# Determination of Optimum Row-Spacing and Plant Density for Uni-branched Sesame in Khuzestan Province 

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#### Abstract

There are varying patterns for growing different varieties of branched or non-branched sesame. This experiment was conducted during a two-year period (2000-2001) to identify the optimal practice for cultivation of the uni-branched sesame in the Safi-Abad Agricultural Research Center, Khuzestan Province. The statistical design was set up as strip-plot in a randomized complete block with four replications. Rows were adopted at varying spaces of $37.5,50$ and 60 cm while the plants were arranged horizontally at $5,10,15$ and 20 cm . In this way, the density of the plot was surveyed over an area ranging from 83000 to 530,000 plant/ha. Combined analysis of two years, results showed a significant effect on the yield component due to an increase in row-spacing from 37.5 to 60 cm . This increase in row-spacing from 37.5 to 60 cm . could also increase the stem diameter from 16.3 to 19.4 mm , the pod number from 59 to 84 per plant, as well as the weight per thousand seeds from 3 to 3.3 grams. Moreover, an increase in plant spacing from 5 to 20 cm caused a decrease in stem height from 180.2 to 169.7 cm , an increase in stem diameter form 15.8 to 19.8 mm , a rise in pod number from 44.6 to 96.5 and in the seed content from 59.3 to 74.4 per pod. The relevance of the seed yield and row spacing obeyed a falling linear regession curve, while the seed yield and plant intervals showed a non-linear behaviour and estimated a maximum yield at 10 cm distance. Finally, the planting density reflected a non-linear fourth power equation. The maxinum seed and oil yield was then estimated at a density of $\mathbf{2 0 0 , 0 0 0 - 2 5 0 , 0 0 0}$ plant per hectare. In view of higher yield at the 37.5 cm row treatment and the 10 cm plant treatment, together with regressive equations, the above pattern $(37.5 \times 10 \mathrm{~cm})$ shall be recommended for unibranched sesame growing in Khuzestan.


Keywords: Plant density, Row spacing, Sesame, Yield component.

## INTRODUCTION

Sesamum Indicum L. is an erect annual plant of numerous types and varieties belonging to the family pedaliacea, cultivated since antiquity for its seeds, which are used as food and flavouring and from which a prized oil is extracted. Depending on conditions, varieties grow from about 0.5 to 2.5 m tall; some have branches, others do not. One to three flowers appear on the leaf axils. The hulled seeds are creamy or early white, about 3 mm long and have a flattened
pear shape. The seed capsules open when dry, allowing the seed to scatter. Probably originating in Asia or East Africa, sesame is now found in most of the tropical, subtropical, and southern temperate areas of the world. Before the time of Moses, the Egyptians used the ground seed as grain flour. The Chinese used it 5000 years ago, and for centuries they have burned the oil to make soot for the finest Chinese ink blocks. The Romans ground sesame seed with cumin to make a pasty spread for bread $(3,11)$. Sesame prefers high temperatures

[^0]throughout the growing season and, because of its tolerance, is one of few crops that can be sown during July and early August, the hottest part of the year. The crop can tolerate dry conditions, but will respond to good rainfall as long as waterlogging does not occur Some varieties can grow on only 450 mm of rainfall $(1,10)$. Sesame total world planting area, production and mean yield per hectare in 2001 were 7779 thousand hectares and 3165 thousand tons with 407 kilograms per hectare respectively. Countries like India, Sudan, Myanmar and China are the main producers of this crop (8). In Iran near to 34 thousands hectare were allocared to sesame with 25 thousand kilograms of seed production and 729 kilograms per hectare mean yield. Khuzestan Province after Fars, has a potential for growing this seed over 15 thousand hectares of farming area (4). Local varieties have a remarkably low efficiency due to their poor resistance against pests and disease (3).
In 1989, several local and foreign lines from Karaj were crossed in the Safi-abad Agricultural Research Center and the new generations were cultivated for purification. Further more, in 1998 after preliminary yield comparisons, the merit lines were adopted for optimiztion tests. Among the existing lines, crossing of the Sirgan line into a rapid growing line was sclected for its prevailing uni-branched type, multicapsule at the base of petiole, and higher potential yield (9). Thus it was untroduced into experimental agronomy and showed itself superior to local varieties (5). Sesame germination and seedling growth will be delayed if temperatures fall below $20^{\circ} \mathrm{C}$. Seed beds need to be moist for 3-5 days for good establishment and, to prevent soil crusting, press wheels or some form of seed row covering device (for example, finger harrows or a chain) may or may not be needed at sowing. Sesame can be grown under reduced and zero tillage management, and is a useful crop for inclusion in a rotation system. The recommended range of planting density for branched type is form 200 to 400 thousand plants per hectare; this
will vary depending on germination rate, soil type and availability of irrigation (14).
Bikran et al (1986) conducted surveys on the density effects on seed yield and yield components of four branched and nonbranched sesame varieties. They concluded that in branched varieties the capsule number, seed number per capsule and the seed weight showed a decrease against increase of plant density from 330 to 550 thousand plants per hectare, while the nonbranched varieties showed a 34-37\% seed yield raise.
In India, Gnanamorty et al (1988) investigated five cultivation patterns of $30 \times 10,30 \times 15,30 \times 20,30 \times 25$ and $30 \times 30 \mathrm{~cm}$ for branched sesame varieties. Resultes showed a seed yield increase from 417, 552 and $561 \mathrm{~kg} / \mathrm{ha}$ while a row space increase from 10 to 20 cm and a greater row space increase to 25 and 30 cm caused a seed yield decrease to 510 and $395 \mathrm{~kg} / \mathrm{ha}$. On the basis of this, we could recommend the $30 \times 20$ pattern planting as the optimal practice.
Tiwari et al (1990) also conducted some experiments to identify the best pattern and density for branched sesame seed yield and, as a result, introduced the $30 \times 20 \mathrm{~cm}$ pattern in perference to the others.
Ghosh and Patra (1989), conducted an experiment on branched sesame for best plant density and fertilization rate, in West Bengal. Results showed a remarkable rise in the harvesting index, oil yield and total biomass against plant density which rose from 167 to 333 thousand per hectare. This, then was the reason behind their proposing a recommended 333 thousand plants per hectare.
Dawoudi (1997), had also ran an experiment on two branched domestic varieties as Dezful and Darab-14 over four varying plant densities of 100, 150, 200 and 250 thousand plants per hectare in Ramin district, Ahwaz. His conclusion revealed no significant difference between seed yield, biological yield, harvesting index and the seed weight of the foregoing densities, as the crop could compensate the plant deficiency
by reproducing subsidiary branches at lower densities.
Local varieties with $10-12 \mathrm{~kg}$ of seed per hectare by plot is a common planting method. Un suitable density and planting methods are the major reasons for sesame yield decrease, in Khuzestan Province. Certainly, the recommended pattern for the branched varieties would differ from that for nonbranched, and the above scheme was therefore conducted to obtain the best practice for the synthetic nonbranched sesame (12).

## MATERIALS AND METHODS

This experiment was carried out over a two-year period in Safi-abad Agricultural Research Center located at $48^{\circ}, 26^{\prime \prime} \mathrm{E}$ and $32^{\circ}, 16^{\prime \prime} \mathrm{N}$ with an altitude of 82.9 m above sea level. Based on meteorological statistics, the annual rainfall is 349.6 mm , mean annual air temperature $32.8^{\circ} \mathrm{C}$, maximum and minimum absolute annual temperature are $+35.6^{\circ} \mathrm{C}$ and $-9^{\circ} \mathrm{C}$ respectively. The pilot farm indicated a silty clay texture, Table 1 shows to the soil farm trial characters.
The experiment was conducted in four replications using statistical strip plots. The vertical plots were arranged in rows at 37.5 , 50 , and 60 cm spaces, and plant intervals of $5,10,15$ and 20 cm Table 2 shows the various densities in different cultivation patterns.
Each plot was composed of four lines of 10
m long. The uni-branched line from a crossing of the Sirgan line into an early maturity line (9), were planted in early July every year, receiving furrow irrigation. During the growth period, the sesame were 11 next irrigated at 8-12 day intervals. For fertilization, various applications were tested on the soil, such as 100 kg urea, 250 kg amunium phosphate, and 100 kg potash per hectare during plantation; during the rapid growing of stems, 100 kg urea per hectare was used. Flowering the initiation occurred around early August and completed in early October. Harvesting was carried out in early November (Table 3). The harvesting areas for the determination of seed yield, after deletion of the plot sides, were from two middle rows and ranged from 3,4 and 4.8 square meters at $37.5,50$ and 60 cm row width treatment, respectively. Moreover, other aspects such as stem height and diameter, number of pods per plant, number of seeds per pod and thousand seed weight were recorded from 10 randomized plant samples in each replication. The data for each experiment were then analysed by MSTATC software for comparison of the mean values by the Duncan test at the 5\% level. Mini Tab software was also used for analysing the correlation of the yield, yield component and density.

## RESULTS AND DISCUSSION

In this investigation the impact of plant

Table1. Soil farm trial characters at two depths.

| Soil depth <br> Cm | N <br> $\%$ | P <br> ppm | K <br> ppm | PH | EC <br> $\mathrm{ds} / \mathrm{m}$ | Soli Texture |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $0-30$ | 0.88 | 13.7 | 121 | 7.8 | 1.5 | Silty clay Loam |
| $30-60$ | 0.73 | 12.1 | 114 | 7.8 | 2.1 | Silty Loam |

Table2. Plant numbers per square meter at different row spacings and plant distances.

| Plant distance (cm.) <br> Row spacing (cm.) | 5 | 10 | 15 | 20 |
| :--- | :---: | :---: | :---: | :---: |
| 37.5 | 530 | 266 | 177 | 133 |
| 50 | 400 | 200 | 133 | 100 |
| 60 | 333 | 166 | 111 | 83 |

Table 3. Flowering initiation, completion date and harvesting time for different row spacings and densities.

| Treatment | Flowering | Flowering <br> initiation <br> complete <br> date | Harvesting <br> date |  |
| :--- | :--- | :--- | :--- | :--- |
| Row Spacing | 37.5 | 12/Aug | 8/Oct | 9/Nov |
|  | 50.0 | 9/Aug | 6/Oct | 5/Nov |
| Plant Distance | 60.0 | 6/Aug | 5/Oct | 5/Nov |
|  | 5 | 10/Aug | 10/Oct | 9/Nov |
|  | 10 | 8/Aug | 10/Oct | 8/Nov |
|  | 15 | 6/Aug | $7 /$ Oct | 4/Nov |
|  | 20 | 6/Aug | $7 /$ Oct | 4/Nov |

density over twelve growing patterns, ranging from 83000 up to 530000 plants per unit area were monitored on the seed yield and yield componients. Despite the significant difference of the year effects as well as the uniformity of the variances, and similarity of the results, a series of observations were made on the biannual average values of stem height and diameter, pod number, seed quantity of the pod, thousand seed weight and, finally, on the relation between the plant density and yield (Table 4).
There were not significantly different results values between stem height on the
rows spacing treatments but, as well as plant distance being increased, inter-plant competition and stem height were decreased, although stem diameter was increased (Table 5). Also, the resultes showed that, by spacing the rows more widely from 37.5 to 60 cm ., and by distancing the plants from 5 to 20 cm , led to an increase in pod number per plant from 59 to 84.1 and 44.6 to 96.5 respectively (Table 5). The average pod number per plant in interaction effects between row spacing with plant distance was also significant and revealed that widening distance between the plants, which caused competition decrease among the

Table 4. Mean squares for yield and yield components.

| Mean of Squares |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| S.O.V | Df | Stem <br> Height | Stem diameter | Pod <br> Per plant | Seed <br> Per Pod | Thousand Grain weight | Seed Yield | Oil Yield |
| Year | 1 | 13944.3 ** | $1.7{ }^{\text {ns }}$ | 2370.1** | 4.6 | $1.4{ }^{* *}$ | 3947015.7** | $885139.3{ }^{\text {ns }}$ |
| Rep $\times$ Y | 6 | 508.4 | 5.5 | 23.3 | 8.2 | 0.06 | 415121.2 | 90953.1 |
| Error | 2 | 362.8 | 73.8 | 5054.3 | 18.8 | 0.4 | 3417367.2 | 750036.4 |
| R.s ${ }^{\text {b }}$ | 2 | $1682.5{ }^{\text {ns }}$ | $8.4 * *$ | 1884.4** | $94.3{ }^{\text {ns }}$ | 0.6 ** | $454896.1^{\text {ns }}$ | $101914.2{ }^{\text {ns }}$ |
| Error | 12 | 499.9 | 7.9 | 63.5 | 47.0 | 0.03 | 145487.2 | 33129.0 |
| P.d ${ }^{\text {a }}$ | 3 | $485.9{ }^{\text {ns }}$ | 66.0** | $11791.7^{* *}$ | 2233.1** | $0.1{ }^{\text {ns }}$ | $246312.7{ }^{\text {ns }}$ | 56923.3* |
| Y $\times$ p.d | 3 | 159.3 | 3.8 | 321.7 | 51.0 | 0.02 | 242935.7 | 52054.7 |
| R.S $\times$ P.d | 6 | 77.4* | $4.1{ }^{\text {ns }}$ | 108.8** | $146.7^{* *}$ | $0.1{ }^{*}$ | 231972.5** | 50549.8** |
| $\mathrm{Y} \times$ R.s $\times$ p.d | 6 | 72.8 | 0.6 | 36.8 | 33.4 | 0.1 | 123525.3 | 27235.0 |
| Error | 54 | 187.6 | 3.8 | 26.6 | 25.7 | 0.1 | 104941.2 | 23608.3 |

* significant at $5 \%$
** significant at $1 \%$
${ }^{\text {ns }}$ non significant
${ }^{a}$ Plant distance
${ }^{b}$ Row space

Table5. Yield and yield components comparison for different row spacings and densities.

| Treatment |  | Stem heigt cm | Stem diameter mm | Pod Per plant | $\begin{aligned} & \hline \text { Seed } \\ & \text { Per } \\ & \text { Pod } \end{aligned}$ | Thousand grain wight | Seed yield kg/ha | oil <br> yield <br> kg/ha |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Row spacing | 37.5 | 173.1a | 16.3b | 59.dc | 64.0a | 3.0b | 2352.6a | 2352.6a |
|  | 50.0 | 178.8a | 17.9b | 73.3b | 65.6a | 3.0b | 1947.5b | 1947.5b |
|  | 60.0 | 175.9a | 19.4a | 84.1a | 64.8a | 3.3a | 1705.9c | 1705.9c |
| Plant Distance | 5 | 180.2a | 15.8c | 44.6d | 52.3d | 3.1ab | 2010.8.ab | 2010.8.ab |
|  | 10 | 177.7a | 17.6b | 66.0c | 62.6c | 3.1ab | 2140.6a | 2140.6a |
|  | 15 | 175.0b | 18.3b | 81.3b | 69.7b | 3.2a | 1910.6b | 1910.6b |
|  | 20 | 169.7b | 19.8a | 95.5a | 74.5a | 3.1ab | 1945.9b | 1945.9b |

Means followed by similar letters in each column for each main row or plant distance are not significantly different at the $5 \%$ level.
prevailing variety (non-branch), also increased the pod number of plant. The greatest number of plant pods was recorded as 114.5 in the $60 \times 20 \mathrm{~cm}$. pattern, whereas the least, recorded as 31.8 , was detected in $37.5 \times 5 \mathrm{~cm}$ pattern (Table 6). The seed number of the pod as another component of yield was affected by the plant distance applied. Although no significantce was indentified between the seed number of the pods at varying row spaces by spacing the plants futher from 5 cm to 20 cm ., there was an increase in seed quantity from 52.3 to 74.5 per pod, respectively. The significant interaction effects of row and plant spacing were indicated that in increasing plant
distance each row spacing, would increase the seed content of the pod. The least quantity of the pod seeds at 46.1 was seen in its highest density in the $37.5 \times 5 \mathrm{~cm}$ pattern, while the greatest content was reported equal to 78.1 in the $37.5 \times 20 \mathrm{~cm}$ growing arrangement. The patterns of $50 \times 20 \mathrm{~cm}$ and $60 \times 20 \mathrm{~cm}$ had average seed quantities of 73 and 82.5 seed per pod compared to the $37.5 \times 20 \mathrm{~cm}$ Pattern. The thousand seed weight was also affected by the above spacings, so that the greatest weight was yielded at 60 cm wide.
The mean seed weight interaction effects showed no specific trend despite its

Table 6. yield nad yield components comparison for different row spacing and plant distance.

| Treatment |  | Stem <br> heigt <br> cm | Stem <br> Diameter mm | Pod <br> Per <br> plant | Seed <br> Per <br> Pod | Thousand grain wight | Seed <br> Yield <br> kg/ha | oil <br> Yield <br> kg/ha |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $37.5 \times$ | 5 | 179.1ab | 14.1f | 31.8g | 46.1g | 3.0c | 2133.2bd | 1002.3 bcd |
|  | 10 | 175.4a-c | 16.5 de | 53.1e | 63.6cd | 3.1bc | 2594.0oa | 1219.0 a |
|  | 15 | 170.8b-d | 17.1 c-e | 70.1d | 62.3bc | 3.1bc | 2255.4a-c | 1051.4 bc |
|  | 20 | 163.3d | 17.6b-d | 81.1f | 72.1a | 3.0c | 2427.9ab | 1140.5ab |
| $50.0 \times$ | 5 | 181.0a | 15.0e-f | 74.4f | 52.6 f | 3.1c | 1861.4 de | 957.5 cd |
|  | 10 | 178.4ab | 17.9b-d | 69.8d | 64.5cd | 3.3b | 1922.4c-e | 903.3cd |
|  | 15 | 178.3ab | 18.6b-d | 81.8c | 72.1b | 3.5a | 1893.2c-e | 889.8de |
|  | 20 | 177.8ab | 19.9ab | 94.0b | 73.0b | 3.2bc | 1936.2c-e | 897.8cde |
| $60.0 \times$ | 5 | 180.4a | 18.1b-d | 54.8e | 58.3e | 3.1c | 1861.4de | 874.7de |
|  | 10 | 179.3ab | 18.5b-d | 75.1f | 59.2e | 3.3 b | 1905.4c-d | 891.6de |
|  | 15 | 175.9ac | 19.1bc | 92.0b | 68.8bc | 3.5a | 1583.1ef | 743.9ef |
|  | 20 | 163.0cd | 21.8a | 114.5a | 82.5b | 3.2bc | 1473.2f | 692.1f |

Means followed by a similar letter in each column for each row space by plant distance are not significantly different at the $5 \%$ level.


Figure 1. The relation between row spacing and seed yield which follows the linear equation: of $y=3422.5-988.9 x$ representing yield decrease against row space increase.


Figure 2. The relation between plant distance and the seed yield which follows the equation: $y=\left(12.8+629.8 x-55.2 x^{2}+1.4 x^{3}\right)$, remarking the highest yield at 10 cm plant distance.
significance. The range of thousand seed weight in the above treatment was 3 to 3.5 grams. Finally, the highest seed and oil yield of 2352.6 kg seed $/ \mathrm{ha}$ and 1103.3 kg oil/ha was achieved the row spacing of 37.5 cm ; the relationship between seed yield and row spacing represented a linear character and followed the equation $Y=3122.6-18.7 x$ ( $\mathrm{x}=$ row spacing, $\mathrm{y}=$ seed yield, $\mathrm{R}=0.99$ ) which means a falling trend of seed yield against row spacing (Figure1). The regressive relation of plant distance and seed
yield showed a non-linear trend and fallowed the equation $y=12.8+629.8 x-55.2 x^{2}$ $+1.4 \mathrm{x}^{3} \quad$ ( $\mathrm{x}=$ plant distance, $\mathrm{y}=$ seed yield, $\mathrm{R}=0.99$ ). On the basis of this equation, the highest seed and oil yield was achieved at a 10 cm plant distance (Table 6 and Figure 2). Finally, the regressive relation of plant density and seed yield followed the equation $\mathrm{y}=\mathrm{a}+\mathrm{bx}+\mathrm{cx}^{2}+\mathrm{dx}^{3}+\mathrm{ex}^{4}$ (where as $\mathrm{x}=$ plant density, $y=$ seed yield, $a=6.24, b=0.026$, $\mathrm{c}=1.03 \mathrm{E}^{-7}, \mathrm{~d}=1.57 \mathrm{E}^{-13}$ and $\left.\mathrm{e}=7.6 \mathrm{E}\right)^{-20}$. According to the above equations, the


Figure 3. The relation between the plant density and the seed yield obeys the equation: $Y=\left(6.2+0.026 x-1.03 e-07 x^{2}+1.57 e-13 x^{3}-7.6 e \times 20 x^{4}\right)$. This means that the highest yield is achieved at a density of 200,000-250,000 plants per hectare.
highest seed yield was obtianed at a 10 cm plant distance for every row space treatment. The 5 cm row spacing, possibly due to excessive competition, and the row spacing of 15 and 20 cm , for their lower plant density per unit area, demonstrated less yield. Also, the planting density of 200.000 to 250.000 plants per unit area resulted in the highest seed yield (Figure 3). Having the higher yield in all treatments at a 37.5 cm row spacing, as well as with the preferred 10 cm, plant distance for all row spacings, a growing pattern of $37.5 \times 10 \mathrm{~cm}$ is therefore recommended for synthetic sesame sowing. In conjunction with other researchers who advised a growing pattern of 250,000 to 300,000 plants per hectare, the scheme noted an enabling practice of 266,00 density with relatively unique distribution over the farm. Therefore, the inter- and intra-plant competition falls to a minimum, for which soil ridges of a 30 inch base with 2 kg seeds per hectare was constructed for sesame cultivation. The growing pattern is arranged in such a way that the volunteer weeds can easily be controlled by a tractor passing through the rows. Moreover, there will be the possibility for tip-fertilization at the rapid growth stage of the stem elongation by tractor. Irrigation practice is also properly performed for optimum growth which
results in elimination of the risk plants of harming as was caused by the oversaturation of the old methods.

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## تعيين مناسبترين الگو و تراكم كاشت كنجد تك شاخه در شمال خوزستان

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#### Abstract

چحكيده

الگُ و تراكم كاشت توصيه شده ارقام مختلف كنجد با شاخه فرعى يا بدون شاخه فرعى متفاوت مى باشد. اين آزمايش به مدت دو سال زراعى طى سالهاى 1379 و 1380 بهمنظور بررسى و تعيين مناسبترين الگُ و تراكم كاشت كنجد تك شاخه در مركز تحقيقات كشاورزى صفى آباد اجراء گرديد. آزمايش درقالب طرح آمارى بلو كهاى كامل تصادفى به روش استريب پالات با 4 تكرار اجراء گرديد. سه فاصله خطوط كاشت 37/5، 50 و 60 سانتىمتر بين رديفهاى كاشت در كرتهاى عمودى و پهار فاصله بوته 5، 10، 15 و 20 سانتىتر بين بوتهها در كرتهاى افقى قرار گرفتند. بدين ترتيب تراكم بوته در دامنهاى از 83 تا 530 هزار بوته در هكتار مورد بررسى قرار گرفت نتايج تجزيه واريانس مر كب دو سال نشان داد كه افزايش فاصله بين رديفها از 37/5 به 60 سانتىمتر تأثير معنىدار بر اجزاء عملكرد داشت، بنحويكه قطر ساقه از 16/3 و 19/4 ميلىمتر، تعداد غلاف در بو ته از 59 به 84/1 و وزن هزار دانـه انه از 3 به به 3/3 گرم افزايش يافت. با افزايش فاصله بين بوته از 5 به 20 سانتىمتر ارتفاع ساقه از 180/2 به 169/7 سانتىتر كاهش، قطر ساقه از 15/8 به 19/8 ميلىمتر افزايش، تعداد غلاف در بوته از 44/6 به 96/5 و تعداد دانه در غلاف از 52/3 به 54/5 افزايش يافت. رابطه رگر سيونى عملكرد دانه و فاصله رديف خطى و بصورت كاهشى بود، رابطه بين عملكرد دانه و فاصله بوته غيرخطى و بيشترين عملكرد در فاصله 10 سانتىمتر بين بوتهها تخمين زده شد. نهايتاً رابطه بين عملكرد دانه و تراكم كاشت نيز غيرخطى و درجه 4


توسط معادلات رگرسيونى، الگوى كاشت 10×37/5 سانتىمتر جهت كاشت كنجد تك شار شاخه در شمال
خوزستان توصيه گرديد.


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