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MORPHO-PHYSIOLOGICAL TRAITS AND YIELD IN CHICKPEA AS INFLUENCED BY FOLIAR APPLICATION OF ASCORBIC ACID AND ZINC SULPHATE

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ABSTRACT

Field trial with chickpea (*Cicer arietinum* L.) was conducted at farm of Botany section, College of Agriculture, Nagpur during the *rabi* season of 2018-2019. The experimental design was randomized block design, consisting of ten treatments with three replications. The aim of this work was to study the effect of foliar application of ascorbic acid at 100, 200, 300 and 400 ppm and zinc sulphate at 0.5 % as well as their combine effect on morpho-physiological attributes and yield in chickpea. The foliar sprays at 25 and 40 DAS showed significant changes in all the growth parameters i.e. plant height, leaf area, dry matter, number of secondary branches, RGR, NAR, seed yield ha^{-1}and harvest index. Application of 200 ppm ascorbic acid + 0.5 % $ZnSO_4$ gave significantly higher results in all parameters studied. Also, by considering B:C ratio treatment T_8 (200 ppm ascorbic acid + 0.5 % $ZnSO_4$) was found superior having B:C ratio of 2.78 compared to 2.36 in control

(Key words: Chickpea, ascorbic acid, zinc sulphate, foliar application, morpho-physiological parameters, yield)

INTRODUCTION

Chickpea is a self-pollinated annual crop that can complete its life cycle in 90 to 120 days depending on the prevailing meteorological condition. It is a winter season crop but severe cold and frost are injurious to it. Excessive rains soon after sowing or at the flowering and fruiting or hailstorms at the ripening stage cause heavy loss. It is best suited to areas having moderate rainfall of 60-90 cm annum^{-1}. It is said to be one of the oldest pulses known and cultivated from ancient times both in Asia and in Europe. It's probable place of origin lies in south western Asia, which is lying to the north-west of India such as Afganistan and Persia.

Ascorbic acid is a naturally occurring organic compound with antioxidant properties. It was synthesized in higher plants and considered an important antioxidant.

It is the most abundant antioxidant currently considered to be a regulator on cell division and differentiation, photoprotection and regulation of photosynthesis and growth, played an important role as co-enzymatic reaction in the electron transport system and metabolism. It is considered essential for plant's growth. This vitamin helps in plant growth and development when applied exogenously. Plants cannot mature without vitamin C.

Zinc is involved in most of the plant growth functions. Zinc helps to produce auxins and is a growth promoting substance that controls the development of the shoot. Zinc also forms enzyme systems, which regulate plant life. Zinc take over 16 different roles in crops, such as formation, partitioning and utilization of photosynthesis assimilates. As a matter of fact, the importance of zinc as a foliar application is given to crop immediately. Zinc plays a special role in synthesizing proteins, RNA and DNA (Kobraee *et al.,* 2011).The foliar application of zinc @ 0.1 per cent had a positive impact on reproductive structures development, number of pods plant^{-1}, number of seeds pod^{-1}, seed size and weight and seed yield in zinc deficient blackgram plants (Nalini *et al.,* 2013). Yashana *et al.* (2018) reported that combined application of zinc with organic manures and foliar applications proved more beneficial among any sole mode of application with respect to increment in plant growth, yield and produce quality of pulses.

MATERIALS AND METHODS

A field experiment was conducted at farm of Botany section, College of Agriculture, Nagpur in a Randomized Block Design with ten treatments and three replications. Treatments consists of T_1- Control, T_2- Foliar application

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of zinc sulphate @ 0.5 per cent, T_3- ascorbic acid @ 100 ppm, T_4- ascorbic acid @ 200 ppm, T_5- ascorbic acid @ 300 ppm, T_6- ascorbic acid @ 400 ppm, T_7- zinc sulphate @ 0.5 per cent + ascorbic acid @ 100 ppm, T_8- zinc sulphate @ 0.5 per cent + ascorbic acid @ 200 ppm, T_9- zinc sulphate @ 0.5 per cent + ascorbic acid @ 300 ppm and T_{10}-zinc sulphate @ 0.5 per cent + ascorbic acid @ 400 ppm. The gross plot size was 2.20 m × 3.00 m and net 2.00 m × 2.40 m with spacing of 30 cm x 10 cm. Two foliar sprays of ascorbic acid and zinc sulphate were given at 25 and 40 DAS. Five plants from each plot were selected randomly and data were collected at 25, 45, 65 and 85 DAS on plant height, number of branches, leaf area plant^{-1}, total dry matter production of plant. RGR and NAR were calculated at 25-45, 45-65 and 65-85 DAS. Seed yield ha^{-1} was recorded after harvest. Harvest index, per cent increase and B:C ratio were also calculated.Data were analysed by statistical method suggested by Panse and Sukhatme (1954).

RESULTS AND DISCUSSION

Plant height

At 85 DAS significantly highest plant height was registered in treatment T_8 (0.5 % zinc + 200 ppm ascorbic acid) followed by treatments T_9 (0.5 % zinc + 300 ppm ascorbic acid), T_{10} (0.5 % zinc + 400 ppm ascorbic acid), T_7 (0.5 % zinc + 100 ppm ascorbic acid) and T_4 (200 ppm ascorbic acid) when compared with treatment T_1 (control).

Zinc helps in production of auxin which regulate the growth hormone and enhanced plant growth resulted in increase in plant height. Ascorbic acid have an essential role in several physiological processes in plants including the regulation of growth, differentiation and metabolism (Horemans *et al*. 2000). These might be the reasons in increase in plant height by the application of ascorbic acid and zinc in the present study.

The above results are in close agreement with those of Gul *et al*. (2011). They revealed that maximum plant height of wheat was recorded in those plots which were sprayed with 0.5% N + 0.5% K + 0.5% Zn solution two times, while minimum plant height was recorded in control plots. This might be due to foliar application of N, K and Zn solution to increase the stem length at boot stage which in turn resulted in maximum plant height. Gad *et al*. (2012) reported that foliar spray of ascorbic acid at 200 ppm concentration produced the highest values of plant height in pea.

Leaf area plant^{-1}

Leaf area fairly gives good idea of the photosynthetic capacity of the plant. Leaf area depends upon the number and size of leaves. Leaves play an important role in the absorption of light radiations and using it in photosynthetic process. Leaf size is influenced by light, moisture and nutrients. Hence, yield depends on leaf area of crop.

At 45 DAS significantly higher leaf area was recorded in treatments T_8 (0.5 % zinc + 200 ppm ascorbic acid) , T_9 (0.5 % zinc + 300 ppm ascorbic acid), T_{10} (0.5 % zinc + 400 ppm ascorbic acid), T_7 (0.5 % zinc + 100 ppm ascorbic acid), T_4 (200 ppm ascorbic acid), T_2 (0.5 % zinc), T_5 (300 ppm ascorbic acid) and T_6 (400 ppm ascorbic acid) when compared with treatment T_1 (control). At 65 DAS significantly maximum leaf area was measured in treatments T_8 (0.5 % zinc + 200 ppm ascorbic acid), T_9 (0.5 % zinc + 300 ppm ascorbic acid), T_{10} (0.5 % zinc + 400 ppm ascorbic acid) and T_7 (0.5 % zinc + 100 ppm ascorbic acid) over T_1 (control). At 85 DAS treatments T_8 (0.5 % zinc + 200 ppm ascorbic acid), T_9 (0.5 % zinc + 300 ppm ascorbic acid), T_{10} (0.5 % zinc + 400 ppm ascorbic acid) and T_7 (0.5 % zinc + 100 ppm ascorbic acid) showed their superiority and enhanced leaf area significantly over control.Similarly, treatments T_4 (200 ppm ascorbic acid), T_2 (0.5 % zinc), T_5 (300 ppm ascorbic acid) and T_6 (400 ppm ascorbic acid) also increased leaf area significantly over control and rest of the treatments under study.

Hence, it can be inferred that when nutrients and vitamins are applied through foliar spray, they might have accelerated the metabolic and physiological activities of plant and put up more growth by assimilating more amount of major nutrients and ultimately increased leaf area of plant. This might be the reason for increase in leaf area by the application of zinc and ascorbic acid in the present study.

Hussein and Alva (2014) recorded that foliar application of ascorbic acid at 150 ppm and 200 ppm significantly increased leaf area in millet plants as compared to those of the plants which were sprayed with tap water. Purushottam *et al.* (2018) found that the leaf area index of chickpea was significantly influenced by spraying of zinc @ 0.5 %. At 70 DAS leaf area index of chickpea plants with foliar spray of 0.5 % zinc sulphate was significantly higher than that of other treatments.

Dry weight plant^{-1}

At 45 DAS significantly highest dry weight was found in treatments T_8 (0.5 % zinc + 200 ppm ascorbic acid) and T_9 (0.5 % zinc + 300 ppm ascorbic acid) over control.Similarly, treatments T_{10} (0.5 % zinc + 400 ppm ascorbic acid), T_7 (0.5 % zinc + 100 ppm ascorbic acid) and T_4 (200 ppm ascorbic acid) were significantly superior over treatment T_1 (control) and rest of the treatments. At 65 DAS among all treatments T_8 (0.5 % zinc + 200 ppm ascorbic acid), T_9 (0.5 % zinc + 300 ppm ascorbic acid) and T_{10} (0.5 % zinc + 400 ppm ascorbic acid) were found highly significant over control.Whereas treatments T_7 (0.5 % zinc + 100 ppm ascorbic acid), T_4 (200 ppm ascorbic acid) and T_2 (0.5 % zinc) were significantly superior over treatment T_1 (control) and rest of the treatments in dry matter production. At 85 DAS the highest dry matter production was recorded by the application of 0.5 % zinc + 200 ppm ascorbic acid and 0.5 % zinc + 300 ppm ascorbic acid when compared with control and rest of the treatments. Similarly, treatments T_{10} (0.5 % zinc + 400 ppm ascorbic acid), T_7 (0.5 % zinc + 100 ppm ascorbic acid), T_4 (200 ppm ascorbic acid) and T_5 (300 ppm ascorbic acid) were also found significantly superior over treatment T_1 (control) and rest of the treatments in dry matter production.

Dry matter production and its partitioning towards reproductive parts is an important attributing character and a basic vegetative phase is essential for the development of the reproductive parts. Although, the .dry matter production in general is an inductive of the efficiency of genotype, the pattern in which it is distributed in different plant parts that do more towards the reproductive parts would give a better understanding of its productivity potential. The application of nutrients and plant growth regulators help in improving the canopy structure and also increase in the productivity through the manipulation of source – sink relationship. These might be the reasons for increase in dry matter production in the present investigation.

Purushottam *et al*. (2018) revealed that treatment I_4 (i.e. irrigation at branching + pre flowering + pod development) and Zn_2 (0.5% zinc sulphate) recorded highest dry matter accumulation (231.33 gm^{-2}) among all the treatments in chickpea. Amin *et al*. (2008) found that ascorbic acid at 100, 200 and 400 mg l^{-1} was more effective than salicylic acid treatments in increasing dry weight of wheat $plants^{-1}$ at milky and softy-dough stages.

Number of secondary branches $plant^{-1}$ at harvest

Number of secondary branches $plant^{-1}$ is one of the important yield attributing character for estimation of the yield of the crop.

At harvest the data recorded about number of secondary branches $plant^{-1}$ was statistically significant. At harvest range of number of secondary branches $plant^{-1}$ recorded was 27.86-32.82. The significantly highest number of secondary branches $plant^{-1}$ was produced in treatment T_8 (0.5 % zinc + 200 ppm ascorbic acid) followed by treatments T_9 (0.5 % zinc + 300 ppm ascorbic acid), T_{10} (0.5 % zinc + 400 ppm ascorbic acid), T_7 (0.5 % zinc + 100 ppm ascorbic acid) and T_4 (200 ppm ascorbic acid) when compared with treatment T_1 (control) and remaining treatments under study.

Positive effect of foliar application of Zn on an enhanced branching in pulses mainly attributed to promotion of bud and branch development by the auxins whereas Zn application ultimately increased the availability of other nutrients and accelerated the translocation of photoassimilates. (Guhey,1999; Barlay and Mcdavid, 1980).

Gad *et al*. (2012) stated that foliar spray of ascorbic acid at 200 ppm produced higher number of branches $plant^{-1}$ in pea plant. Sale *et al*. (2018) observed the highest number of branches (16.83 $plant^{-1}$) in treatment receiving combined application of zinc ($ZnSO_4$ at 0.5% spray), iron ($FeSO_4$ at 0.5% spray) and seed fortification of molybdenum in soybean.

Relative growth rate (RGR)

Relative growth rate (RGR) is a prominent indicator of plant strategy with respect to productivity. RGR is the (exponential) increase in size relative to the size of the plant present at the start of a given time interval. Expressed in this way, growth rates can be compared among species and individuals that differ widely in size. By separate measurement of leaf, stem and root mass as well as LA, good insight into the components underlying growth variation can be obtained in a relatively simple way. These underlying parameters are related to allocation (leaf-mass fraction, the fraction of plant biomass allocated to leaf), leaf morphology and physiology (unit leaf rate, the rate of increase in plant biomass unit-1 LA, a variable closely related to the daily rate of photosynthesis unit-1 LA; also known as net assimilation rate).

At 25-45 DAS all the treatments gave significant variation in respect of RGR when compared with control. Significantly maximum RGR was recorded in treatment T_8 (0.5 % zinc + 200 ppm ascorbic acid) followed by treatment T_9 (0.5 % zinc + 300 ppm ascorbic acid) when compared with treatment T_1 (control) and remaining treatments under study. Treatments T_{10} (0.5 % zinc + 400 ppm ascorbic acid), T_7 (0.5 % zinc + 100 ppm ascorbic acid), T_4 (200 ppm ascorbic acid), T_2 (0.5 % zinc) and T_5 (300 ppm ascorbic acid) also registered significantly more RGR when compared with treatment T_1 (control).At 45-65 DAS significantly maximum RGR value was reached in treatment T_8 (0.5 % zinc + 200 ppm ascorbic acid) followed by treatments T_9 (0.5 % zinc + 300 ppm ascorbic acid), T_{10} (0.5 % zinc + 400 ppm ascorbic acid) and T_7 (0.5 % zinc + 100 ppm ascorbic acid) when compared with treatment T_1 (control) and rest of the treatments. Similarlly, treatments T_4 (200 ppm ascorbic acid), T_2 (0.5 % zinc), T_5 (300 ppm ascorbic acid) and T_6 (400 ppm ascorbic acid) significantly superior over treatment T_1 (control) and rest of the treatments in respect of RGR.At 65-85 DAS significantly highest RGR value was calculated in treatment T_8 (0.5 % zinc + 200 ppm ascorbic acid) followed by treatments T_9 (0.5 % zinc + 300 ppm ascorbic acid), T_{10} (0.5 % zinc + 400 ppm ascorbic acid) and T_7(0.5 % zinc + 100 ppm ascorbic acid) when compared with treatment T_1 (control) and rest of the treatments. Also, treatments T_4 (200 ppm ascorbic acid) and T_2 (0.5 % zinc) registered significantly more RGR when compared with treatment T_1 (control).

Net assimilation rate (NAR)

NAR is closely connected with photosynthetic efficiency of leaves, but it is not a pure measure of photosynthesis. NAR depends upon the excess dry matter gained, over the loss in respiration. It is increase in plant dry weight $unit^{-1}$ area of assimilatory tissue $unit^{-1}$ time.

At 25-45 DAS significantly maximum NAR was recorded in treatment T_8 (0.5 % zinc + 200 ppm ascorbic acid) followed by treatment T_9 (0.5 % zinc + 300 ppm ascorbic acid) when compared with treatment T_1 (control) and remaining treatments under study. Treatments T_{10} (0.5 % zinc + 400 ppm ascorbic acid), T_7 (0.5 % zinc + 100 ppm ascorbic acid) and T_4 (200 ppm ascorbic acid) also registered significantly more NAR when compared with treatment T_1 (control).At 45-65 DAS significantly more NAR was registered in treatment T_8 (0.5 % zinc + 200 ppm ascorbic acid) followed by treatments T_9 (0.5 % zinc + 300 ppm ascorbic acid), T_{10}(0.5 % zinc + 400 ppm ascorbic acid), T_7 (0.5 % zinc + 100 ppm ascorbic acid) and T_4 (200 ppm ascorbic acid) when compared with treatment T_1 (control) and remaining treatments under study.At 65-85 DAS significantly highest NAR was calculated in treatment T_8 (0.5 % zinc + 200 ppm ascorbic acid) followed by treatment T_9 (0.5 % zinc + 300 ppm ascorbic acid) when compared with treatment T_1 (control) and remaining treatments under study. Treatments T_{10} (0.5 % zinc + 400 ppm ascorbic acid), T_7 (0.5 % zinc + 100 ppm ascorbic acid), T_4 (200 ppm ascorbic acid) and T_2 (0.5 % zinc) also registered significantly more NAR when compared with treatment T_1 (control).

Seed yield

Seed yield is the economic yield which is final result of physiological activities of plant. Economic yield is the part of biomass that is converted into economic product. (Nichiporovic, 1960).

Source–sink relation contributes to the seed / grain yield. It includes phloem loading at source (leaf) and unloading at sink (seed and fruit) by which the economic part will be getting the assimilates synthesized by photosynthesis. Partitioning of assimilate in the plant during reproductive development is important for flower, fruit and seeds. Thus, crop yield can be increased either by increasing the total dry matter production or by increasing the proportion of economic yield (harvest index) or both (Gardner *et al.,* 1988).

Data regarding seed yield ha^{-1} (q) were significantly maximum in treatments T_8 (0.5 % zinc + 200 ppm ascorbic acid), T_9 (0.5 % zinc + 300 ppm ascorbic acid), T_{10} (0.5 % zinc + 400 ppm ascorbic acid), T_7 (0.5 % zinc + 100 ppm ascorbic acid), T_4 (200 ppm ascorbic acid) and T_2 (0.5 % zinc) over control and rest of the treatments.

Plant growth regulators are known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates thereby helping in effective flower formation, fruit and seed development and ultimately enhance productivity of the crops. Growth regulators can improve the physiological efficiency including photosynthetic ability and enhance the effective partitioning of accumulates from source and sink in the field crops (Solamani *et al*., 2001).

Thomson *et al*. (2017) recorded maximum $plot^{-1}$ yield as well as maximum yield ha^{-1} of garden pea with the application of ascorbic acid 200 ppm.Purushottam *et al.* (2018) tried a field experiment on chickpea (*Cicer arietinum* L.) and observed that irrigation scheduled at branching + pre flowering + pod development combined with spraying of zinc @ 0.5 % showed the significantly higher seed yield (1166 kg ha^{-1}) and stalk yield (1652 kg ha^{-1}) over the control.

Harvest index (HI)

Harvest index (HI) is the genetic character of the crop and varies with cultivar. The harvest index of the crop generally remain unchanged but some crucial management practices make some changes in HI.

Among different treatments significantly maximum harvest index was calculated in treatment T_8 (0.5 % zinc + 200 ppm ascorbic acid) followed by treatments T_9 (0.5 % zinc + 300 ppm ascorbic acid), T_{10} (0.5 % zinc + 400 ppm ascorbic acid), T_7(0.5 % zinc + 100 ppm ascorbic acid), T_4 (200 ppm ascorbic acid) and T_2 (0.5 % zinc) when compared with treatment T_1 (control) and remaining treatments under study. Whereas treatments T_5 (300 ppm ascorbic acid) and T_6 (400 ppm ascorbic acid) also found significantly superior over treatment T_1 (control) and rest of the treatments.

Harvest index is an indication of the rate of assimilates transport from source to sink and it is clear that with increasing the rate of photo-assimilates transport from green leaves to the seeds, the proportion of seed weight to the total biomass will increased.

Zarghamnejad *et al*. (2014) concluded that 200 mg l^{-1} ascorbic acid recorded the highest rate of harvest index in chickpea. Purushottam *et al*. (2018) observed 15-20% higher harvest index of pigeonpea under foliar application of zinc. The harvest index was observed 28.2% in control whereas, it was found 32.3% and 33.8% in the treatment with 0.25% $ZnSO_4$ and 0.50% $ZnSO_4$, respectively.

The highest per cent increase in yield over control was observed in foliar application of 0.5% zinc + 200 ppm ascorbic acid (T_8) i.e. 28.48 % over control (T_1). Considering the B:C ratio foliar application of 0.5% zinc + 200 ppm ascorbic acid was found most effective treatment having B:C ratio of 2.78 as compared to 2.36 in control.

Table 1. Effect of ascorbic acid and zinc sulphate on plant height, numberof secondary branches, leaf area and dry matter production in chickpea

Treatments	Plant height $plant^{-1}$ (cm)	Number of secondary branches $plant^{-1}$ at harvest	Leaf area (dm^2)				Total dry matter production $plant^{-1}$ (g)			
	85 DAS		25 DAS	45 DAS	65 DAS	85 DAS	25 DAS	45 DAS	65 DAS	85 DAS
T_1 (control)	43.33	27.86	0.84	1.10	1.35	1.41	0.87	1.08	2.03	2.55
T_2 (0.5 % zinc)	48.56	31.62	0.85	1.49	1.52	1.90	0.94	1.27	2.65	3.49
T_3 (100 ppm ascorbic acid)	44.18	29.93	0.87	1.15	1.37	1.43	0.88	1.10	2.11	2.71
T_4 (200 ppm ascorbic acid)	49.11	31.73	0.90	1.60	1.65	1.93	1.02	1.48	3.03	4.19
T_5 (300 ppm ascorbic acid)	46.89	30.69	1.02	1.48	1.50	1.88	0.94	1.26	2.6	3.39
T_6 (400 ppm ascorbic acid)	46.67	30.26	1.13	1.47	1.48	1.84	1.03	1.25	2.52	3.29
T_7 (0.5 % zinc + 100 ppm ascorbic acid)	50.01	32.00	0.84	1.61	2.12	2.23	1.01	1.61	3.43	4.82
T_8 (0.5 % zinc + 200 ppm ascorbic acid)	51.44	33.82	1.16	1.72	2.25	2.41	1.06	2.36	4.45	7.50
T_9 (0.5 % zinc + 300 ppm ascorbic acid)	51.20	33.53	1.13	1.71	2.17	2.37	1.04	2.35	4.39	7.31
T_{10} (0.5 % zinc + 400 ppm ascorbic acid)	50.89	32.27	0.90	1.66	2.14	2.29	1.11	1.92	3.87	5.86
SE (m) ±	1.836	1.337	0.116	0.095	0.111	0.124	0.084	0.097	0.194	0.279
CD at 5 %	5.456	3.818	-	0.283	0.332	0.369	-	0.289	0.577	0.829

Table 2.Effect of ascorbic acid and zinc sulphate on RGR, NAR,seed yield hectare^{-1}, B:C ratio and harvest index in chickpea

Treatments	RGR			NAR			Seed yield ha^{-1} (q)	B:C Ratio	Harvest Index (%)
	25-45 DAS	45-65 DAS	65-85 DAS	25-45 DAS	45-65 DAS	65-85 DAS			
T_1 (control)	0.01081	0.03155	0.01140	0.0109	0.0389	0.0188	19.49	2.36	32.12
T_2 (0.5 % zinc)	0.01504	0.03621	0.01434	0.0145	0.0458	0.0255	22.62	2.55	35.69
T_3 (100 ppm ascorbic acid)	0.01116	0.03257	0.01251	0.0110	0.0402	0.0214	20.28	2.42	33.41
T_4 (200 ppm ascorbic acid)	0.01861	0.03697	0.01506	0.0189	0.0477	0.0305	22.86	2.69	36.11
T_5 (300 ppm ascorbic acid)	0.01465	0.03583	0.01365	0.0129	0.0450	0.0241	22.09	2.57	35.28
T_6 (400 ppm ascorbic acid)	0.01372	0.03506	0.01333	0.0116	0.0431	0.0233	21.39	2.46	34.86
T_7 (0.5 % zinc + 100 ppm ascorbic acid)	0.02331	0.03840	0.01643	0.0253	0.0491	0.0310	23.17	2.58	36.55
T_8 (0.5 % zinc + 200 ppm ascorbic acid)	0.03508	0.03960	0.01822	0.0419	0.0530	0.0492	25.04	2.78	37.74
T_9 (0.5 % zinc + 300 ppm ascorbic acid)	0.03402	0.03903	0.01771	0.0414	0.0528	0.0480	24.18	2.63	37.35
T_{10} (0.5 % zinc + 400 ppm ascorbic acid)	0.02695	0.03866	0.01713	0.0322	0.0516	0.0384	23.95	2.58	36.87
SE (m) ±	0.0010	0.0014	0.0009	0.00139	0.00260	0.00193	0.953	-	0.756
CD at 5 %	0.0029	0.0020	0.0026	0.00412	0.00780	0.00572	2.721		2.246

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