% RDN via (313 Kg N)100% RDN as PU + 25% RDN as NU was found to be effective practice for getting higher yield

and economic return in maize during kharif season of Tamil Nadu.

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