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Enhancing productivity and nutritional quality of groundnut (*Arachis hypogaea* L.) through foliar nutrition

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Abstract

The field experiment was conducted during kharif to study "Foliar nutrition in groundnut (*Arachis hypogaea* L.) At under rainfed situation. The experiment was laid out in a Randomized Complete Block Design with three replications and ten foliar treatments of major nutrients.Among the various foliar treatments net returns (₹. 108730 ha^{-1}) and B: C ratios (4.12) were the higher in foliar spray of 2.0% urea + DAP + MOP combination at 45 DAS followed by foliar spray of 19:19:19 (₹. 108095ha^{-1} and 4.12, respectively). Similarly, yield parameters and yield such as 100 pod weight (117.65 g), total number of pods plant^{-1} (28.37), 100 kernel weight (42.19 g), pod yield (3746 kg ha^{-1}), kernel yield (2905 kg ha^{-1}), haulm yield (4253 kg ha^{-1}) and harvest index (0.36) were also higher in foliar spray of 2.0% urea + DAP + MOP.Oil content (46.73%), protein content (27.65), oil yield (1356kg ha^{-1}) and nutrient uptake (209.66 kg N, 32.25 kg P_2O_5, and 357.95 kg K_2O) were significantly higher in foliar treatment compared to control.

Keywords: Economics, foliar spray groundnut, major nutrients, nutrition

Introduction

Among oilseed crops groundnut is an important crop grown in tropical and sub-tropical regions in the world for vegetable oil. It is the most versatile legume because of drought tolerant characters, soil restoring properties, weeds smothering, and multi-purpose confectionary and dilatory uses. As a legume oil yielding crop, it fits well into most of the cropping systems. Commercially, groundnut is the world's fourth most important sources of edible oil and third most important sources of vegetable protein. The groundnut crop is grown over an area of 26.62 million ha spread over 84 countries with an annual production of 35.66 million tonnes of pods with a productivity of 1348 kg ha$^{-1.}$ In India, it is being grown in 11 states in an area of 4.19 million ha with a production of 5.62 million tonnes of pods per annum. The average productivity of groundnut in India (1341 kg ha^{-1}) can be comparable to world average (Anon., 2013).

The low groundnut productivity in Karnataka could be attributed to several production constraints, which include poor and imbalanced nutrition and cultivation in marginal lands. Therefore, it is most essential to pay a great attention to the nutrition of groundnut to enhance its productivity. Among the agro-techniques of groundnut production, appropriate nutrient management practices appear to be more important in rainfed situation because of low nutrient use efficiency. Selection of proper crop nutrition practice through both soil and foliar feeding is the need of present agriculture.

The ability of plant leaves to absorb water and nutrients was recognized approximately three centuries ago. Moreover, foliar feeding practice would be more useful in exhaustive crop like groundnut. Foliar nutrition reduces the amount of fertilizer thereby reducing the fertilizer loss and also economizing crop production. Crop nutrition through foliar feeding at particular stage may improve the crop growth and seed yield of legumes without involving root absorption at critical stages (Latha and Nadanasababady, 2003) [11].

Among the macronutrients, nitrogen is a major structural component of the plant cell. It plays an important role in plant metabolism and is involved in synthesis of proteins, amino acids and nucleic acids. Phosphorus is essential for the formation of protoplasm, cell division, development of meristematic tissues and also hastens nodule formation. Potassium plays an important role in enzyme activation, provides turgidity to plants, translocation of assimilates, photosynthates, proteins, starch synthesis besides improving the quality of the produce. Groundnut being a leguminous crop, it fixes (42 kg N ha^{-1}year^{-1}) substantial quantity of atmospheric nitrogen (Patel *et al.*, 1993).

Phosphorus requirement of groundnut is more compared to nitrogen and potassium. Usually phosphorus requirement is high at initial stages particularly for root development.

The loose friable sandy soils are said to be ideal for groundnut production, wherein applied nitrogenous fertilizer is subjected to leaching losses along with other basic cations. Groundnut is popularly known as unpredictable legume as its productivity largely depends on soil physical properties. Since the pods are produced below the ground (positively geotropic) and difficult to predict its performance before harvest as in the case of other crops. Further, groundnut is highly influenced by environment. Among the agro-techniques followed in rainfed crop like groundnut nutrition aspect play a greater role to decide the total productivity, because basal application of major nutrients through soil may not meet the nutrient demand by the crop at later stages of the crop like flowering and pod development? Hence, to encourage the improve development of sound reproductive parameters like flowers, pegs and pods there is a need for sufficient supply of mineral nutrition at reproductive stage. Bulk of the applied P fertilizer is fixed and is rendered unavailable to plants. The studies involving P isotopes indicated that only 2 to 10 per cent of the soil applied phosphorus can be recovered in plants (Lakshmi Narayan *et al.*, 1979) while the rest is subjected to fixation. Because of these reactions, the use efficiency of soil applied fertilizers is low and soil application of nutrients may not produce desirable yields. Under these situations foliar application seems to be promising for ensuring better use efficiency of applied nutrients. Foliar spray enables plant to absorb the applied nutrients from the solution through their leaf surface and thus, may result in efficient use of fertilizer.

Foliar nutrition is an effective method for correcting deficiencies and overcoming the soil's inability to transfer nutrients to the plant. Availability of essential nutrients and trace minerals from the soil may be limited at times by root distribution, soil temperature, soil moisture, nutrient imbalances and other factors. Foliar nutrition can help to maintain a nutrient balance within the plant, which may not occur strictly with soil uptake (Meena *et al.*, 2007) [13]. The effectiveness of foliar applied nutrients is determined by the type of formulation and the time of application. Yield increase to an extent of 5-10 per cent (Sona wane *et al.*, 2010) can be achieved by using the right product at the right time. Foliar nutrition is 8-10 times more effective than soil application. Foliar spray stimulates an increase in chlorophyll production, cellular activity and respiration. It also triggers a plant response to increased water and nutrient uptake from the soil (Veer Amani *et al.*, 2012) [20].

Hence, it is feasible, economically viable and environment friendly approach of nutrient management and a need was felt to optimize the foliar application of all macro nutrients along with recommended doses of nutrient application through soil for nutritionally hungered soils of groundnut belt of Karnataka.

Material and Methods

Field experiment was conducted at Main Agricultural Research Station, Dharwad and at Krishi Vigyan Kendra, Mattikoppa during *Kharif* 2013. The soil was texturally clay, neutral in pH, non saline (0.61 dSm^{-1}), medium in organic carbon (0.73%), low in available nitrogen (213.8 kg N ha^{-1}), medium in available phosphorus (34.22 kg P_2O_5 ha^{-1}) and high in available potassium (391.30 kg K_2O ha^{-1}). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and ten foliar treatments of major nutrients*viz*., foliar sprays of 1.5% Urea, 2.0% Urea, 1.5% DAP, 2.0% DAP, 1.5% MOP, 2% MOP, 1.5% Urea: DAP: MOP (0.5% of each), 2.0% Urea: DAP: MOP (0.7% of each), 0.5% 19 All (19:19:19 N:P_2O_5:K_2O) and control with genotype TAG-24was used in the study. Recommended fertilizers (25:75:25 kg N: P_2O_5:K_2O) were applied in the form of Urea, DAP and MOP as basal at the time of sowing. Zinc sulphate @ 25 kg ha^{-1} and ferrous sulphate @ 25 kg ha^{-1} were applied to soil along with FYM @ 7.5 t ha^{-1} before sowing. Gypsum @ 500 kg ha^{-1} was applied to root zone of groundnut at 40 DAS through last intercultivation. Five plants from net plot area were randomly selected and observations on growth and yield parameters were recorded at 30, 60, 90 DAS (days after sowing) and at harvest. At harvest, yield and its components such as 100 pod weight, 100 kernel weight, and number of pods plant^{-1}, pod yield, kernel yield and haulm yield were determined at maturity stage. From each net plot produce, 200 g of clean pods were weighed and kernels were obtained after shelling. Shelling per cent was worked out by dividing kernel weight by pod weight and expressed in percentage. Seed oil content (%) was determined by nuclear magnetic resonance (NMR) spectrometer against a standard reference sample (A.O.A.C., 1975).

Nitrogen content of kernel on dry weight basis was estimated by modified Microkjeldhal method (Banerjee, 1978). Crude protein content was calculated by using formula and expressed in percentage.

$$CP\ (\%) = \%\ N \times 6.25$$

For analysis of N, P and K in crop and estimation of their uptake, plant samples were collected at harvest, oven dried and grind in a Wiley mill to pass through 2 mm sieve. The sieved sample was used for the estimation of nitrogen, phosphorus and potassium content in plant.

Total nitrogen on the dry weight basis at harvest of groundnut (haulm and pod) was estimated by micro Kjeldhal's method. Total phosphorus on the dry weight basis at harvest of groundnut (haulm and pod) was estimated by Van ado molybdate-phosphoric acid yellow colour method. Total potassium on the dry weight basis at harvest of groundnut (haulm and pod) was estimated by Flame photometer method.

Market price of inputs that were prevailing at the time of their use was considered for working out of cost of cultivation. The gross return was calculated on the basis of market price of the produce at the time when the produce was ready for sale.

Results and Discussion

Significant differences were observed in pod yield of groundnut as a consequence of foliar feeding of major nutrients. The maximum dry pod yield was observed in the foliar spray of 2.0% urea + DAP + MOP combination (T_8: 3746kg ha^{-1}) and was higher to an extent of 16.28% compared to control (T_{10}: 3136 kg ha^{-1}). However, it was on par with all other treatments (3447 to 3723 kg ha^{-1}) except foliar spray of 1.5% MOP (T_5: 3337 kg ha^{-1}).The present results are in close proximity with the findings of Veerabhadrappa (2003) and Chandrasekaran *et al.* (2008) [5].They reported that foliar application of major nutrients recorded significantly higher pod yields especially when groundnut grown under rainfed condition. There was significant correlation between nutrient uptake and pod yield. The flowering in groundnut started 35-45 DAS and followed by peg initiation 10-12 days after flowering (Bewali *et al.*, 1980). Therefore, crop needs greater quantity of major nutrients to meet the demand of developing pods. Spraying of DAP helped in quick absorption of nitrogen and phosphorus, at the time of reproductive stage where the nutrient demand is at the peak due to in determinate growth habit of the crop. Hence, it reduces the flower drop and ultimately enhanced the pegging and pod development. These results are in conformity with the findings of Chandrasekaran (2004) [4] and Dalei *et al.* (2014) [8].

In addition, foliar feeding of major nutrients especially N resulted in development and maintenance of more chlorophyll and photosynthetic area in terms of higher leaf area and leaf area index which resulted in higher photosynthesis. In addition, foliar feeding of K helps in higher translocation of photosynthates from leaves to the developing pods and resulted in more pod to gynophores ratio. These two factor combined together increased the photosynthates trasnslocated to developing pods and resulted in development of sound and mature kernels and hence the foliar spray of 2.0% Urea + DAP+ MOP combination recorded significantly higher kernel yield (T_8: 2905kg ha^{-1}) compared to control (2339 kg ha^{-1}), foliar spray of 1.5% urea (2636 kg ha^{-1}), 2% MOP (2607 kg ha^{-1}) and foliar spray of 1.5% MOP (2516 kg ha^{-1}). While remaining foliar treatments were produce on par kernel yield to foliar spray of 2.0% Urea + DAP+ MOP. Similar observations were made by Polara *et al.* (1991) and Balasubramanian and Palaniappan (1996) [2]. The variation in pod yield of groundnut could be traced back to variations in yield parameters. The pod yield is governed by a number of factors having direct or indirect influence. The main factors which have direct bearing on pod yield are total number of pods plant^{-1}, 100 pod weight, 100 kernel weights and shelling percentage.

Among the yield components, 100 pod weight g plant^{-1} was more closely associated with the dry pod yield ha^{-1}. Foliar spray of 2.0% urea + DAP + MOP combination produced higher number of pods plant^{-1} (28.37) which was 15.54% more than control (23.96), while it was on par with foliar spray of 19:19:19 (T_9: 28.15) and 1.5% urea + DAP + MOP (28.00). Significant positive correlation between yields attributes and pod yield was observed. The increased number of pods per plant was mainly attributed to increased pod to gynophore ratio because of supply of required demand of photosynthates to developing pods and hence sustains the more number of pods per plant. The similar observations were made by Naveen Kumar (2012), observed that basal application of NPK along with foliar spray of urea at 45 DAS recorded improvement in yield components such as number of pods plant^{-1}, pod dry weight, 100 pod weight and higher 100 kernel weight. However, all foliar spray treatments were on par with each other except 1.5% foliar spray of MOP. Application of recommended dose of fertilizers along with foliar application of nutrients at critical stages boosted the growth and yield components in foliar spray treatments (Chandrashekharan, 2004).

Similarly, 100 kernel weight (42.19 g) was higher in foliar spray of 2.0% urea + DAP + MOP combination and were higher to an extent of 20.76% over control. However, it was on par with foliar spray of 19:19:19 (T_9: 40.58 g), 1.5% urea + DAP + MOP (T_7: 40.56 g), 2% DAP (T_4: 40.25 g), 2% urea (T_2: 39.75 g) and 1.5% DAP (T_3: 38.81g) (Table 2). Improved 100 kernel weight under above foliar treatments was mainly because of increased translocation of photosynthates from leaves and stem to developing pods resulted in sound mature pods and bolder seeds. Also it was evident from the data on leaf area duration that these foliar feeding treatments maintain leaf area for longer duration resulted in extended period of photosynthates translocated to developing seeds and hence recorded bolder and well-shaped seeds. Similar differences with respect to yield components were also reported earlier by Subrahmaniyan *et al.* (2000) [18] and Chandrasekaran (2004) [4].

Pod weight plant^{-1} was greatly influenced by dry matter accumulation in pods. The higher number of pods plant^{-1} was due to the fulfillment of the demand of the crop by higher assimilation and translocation of photosynthates from source to sink. In addition foliar feeding of major nutrients especially phosphorous resulted in development of sound pod wall and as a consequence, significantly higher pod weight per plant and increased seed filling capacity. Similar influence of phosphorus on pod development and its filling capacity was reported by Charan and Karla (1983) [6-7] and Shashikumar *et al.* (2013) [16].

Groundnut is being an oilseed crop grown for oil extraction. Although oil content in groundnut kernels was a genetic factor but, was also greatly influenced by environment and management practices. Foliar spray of 2.0% urea + DAP + MOP combination at 45 DAS recorded higher seed oil content (46.73%) compared to control (44.18%). However, it was on par with all foliar spray treatments except 1.5% MOP. As a consequence of increased oil seed content in above foliar spray treatments significantly higher oil yield per hectare was recorded. This increased oil content and oil yield in foliar treatments were due to increased availability and use of phosphorous. It was a major constituent of fatty acids; higher accumulation of phosphorus might have resulted in higher seed oil content. Hence, availability of phosphorous through foliar feeding resulted in higher kernel oil content and in turn higher yield per hectare. Higher oil yield per hectare might also be due to higher kernel yield. The results of present investigation are in confirmity with the findings of Krishnappa *et al.* (1994) [10], Shinde *et al.* (2001) [17] and Manasa (2013) [12].

Nitrogen, phosphorus and potassium uptake was significantly higher with foliar application of 2.0% urea + DAP + MOP combination (T_8: 218.36, 34.25 and 132.65 kg N, P_2O_5 and K_2O, respectively) and it was 10.74%, 19.15 and 26.7% higher compared to control (171.11, 27.69 and 97.11 kg NPK ha^{-1} respectively). However, foliar spray of 19:19:19, 1.5% urea + DAP + MOP, 2% DAP and 2% urea treatments were on par with T_8 with respect to nitrogen uptake. Whereas, phosphorus and potassium uptake in all foliar treatments were on par except 1.5% MOP. The higher uptake of N, P and K was due to increased application of urea, DAP and MOP through foliar spray leading to higher production of nodules plant^{-1}which resulted in higher biological nitrogen fixation and absorption of nutrients from the soil. The nitrogen concentration in leaves decreased during pod development stage and at harvest as the symbiotic nitrogen fixation is known to decline after flowering and indicating its withdrawal for pod filling. These results are in accordance with the findings of Sathyanarayana and Krishna Rao (1962) [15] who also reported in the groundnut a higher concentration of nutrients at the start of flowering (3.23% N, 0.49% P_2O_5 and 1.8% K) tend to decrease with advancement of age of the crop. In groundnut at 45 and 60 DAS coincides with pegging and pod development stages wherein nutrient requirement of the crop is higher. The accumulation of phosphorus was more because of foliar application of major nutrients which leads to increased absorption of nutrients. The greater mobilization of phosphorus in the presence of nitrogen may also be a reason for higher uptake of P as reported by Hocking and Pinkerton (1993) [9] and Manasa (2013) [12].

The acceptance of any generated technology is ultimately based on the cost of cultivation involved and net returns. In the present investigation, cost of cultivation was higher (₹. 34930 ha^{-1}) for the foliar spray of 2.0% DAP followed by 1.5% DAP (T_3:₹.34848).The control (T_{10}) recorded lower cost of cultivation (₹. 34352 ha^{-1}). Further foliar spray of 2.0% urea + DAP + MOP combination (T_8) recorded higher gross returns (₹.143548 ha^{-1}) as well as net returns (₹.108730 ha^{-1}). The B: C ratio was also higher (4.12) in foliar spray of 2.0% urea + DAP + MOP combination (T_8) and foliar spray of 19:19:19 (T_9). The control treatment recorded lower gross returns (₹.120381ha^{-1}) and net returns (₹.86029 ha^{-1}). Whereas, the lowest B: C ratio (3.50) was observed in control (T_{10}). All treatments receiving foliar sprays of more than one nutrient (2.0% urea + DAP + MOP) recorded higher gross returns, net returns, B: C ratio compared to control (T_{10}) and 1.5% MOP (T_5). Similar observations were recorded by Naveen Kumar (2012) and Manasa (2013) [12].

Table 1: Economics of groundnut cultivation as influenced by foliar spray of major nutrients

Treatment	Cost of cultivation (₹. ha^{-1})	Gross return (₹. ha^{-1})	Net returns (₹. ha^{-1})	B:C ratio
T_1 - Foliar spray of 1.5% urea	34650	133529	98879	3.85
T_2 - Foliar spray of 2.0% urea	34669	139229	104560	4.02
T_3 - Foliar spray of 1.5% DAP	34848	135751	100903	3.90
T_4 - Foliar spray of 2.0% DAP	34930	141106	106176	4.04
T_5 - Foliar spray of 1.5% MOP	34768	128019	93251	3.68
T_6 - Foliar spray of 2% MOP	34825	132199	97374	3.80
T_7 - Foliar spray of 1.5% urea: DAP: MOP (0.5% of each)	34754	141483	106729	4.07
T_8 - Foliar spray of 2.0% urea: DAP: MOP (0.7% of each)	34818	143548	108730	4.12
T_9 - 0.5% foliar spray of 19:19:19 N: P_2O_5:K_2O	34592	142687	108095	4.12
T_{10} – Control	34352	120381	86029	3.50
S. Em ±	-	3955	3955	0.11
CD (5%)	-	11751	11751	0.34

Table 2: Nutrient concentration (%) and nutrients uptake (kg ha^{-1}) in groundnut at harvest as influenced by foliar spray of major nutrients

Treatment	Nutrient concentration (%)			Nitrogen (kg N ha^{-1})	Phosphorus (kg P_2O_5 ha^{-1})	Potassium (kg K_2O ha^{-1})
	N	P	K			
T_1 - Foliar spray of 1.5% urea	2.54	0.42	1.53	190.28	31.43	114.60
T_2 - Foliar spray of 2.0% urea	2.56	0.39	1.57	198.05	31.98	121.58
T_3 - Foliar spray of 1.5% DAP	2.52	0.42	1.55	190.58	31.64	117.56
T_4 - Foliar spray of 2.0% DAP	2.66	0.41	1.56	208.66	32.16	122.33
T_5 - Foliar spray of 1.5% MOP	2.51	0.40	1.46	179.19	30.92	104.97
T_6 - Foliar spray of 2% MOP	2.53	0.42	1.49	188.14	31.35	110.19
T_7 - Foliar spray of 1.5% urea: DAP: MOP (0.5% of each)	2.59	0.41	1.60	204.18	32.41	125.89
T_8 - Foliar spray of 2.0% urea: DAP: MOP (0.7% of each)	2.73	0.43	1.66	218.36	34.25	132.65
T_9 - 0.5% foliar spray of 19:19:19 N: P_2O_5: K_2O	2.61	0.42	1.62	207.71	33.13	128.96
T_{10} – Control	2.50	0.40	1.42	171.11	27.69	97.11
S. Em ±	0.05	0.01	0.04	8.15	0.98	2.71
CD (5%)	0.14	NS	0.12	24.22	2.92	8.05

Table 3: Seed oil content (%), protein content (%) and oil yield (kg ha^{-1}) of groundnut as influenced by foliar spray of major nutrients

Treatment	Oil content (%)	Protein content (%)	Oil yield(kg ha^{-1})
T_1 - Foliar spray of 1.5% urea	45.64	25.59	1204
T_2 - Foliar spray of 2.0% urea	46.60	26.02	1295
T_3 - Foliar spray of 1.5% DAP	46.50	25.90	1264
T_4 - Foliar spray of 2.0% DAP	46.63	26.37	1322
T_5 - Foliar spray of 1.5% MOP	45.07	25.01	1133
T_6 - Foliar spray of 2% MOP	45.91	25.37	1199
T_7 - Foliar spray of 1.5% urea: DAP: MOP (0.5% of each)	46.27	26.83	1313
T_8 - Foliar spray of 2.0% urea: DAP: MOP (0.7% of each)	46.73	27.65	1356
T_9 - 0.5% foliar spray of 19:19:19 N: P_2O_5: K_2O	46.40	27.14	1327
T_{10} – Control	44.18	23.26	1032
S. Em ±	0.52	0.79	31.15
CD (5%)	1.55	2.34	92.56

Table 4: Number of pods plant^{-1}, 100 pod weight (g), shelling (%) and 100 kernel weight (g) of groundnut as influenced by foliar spray of major nutrients

Treatment	Number of pods plant^{-1}	100 pod weight (g)	Shelling (%)	100 kernel weight (g)
T_1 - Foliar spray of 1.5% urea	26.2	108.21	75.7	37.68
T_2 - Foliar spray of 2.0% urea	27.3	108.41	76.6	39.75
T_3 - Foliar spray of 1.5% DAP	26.9	109.26	76.6	38.81
T_4 - Foliar spray of 2.0% DAP	27.6	110.67	77.1	40.25
T_5 - Foliar spray of 1.5% MOP	25.9	103.44	75.3	35.96
T_6 - Foliar spray of 2% MOP	26.5	104.61	75.6	37.26

T_7 - Foliar spray of 1.5% urea: DAP: MOP (0.5% of each)	28.0	114.10	77.0	40.56
T_8 - Foliar spray of 2.0% urea: DAP: MOP (0.7% of each)	28.3	117.65	77.4	42.19
T_9 - 0.5% foliar spray of 19:19:19 N: P_2O_5: K_2O	28.1	115.52	76.8	40.58
T_{10} – Control	23.9	102.20	74.5	33.43
S. Em ±	0.76	3.30	1.07	1.24
CD (5%)	2.25	9.81	NS	3.68

NS = Non significant

Table 5: Dry pod yield (kg ha^{-1}), kernel yield (kg ha^{-1}), haulm yield (kg ha^{-1}) and harvest index of groundnut as influenced by foliar spray of major nutrients

Treatment	**Dry pod yield(kg ha^{-1})**	**Kernel yield (kg ha^{-1})**	**Haulm yield (kg ha^{-1})**	**Harvestindex (HI)**
T_1 - Foliar spray of 1.5% urea	3482	2636	3998	0.36
T_2 - Foliar spray of 2.0% urea	3632	2781	4096	0.36
T_3 - Foliar spray of 1.5% DAP	3541	2715	4030	0.36
T_4 - Foliar spray of 2.0% DAP	3682	2839	4177	0.36
T_5 - Foliar spray of 1.5% MOP	3337	2516	3816	0.34
T_6 - Foliar spray of 2% MOP	3447	2607	3988	0.35
T_7 - Foliar spray of 1.5% urea: DAP: MOP (0.5% of each)	3692	2838	4196	0.36
T_8 - Foliar spray of 2.0% urea: DAP: MOP (0.7% of each)	3746	2905	4253	0.36
T_9 - 0.5% foliar spray of 19:19:19 N: P_2O_5: K_2O	3723	2862	4223	0.36
T_{10} – Control	3136	2339	3718	0.34
S. Em ±	104	72	90	0.008
CD (5%)	309	214	268	NS

NS = Non significant

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