

Leaf Water Potential, SPAD Chlorophyll Meter Reading Nitrogen Content and Uptake and Soil Moisture Content as Influenced by Natural Nitrification Inhibitors in Rainfed Maize (*Zea mays* L.)

D. Sravanthi, B. Padmaja, G. Pratibha,
 Sameena Khathoon

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Abstract Soil moisture content is major limiting factor for crop production in drylands. Major source of nitrogen in India is urea. When urea applied to soil, it will leads to hydrolysis and further nitrification process. This nitrogen is lost into atmosphere by different ways . Finally the use efficiency has decreased. The time of fertilizers application depends on soil moisture availability indicated leaf water potential and SPAD chlorophyll meter reading is indicated by leaf chlorophyll content. Urea coated with natural nitrification inhibitors viz., neem cake, karanj cake, *Vitex negundo* leaf powder @ 2.5% with coal tar and castor oil adjuvant @ 1%. This coating improving the nitrogen availability throughout the crop growth intern nitrogen uptake and use efficiency. If the moisture is available, urea hydrolysis will takes place further ni-

trification proceeds and releases nitrate and ammonical nitrogen immediately, it become a serious issues it releases green house gases further. To mitigate those loss, urea coated with different natural nitrification inhibitors. Urea coated with natural nitrification inhibitors like neem cake + castor oil (NCU), neem cake + coal tar (NCTU), *Vitex negundo* leaf powder + castor oil (VCU), *Vitex negundo* + coal tar (VCTU), karanj cake + castor oil (KCU), karanj cake + coal tar (KCTU), coal tar (CTU) and castor oil (CU) along with uncoated urea and absolute control with no nitrogen and they were replicated thrice.

Keywords SPAD, Leaf water potential, N uptake, Use efficiency, Moisture.

Introduction

Maize crop can be cultivated under diverse climate and management practices and contributes to 36% (782 M t) in the global cereal production. India produces 24.19 million tones maize grain from an area of 8.40 million ha, with an average productivity of 2.55 t/ha and shares 5.25% of area and 2.41% of world maize production [1]. Generally the rainfed maize production depends on available soil moisture in soil, which essential to crop growth and development. When applied to soil, urea is hydrolyzed by urease enzyme to form ammonium and is subsequently converted to

D. Sravanthi¹, B. Padmaja², S Khathoon⁴
¹MSc (Agronomy), ² Associate Professor, ⁴MSc (SSAC)
 Agricultural College, PJTSAU, Jagtial 505529, Karimnagar
 district, Telangana State, India

G. Pratibha
 Principal Scientist
 Central Research Institute for Dryland Agriculture,
 Santhoshnagar, Hyderabad 500059, Telangana State, India
 e-mail : danamsravanthi@gmail.com
 *Correspondence

nitrate by nitrifying bacteria [2] which can be either leached or denitrified. Average estimates indicate that recovery of applied urea by *kharif* crops in India is 30-50% because it can be lost through different processes. The excessive loss of N either due to ammonia volatilization, nitrate leaching and denitrification not only causes large economical and resource losses but also very serious environmental pollution. By the estimation of leaf water potential we can know the water content in leaf availability of water and by the SPAD chlorophyll meter reading we can measure chlorophyll content in rainfed maize.

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Materials and Methods

The experiment was conducted during *kharif* season of 2014 at Central Research Institute for Dryland Agriculture (CRIDA), Hayathnagar, Hyderabad (Telangana). The Hayathnagar farm is geographically situated at 17° 18' N latitude, 78° 36' E longitude and at an altitude of 542.6 m above the mean sea level in Southern Telangana. According to Trolls classification, the site falls under semi arid tropics (SAT). Total rainfall of 215 mm was received in 25 rainy days during the crop growth period. The weekly mean minimum and maximum temperatures during the crop period i.e., July to October ranged from 22.1 to 25.2°C and 28.3 to 34.9°C respectively. The mean relative humidity ranged between 47.2 to 88.6%. The weekly mean evaporation during crop season varied from 3.9 to 6.9 mm day. The soil was neutral in reaction (pH 7.0), EC (0.16 dS m⁻¹). Bulk density (1.39 g cc⁻¹) with low organic carbon (0.49%) and available nitrogen (172.1 kg ha⁻¹), high available phosphorus (22.4 kg ha⁻¹) and medium in available potassium (233.0 kg ha⁻¹).

The experiment was arranged in a randomized block design with three replicates in plot sizes of 6.3 m × 5m. Treatment level of N @ 100 kg ha⁻¹ in form of urea coated with neem seed cake (*Azadirachta in-*

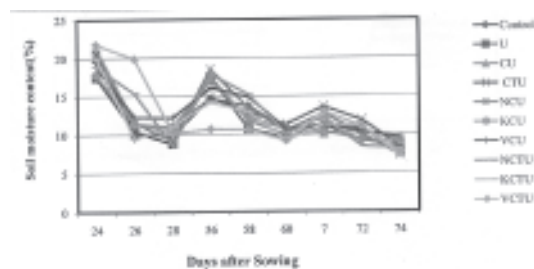


Fig. 1. Influence of urea and different NNI coated urea on soil moisture content (%) of rainfed maize.

dica), karanj cake (*Pongamia* sps), *Vitex negundo* leaf powder @ 2.5% by using adjuvant like castor oil and coal tar (1%) applied in splits as basal and knee high stage. The phosphorus and potassium were applied at the rates of 60 kg P₂O₅ and 40 kg K₂O per hectare applied as basal. Maize seed variety, DHM-117 was selected. Data involving soil moisture, leaf water potential, SPAD chlorophyll reading and nitrogen content and uptake in plant collected.

SPAD chlorophyll content

SPAD chlorophyll (SPAD) content was measured in corn leaves with Minolta SPAD-520 meter (Minolta Sensing, Inc., Japan) at the different crop growth stages. At least ten SPAD meter readings were collected either in the upper most fully expanded corn leaves or ear leaves at (RI stage) from each plot and the average value was recorded.

Results and Discussion

Soil moisture content

Soil moisture content is an important factor influencing the nitrogen mineralization especially the nitrification [3]. Soil moisture content is an important factor under rainfed conditions, rainfall is the only source of soil moisture. Hence, the soil moisture content was determined at different time intervals during the crop growth period coinciding with the rain events and was presented in the Figure 1. Soil moisture content immediately after rainfall was high and decreased with

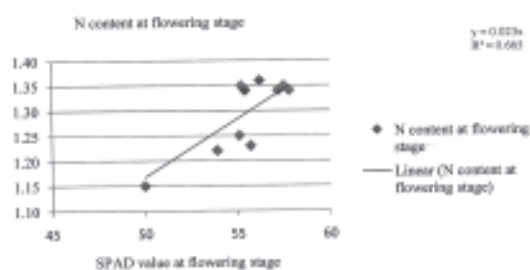


Fig. 2. Correlation between SPAD value and N content at flowering stage.

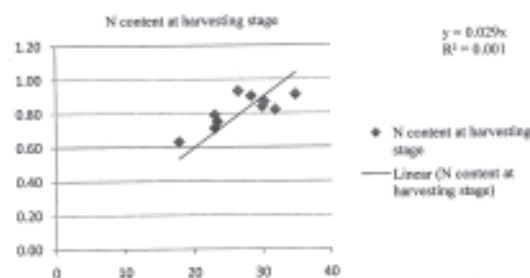


Fig. 3. Correlation between SPAD value and N content at harvesting stage.

the time. Though the soil moisture content was not significantly influenced by the natural nitrification inhibitors (NNI) but lower soil moisture content was observed in urea applied plots as compared to NNI applied plots immediately after fertilizer application. This might be due to utilization of soil moisture for urea hydrolysis and crop exhibited stress symptoms early as it is evident in leaf water potential (Fig. 1).

SPAD chlorophyll meter reading

The SPAD meter reading is a measure of greenness and chlorophyll content of leaf. SPAD readings were recorded at different stages (Table 1). The SPAD reading increased progressively up to 60 DAS and decreased thereafter. The SPAD reading were not significantly influenced by the application of urea and NNI coated fertilizers at 30, 60 DAS, but at harvest, which was significantly influenced by NNIs. Control has recorded the lowest SPAD value as compared to other fertilizer application treatments in all the stages. The NNI coated urea (neem cake, karanj cake and *Vitex* leaf powder) with castor oil and coal tar adjuvants has recorded significantly higher SPAD value (26.5-35) as compared to uncoated urea or adjuvants coated urea at harvest except neem cake coated with castor oil and coal tar (NCU, NCTU). This chlorophyll meter readings indicated that plants were greener with NNI coated ureas as compared to uncoated urea or control. A strong correlation was observed between the SPAD reading and N content in plant at flowering and harvest of maize crop [4].

Similar observations of increased chlorophyll

content with slow release fertilizer were recorded by Bahr et al. [6]. A strong linear correlation between SPAD and plant N content at flowering (0.66) and at harvest (0.001) was also observed (Fig. 2, 3). Hence the higher chlorophyll content in NNI coated urea plots as compared to other treatments was due to higher N assimilation in these treatments as compared to urea or adjuvants treatments.

Table 1. Influence of urea and different NNI coated urea on SPAD chlorophyll reading and leaf water potential at different crop stages of rainfed maize. Control– 0 kg N ha⁻¹; U– Uncoated urea (100 kg N ha⁻¹); CU–Castor oil coated urea; CTU–Coal tar coated urea; NCU–Neem cake coated urea with castor oil adjuvant; KUC–Karanj cake coated urea with castor oil adjuvant; VCU– *Vitex negundo* leaf powder coated urea with castor oil adjuvant; NCTU–Neem cake coated urea with coal tar adjuvant; KCTU– Karanj cake coated urea with coal tar adjuvant; VCTU– *Vitex negundo* leaf powder coated urea with coal tar adjuvant.

Treatments	SPAD chlorophyll reading			Leaf water potential	
	30 DAS	30 DAS	65 DAS	60 DAS	Harvest
Control	43.9	-0.27	-0.27	50.0	17.9
U	45.2	-0.41	-0.27	53.9	23.1
CU	48.5	-0.49	-0.32	55.7	23.1
CTU	41.6	-0.15	-0.21	55.1	23.5
NCU	46.1	-0.16	-0.16	55.4	26.5
KCU	46.9	-0.12	-0.13	57.5	30.0
VCU	49.4	-0.22	-0.15	57.2	34.9
NCTU	44.8	-0.14	-0.13	55.2	28.4
KCTU	41.2	-0.22	-0.21	57.8	31.9
VCTU	47.5	-0.16	-0.15	56.2	30.3
SEm ±	2.76	0.01	0.01	2.18	1.57
CD (p=0.05)	NS	0.04	0.04	NS	6.4
CV (%)	7.4	-11.8	-12.7	6.8	10.0

Table 2. Influence of urea and different NNI coated urea on nutrient content (%) and uptake at flowering and harvest in rainfed maize.

Treatments	Flowering		Harvest			
	N		Grain		Stover	
			N		N	
Controls	1.15	77.7	0.63	15.3	1.15	20.8
U	1.22	87.2	0.71	25.3	1.20	29.7
CU	1.23	102.5	0.79	28.1	1.29	34.7
CTU	1.25	108.3	0.75	25.7	1.29	31.4
NCU	1.34	135.1	0.93	33.5	1.37	45.7
KCU	1.35	130.9	0.84	26.6	1.35	34.4
VCU	1.34	136.3	0.91	43.9	1.36	60.8
NCTU	1.35	132.4	0.90	40.7	1.36	52.8
KCTU	1.34	139.6	0.82	35.5	1.32	45.4
VCTU	1.36	154.4	0.87	43.3	1.34	54.0
SEm \pm	0.06	7.55	0.04	2.41	0.04	3.45
CD ($p=$ 0.05)	NS	22.62	0.13	7.23	0.12	10.3
CV (%)	7.6	10.9	9.6	13.1	5.3	14.6

Leaf water potential

Leaf water potential is a useful parameter in defining plant water status and also indicates the degree of moisture stress. Hence the leaf water potential was recorded during stress periods at two different stages of crop growth. Leaf water potential was significantly influenced by the application of urea and nitrification inhibitors (Table 1). At 30 and 65 DAS higher leaf water potential was recorded with castor oil coated urea (CU) (-0.49, and -0.32 at 30 and 45 DAS respectively) and this was closely followed by uncoated urea (-0.41, -0.27 at 30 and 65 DAS respectively) indicating that these two treatments were under higher stress as compared to the other treatments. The NNI coated urea has recorded lower leaf water potential as compared to uncoated urea. This indicates that uncoated urea immediately after application has utilized soil moisture for hydrolysis. Hence stress was observed in urea applied plots as compared to NNI coated urea plots.

Nitrogen content

The plant samples were analyzed for nitrogen content at flowering and harvest stage (Table 2).. The nitrogen content varied significantly between control, application of uncoated urea and different nitrifi-

cation inhibitors at harvest stage in stover and grain content but no significant difference in N content among the treatments was observed at flowering stage. At harvest, the N content in grain (range 1.29-1.37) and stover (range 0.79-0.93) was highest in natural nitrification inhibitors coated urea over the uncoated urea. All the NNI treatments registered significantly higher N content over castor oil and coal tar adjuvants coated urea, uncoated urea and control. But, at harvest, adjuvant castor oil and coal tar coated urea were also on par with NNIs.

Nitrogen uptake by the crop

The N uptake at flowering stage was significantly influenced by application of urea and different NNI coated urea. Application of VCTU (154.4 kg ha⁻¹), VCU (136.3 kg ha⁻¹), NCU (135.1 kg ha⁻¹) and NCTU (132.4 kg ha⁻¹) has recorded higher N uptake and these were superior over the treatments viz., KCU, KCTU, CU, CTU, uncoated urea and control. Among the later treatments KCU (130.9 kg ha⁻¹) and KCTU (130.6 kg ha⁻¹) were on par with each other and were superior over castor oil and coal tar adjuvant coated urea (108.3, 102.5 kg ha⁻¹ CU, CTU respectively), uncoated urea (87.2 kg ha⁻¹) and control (77.7 kg ha⁻¹).

Data on nitrogen uptake both in the grain and stover furnished in (Table 2) has shown that higher N uptake in grain and stover was recorded in urea coated with VCU, VCTU and NCTU over castor oil (60.8, 43.9 kg ha⁻¹), coal tar adjuvants coated urea (54, 43.3 kg ha⁻¹), uncoated urea (52.8, 40.7 kg ha⁻¹) in stover and grain respectively. This was followed by KCTU (35.5, 45.4 kg ha⁻¹), NCU (33.5, 45.7 kg ha⁻¹). Among the NNI coated urea, KCU (26.6, 34.4 kg ha⁻¹) recorded lowest nitrogen uptake and this was on par with castor oil and coal tar adjuvant coated urea, uncoated urea and control.

Neem cake contains N (2.0% to 5.0%), P (0.5% to 1.0%), K (1.0% to 2.0%), karanj cake contains N (5.1%), P (1.1%) and K (1.3%) respectively might also help in increased availability of nutrients which in turn increases the uptake of NPK. This higher uptake of nutrients (N, P and K) resulted in increased growth of plants. These results are in line with the findings of Hangs et al. [6] who reported higher nutrient uptake

by plants due to nitrification inhibitors.

The encapsulation or coating of urea with natural nitrification inhibitors controls water entry and rate of dissolution, thus decreases the nitrification. Furthermore the compounds like tetranotriterpenoids in neem, furano flavonoids in karanjin and alkaloids like nishindine and flavonoids flavones luteolin-7-glucoside, casticin, iridoid glycosides [7] in *Vitex* are reported to be responsible for reducing the activity of nitrifying bacteria which inturn helps in inhibition of nitrification.

Conclusion

NNI coated urea has recorded significantly higher SPAD value (26.5-35) as compared to uncoated urea or adjuvants coated urea. This chlorophyll meter readings indicated that plants were greener with NNI coated ureas as compared to uncoated urea of control due to the nitrogen availability. In case of uncoated urea immediately after application has utilized soil moisture for hydrolysis. Hence stress was observed in urea applied plots as compared to NNI coated urea plots. N content and uptake was higher with natural nitrification inhibitors coated urea, which make the nitrogen available throughout the crop duration. This natural nitrification inhibitors contains

alkaloids which inhibiting action of urease enzyme and nitrification bacteria.

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