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Effects of Seed Weights on Plant Growth and Mineral Nutrition of Wheat and Bean Plants

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Abstract: This study was aimed to investigate the effects of different seed weights on plant growth, mineral nutrition and nutrient uptake of wheat and been plants. Also relations among seed weights and examined parameters were examined. For this purposes, 3 groups of wheat grains having 3.35, 4.05 and 4.98 g 100 seeds^{-1} and 4 groups of been grains having 30.02, 45.18, 54.01 and 58.6 g 100 seeds^{-1} were selected. Experiment was set up under greenhouse condition and left for growing during 2 months. After the experimental period, plants were harvested and analyzed for mineral analysis. According to the results it was seen that dry weights of both plants increased with the seed weights. For wheat plants, increasing of seed weights led to increase of plant Fe, Zn and Mn concentrations. Also K, Ca, Mg, Fe, Zn and Mn uptake of plant from the soil increased with increase of 100 seed weights. Similarly, N, Ca, Mg and concentrations of bean and nutrient uptake (K, Ca, Mg, Fe, Cu, Zn and Mn) from the pot increased with the seeds weights. For both plants, while there were not any correlations among seeds weights and seed nutrient concentrations generally, there were some significant correlations among the seeds weights and dry weights, leaf nutrient concentrations and nutrient uptake.

Tohum Ağırlığının Buğday ve Fasulyenin Gelişimi ve Mineral Beslenmesine Etkileri

Anahtar Kelimeler
Fasulye,
Mineral beslenme,
Bitki gelişimi,
Tohum boyutu,
Buğday

Özet: Bu çalışmada, buğday ve fasulye bitkilerinin gelişimi, mineral beslenmesi ve besin elementi alımları üzerine farklı tohum ağırlıklarının etkilerini incelemek amaçlanmıştır. Bu nedenle ağırlıkları 3.35, 4.05 ve 4.98 g/100 tohum olan buğday tohumlarıyla, ağrılıkları 30.02, 45.18, 54.01 ve 58.6 g/ 100 tohum olan fasulye tohumları iki kg toprak alan saksılara ekilerek 2 ay süreyle sera koşullarında gelişmeye bırakılmışlardır. Deneme süresi sonunda bitkiler hasat edilmiş ve besin maddesi tayinleri için analiz edilmişlerdir. Analiz sonuçlarına göre, bitki kuru ağırlıklarının her iki bitkide de tohum ağırlığıyla arttığı görülmüştür. Buğdayda Fe, Zn ve Mn konsantrasyonlarıyla topraktan alınan K, Ca, Mg, Fe, Zn ve Mn miktarları tohum ağırlıklarının artmasıyla artmıştır. Benzer şekilde fasulye bitkisinin N, Ca ve Mg konsantrasyonuyla topraktan kaldırılan K, Ca, Mg, Fe, Cu, Zn ve Mn miktarları artan tohum ağırlıklarıyla artmıştır. Her iki bitki için de, genelde tohum ağırlıklarıyla tohumun besin elementi içerikleri arasında bir ilişki görülmezken, tohum ağırlıklarıyla bitki kuru ağırlığı, besin elementi içeriği ve topraktan alınan besin elementi miktarları arasında bazı korelasyonlar belirlenmiştir.

1. Introduction

Seed quality is one of the important factor effecting plant growth, yield and nutrient uptake by the plants. For a good and healthy growing start seed quality is important. Seed quality is one of the best criteria for cereal productions and qualified seeds led to about 25 to 40 percent yield increase [1]. In several studies conducted on different plants it was indicated that seed size and weight significant increased seedling shoot and root growth, biomass yield and some seed quality parameters [2, 3, 4, 5]. Large scale seeds contain higher amount of energy and thus seedlings grow faster. Also big seeds form bigger and longer root systems helping stronger seedling growth and promote early plant growth [6, 7]. Effect of seed size on plant growth and some plant parameters can vary with environmental factors such as rainfall and irrigation. In a study, it was stated that effect of seed size did not affect some yield and yield characteristics of wheat under dry conditions, whereas under irrigated conditions big sized grains significantly

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increased grain yield and some yield parameters [4]. High mineral nutrient contents in the seeds for a strong growth beginning and strong rooting system are needed especially on mineral deficient soils. During the early stage, plants meet their nutrient and energy demand from the reserves in their seeds mostly. So, huge nutrient stocks in the seeds are vitally important for plants to be able to survive their growth healthy [8]. There is a general agreement that seedlings from bigger seeds have better start in growth due to their larger carbohydrate storage giving higher energy and higher nutrient content [7, 9].

The aims of the present study were to assess the importance of seed weights on seed nutrient content, plant growth, nutrient concentrations and nutrient uptake of bean and wheat plants.

2. Material and Method

Wheat seeds were divided in 3 groups depending on 100 seeds weights as 3.35, 4.05 and 4.98 g 100 seeds^{-1} and bean seeds were divided in 4 groups as 30.02, 45.18, 54.01 and 58.60 g 100 seeds^{-1}. Seeds were selected from the Gun-91 cultivar for wheat and from the Sehirali-90 cultivar for bean. Seeds were sown in 2 kg soil containing pots under greenhouse conditions with 3 replicates and the experiment was conducted for 2 months. As basal fertilization 200 mg kg^{-1} N from ammonium nitrate, 100 mg kg^{-1} P from trip-l super phosphate and 100 mg kg^{-1} K from potassium sulfate were mixed to the soil before sowing. Some characteristics of the soil used for the experiments were indicated in Table 1.

After 2 months, plants were harvested above the soil and washed with water, dilute acid (0.2 N HCl) and distilled water. Later, samples were dried at 65±5 C^{o} for 2 days. Afterwards, samples were dried, weighted, grounded and wet digested with microwave oven. Total N was determined according to Kjeldahl method. Other nutrient (K Ca, Mg, Fe, Cu, Zn, and Mn) concentrations were determined using atomic absorption spectrophotometer (Varian 240 FS). Also seed analyses were conducted with the same procedures used for plant analysis [10]. Seeds nutrient contents and plant nutrient uptakes were calculated using seed and plant dry weights and nutrient concentrations. Statistical evaluations of the results were made using Co-Stat statistical software and the means were grouped using DUNCAN test.

Table 1. Some characteristics of the soil used for the experiments

Characteristics	Value	References
pH (1/2.5, soil/water)	8.0	[11]
$CaCO_3$ (%)	18.5	[12]
O. matter (%)	1.1	[13]
Available nutrients		
P (mg kg^{-1})	13.6	[14], [15], [16]
K (mg kg^{-1})	115	
Ca (mg kg^{-1})	684	
Mg (mg kg^{-1}))	37.5	
Cu (mg kg^{-1})	0.64	
Mn (mg kg^{-1})	12.3	
Fe (mg kg^{-1})	3.1	
Zn (mg kg^{-1})	1.39	

3. Results

3.1. Plant dry weights, macro nutrient concentrations and uptakes

Seed weights (SW) had a significant effect on dry weights (DW) of wheat and bean plants. For bean plants, dry weight showed increase depending on the seed weights. Also wheat dry weight obtained from the highest seed weight significantly higher comparing to others (Table 2).

Table 2. Effect of seed weight on dry weight of plants

Wheat		Bean	
SW, g 100 seeds^{-1}	DW, g pot^{-1}	SW, g 100 seeds^{-1}	DW, g pot^{-1}
3.35	0.72 B*	30.02	1.63 D**
4.05	0.77 B	45.18	1.88 C
4.98	0.82 A	54.01	2.39 A
		58.60	2.11 B

*P<0.05;**P<0.01

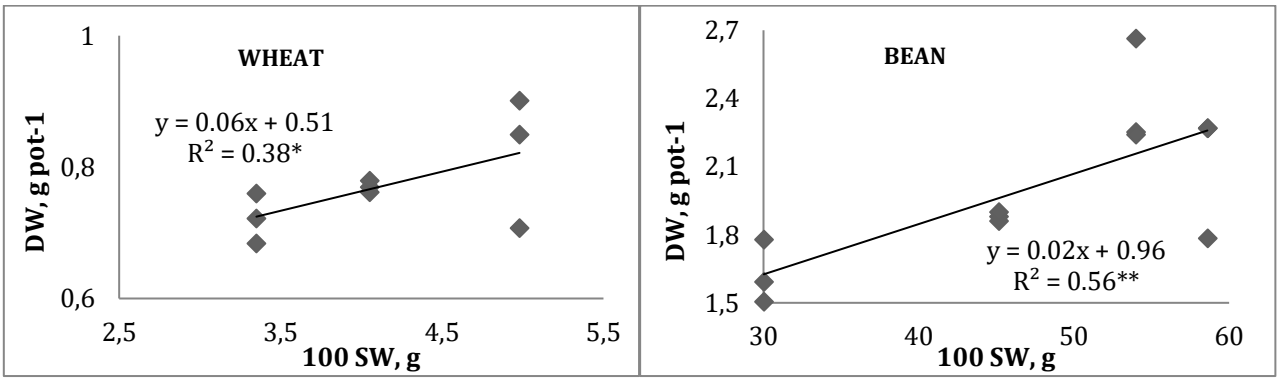

Figure 1. Correlations between seed weights and dry weights of wheat and bean

Table 3. Effects of seed weight on seed and leaf macro element concentrations, 100 seeds nutrient content and nutrient uptake of wheat and bean

Wheat	N	SW g 100 seeds^{-1}	Seed N, %	Seed N, mg 100 seeds^{-1}	Leaf N, %	N uptake, mg/pot
		3.35	1.3B*	43.6 C**	3.3	23.8
		4.05	1.8A	72.9 B	3.1	23.9
		4.98	2.0A	99.6 A	3.3	27.1
	K		Seed K, %	Seed K, mg 100 seeds^{-1}	Leaf K, %	K uptake, mg/pot
		3.35	0.65	21.8C***	5.7	41.6B*
		4.05	0.64	26.1B	6.0	46.0A
		4.98	0.64	31.9A	5.6	47.1A
	Ca		Seed Ca, %	Seed Ca, mg 100 seeds^{-1}	Leaf Ca. %	Ca uptake, mg/pot
		3.35	0.20	6.9C***	0.98	7.0B*
		4.05	0.20	8.2B	1.06	8.2A
		4.98	0.20	9.7A	1.03	8.3A
	Mg		Seed Mg, %	Seed Mg, mg 100seeds^{-1}	Leaf Mg, %	Mg uptake, mg pot^{-1}
		3.35	0.14	4.7C***	0.2	1.45C*
		4.05	0.14	5.7B	0.2	1.54B
		4.98	0.13	6.5A	0.2	1.61A
Bean	N	SW g 100 seeds^{-1}	Seed N, %	Seed N, mg 100seeds^{-1}	Leaf N, %	N uptake, mg pot^{-1}
		30.02	3.2	966C**	3.1B*	50.5 D**
		45.18	3.2	1446B	3.4A	63.9 C
		54.01	3.4	1836A	3.5A	83.6 A
		58.60	3.3	1934A	3.6A	76.0 B
	K		Seed K, %	Seed K, mg 100seeds^{-1}	Leaf K, %	K uptake, mg pot^{-1}
		30.02	2.2A***	652D***	4.3	69.6C**
		45.18	1.9B	876C	4.1	72.3C
		54.01	1.8C	964B	4.2	100.0A
		58.60	1.8C	1074A	4.3	90.9B
	Ca		Seed Ca, %	Seed Ca, mg 100 seeds^{-1}	Leaf Ca, %	Ca uptake, mg pot^{-1}
		30.02	0.43	129.7D***	2.62C***	42.6C***
		45.18	0.39	176.6C	2.89B	54.3B
		54.01	0.42	226.7B	2.91B	69.4A
		58.60	0.43	248.7A	3.16A	66.6A
	Mg		Seed Mg, %	Seed Mg, mg 100 seeds^{-1}	Leaf Mg, %	Mg uptake, mg pot^{-1}
		30.02	0.22	66.8D***	0.34B**	5.5C**
		45.18	0.22	96.1C	0.36B	6.8B
		54.01	0.21	115.8B	0.36B	8.5A
		58.60	0.21	124.6A	0.41A	8.8A

*p<0.05; **p<0.01; ***P<0.001

Only seed N concentrations varied significantly with seed weight. But all macronutrient contents of seeds showed significant variations depending on the seed size in wheat (Table 3). While macronutrient contents in the smallest seeds were the lowest, the highest values were determined in the biggest seeds (Table3). Although leaf nutrient concentrations of wheat were not affected from the seed weights, nutrients uptake (except for N) by the plants significantly increased depending on the seed weights. Bean seed macronutrient concentrations did not vary significantly with the seed size except for K. But, nutrient content of seeds increased with the seed weights and these increments were found to be significant. Also leaf nutrient concentrations and nutrient uptakes of bean plants increased with the seed size, generally (Table 3).

3.2. Micro nutrient concentrations and uptakes

Iron, Cu, Zn and Mn concentrations of both grains did not change with the seed weights; however their contents in 100 seeds varied with the seed weight significantly. Micro element contents in the seeds increased with the seed weight increase. While the lowest micro element contents were measured in the lightest seeds, the highest nutrient contents were determined in the heaviest seeds. Leaf nutrient concentrations showed different response to seed weights and plant types. Leaf Zn and Mn concentrations in wheat and Fe and Mn concentrations in bean increased with the seed weight. Also plant nutrient uptake from the soil increased (except for wheat Cu uptake) with the increment of seed weight for both plants generally (Table 4).

3.3. Some correlations among the examined parameters

For both plant, significant correlations were found between 100 SW and DW (Figure 1). Also leaf Fe, Mn and Zn concentrations in wheat and N and Ca concentrations in bean significantly affected from the seed size and positive correlations were observed between them (Figure 2 and Figure 3).

Table 4. Effects of seed weight on seed and leaf micro element concentrations, 100 seeds nutrient content and nutrient uptake by wheat

Wheat	Fe	S W, g 100seeds^{-1}	Seed Fe, ppm	Seed Fe, mg 100 seeds^{-1}	Leaf Fe, ppm	Fe uptake, mg pot^{-1}
		3.35	41	0.14B*	100	0.072C**
		4.05	38	0.15B	103	0.080B
		4.98	41	0.20A	115	0.094A
	Cu		Seed Cu, ppm	Seed Cu, mg 100 seeds^{-1}	Leaf Cu, ppm	Cu uptake, mg pot^{-1}
		3.35	8.7	0.029C***	14.1	0.010
		4.05	8.4	0.034B	15.0	0.012
		4.98	8.5	0.042A	14.2	0.012
	Zn		Seed Zn, ppm	Seed Zn, mg 100 seeds^{-1}	Leaf Zn, ppm	Zn uptake, mg pot^{-1}
		3.35	31.5	0.11B*	27.5B**	0.020B***
		4.05	27.8	0.11B	25.7B	0.020B
		4.98	30.4	0.15A	43.5A	0.035A
	Mn		Seed Mn, ppm	Seed Mn, mg 100 seeds^{-1}	Leaf Mn, ppm	Mn uptake, mg pot^{-1}
		3.35	34.8	0.12B*	75B**	0.055C**
		4.05	32.5	0.13B	75B	0.062B
		4.98	33.7	0.17A	83A	0.069A
Bean	Fe	S W, g 100seeds^{-1}	Seed Fe, ppm	Seed Fe, mg 100 seeds^{-1}	Leaf Fe, ppm	Fe uptake, mg pot^{-1}
		30.02	57.4	1.72D***	96.3A*	0.14B
		45.18	54.7	2.47C	79.7B	0.15B
		54.01	56.8	3.07B	80.5B	0.19A
		58.60	59.5	3.49A	101.3A	0.21A
	Cu		Seed Cu, ppm	Seed Cu, mg 100 seeds^{-1}	Leaf Cu, ppm	Cu uptake, mg pot^{-1}
		30.02	13.7	0.41D***	13.0	0.021B**
		45.18	13.5	0.61C	12.2	0.023B
		54.01	13.5	0.73B	12.6	0.030A
		58.60	13.4	0.78A	13.3	0.028A
	Zn		Seed Zn, ppm	Seed Zn, mg 100 seeds^{-1}	Leaf Zn, ppm	Zn uptake. mg pot^{-1}
		30.02	30.3	0.91A***	23.3	0.038B**
		45.18	29.4	1.33B	22.4	0.042B
		54.01	31.2	1.68C	23.5	0.056A
		58.60	30.6	1.79D	26.0	0.055A
	Mn		Seed Mn, ppm	Seed Mn, mg/100 seeds	Leaf Mn, ppm	Mn uptake, mg pot^{-1}
		30.02	17.3	0.52D***	81.3D***	0.13C***
		45.18	17.0	0.77C	93.4C	0.18B
		54.01	16.6	0.89B	108.7B	0.26A
		58.60	16.0	0.94A	117.8A	0.25A

*p<0.05; **p<0.01; ***P<0.001

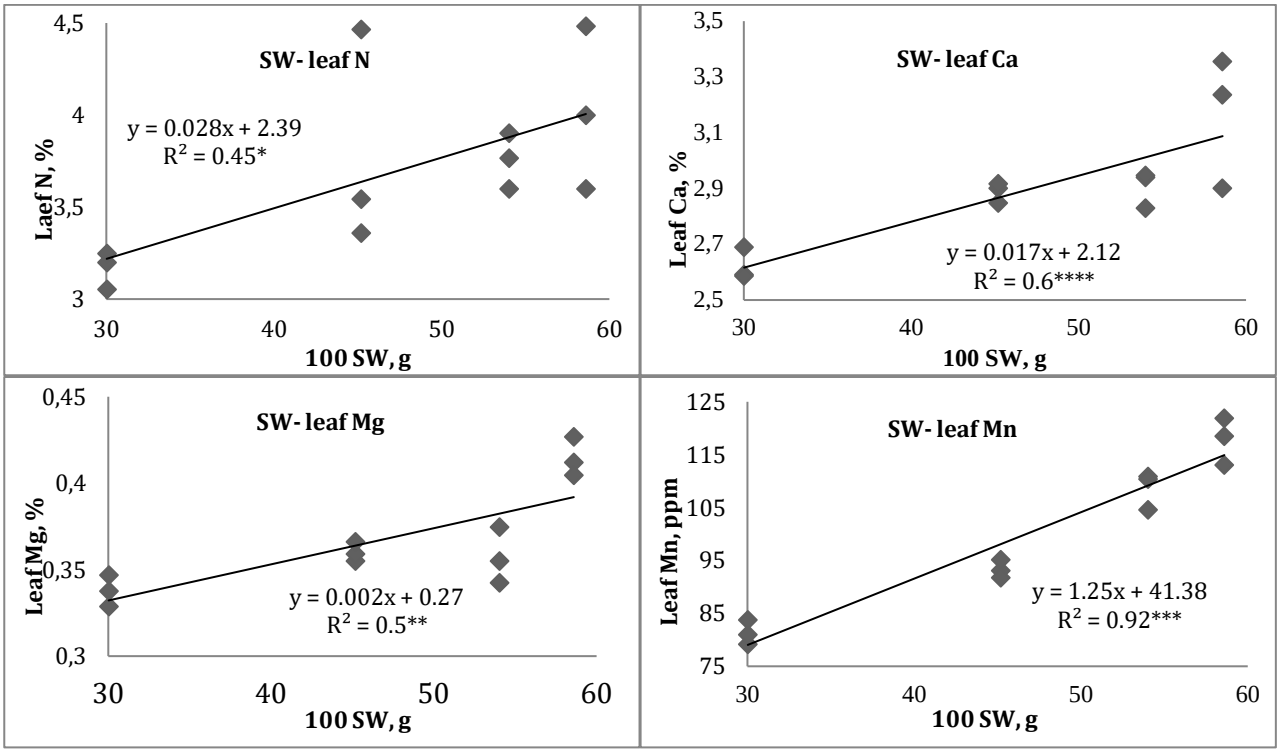

Figure 2. Correlations between seed weight and leaf nutrient concentrations in bean

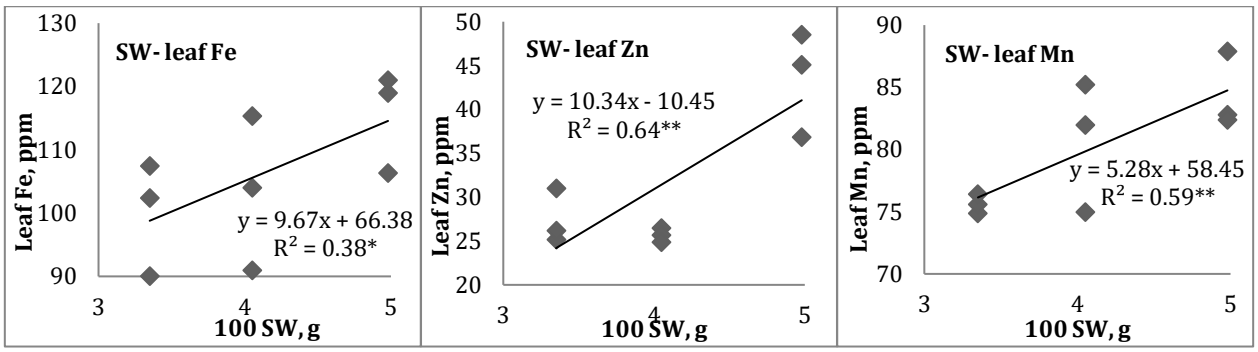

Figure 3. Correlations between seed weights and leaf nutrient concentrations in wheat

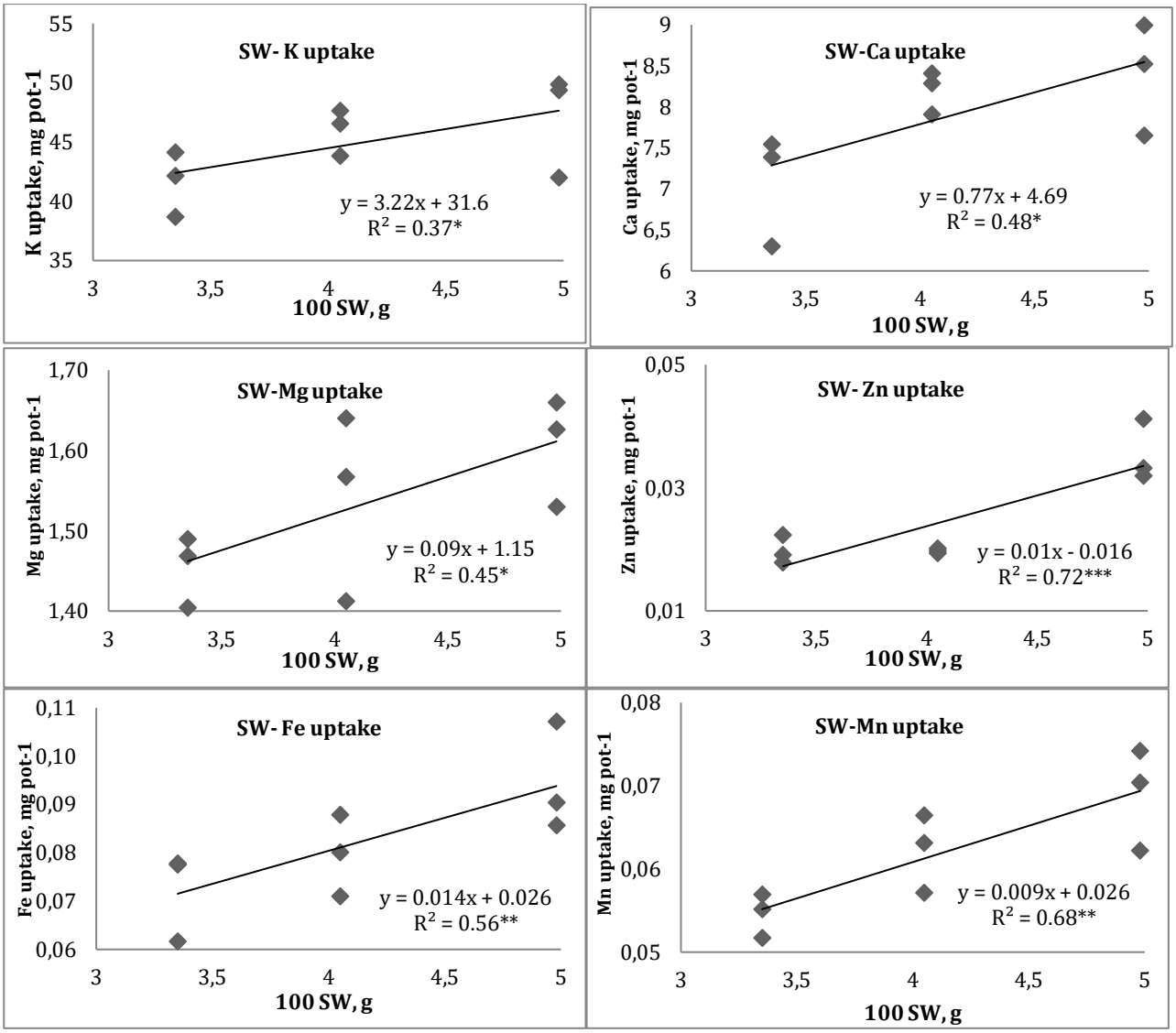

Figure 4. Correlations between seed weight and nutrient uptakes by wheat

While there were not significant correlations between seed weight and N and Cu uptake by wheat, there were significant correlations between seed size and other nutrient uptakes (Figure 4). It was seen that there were significant correlations between bean seed weights and all nutrient uptakes (Figure 5).

4. Discussion and Conclusion

In general, Seed weight did not affect seed nutrient concentrations. However nutrient content in seeds affected significantly from seed weights. Also there was not a significant effect of seed weight on leaf nutrient concentrations, but plant nutrient uptakes for both wheat and bean affected significantly from seed weigh. These results can be explained with the higher nutrient content resulting in higher plant growth. Also it may be due to greater root and shoot formation from the higher nutrient containing seeds. Faster root formation and faster growth due to higher energy in large seeds may help this [7]. As indicated in a study, big seeds contain higher

nutrient comparing to smaller seeds. And this improves vegetative growth and plant nutrient uptake from the soil [8]. There is a general agreement that seedlings from bigger seeds have better start in growth due to their larger carbohydrate storage giving higher energy and higher nutrient content [3, 7, 9].

Previous study stated that large seeded plant might adapt easily to nutrient poor soils [9]. Mian and Nafziger [17] postulated that size is an important parameter for vigor and faster growth for seeds. Also large seeds produce healthy and improved plant growth comparing to small seeds [18, 19]. Although leaf nutrient concentrations did not increase generally, nutrient uptake increase by both plants are related to higher dry matter production from heavier seeds. And also plants growing from the heavier seeds produce more biomass and these plants uptaked more nutrients from the soils. Therefore using heavier seeds can potentially be used for overcoming nutritional problems of the plants especially under nutrient deficient conditions.

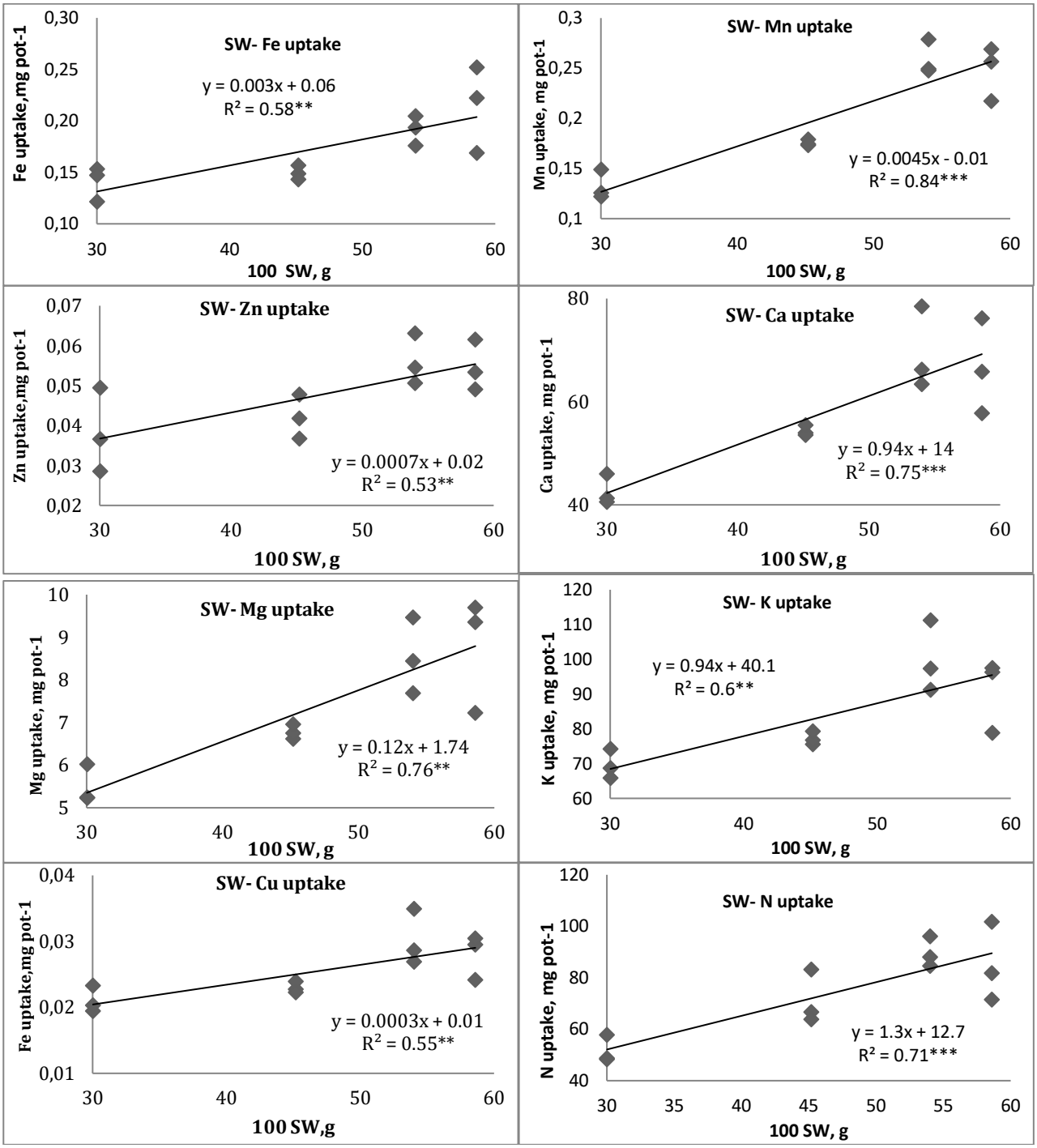

Figure 5. Correlations between seed weight and nutrient uptakes by bean

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