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Influence of nano zinc oxide application on chlorophyll content, leaf water status and productivity of summer maize (*Zea mays* L.) under deficit drip fertigation

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Abstract

A field investigation was conducted in two consecutive years 2023 and 2024 at the Agricultural Farm of Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, West Bengal, to assess the influence of nano zinc oxide (ZnO) application on SPAD (chlorophyll content) and relative leaf water content (RLWC) of summer-maize under different drip fertigation levels. The experiment followed a split-plot design with three replications, comprising four drip fertigation levels in main plots along with four nano ZnO application methods in subplots. The findings indicated that drip fertigation with 100% RDF significantly improved SPAD values at 30 DAS and remained statistically at par with surface irrigation with 100% RDF at 60 and 90 DAS, whereas the lowest SPAD values were recorded under drip fertigation with 50% RDF throughout the crop growth stages. RLWC was not significantly influenced by fertigation levels at 30 DAS; however, at 60 and 90 DAS, 100% RDF through drip and surface irrigation maintained significantly higher RLWC compared to deficit fertigation treatments. Among nano zinc oxide applications, seed coating with 50 ppm ZnO resulted in significantly greater SPAD values at 30 and 60 DAS and remained comparable with seed priming at 90 DAS. Similarly, seed coating and seed priming recorded higher RLWC compared to foliar application and control at most growth stages, with seed coating showing the maximum effect at 60 DAS. Correlation analysis indicated a significant positive relationship between SPAD and RLWC, suggesting that improved chlorophyll content is closely associated with better plant water status. Furthermore, both SPAD and RLWC exhibited strong positive-correlations with grain yield. The findings confirm that enhanced physiological efficiency under optimum fertigation and nano ZnO application contributes to increased productivity of summer maize.

Keywords: Seed coating, drip fertigation, nano zinc oxide, priming, relative leaf water content, SPAD, summer maize

Introduction

Maize (*Zea mays* L.) is an important cereal crop cultivated worldwide due to its high yield potential and diverse applications in food, feed, and industrial sectors (Malhotra, 2017) [30]. Maize ranks as the third most important cereal globally and is often referred to as the “queen of cereals” because of its superior genetic yield potential and adaptability to a wide range of agro-climatic conditions and soils (Divyavani *et al.*, 2024) [11]. In India, maize is grown across different seasons, namely kharif, rabi, and summer, with summer maize gaining prominence owing to its higher productivity under assured irrigation conditions (Jaidka *et al.*, 2019) [20]. Summer maize is a prominent cultivation system, covering about 7.37 lakh hectares with an average productivity of 4.6 tonnes ha⁻¹ (Anonymous, 2024) [1]. Despite its potential, maize productivity is often constrained by water stress, particularly during critical reproductive stages such as tasseling and silking. Such stress disrupts key physiological processes and leads to reduced grain formation (Chen and Setter, 2024) [10]. Maize, being a C4 plant is highly responsive to water and nutrient stress, particularly during critical growth phases such as tasselling and grain filling. Inadequate irrigation and imbalanced nutrient application often result in poor kernel development and reduced grain yields.

Advanced irrigation techniques including drip and sprinkler systems, have been recognized for their efficiency in improving water use and crop productivity compared to conventional surface irrigation (Sivanappan, 1998) [44]. Deficit irrigation (DI) is an approach aimed at improving water use efficiency (WUE) by achieving greater yield per unit of water applied. It focuses on enhancing WUE by either reducing the quantity of water supplied during irrigation or by decreasing the frequency of irrigation events (Kirda, 2002) [23]. In deficit irrigation, crops are intentionally subjected to water stress, which can potentially result in reduced yield (Prichard *et al.*, 2004; Smith *et al.*, 2002; Zhang *et al.*, 2004) [34, 45, 53]. Drip fertigation, a modern technique that combines irrigation and nutrient application, has evolved into a reliable approach to these challenges. It allows precise and frequent application of water-soluble fertilizers directly to the root zone, enhancing nutrient uptake, reducing losses caused by leaching and volatilization and ultimately improving crop performance (Li *et al.*, 2021). Compared to conventional methods, enabling synchronized delivery of water and nutrients according to crop demand patterns (Sidhu *et al.*, 2019) [40].

Plant growth largely relies on zinc (Zn) nutrition, as it functions as both a structural and catalytic cofactor for a wide range of enzymes and proteins. Zinc plays a paramount role in auxin regulation, protein metabolism, carbohydrate biosynthesis, and in improving plant resistance to pathogens and various environmental stresses (Broadley *et al.*, 2018). In recent years, zinc-based nanofertilizers (Zn NFs), notably in the form of zinc oxide (ZnO), have gained considerable attention in agriculture (Broadley *et al.*, 2018) [8]. These nano-formulations are considered more efficient and cost-effective compared to conventional synthetic zinc fertilizers (Seleiman *et al.*, 2020; Khanm *et al.*, 2018) [21]. Moreover, ZnO nanofertilizers can be applied through multiple methods, including soil application, seed priming (Sharifi *et al.*, 2016), and foliar spraying (Seleiman *et al.*, 2020), thereby offering flexibility and improved nutrient use efficiency [37, 39].

Relative leaf water content (RLWC) and SPAD (chlorophyll content) are vital and sensitive physiological indicators commonly used to evaluate the plant response under water deficit. The RLWC is an indicator of hydration status of leaf tissues and serves as a reliable measure of plant water balance. Sampathkumar (2003) [35] reported that cotton plants irrigated at optimum levels (100% pan evaporation) maintained greater RLWC compared to plants under water stress. In maize, water deficit at vegetative phase significantly reduced the RLWC in sensitive cultivars (Li and Staden, 1998). Higher RLWC under well-watered maize leaves retained comparatively high-water content than those under stress (Song *et al.*, 1995) [46]. The SPAD chlorophyll meter delivers a rapid, non-destructive assessment of leaf chlorophyll content and assists as an effective tool for monitoring plant-nutrient status. SPAD chlorophyll meter provides an opportunity in making significant decisions on nutrient management by using spectral signatures of the plant (Yadav *et al.*, 2016) [51]. We hypothesize that deficit drip irrigation with nano zinc oxide, enhances physiological efficiency and yield outcomes compared to traditional surface irrigation systems.

Materials and Methods: A two-year field experiment was carried out on sandy loam soil during summer seasons

(February - May) of 2023 and 2024 at Agriculture farm, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, in Red and Lateritic zone of West Bengal, India. The farm was situated at 23° and 40.190' of north latitude and 87° and 39.485' of east longitude with height of 60 m from the sea level. During the cropping period the average fortnightly meteorological parameters of the experiment site for the two consecutive years were like maximum temperature was observed 16th SMW of April, 2023 (41.5 °C) and 17th SMW of April, 2024 (41.2 °C), minimum temperature on 7th SMW of February, 2023 (13.5 °C) and 6th SMW of February, 2024 (12.3 °C).

The experiment was conducted in the form of a split plot design with three repetitions. The main plot included the treatment of drip fertigation at different rate of recommended dose of fertilizer and surface irrigation with recommended dose of fertilizer i.e. surface irrigation with 100% RDF, drip fertigation with 50% RDF, drip fertigation with 75% RDF and drip irrigation with 100% RDF. However, the sub plot included four methods of application of nano zinc oxide i.e. control or no zinc application, seed coating of nano ZnO at 50 ppm, seed priming of nano ZnO at 50 ppm and foliar application of nano ZnO at 50 ppm. The maize variety 'P3532' was sown on 13th and 9th February during 2023 and 2024, respectively and average harvesting done on 24th May in both the years. Preparatory tillage was done as per treatments and seeds were sown @ 20 kg ha⁻¹ with a spacing of 60 cm × 30 cm.

Chlorophyll content indicates the pigment pool available for light capture and photosynthesis. Chlorophyll meter (SPAD) reading was recorded from top most third and fully expanded leaves of ten randomly selected plants and mean values were reported. The readings were taken at every 30 days interval from days after sowing. The value measured by the chlorophyll meter (MC-100 chlorophyll meter) related to the amount of chlorophyll present in the leaf of plant. The values calculated are based on the amount of light transmitted by the leaf in two wavelength regions where the absorption of chlorophyll is different. Peak absorption areas of chlorophyll are in blue and red regions. The range of wavelength chosen to measure the light adsorption of chlorophyll is 650 nm to 940 nm. At 650 nm the absorption is high whereas, at 940 nm the absorption is low. The light, which passes through the sample leaf, strikes the receptor which convert the transmitted light to analog electrical signals, these signals are boosted by the amplifier and are converted into digital signals by the A/D converter. These digital signals are then used by the micro process to calculate the SPAD value, which is shown on the display and stored in the memory. Memory data can be recalled by pressing the appropriate key.

With an aim to determine the water supply vs. loss the relative leaf water content (RLWC) was determined which is an indicator of hydration and turgidity of leaf tissue. The relative leaf water content (RLWC) was estimated following the procedure of Barrs and Weatherly (1962) [5] at 30 days interval from the sowing of summer maize. RLWC measures the difference between a leaf's actual water status and its maximal water-holding capacity. At an interval of 30 days after sowing, leaf discs of third fully expanded leaf from the top were collected and fresh weight was recorded using precision electronic balance. These leaf discs were floated in distilled water for four hours in petri dish to make the leaf tissue turgid. Then the discs were removed and after

gently soaking between the two filter papers, the turgid weights of the leaf components were recorded. This leaf material was then kept in a butter paper bag and dried in a hot air oven at 65°C for 24 hours until it attains consistent weight, to record the dry weights. The RLWC was calculated by using the following formula and expressed in percentage.

$$\text{RLWC (\%)} = \frac{(\text{fresh weight} - \text{dry weight})}{(\text{turgid weight} - \text{dry weight})} \times 100$$

The experimental data recorded for various parameters under study were subjected to statistically analysed ANOVA given by Gomez and Gomez (1984) to draw a valid conclusion. The variation in the treatments mean was tested by using least significant differences (LSD) values at 5% level of significance. Before performing combined or pooled analysis across years, we made sure that the error mean squares were homogeneous using Bartlett's Chi-square test. Pearson correlation matrix and regression analyses were employed to quantify and interpret the relationships among agronomic, physiological, and yield parameters.

Results and Discussions

SPAD Value (Leaf Chlorophyll Content)

The Soil Plant Analysis Development (SPAD) value is an indirect measure of leaf chlorophyll density and plant nitrogen content, was significantly influenced by drip fertigation levels and nano zinc oxide (ZnO) application at different growth phases i.e., 30, 60 and 90 DAS. The pooled data of two years directed a progressive increase in SPAD values up to 60 DAS, followed by a decline at 90 DAS, regardless of treatments (Table No. 1). This inclination may be ascribed to active vegetative growth and chlorophyll synthesis during vegetative stages, followed by leaf senescence which makes nutrients available for younger plant organs and contributes to nutrient use efficiency (Himelblau and Amasino, 2001; Fischer and Gan, 2007; Avise and Etienne, 2014) [4] and remobilization of nutrients processes may also occur during reproductive growth when root activity and nutrient uptake generally decrease while new sinks are emerging (Malagoli *et al.*, 2005) [14, 18, 29].

Effect of Drip Fertigation Levels

At 30 DAS, drip irrigation with 100% RDF documented the highest SPAD value (17.58), which was significantly superior to drip irrigation with 50% RDF (13.68), but statistically at par with surface irrigation with 100% RDF (16.72) and drip irrigation with 75% RDF (15.98). However, at 60 DAS, drip irrigation with 100% RDF (44.99) and surface irrigation with 100% RDF (43.41) were statistically at par and significantly superior to drip irrigation with 75% RDF (41.32) and 50% RDF (36.63). A similar trend was observed at 90 DAS, where drip irrigation with 100% RDF (34.08) and surface irrigation with 100% RDF (33.33) recorded significantly higher SPAD values compared to lower fertigation levels. The higher SPAD values under 100% RDF through drip irrigation might be due to better nutrient availability and efficient water-nutrient synchronization in the rhizosphere, leading to enhanced nitrogen uptake and chlorophyll synthesis. Reduced SPAD values under lower fertigation levels might be due to inadequate supply of nutrients to the root zone, which results in a reduction in chlorophyll synthesis and its

concentration in the leaves. These results are consistent with the observations of Széles *et al.* (2023). In addition, water deficit promotes chlorophyll breakdown and accelerates leaf senescence (Padilla *et al.*, 2018; Illés *et al.*, 2021) [19, 32, 47].

Effect of Nano Zinc Oxide Application

Application of nano zinc oxide significantly influenced SPAD values at all growth. At all the growth stages i.e., at 30, 60 and 90 DAS, seed coating with nano ZnO @ 50 ppm recorded the highest SPAD value followed by seed priming, foliar application, and control

The enhanced SPAD values due to nano ZnO application, particularly through seed coating, may be attributed to greater zinc availability during early growth stages, leading to increased chlorophyll biosynthesis, enzyme activation, and nitrogen metabolism. Zinc is an essential constituent of many plant enzymes and plays a key role in chlorophyll and auxin synthesis, as well as in the formation and transformation of carbohydrates (Mathpal *et al.*, 2015) [31]. Thus, the application of zinc via seed coating and priming enhances photosynthetic activity and efficiency, resulting in higher SPAD values (Zhang *et al.*, 2021). These results are also in harmoniousness with the findings of Faizan *et al.* (2018); Wang *et al.* (2024) [13, 49, 53].

Relative Leaf Water Content (RLWC)

Relative leaf water content (RLWC), an important physiological indicator of plant water status and cellular hydration, was significantly influenced by drip fertigation levels and nano zinc oxide (ZnO) application at 30, 60 and 90 DAS (Table No. 2). The pooled analysis of both years revealed a steady decrease in RLWC from 30 DAS to 90 DAS. This decrease may be attributed to augmented transpiration demand, ageing of leaf, and reduced water uptake efficiency at advanced growth stages, which is in conformity with the findings of Barrs and Weatherley (1962) and Sinclair and Ludlow (1986) [5, 41].

Effect of Drip Fertigation Levels

Drip fertigation levels did not exert a significant influence on relative leaf water content (RLWC) at the early growth stage (30 DAS). This may be accredited to better soil moisture availability and relatively lower crop water demand during initial growth. However, at later growth stages (60 and 90 DAS), RLWC was significantly affected by fertigation levels.

The higher relative water content in the maize leaves with application of water through drip fertigation with 100% RDF as well as with 75% RDF is due to adequate moistening rhizosphere along with soluble nutrients which enhance the growth of the plant's root system. The increases in the root surface may be due to increase of absorption water and soluble nutrients from the soil, which helps maintain cell turgidity and physiological activity. The lower relative leaf water content with application of water through drip fertigation with 50% RDF due to the inadequate quantity nutrients, which is induced moisture stress, leading to impaired water uptake and increased transpiration losses as well as reduced the turgor pressure. These findings are in agreement with Kebede *et al.* (2014). Kirmak *et al.* (2010) [22, 24] observed that water stress led to a reduction in vegetative growth and relative leaf water content. Comparable results have also been reported by Xu and Leskovar (2014); Singh (2016); Singh (2019); Sahu *et al.* (2023) [36, 42, 43, 50].

Effect of Nano Zinc Oxide Application

Application of nano zinc oxide significantly affected RLWC at all growth stages. At the early stage (30 DAS), seed-based treatments (seed priming and seed coating) revealed comparatively higher RLWC than foliar application and control, although some treatments remained statistically at par. At subsequent stages, particularly at 60 and 90 DAS, seed coating with nano ZnO proved most effective in maintaining higher RLWC, followed by seed priming and foliar application, while the lowest RLWC was recorded under no zinc application. The enhancement in RLWC due to nano ZnO application may be attributed to improved root growth, improved water absorption, and better integrity of cell membranes and increasing relative water content in cell (Semida *et al.*, 2021). Linh *et al.* (2020) [28] reported that plants treated with nano ZnO exhibit greater water retention capacity compared to those without nano ZnO application, making it a reliable indicator of plant water status under cellular water deficit conditions. Consequently, the use of nano ZnO helps alleviate the adverse effects of water stress by improving relative leaf water content and associated traits (Al-Selwey *et al.*, 2023) [2]. This improvement may be attributed to enhanced leaf anatomical characteristics, which contribute to better photosynthetic efficiency under water-limited conditions (Semida *et al.*, 2021). Similar increases in relative leaf water content have also been documented by Pandya *et al.* (2023) [33, 38].

SPAD vs RLWC

The relationship between SPAD values and Relative Leaf Water Content (RLWC) showed a consistent positive trend across 30, 60, and 90 DAS, with variation in the strength of association over time (Fig. 1). At 30 DAS, the relationship was weak ($R^2 = 0.2634$), indicating limited influence of chlorophyll content on plant water status during early growth, where other environmental and physiological factors may predominate. At 60 DAS, the relationship became stronger ($R^2 = 0.5262$), demonstrating a moderate to strong correlation. This suggests that chlorophyll content plays a more significant role in maintaining leaf water status during the active vegetative stage, supported by increased photosynthetic activity and physiological integration. At 90 DAS, a moderate correlation was observed ($R^2 = 0.4548$), slightly lower than at 60 DAS, possibly due to increased variability associated with reproductive development and onset of senescence.

Overall, the results indicate that the association between SPAD and RLWC strengthens from early to mid-growth stages and slightly declines thereafter, highlighting that SPAD is a more reliable indicator of plant water status during the mid-growth stage (60 DAS) compared to early and late stages. Studies by Araus *et al.* (1998) and Gholipour *et al.* (2012) [3, 16] demonstrated that under moderate water stress, SPAD values correlate significantly with RLWC and photosynthetic capacity in maize. In cereals like *Triticum aestivum* and *Oryza sativa*, Blum (2011) and Yang *et al.* (2002) [6, 52] reported increased variability in SPAD-RLWC relationships due to senescence, remobilization of nutrients, and differential leaf aging, which decouple chlorophyll content from water status. Similarly, in *Sorghum bicolor*, Borrell *et al.* (2000) [7] found that SPAD remains relatively stable even when RLWC declines at later stages, again reducing correlation strength.

SPAD vs Grain yield

The relationship between SPAD values and grain yield at 30, 60, and 90 DAS showed a consistent positive trend, with the strength of association increasing as the crop matured (Fig. 1). At 30 DAS, the relationship was weak ($R^2 = 0.2854$), indicating limited predictive ability of early-stage chlorophyll content due to the influence of establishment and environmental factors. At 60 DAS, the correlation improved ($R^2 = 0.3877$), suggesting that chlorophyll content during the mid-growth stage contributes more significantly to yield through enhanced photosynthesis and biomass accumulation. The strongest relationship was observed at 90 DAS ($R^2 = 0.6126$), indicating a moderate to strong association, where chlorophyll content during the reproductive and grain-filling stages plays a crucial role in determining final yield.

Overall, the progressive increase in R^2 values shows that the predictive strength of SPAD measurements improves with crop maturity. Thus, SPAD readings at later growth stages, particularly at 90 DAS, serve as a more reliable indicator for estimating grain yield. Dwyer *et al.* (1995) [12] demonstrated that SPAD values measured near silking and grain filling were more closely correlated with grain yield compared to early vegetative stages in maize. Uddling *et al.* (2007) [48] reported that SPAD readings are better predictors of yield when taken at stages where photosynthetic demand is high and closely linked to assimilate partitioning. In *Triticum aestivum*, Flagella *et al.* (2002) [15] found that chlorophyll content during anthesis and grain filling showed a strong positive correlation with grain yield under both normal and water-stressed conditions.

RLWC vs Grain yield

The association between Relative Leaf Water Content (RLWC) and grain yield was evaluated at 30, 60, and 90 DAS, using linear regression analysis (Fig. 2). At 30 DAS, RLWC exhibited a positive but weak relationship with grain yield ($R^2 = 0.2473$), indicating limited influence of early-stage plant water status on final yield. In contrast, at 60 DAS, the relationship strengthened considerably ($R^2 = 0.586$), suggesting that RLWC during the mid-growth stage plays a significant role in determining yield. This stage likely corresponds to critical physiological processes such as flowering and grain setting, where adequate water availability is essential. At 90 DAS, RLWC maintained a positive association with grain yield, though the strength of the relationship declined ($R^2 = 0.2955$). This reduced influence may be due to the fact that yield potential is largely established before this stage, during earlier developmental phases.

Overall, the findings indicate that RLWC is positively related to grain yield across all stages, with the strongest effect observed at 60 DAS. This expresses the importance of maintaining optimal plant water status during the mid-growth period to maximize crop productivity. In maize, Çakir (2004) [9] showed that water deficits during vegetative stages had limited effects on final yield, whereas stress during flowering and early grain development significantly reduced yield. Similarly, Grant *et al.* (1989) [17] reported that leaf water status around tasseling and silking stages was highly correlated with kernel number and grain yield in maize. In *Oryza sativa*, Lafitte *et al.* (2004) [25] demonstrated that maintaining higher RLWC during panicle initiation and flowering stages resulted in improved grain yield under

water-limited conditions, emphasizing the sensitivity of these stages. In cereals like *Sorghum bicolor*, Blum (2011)^[6] noted that once grain number and size are largely determined, variations in RLWC during late grain filling have a comparatively smaller impact on final yield,

Correlation matrix of Grain Yield vs SPAD-RLWC

In this experiment (Fig. 2) expressively optimistic correlation was noticed of grain yield with SPAD data at 30 DAS (0.534***), 60 DAS (0.623***), and 90 DAS

(0.783***), and relative leaf water content at 30 DAS (0.497***), 60 DAS (0.766***), and 90 DAS (0.544***). Significantly higher positive correlation of SPAD value at 30 DAS was observed with SPAD value at 60 DAS (0.930***), and 90 DAS (0.669***). SPAD value at 60 DAS shows positive and significant correlation with SPAD value at 90 DAS (0.835***), RLWC value at 60 DAS (0.725***). SPAD value at 90 DAS was significantly and positively correlated with RLWC at 30 DAS (0.706***), and 60 DAS (0.833***).

Table 1: Effect of drip fertigation and nano zinc oxide application on SPAD value of summer maize

Treatments	SPAD Value								
	30 DAS			60 DAS			90 DAS		
	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled
Drip Fertigation									
Surface irrigation with 100% RDF	15.88	17.56	16.72	43.79	43.02	43.41	31.42	35.25	33.33
Drip fertigation with 50% RDF	13.51	13.86	13.68	34.69	38.57	36.63	26.98	27.42	27.20
Drip fertigation with 75% RDF	16.07	15.89	15.98	39.70	42.93	41.32	31.28	31.88	31.58
Drip fertigation with 100% RDF	16.63	18.53	17.58	45.53	44.46	44.99	32.95	35.21	34.08
SEm ($\pm$)	0.36	0.31	0.24	0.77	0.89	0.59	0.88	0.66	0.55
LSD at 5%	1.25	1.07	0.73	2.66	3.06	1.81	3.05	2.27	1.69
Nano zinc oxide application									
Control (no nano ZnO application)	13.78	14.64	14.21	36.59	38.50	37.55	26.91	29.67	28.29
Seed priming with 50 ppm nano ZnO	16.09	16.61	16.35	41.46	44.33	42.89	32.69	34.03	33.36
Seed coating with 50 ppm nano ZnO	18.17	19.65	18.91	48.24	44.86	46.55	33.28	34.44	33.86
Foliar application of 50 ppm nano ZnO	14.04	14.95	14.49	37.42	41.29	39.35	29.75	31.61	30.68
SEm ($\pm$)	0.25	0.28	0.19	0.72	0.76	0.52	0.74	0.52	0.46
LSD at 5%	0.73	0.82	0.54	2.09	2.23	1.49	2.17	1.53	1.29

Table 2: Effect of drip fertigation and nano zinc oxide application on relative leaf water content of summer maize

Treatments	Relative leaf water content (%)								
	30 DAS			60 DAS			90 DAS		
	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled
Drip Fertigation									
Surface irrigation with 100% RDF	83.70	87.41	85.55	77.72	82.45	80.09	68.20	74.90	71.55
Drip fertigation with 50% RDF	79.50	80.59	80.05	70.06	71.68	70.87	63.26	65.65	64.45
Drip fertigation with 75% RDF	81.08	85.56	83.32	74.54	77.27	75.90	67.93	71.65	69.79
Drip fertigation with 100% RDF	83.83	87.48	85.66	80.13	84.36	82.25	70.31	74.38	72.35
SEm ($\pm$)	1.84	1.83	1.30	1.76	1.64	1.20	1.32	1.89	1.15
LSD at 5%	NS	NS	NS	6.09	5.66	3.70	4.59	6.54	3.56
Nano zinc oxide application									
Control (no nano ZnO application)	79.04	83.07	81.06	69.71	68.66	69.18	65.28	64.14	64.71
Seed priming with 50 ppm nano ZnO	86.01	86.66	86.33	77.77	82.44	80.10	68.25	75.91	72.08
Seed coating with 50 ppm nano ZnO	83.18	86.56	84.87	81.14	86.25	83.70	67.02	76.39	71.71
Foliar application of 50 ppm nano ZnO	79.88	84.75	82.31	73.84	78.42	76.13	69.14	70.14	69.64
SEm ($\pm$)	1.78	1.69	1.23	1.41	1.57	1.06	1.27	1.52	0.99
LSD at 5%	5.19	NS	3.49	4.12	4.58	3.00	NS	4.43	2.82

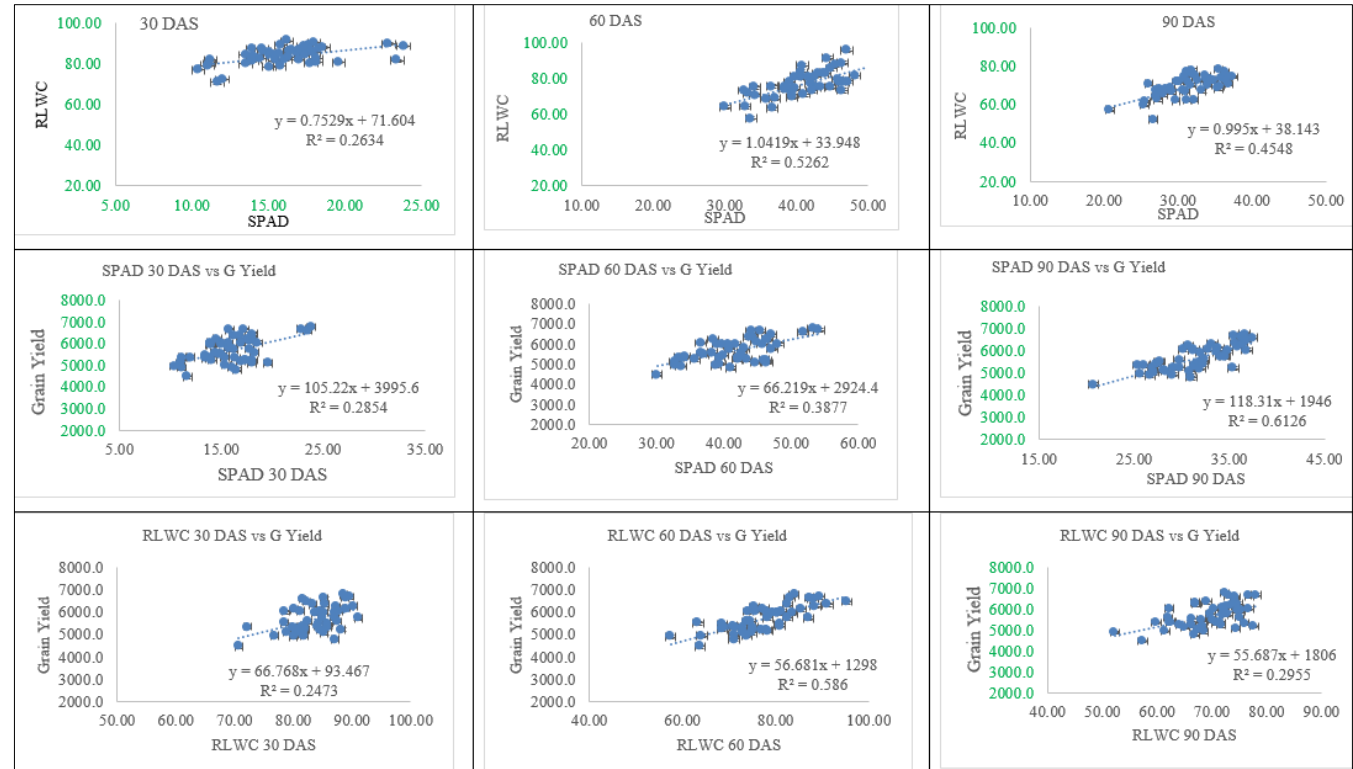


Fig 1: SPAD-RLWC relationships and SPAD-RLWC–yield relationships in maize under drip fertigation and nano zinc oxide

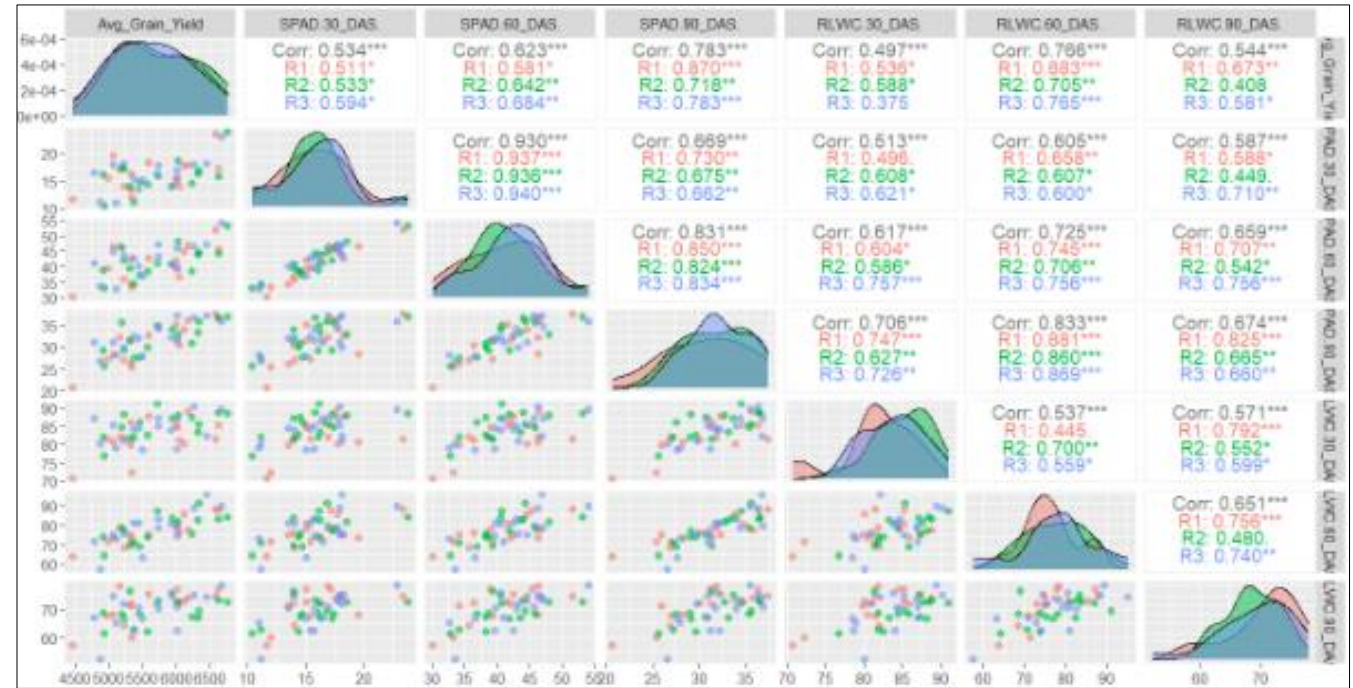


Fig 2: Correlation matrix of grain yield vs SPAD-RLWC in maize under drip fertigation and nano zinc oxide

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