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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 200,000–250,000 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 (37.5×10cm) shall be recommended for uni-branched 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

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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 200l 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˚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 30×10, 30×15, 30×20, 30×25 and 30×30 cm for branched sesame varieties. Resultes showed a seed yield increase from 417, 552 and 561 kg/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 kg/ha. On the basis of this, we could recommend the 30×20 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 30×20 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

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by reproducing subsidiary branches at lower densities.

Local varieties with 10-12 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°, 26" E and 32°, 16" 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˚C, maximum and minimum absolute annual temperature are +35.6˚C and -9˚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, 100kg 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 Cm	N %	P ppm	K ppm	PH __	EC ds/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.) Row spacing (cm.)	5	10	15	20
37.5	530	266	177	133
50	400	200	133	100
60	333	166	111	83

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

Treatment		Flowering initiation date	Flowering complete date	Harvesting date
Row Spacing	37.5	12/Aug	8/Oct	9/Nov
	50.0	9/Aug	6/Oct	5/Nov
	60.0	6/Aug	5/Oct	5/Nov
Plant Distance	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 components. 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 Height	Stem diameter	Pod Per plant	Seed Per Pod	Thousand Grain weight	Seed Yield	Oil Yield
Year	1	13944.3**	1.7ns	2370.1**	4.6	1.4**	3947015.7**	885139.3 ns
Rep × 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 ^{b}	2	1682.5 ns	8.4**	1884.4**	94.3 ns	0.6**	454896.1 ns	101914.2 ns
Error	12	499.9	7.9	63.5	47.0	0.03	145487.2	33129.0
P.d ^{a}	3	485.9 ns	66.0**	11791.7**	2233.1**	0.1 ns	246312.7 ns	56923.3*
Y × p.d	3	159.3	3.8	321.7	51.0	0.02	242935.7	52054.7
R.S × P.d	6	77.4*	4.1 ns	108.8**	146.7**	0.1*	231972.5**	50549.8**
Y×R.s×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%
ns non significant
^{a} Plant distance
^{b} Row space

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

Treatment		Stem heigt cm	Stem diameter mm	Pod Per plant	Seed Per Pod	Thousand grain wight	Seed yield kg/ha	oil yield 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 60×20 cm. pattern, whereas the least, recorded as 31.8, was detected in 37.5×5 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 37.5×5 cm pattern, while the greatest content was reported equal to 78.1 in the 37.5×20 cm growing arrangement. The patterns of 50×20 cm and 60×20 cm had average seed quantities of 73 and 82.5 seed per pod compared to the 37.5×20 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

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

Treatment		Stem heigt cm	Stem Diameter mm	Pod Per plant	Seed Per Pod	Thousand grain wight	Seed Yield kg/ha	oil Yield kg/ha
37.5 ×	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 ×	5	181.0a	15.0e-f	74.4f	52.6f	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 ×	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	3.3b	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.

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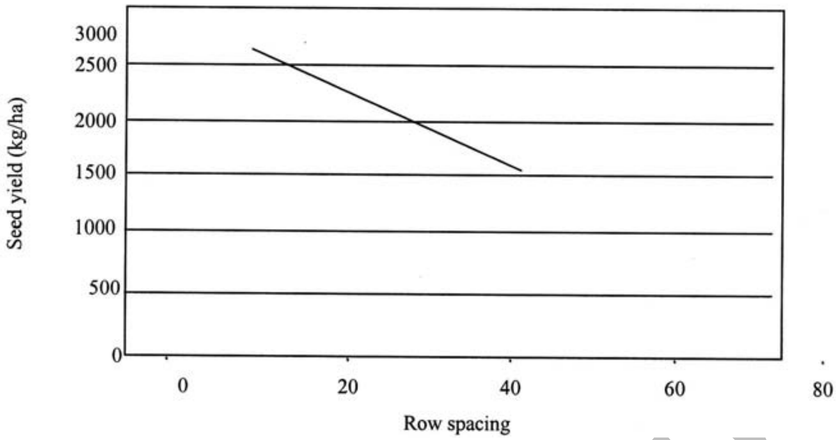

Figure 1. The relation between row spacing and seed yield which follows the linear equation: of y = 3422.5-988.9 x representing yield decrease against row space increase.

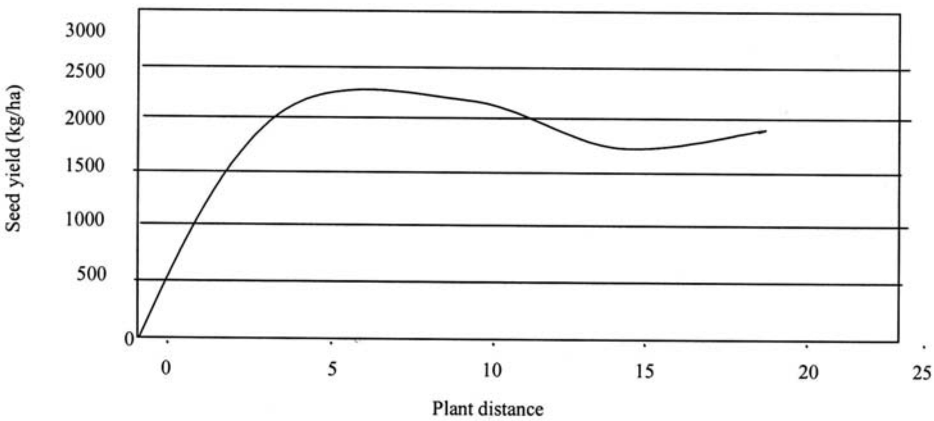

Figure 2. The relation between plant distance and the seed yield which follows the equation: y= (12.8+629.8 x – 55.2 x^2 + 1.4x^3), remarking the highest yield at 10 cm plant distance.

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/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=3122.6-18.7x (x=row spacing, y=seed yield, 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+629.8x-55.2x^2 +1.4x^3 (x=plant distance, y=seed yield, 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 y=a +bx+cx^2+dx^3+ex^4 (where as x = plant density, y=seed yield, a = 6.24, b= 0.026, c=1.03E^{-7}, d =1.57 E^{-13} and e=7.6E)$^{-20}$. According to the above equations, the

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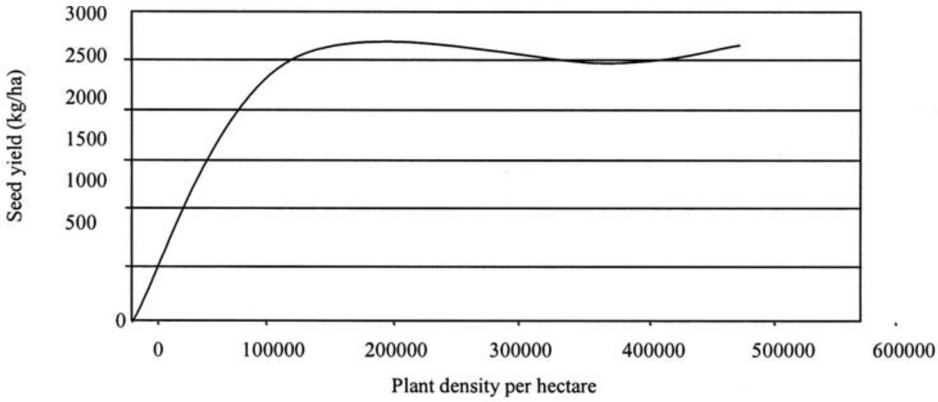

Figure 3. The relation between the plant density and the seed yield obeys the equation: $Y= (6.2 + 0.026\ x–1.03e\ –07x^2 + 1.57e\ –13\ x^3 – 7.6e \times 20x^4)$. This means that the highest yield is achieved at a density of 200,000- 250,000 plants per hectare.

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 37.5×10 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 over-saturation of the old methods.

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تعیین مناسبترین الگو و تراکم کاشت کنجد تک شاخه در شمال خوزستان

ع.ا. راهنما و ع. م بخشنده

چکیده

الگو و تراکم کاشت توصیه شده ارقام مختلف کنجد با شاخه فرعی یا بدون شاخه فرعی متفاوت می‌باشد. این آزمایش به مدت دو سال زراعی طی سالهای 1379 و 1380 به‌منظور بررسی و تعیین مناسبترین الگو و تراکم کاشت کنجد تک شاخه در مرکز تحقیقات کشاورزی صفی‌آباد اجراء گردید. آزمایش درقالب طرح آماری بلوکهای کامل تصادفی به روش استریپ پلات با 4 تکرار اجراء گردید. سه فاصله خطوط کاشت 37/5، 50 و 60 سانتی‌متر بین ردیفهای کاشت در کرتهای عمودی و چهار فاصله بوته 5، 10، 15 و 20 سانتی‌متر بین بوته‌ها در کرتهای افقی قرار گرفتند. بدین ترتیب تراکم بوته در دامنه‌ای از 83 تا 530 هزار بوته در هکتار مورد بررسی قرار گرفت نتایج تجزیه واریانس مرکب دو سال نشان داد که افزایش فاصله بین ردیفها از 37/5 به 60 سانتی‌متر تأثیر معنی‌دار بر اجزاء عملکرد داشت، بنحویکه قطر ساقه از 16/3 و 19/4 میلی‌متر، تعداد غلاف در بوته از 59 به 84/1 و وزن هزار دانه از 3 به 3/3 گرم افزایش یافت. با افزایش فاصله بین بوته از 5 به 20 سانتی‌متر ارتفاع ساقه از 180/2 به 169/7 سانتی‌متر کاهش، قطر ساقه از 15/8 به 19/8 میلی‌متر افزایش، تعداد غلاف در بوته از 44/6 به 96/5 و تعداد دانه در غلاف از 52/3 به 74/5 افزایش یافت. رابطه رگرسیونی عملکرد دانه و فاصله ردیف خطی و بصورت کاهشی بود، رابطه بین عملکرد دانه و فاصله بوته غیرخطی و بیشترین عملکرد در فاصله 10 سانتی‌متر بین بوته‌ها تخمین زده شد. نهایتاً رابطه بین عملکرد دانه و تراکم کاشت نیز غیرخطی و درجه 4

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بود. بیشترین عملکرد دانه در تراکم 200 تا 250 هزار بوته در واحد سطح تخمین زده شد، باتوجه به برتری عملکرد تیمار فاصله ردیف 37/5 و تیمار فاصله بوته 10 سانتی‌متر بین بوته‌ها و تخمین عملکرد توسط معادلات رگرسیونی، الگوی کاشت 10×37/5 سانتی‌متر جهت کاشت کنجد تک شاخه در شمال خوزستان توصیه گردید.

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