Original Research Article

THE EFFECT OF GRANULARKCl FERTILIZER DOSAGE ON K-AVAILABLE,PLANT K-UPTAKE, AND YIELD OF SWEET CORN (*Zea mays saccharata* Sturt.) IN INCEPTISOL FROM JATINANGOR

ABSTRACT

Low fertility in Inceptisols is one of the causes of low sweet corn production in Indonesia. One way to increase soil fertility is by fertilizing using granular KCl fertilizer. This study aimed to determine the effect and the best granular KCl fertilizer dosage in increasing K-available, K-Uptake, and yield of sweet corn (*Zea mays saccharata* Sturt.) Talenta variety on Inceptisols from Jatinangor. The method used was a randomized ~~completely~~complete block design (RCBD) with nine treatments and three replications. The treatment consists of the control treatment (without fertilization); ~~single N, P, K; ¼ K + N, single P; ½ K + N, single P; ¾ K + N, single P; 1 K + N, single P; 1 ¼ K + N, single P; 1 ½ K + N, single P; and 1 ¾ K + N, single P.~~N,P,K Standard;¼ dose KCl Granular + N, P Single;½ dose KCl Granular + N, P Single;¾ dose KCl Granular + N, P Single;1 KCl Granular +N, P Single;1 ¼ KCl Granular + N, P Single;1 ½ KCl Granular + N, P Single;1 ¾ KCl Granular + N, P Single

The results showed that granular KCl fertilizer affected available K, K uptake, and sweet corn yields. The dose of fertilizer that had the best effect on sweet corn yield was a combination of 1 K + N, P single with 100 kg ha^{-1}KCl granules which produced a cob weight of 0.49 kg $plant^{-1}$ on Inceptisol from Jatinangor.

Keywords: Granular KCl Fertilizer, K-available, Plant K-Uptake, Sweet Corn, Inceptisols

INTRODUCTION

Inceptisols are one of Indonesia's most widespread soil orders, covering almost 70.52 million ha or around 37.5% of Indonesia's land area [1]. The wide distribution of Inceptisols can be utilized to generate high economic value, but the constraints are also quite significant [2]. Dryland, such as Inceptisols, generally has relatively low nutrient content. Potassium levels in Inceptisols are in the range of 0.1–0.2 cmol kg^{-1}, which is relatively low (Putra & Hanum, 2018), even though element K is needed in large enough quantities for plant growth. So that the application of inorganic KCl fertilizers can be a solution to sufficient K nutrient deficiencies. In addition to soil factors, high rainfall in the tropics causes K nutrients to be easily leached, so much K is lost (Putra and Hanum, 2018).

Potassium is one of the elements that plants need, but farmers generally do not provide sufficient amounts of K fertilization, so the availability of soil K decreases. Meet the needs of Potassium can be done by giving inorganic fertilizers, namely KCl fertilizer (Mutaqin et al., 2019). One of the advantages of inorganic fertilizers is that they dissolve more quickly than solid organic fertilizers so that nutrients are available to plants (Lestari et al., 2016). KCl fertilizer consists of various forms, one of which is in the form of granules. Granular KCl fertilizer has the advantage of gradually releasing K into the soil and can reduce environmental losses[6-8]. Thus

KClfertilizer is not easily leached and lost from the soil. KCl fertilizer has a high K nutrient content of 60%, so KCl fertilization is considered capable of the K needs of plants.

Sweet corn is a horticultural commodity that can be developed on Inceptisol. The delicious and sweet taste makes sweet corn popular with people; sweet corn also contains carbohydrates, a little protein, and fat. This makes the demand for sweet corn increasingly high (Puspadewi et al., 2016). The average productivity of sweet corn in Indonesia is 8.3 tons ha^{-1}. This productivity value is far from the potential for sweet corn, which can reach 14-18 tons ha^{-1} (Budiyanto et al., 2017).

The study aimed to determine the effect and obtain the best granular KCl fertilizer dose in increasing K-available, K-uptake, and yield of sweet corn (*Zea mays saccharata* Sturt.) Talenta variety on Inceptisols from Jatinangor.

RESEARCH METHODOLOGY

The experiment was carried out in July-October 2020 at the Experimental Field of the Faculty of Agriculture, and soil and plant analysis was carried out at the Laboratory of Soil Chemistry and Plant Nutrition, Department of Soil Science and Land Resources, Faculty of Agriculture, Padjadjaran University, Jatinangor, Sumedang Regency, West Java.

The materials used consisted of planting media in the form of Inceptisol from Jatinangor, sweet corn seeds of the Talenta variety, granular KCl fertilizer, single inorganic fertilizer Urea (45% N), SP-36 (36% P_2O_5), and KCl (60% K_2O), insecticides which have the active ingredient profenofos, fungicide with the active ingredient mancozeb and chemicals used in the laboratory to analyze available K and K absorption in the plants tested. The tools used in the experiment were used in the field and the laboratory.

The design used was a randomized completely block design (RCBD), which consisted of nine treatments. Each treatment was repeated three times so that there were 27 experimental plots in total.

Table 1. Arrangement of Granular KCl Fertilizer Treatment and Standard N, P, K for Corn Sweet

Code	Treatment	kg ha^{-1}			
		Test Fertilizer	Urea	SP-36	KCl
A	Control	0	0	0	0
B	N,P,K Standard	0	300	150	50
C	¼ dose KCl Granular + N, P Single	25	300	150	0
D	½ dose KCl Granular + N, P Single	50	300	150	0
E	¾ dose KCl Granular + N, P Single	75	300	150	0
F	1 KCl Granular + N, P Single	100	300	150	0
G	1 ¼ KCl Granular + N, P Single	125	300	150	0
H	1 ½ KCl Granular + N, P Single	150	300	150	0
I	1 ¾ KCl Granular + N, P Single	175	300	150	0

The significance of the observed data was tested using the analysis of variance (ANOVA) test at a 5% confidence level to determine the treatment's effect. If a significant difference exists, the test is continued with Duncan's Multiple Range Test at the 5% level.

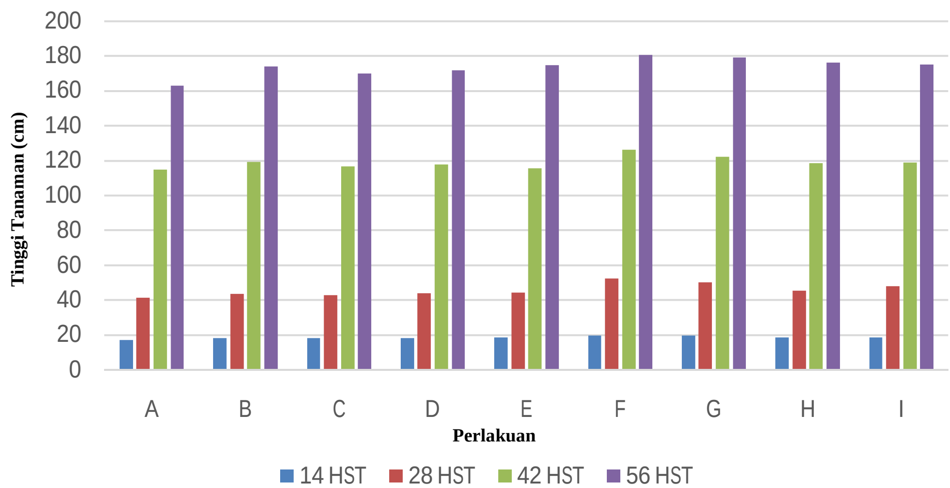
RESULTS AND DISCUSSION

A. Plant Growth

Plant growth is the process of increasing the size of the cells that make up a plant which causes changes in shape and size. The components of maize plant growth observed included plant height, number of leaves, stem diameter, and crown diameter.

1. Plant Height

Corn plant height was observed to determine the response to the treatment given at the maximum vegetative period. The research results on sweet corn plants' Height are presented in Figure 1.



A : Control
B : N, P, K Standar
C : ¼ DoseKCl granular
D : ½ DoseKCl granular
E : ¾ DoseKCl granular
F : 1 DoseKCl granular
G : 1 ¼ DoseKCl granular
H : 1 ½ DoseKCl granular
I : 1 ¾ DoseKCl granular

Figure 1. Histogram of Sweet Corn Plant Height 14-56 Days After Planting

Based on Figure 1, at 14 days after planting (DAP), the Height of the sweet corn plants tends to be uniform. But at the age of 28, 42, and 56 DAP, the effect of K fertilizer began to be seen. This is caused by the absorption of nutrients that are not optimal at the beginning of planting. This is to the statement of Mahdiannoor et al. (2016) that in the early stages of planting sweet corn, slow growth occurs because, in this phase, the roots have not developed and have not actively absorbed nutrients.

Plant height tended to increase and stabilize at 28 DAP, and plant height diversity was seen until the late vegetative phase (56 DAP). At 56 DAP, treatment F (1 dose of KCl granules + N, P single) gave the highest plant growth yields with an average of 180.57 cm compared to other treatments. In line with the research of Amanullah et al. (2016) that the increase in the growth of plant height and the number of corn plants' leaves is caused by applying element K at optimal doses.

Plants without K fertilizer have a low plant height. The average plant height in treatment A (control) was 162.89 cm. This is due to treatment A of corn plants lacking the nutrients needed in the growth process, thus hurting plant growth.

2. Stem Diameter

Stem diameter affects the establishment of sweet corn plants. The diameter of the stem influences a sturdy stem. A graph of stem diameter growth is presented in Figure 2.

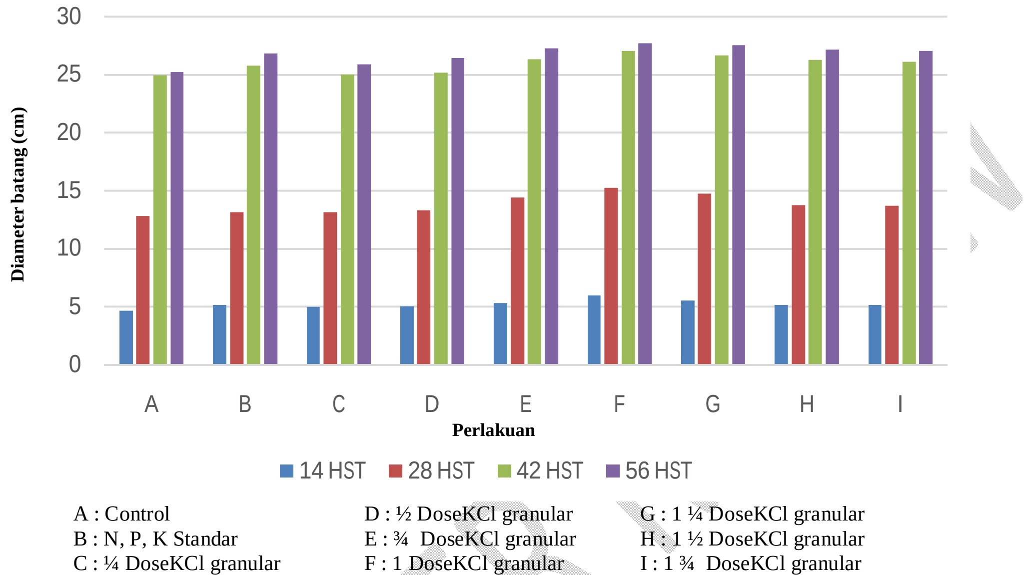


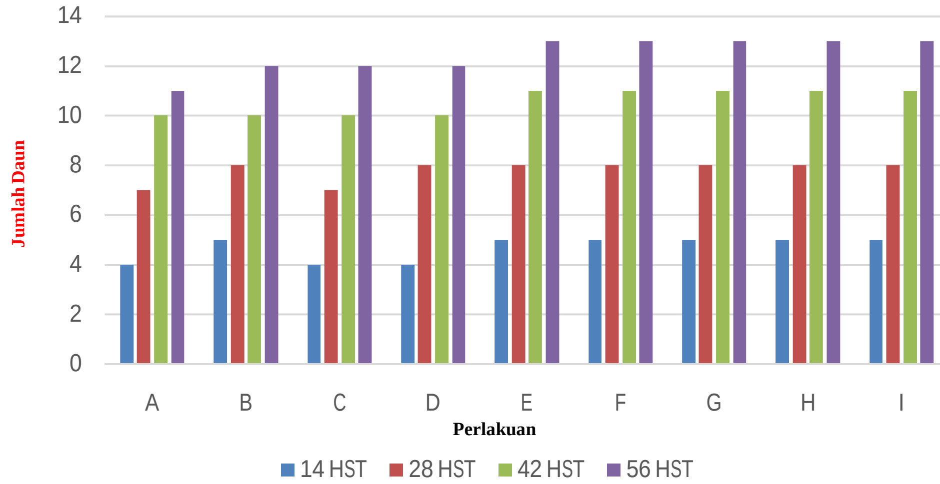
Figure 2. Histogram of Stem Diameter of Sweet Corn 14-56 DAP

Based on Figure 2, an increase in diameter was obtained in all treatments. The treatment with KCl fertilizer gave better results than no treatment. The diameter of the plant stem in treatment A (control) showed the lowest yield of 25.22 mm. This was caused by the absence of the supply of N, P, and K nutrients needed by the corn plant so that growth was hampered compared to other treatments, which obtained a supply of nutrients through fertilization. The largest plant stem diameter was found in treatment F, which was 27.70 mm because, in treatment F, the supply of K was sufficient and could help corn plants form strong and large stems.

Mutaqin research results et al. (2019) stated a clear difference in corn plants treated with KCl fertilizer at a dose of 0 kg ha^{-1} and 150 kg ha^{-1}, the stem diameter of the sweet corn plant increased with increasing amounts. Adequate K supply can help sweet corn plants form strong and large stems; element K can increase the thickness of the cell wall and the strength of the stem.

3. Number of Leaves

The research resultson the average number of sweet corn leaves in various treatments are presented in Figure 3.



A : Control
B : N, P, K ~~Standar~~standard
C : ¼ DoseKCl granular
D : ½ DoseKCl granular
E : ¾ DoseKCl granular
F : 1 DoseKCl granular
G : 1 ¼ DoseKCl granular
H : 1 ½ DoseKCl granular
I : 1 ¾ DoseKCl granular

Figure 3. Histogram of Sweet Corn Leaves 14-56 DAP

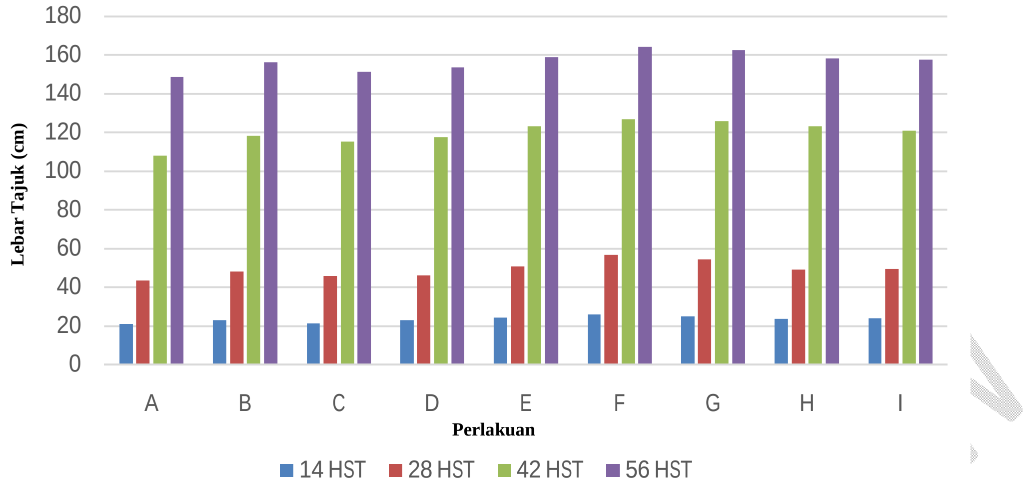
Based on Figure 3, at 14 DAP the average number of leaves for each treatment tends to be not uniform. The number of leaves tends to be consistent from 28 HST to 56 HST. The average number of leaves at 28 DAP was 7 and 8; then it continued to increase until 56 DAP with an average number of leaves of 11 to 13.

Treatment A (Control) at 56 HST showed the lowest average number of leaves, 11. This is because there is no addition of nutrients at all through fertilization. Treatments B (N, P, K Standard), C (¼ Dose of KCl granular), and D (½ Dose of KCl granular) had an average number of leaves of 12 leaves, while the other treatments had an average number of leaves of 13. leaf. In line with the research results reported by Sukma et al. (2019) at 2, 5, and 6 weeks after planting, it was found that the number of leaves on sweet corn plants that were given KCl fertilizer was better than plants that did not receive treatment.

The large number of leaves that grow on sweet corn plants is in line with the high growth of the plants. According to Fi'liyah et al. (2016), the more the length of the stem increases, the more existing stem segments are in the places where leaves are attached.

4. Crown Width

The research results on the average crown width in various treatments are presented in Figure 4.



A : Control
B : N, P, K Standar
C : ¼ DoseKCl granular
D : ½ DoseKCl granular
E : ¾ DoseKCl granular
F : 1 DoseKCl granular
G : 1 ¼ DoseKCl granular
H : 1 ½ DoseKCl granular
I : 1 ¾ DoseKCl granular

Figure 4. Histogram of Sweet Corn Canopy Width 14-56 DAP

Based on Figure 4, it can be seen that at 14 DAP the crown width tends to be uniform for each treatment. This is caused by the absorption of nutrients that have not been optimal by plant roots. According to Mahdiannoor et al. (2016), at 14 and 21 HST, corn plants were in a slow growth phase because plant roots had not developed actively in absorbing nutrients. Differences in the width of the plant canopy began to appear at 28 to 56 HST.

Treatment F with 1 dose of KCl granular + single N, P showed the highest crown diameter of 164.07 cm at 56 DAP. Canopy structure can affect photosynthesis and plant yields. Hidayat et al. (2015) stated that the wider the leaf size, the photosynthesis process will occur optimally and ultimately affect the growth of other organs, such as plant height and stem diameter. The crown diameter with the lowest value was in treatment A (control) 148.43 cm because the soil used in the experiment had low nutrient availability and did not get additional nutrients from fertilization.

B. K-Available and Plant K-Uptake

The results of research on content of K-available and K-uptake by plants are presented in Table 2.

Table 2. Effect of KCl Granular Fertilizer Dosage and Standard Single N, P, K on K-Available and Plant K-Uptake

Code	Treatment	K-dd (cmol kg^{-1})	Plant K-Uptake (g $plant^{-1}$)
A	Control	0,83a(0.83^{a})	0,24 a
B	N, P, K Single	1,82 b	0,30 b
C	¼ dose KCl Granulaar + N, P	1,52 b	0,30 b
D	½ dose KCl Granular + N, P	1,91 c	0,34 c
E	¾ dose KCl Granular + N, P	1,98 c	0,37 cd
F	1 KCl Granular +	2,90 d	0,39 d

	N, P		
G	1 ¼ KCl Granular + N, P	2,37 cd	0,34 c
H	1 ½ KCl Granular + N, P	2,26 c	0,34 c
I	1 ¾ KCl Granul + N, P	2,24 c	0,34 c

Note: The numbers followed by the same letter do not show a significant difference according to Duncan's multiple range test at the 5% level

Based on Table 2, it can be seen that all treatments were significantly different from treatment A (control). This shows the availability of K nutrients with fertilization treatment can be increased. Treatment F (1 KCl Granule + N, P single) showed significantly different values from all treatments except G treatment (1 ¼ KCl Granule + N, P single). Treatment F showed the best value of 2.90 cmol kg-1.

The value of K-available using granular KCl fertilizer tends to be slow to be available at the beginning of its application because this fertilizer is a slow-release K fertilizer, but the longer K availability will increase. So that at the time of sampling, the K-available value was high. In line with the research of Li et al. (2020), the amount of K-available is higher in the use of conventional KCl fertilizer at the beginning of plant growth compared to the use of slow-release K fertilizer. Still, when entering the three final stages (V12, silking, and maturity) of corn plant growth, the availability of K from K treatment slow release increased significantly. This can be advantageous because the element K plays a more significant role when the corn plant begins to enter the generative phase. After all, according to its function, it produces good flowers, fruit, and seeds (Sofyan et al., 2019).

Treatment A (control) showed the lowest result of each treatment, which was 0.83 cmol kg^{-1}. This was because there was no additional K fertilizer in treatment A, so the amount of K-available was measured as the amount already in the soil. The increase in available K in the fertilizer treatment was caused by the K fertilizer that would immediately enter the soluble and absorbed K equilibrium system. The K level in the soil solution increases so that its availability for plants also increases.

Table 2 shows that each treatment can generally increase K-uptake in Inceptisols from Jatinangor. K absorption tends to increase in line with the increase in nutrients and then decreases. Treatment F (1 KCl Granule + N, P single) showed a value that tended to be higher than the other treatments, namely 0.39 g $plant^{-1}$ but was not the best treatment in increasing K-uptake. This was because treatment F was not significantly different from treatment E. (¾ dose of KCl Granular + N, P single), which has a lower granular KCl fertilizer dose. K absorption in treatment E was 0.37 g $plant^{-1}$.

Treatments are given higher doses than treatment F showed decreased ability to uptake K nutrients. The plants had reached optimal fertilization levels, so even higher doses could not increase K-uptake. The nutrient content in the soil in the other treatments was higher than the optimal nutrient content, so the higher doses resulted in lower fertilization effectiveness.

The amount of K nutrient absorption depends on the availability of K in the soil. According to Munawar's statement (2011), K-available for plants is exchangeable K (K-dd) and soluble K. The two are in equilibrium; if the concentration of soluble K decreases as plants absorb it, then a supply of K will be immediately released into the soil solution from exchangeable K. The movement of K^{+} in the soil solution to the roots is regulated mainly by diffusion, so K nutrients in the soil solution and the addition of K fertilizer can be absorbed primarily by plant roots (Mayang & Jamin, 2012).

The lowest K absorption value was obtained in treatment A (control) with a 0.24 g plant^{-1}. The lack of K absorption in treatment A was due to the absence of additional nutrients in this treatment. This causes the growth of vegetative parts of plants, such as leaves, stems, and roots, to be hampered, so the K absorption in plant tissues is not optimal (Mayang & Jamin, 2012).

Sweet Corn Yield

The research results on the yield components of sweet corn observed were cob weight, peeled cob weight, cob diameter, and cob length, presented in Table 3.

Table 3. Effect of Dosage of Granular KCl Fertilizer and Standard Single N, P, K on Sweet Corn Yield

Perlakuan		Cob Weigth	Peeled Cob Weight	Cob Diameter	Cob Lenght
		(kg plant^{-1})		(cm plant^{-1})	
A	Control	0,36 a	0,25 a	5,04 a	18,23 a
B	N,P,K Single	0,42 bc	0,28 bc	5,16 abc	18,66 ab
C	¼ dose KCl Granular + N, P	0,37 a	0,27 b	5,10 ab	18,37 a
D	½ dose KCl Granular + N, P	0,39 ab	0,28 bc	5,20 bc	19,17 bc
E	¾ dose KCl Granular + N, P	0,42 bc	0,28 bc	5,26 cd	19,54 c
F	1 KCl Granular + N, P	0,49 d	0,32 e	5,46 e	20,71 d
G	1 ¼ KCl Granular + N, P	0,43 c	0,30 cd	5,38 de	19,77 c
H	1 ½ KCl Granular + N, P	0,44 cd	0,30 de	5,36 de	19,87 c
I	1 ¾ KCl Granular + N, P	0,45 cd	0,31 de	5,30 cd	19,89 c

Note: The numbers followed by the same letter do not show a significant difference according to Duncan's multiple range test at the 5% level

The best treatment for increasing the yield of sweet corn, including cob weight, peeled cob weight, cob diameter, and cob length, was the combination treatment of 1 dose of granular KCl fertilizer plus 1 dose of standard single N and P fertilizer. This dose has been able to meet the needs of plant nutrients to produce optimal production compared to other treatments. In line with the opinion of Hussain et al. (2015), K fertilization can help increase crop yield and quality. Plants require fertilization with the appropriate dosage to balance nutrients in the soil that can cause plants to grow well (Maruapey&Faesal, 2010). Increasing K fertilization will increase the rate of photosynthesis in plants. Photosynthesis results from leaves to plant roots and will increase the energy supply for root growth and fruit size and quality (Putra & Hanum, 2018).

CONCLUSION

Based on the results of the study, it can be concluded that:

1. The application of granular KCl fertilizer combined with single N and P fertilizers affectedsignificantly on the K-available, plant K-uptake, and yield of sweet corn on Inceptisols from Jatinangor.
2. The highest yields were achieved in treatment F (1 dose of granularKCl fertilizer + N, P) with a cob weight of 0.49 kg plant^{-1} or 17.76 tons ha^{-1},

a cob weight of 0.32 kg $plant^{-1}$. , cob diameter 5.46 cm, and cob length 20.71 cm.

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