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EFFECT OF DIFFERENT TYPES OF SURFACTANTS ON ZINC EFFICIENCY IN SPINACH YIELD

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ABSTRACT
A field experiment was conducted at Agriculture Research Institute Tarnab, Peshawar during 2010 to study the effect of different types of surfactants on Zinc efficiency in spinach yield and uptake of other nutrients. The experiment consisted of two different rates of Zinc Sulphate ($ZnSO_4$) (0.5% and 1%) with three different surfactants (Aerial, Bonus and surf excel) and control without $ZnSO_4$ and Surfactant. The experiment was laid out in RCB design with two factors having three replications. The results indicated that the effect of surfactants on Zinc efficiency had a significant effect on the yield of spinach and uptake of Potash, while Phosphorus and Zinc contents of spinach leaves were not significantly different among various treatments. Maximum yield was recorded on 1% $ZnSO_4$ with surf excel (10.417 ton ha^{-1}), followed by 1% $ZnSO_4$ with Bonus, while lowest yield was recorded in 1% $ZnSO_4$ with Aerial (7.77µg g^{-1}) which was at par with 0.5 % $ZnSO_4$ with Aerial, 0.5% $ZnSO_4$ with Bonus and control. Zinc with different surfactant also significantly affected Potassium (K). Maximum (2.3267µg g^{-1}) was recorded on control followed by 0.5% zinc with Aerial, which is similar with 0.5% $ZnSO_4$ with Bonus, while minimum Potash(1.2267µg g^{-1}) was recorded on 1% zinc with Aerial. The result of Phosphorus (P) and Zinc revealed that there were no statistically differences among difference rate of the zinc application with different surfactants. Among this 0.5% $ZnSO_4$ with Aerial gave maximum (0.844µg g^{-1}) of phosphorus in spinach leaves and minimum (0.7570µg g^{-1}) was at control. Maximum zinc (0.8787µg g^{-1}) was recorded on 0.5% zinc Sulphate, while minimum was recorded on control (0.8007µg g^{-1}) with 0.5 % zinc with Aerial. Among various treatments used, the 1% $ZnSO_4$ with surfactant gave maximum yield of spinach and high percentage mineral contents of spinach leaves.

Keywords: Zinc sulphate, Spinach, Yield, Surfactant, Soil characteristics, Organic matter.

Contribution/ Originality
This study is one of very few studies which have investigated the surfactants role in enhancing Zinc efficiency in agricultural crops. Most farmers do not care about these surfactants and simply uses zinc as spray on their fruit plants especially and field crops generally. The study in hand will definitely develop awareness among researchers, extortionists and farmers.

1. INTRODUCTION
The term surface is a mixture of surface active agents. Surfactants are usually organic compounds that are amphiphilic, as they contain both hydrophobic groups (their *tails*) and hydrophilic groups (their *heads*). It contains water insoluble (and oil soluble component) and a

water soluble component. Surfactant molecules will drift to the water surface, where the insoluble hydrophobic group may extend out of the bulk water phase, either into the air or, if water is mixed with oil, into the oil phase, while the water soluble head group remains in the water phase. This alignment and aggregation of surfactant molecules at the surface, acts to modify the surface properties of water at the water/air or water/oil interface. Surfactant are soluble amphiphiles that are surface acting and capable of reducing surface tension or free energy of the reaction medium (Goto *et al.*, 1997)

Surfactants lower the surface tension of a liquid, allowing easier spreading, and lowering of the interfacial tension between two liquids, or between a liquid and a solid. Surfactants may play a role of detergents, wetting agents, emulsifiers, foaming agents, and dispersants. A micelle the lipophilic tails of the surfactant molecules remain on the inside of the micelle due to unfavorable interactions. The polar "heads" of the micelle, due to favorable interactions with water, form a hydrophilic outer layer that in effect protects the hydrophobic core of the micelle. Micelle making compounds are typically amphiphilic in nature, not only soluble in protic solvents such as water but also in aprotic solvents as a reverse micelle. Surfactants are used in agriculture plants for the control of aphids. They are sprayed on plants invery little amounts mixed with water to avoid aphids feeding green leaves or stems. They are also used in foliar plants nutrients spray with the aim to facilitate the absorbance of nutrients by plant parts and also their equal destitution.

Spinach (*Spinaciaoleracea*) belongs to the family of Amaranthaceous and native to central and southwestern Asia. Normally it is an annual plant (rarely biennial). Height of the plant is up to 30 cm. it may survive over winter in temperate areas. The leaves are very variable in size from about 2–30 cm long and 1–15 cm broad. The flowers are unobtrusive, yellow-green, 3–4 mm diameter, maturing into a small, hard, dry, lumpy fruit cluster 5–10 mm across containing seeds. Spinach is very liked by south Asia people and hence it is cooked and served in the house and hotels. It is a great source of iron and vitamins and is considered a concipant vegetable. Being a short duration crop, it can give 3-4 crops and thus fetches a good value in term of money for the farmers. Zinc is a very important micronutrient, necessary for growth and development of many crops. It is also necessary for human nutrients as its deficiency in human body creates serious problems, especially in children and women. In plants it activates many enzymatic reactions within their various parts. It promotes auxin formation which helps in apical shoot formation and as a result the plants grow efficiently. Therefore keeping in view in the importance of the surfactant, the present study was initiated to determine the effect of different surfactants on the efficiency of zinc in increasing Spinach yield and also to check the effect of surfactants on the uptake of the nutrients by spinach crop.

Sulphonic, the anionic surfactant, had a significant effect on hydraulic properties of both soils. Applications of Sulphonic caused decreases in the capillary rise and penetrability, and an increase in the solid–liquid contact angle, shape factor and sorptivity.(Abu-Zreig *et al.*, 2003)

2. MATERIALS AND METHODS

A field experiment was conducted at Agriculture Research Institute Tarnab, Peshawar during 2010, to study the effect of different types of surfactants on Zinc efficiency in spinach yield. The experiment consisted of two different rates of Zinc Sulphate (0.5% and 1%) with three different surfactants (Aerial, Bonus and surf excel) and control (T1) without Zinc Sulphate and Surfactant. For T2, T3 and T4 the spray composition was (5gm) $ZnSO_4$ + 2gm CaOH + 1gm surfactant (Aerial, Bonus and surf excel respectively) dissolved in 1L water for T5,T6 and T7 the spray composition was 10gm $ZnSO_4$ + 4gm CaOH + 1gm surfactant (Aerial, Bonus and surf excel respectively) were dissolved in 1L water (Table 1). The experiment was laid out in RCB design with two factors having three replications. Basal dose of N-P @ 100-60 $kgha^{-1}$ were applied in sub plots. A composite soil sample was collected before crop and analyzed for their physicochemical characteristics; the fertilizer was applied by band placement method. Soil samples were collected from each treatment before crop sowing and were analyzed for physicochemical characteristics of the composite soil, as shown in Table 2.

2.1. Soil pH and EC

Soil pH and EC were determined in soil water (1:5) suspension. For this, 10g soil Sample was shaken with 100 ml distilled water for 30 min. After filtering, the extract was read for pH on pH meter (Inolab pH level) and EC on EC meter (DDC-308A Conductivity meter).

2.2. Soil Organic Matter

Walkley-Black procedure was used for soil organic matter. 1.0g soil sample was treated with 10 mL of 1 N $K_2Cr_2O_7$ and 20 mL of concentrated H_2SO_4. After adding of 200 ml distilled water upon cooling, the suspension was filtered and filtrate was titrated against 0.5 N $FeSO_4$ solution using ortho-phenopthaline as indicator with appearance of maroon color as end point. The amount organic matter was calculated from the number of moles of $K_2Cr_2O_7$ utilized in the oxidation of organic C in soil.

2.3. Soil Texture

Bouyoucos hydrometer method was used to determined soil texture. 50 g air-dry soil was dispersed 5 ml 10% sodium exametaphosphate solution in a mechanical dispersion for 5 min. After quantitative transfer of suspension to a 1 L Bouyoucos cylinder, filling the cylinder with distilled water to 1-L mark. After thorough mixing, carefully inserted a hydrometer in the suspension and took the hydromitrec reading after 40 sec for silt + clay and after two for clay. Also note the temperature of the suspension with each hydrometer and made necessary correction in hydro meter reading. Percent silt and clay were calculated from hydrometer while % sand was calculated by difference. Percent sand, silt and clay were used to determined soil textural classes on the USDA soil textural triangle.

2.4. Extractible P and K in Soil

The extractible P and K in soil were also measured in the AB-DTPA extract. Potash was read onFlame photometer, while P on spectrophotometer at 880nm after proper color development. The concentration of extractible P and K were calculated from the regression equation develop from reading their respective standards.

2.5. Extractible Micronutrient in Soil

Theconcentration of extractible micronutrient Zn in soil was determined by the AB-DTPA extraction procedure. In this method, 10g soil sample was shaken with 20 ml AB-DTPA extract in an open Erlenmeyer flask for 15 min. After filtering, extract was read for Zn on an atomic absorbtionspectro meter (Perkin Elmer analyst 200, USA).

Respective leaves from each treatment plot were collected after ashing for the required qualitative and quantitative determination of spinach.

2.6. Plant Analysis

Leaf sample collected were dried and grinded and were analyzed for different quality parameters while for the determination of Zinc, P and K. These samples were digested by wet digestion method.

2.7. Statistical Analysis

The data collected during field and laboratory investigations were analyzed statistically using ANOVA technique and means were compared by LSD-test of significance using software Statistix 8.1. Excel 2003 version 2.0 was used for graphic presentation.

3. RESULTS AND DISCUSSION

3.1. Green Weight

The result revealed that the green weight of spinach is significantly different among the various treatments. The maximum (10.42 ton ha-1) yield was recorded on surf Excel 1% $ZnSO_4$ which is similar with Bonus 1% ZnSo4, Surf Excel 0.5 % ZnSo4 and Bonus 0.5 % $ZnSO_4$. Minimum (7.778 ton ha-1) yield was observed on Aerial 1% $ZnSO_4$ which is at par with control and Aerial 0.5 % $ZnSO_4$. The result in the table 3 indicated that both levels (0.5% and 1%) of Zn foliar application with surf excel exceeded the green leaves yield significantly, followed by Bonus, control and aerial respectively.

3.2. Phosphorus: (P)

The data of Phosphorus in spinach leaves was not significantly different among various treatments. The maximum phosphorous content were recorded for Surf Excel 1% $ZnSO_4$ (0.8893 $\mu g\ g^{-1}$) followed by Aerial 1% $ZnSO_4$, while minimum (0.75 $\mu g\ g^{-1}$) was recorded in control plot. It is evident from the table 3 that all the surfactants have shown a positive response in the P retention by plant leaves; however its effect was not significant statistically. Among all the three surfactants, surf excel was the best, aerial better and the bonus good in respect to P uptake by plant. Irish *et al.* (2002) reported that in greenhouse and field tests, all surfactant treatments showed significant reductions in white rust severity compared with water controls. The surfactants Naiad and sodium dodecyl sulfate (SDS) were highly effective and comparable to fungicides against white rust.

3.3. Zinc: (Zn)

Different surfactants as foliar spray did not affect the efficiency of Zinc in spinach. The Zinc result was not significant among all the treatments. Maximum Zn (0.88 µg g^{-1}) was observed in Surf Excel 0.5 % $ZnSO_4$, which is followed by Bonus 0.5 % $ZnSO_4$. While lower value was recorded in control plot. Zn contents in the leaves were increased by $ZnSO_4$ spray shown in table 3.

Over 99% zinc extraction was achieved in the presence of OPD for all leaching times and surfactant concentrations. Lignin sulfonic acid and MPD resulted in 86–94% and 95–98% zinc extraction, respectively (George *et al.*, 1995)

Zhiyin *et al.* (2004) found that CTAB would affect the growth of the CoHCF film, the electrochemical behavior of the CoHCF film and the electrocatalytic activity of the CoHCF/GC electrode towards the electrochemical oxidation of dopamine (DA). The reasons of the electrochemical behavior of CoHCF/GC electrode influenced by CTAB were investigated using FTIR and scanning electron microscope (SEM) techniques.

Jana *et al.* (2009), observed that Anionic surfactants sodium dodecylsulfate C12H25OSO3Na and sodium dicyclohexylsulfosuccinate C16H25O4SO3Na are sorbed by ivy leaves (Hedera helix L.) immersed in surfactant water solution. Pretreatment of leaves by surfactants increases their capacity to sorb Zn2+ and Sr2+ ions.

Trace amounts of zinc, cadmium, copper, nickel, manganese, cobalt and lead can be separated from natural waters on Chelex-100 resin (50–100 mesh) in the presence of cationic, anionic and non-ionic detergents, washing powder and sodium tripolyphosphate at concentrations as high as 100 mg l-1. Metal recoveries are better than 92% but are poor in the presence of soap or the potential detergent additive, nitrilotriacetic acid. Although strong adsorption of cationic, and to a lesser extent, anionic and non-ionic detergents, occurs on the resin surface, low recoveries can be attributed to incomplete metal elution rather than to blockage of adsorption sites (Pakalns and Batley, 1978)

3.4. Potash: (K)

The data regarding Potash was significant among various treatments. Maximum amount of Potash was observed in Control which is at par with Aerial 0.5 % $ZnSo_4$, Bonus 0.5 % $ZnSo_4$ and Bonus 1 % $ZnSo_4$, while minimum was recorded in Aerial 1% $ZnSo_4$. The native K was in sufficient amount (table 2). There for various levels of Zn along with different surfactants did not show any effect on the luxnious uptake of K, rather they have decreased its uptake to the normal level in the leaves. On the basis of results obtained in this experiment, it can be inferred that the higher Potash was observed in control treatment, because the Potash was not incorporated. These findings agree with Haslett *et al.* (2001)who reported foliar treatments with ZnSO4and chelated Zn forms resulted in shoot Zn concentrations in 7-week-old plants being about two-fold greater than those in plants supplied with Zn in the root environment or via foliar spray of ZnO. No negative growth effects has been noted by adding surfactant to foliar sprays containing chelated forms of Zn, but surfactant added to ZnO or ZnSO4foliar sprays decreased shoot growth, while no effect has been noted on shoot growth by adding urea to the ZnO foliar spray. Foliarly-applied65Zn was translocated to leaves above and below the treated leaf as well as to the root tips. Stem girdling confirmed that65Zn transport toward lower leaves and roots was via the phloem.

4. CONCLUSION

It is concluded that Surf excel among all the surfactants stood first in increasing spinach yield and also Zinc efficient retention by its leaves. All the three surfactants have depressed the retention of potash in the plant leaves but not the critical limits and hence it is recommended that higher yield of spinach was obtained with the application of $ZnSO_4$ @1% foliar along with surf excel as surfactant. Hence it is recommended that Zn foliar spray be includedwith surf excel whenever it is applied to the crops to get good results.

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REFERENCES

Abu-Zreig, M., R.P. Rudra and W.T. Dickinson, 2003. Effect of application of surfactants on hydraulic properties of soils. Biosystems Engineering, 84(3): 363-372

George, O., D.B. Dreisinger and E. Peters, 1995. Effect of surfactants on zinc and iron dissolution rates during oxidative leaching of sphalerite. Hydrometallurgy, 38(3): 315-324.

Goto, R., Q.K. Beg and P. Lorenz, 1997. Hydrophobic moiety of surfactant. 3rd Ed., New York: Worth Publishers. pp: 3.

Haslett, B.S., R.J. Reid and Z. Rengel, 2001. Zinc mobility in wheat. Uptake and Distribution of Zinc Applied to Leaves or Roots Annals of Botany, 87(3): 379-386.

Irish, B.M., J.C. Correll and T.E. Morelock, 2002. The effect of synthetic surfactants on disease severity of white rust on spinach. Plant Disease, 86(7): 791-796.

Jana, M., M. Horník, M. Pipíška and J. Augustín, 2009. Influence of anionic surfactants on Zn2+ and SR2+ uptake by ivy (Hedera Helix L.) leaves. Nova Biotechnologica, 9(3): 333-340.

Pakalns, P. and G.E. Batley, 1978. The effect of surfactants on the concentration of the heavy metals from natural water on chelex-100. Resin Analytica Chimica Acta, 99(2): 333-342.

Zhiyin, X., C. Cai and T. Lu, 2004. Effects of a surfactant on the electro catalytic activity of cobalt hexacyanoferrate modified glassy carbon electrode towards the oxidation of dopamine. Electroanalysis, 16(8): 674–683.

Table-I. Different types of Surfactants with 0, 0.5 and 1 % zinc sulphate

S.No.	Zinc Sulfate Rate	Surfactants
T1	0%	Control
T2	0.5%	Aerial
T3	0.5%	Bonus
T4	0.5 %	Surf excel
T5	1%	Aerial
T6	1%	Bonus
T7	1%	Surf excel

Source: Different rates of Zinc Sulphate for different treatments

Table-2. Physicochemical characteristics of the composite soil samples

Parameters	Unit	Value
pH	-	8.4
Organic matter	%	0.58
EC	dS m^{-1}	0.032
Available Phosphorus	mg kg^{-1}	6.0
Zinc	mg kg^{-1}	0.695
Available Potash	mg kg^{-1}	190.0
Textural class		Silt loam

Source: Analysis for physicochemical characteristics of the composite soil

Table-3. Effect of different types of surfactants on Zn efficiency in spinach yield and mineral contents (P, Zn and K) of spinach leaves

Treatments	GW (ton ha^{-1})	P (µg g^{-1})	Zn (µg ml^{-1})	K (µg g^{-1})
Control	8.056bc	0.7570	0.8007	2.3267a
Aerial 0.5% $ZnSo_4$	7.917bc	0.8443	0.8063	2.1733ab
Bonus 0.5 % $ZnSo_4$	9.444abc	0.8007	0.8783	1.7500abc
Surf Excel 0.5% $ZnSo_4$	9.722ab	0.7760	0.8787	1.4700bc
Aerial 1% $ZnSo_4$	7.778c	0.8513	0.8777	1.2267c
Bonus 1% $ZnSo_4$	9.722ab	0.7917	0.7443	1.7967abc
Surf Excel 1% $ZnSo_4$	10.417a	0.8893	0.8610	1.4400c
LSD value	1.8312	NS	NS	0.7293

Mean followed by the same letter are not significant at 5% level probability using LSD test.