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THE EFFECT OF INFLORSCENCE SIZE ON SEED CHARACTERISTICS AND OIL CONTENT OF SUNFLOWER

By

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Abstract

Low plant populations which are recommended as a means of conserving water in dryland sunflower crops of ten result in a marked increase in the size of individual plants. This developmental plasticity, especially in relation to inflorescence size, has been studied in the variety Peredovik (Sunfola 68) to determine the effects of inflorscence size on the characteristics and oil content of the seed.

Large inflorescences produced a greater number of larger seeds with increased mean weight. For both characters, 50% or more of the variation observed could be accounted for by inflorescence diameter alone. This increase in the size and weight of seed was not associated with any change in the kernel to pericarp ratio.

Within an inflorescence the weight of the seed in the outer half of the floral disk was on average 10% heavier than the seed in the inner half, however, there was no significant variation in kernel to pericarp ratio across the inflorescence.

The oil content of the seed was largely independent of seed weight and inflorescence size. The most important property of the seed with respect to oil yield was the weight of the kernel as a percentage of the total seed weight. This character showed considerable variation within the Peredovik population studied and accounted for approximately 60% of the variation expressed in oil content of the seed. It was also highly correlated with oil percent in seed of a range of diverse breeding populations surveyed in this study.

These results suggest that any manipulations of the plant population in sunflower, with its associated effects on inflorescence size, will have virtually no effect on the oil content of the seed. The proportion of kernel in the seed appears to be a much more important determinant of oil yield and may provide a useful criterion for selection.

Introduction

Many dryland sunflower crops grown in areas with unreliable summer rainfall are sown at relatively low plant densities to make better use of limited water resources and to improve the stability and potential for yield under these conditions.

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One consequence of this strategy can be to increase the size of individual plants and in particular the size of the terminal inflorescence. This developmental flexibility in relation to the inflorescence was first reported by Clements et al (1929), and is particularly apparent in crops sown at low density that experience favorable growing conditions prior to flowering.

If the increase in the size of the inflorescence results in the production of larger or heavier seed as reported by Clements et al (1929), with a thicker pericarp and hence a lower ratio of kernel to pericarp weight, it can be assumed, since most of the oil is located in the kernel, that the yield of oil per unit weight of seed will decline.

This study was undertaken to investigate this hypothesis, by comparing a range of seed characteristics, including number, weight, kernel to pericarp ratio and oil content, in seed from a wide range of inflorescence sizes. The existence, or otherwise, of a plant density effect on the nature and ultimate oil yields of the seed could have important implications for the agronomy of this crop.

Materials and Methods

Plant Material

The sunflower variety Peredovik (Sunfola 68)[1] was sown in 60 cm rows during the early summer in a trial at Armidale, N.S.W. All plots were treated with the pre-emergence weedicide (Trifluralin) to prevent weed competition and after seedling emergence, the plots were thinned to a range of population densities corresponding to 14, 28, 50 and 100 x 10^3 plants ha^{-1}. This range of plant populations covers the variation in sowing densities used by commercial growers in both dryland and irrigated farming practice in Australia.

The trial was replicated four times. Irrigation was used occasionally to supplement natural rainfall when required and the plots were sprayed to control *Heliothis* and other insect pests. During the seed development the plots were protected by nylon nets to prevent bird damage. When the majority of inflorescences had reached physiological maturity (i.e., no further increase in the dry weight of seed), ten inflorescences were sampled from the four replicates of each plant density and dried at 70°C for 48 hours.

Measurements

Before drying, the diameter of each inflorescence was recorded and after drying the seed was threshed and the number and average weight of filled seed (mg) determined. Ten gram samples of seed were taken from each of the 160 inflorescences sampled from the various plant populations and used to determine the percentage of oil in the intact seed using an NMR spectrometer[2] calibrated against sunflower oil.

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[1] Selection from Peredovik.

[2] Newport Instruments.

A second 5 g sample of seed was taken from a subset of 100 inflorescences spanning the range of inflorescence diameters and in each sample the seed was dissected into pericarp and kernel. The weights of each fraction were taken and their respective oil contents determined as for the intact seed.

Additional inflorescences (20) were sampled at random from plots at 50 x 10^3 plants ha^{-1} and these were used to determine if seed weight or kernel to pericarp ratio is influenced by the position of the seed on the floral disk. The disk was divided into four concentric zones of approximately equal area and all filled seed was removed for measurement of mean weight and kernel to pericarp ratio.

Results and Discussion

Inflorescence Size and Seed Characteristics

Sunflower displays considerable developmental plasticity, especially in relation to inflorescence size. In this study the relationship between plant population and inflorescence diameter is shown in Figure 1, where the average inflorescence diameter decreased as the plant populations increased, reaching a maximum around 8 plants m^{-2}. At the highest population (10 plants m^{-2}) dominance effects causes large variation in plant size and hence inflorescence size, but no further reduction in the mean diameter of the inflorescences.

The mean seed number per inflorescence increased with inflorescence diameter with the regression accounting for 64% of the variation found in seed number (Figure 2). Mean seed weight displayed a similar relationship with inflorescence diameter. Over the extreme range of diameters sampled from 60 to 240 mm, there was more than a twofold increase in average seed weight, however, in the regression of seed weight on inflorescence diameter, only 43% of this variation could be accounted for by inflorescence size alone (Figure 3). Other factors associated with the more favorable conditions, or some other advantage gained by the larger plants, must be responsible for the remaining variation.

Although there was an increase in average seed weight with larger inflorescences, there was little or no relationship found between the kernel to pericarp ratio and inflorescence diameter. A slight decline in the value of the ratio with increasing inflorescence diameter suggests that large inflorescences may have seeds with thicker pericarps, but the regression was barely significant and accounted for only about 20% of the variation observed (Figure 4). This reduction in the proportion of the kernel in seeds from large inflorescences is not a function of seed weight as there was no significant relationship (r^2 = 0.05, NS) between kernel to pericarp ratio and mean seed weight.

Within individual inflorescences the seed located on the outer half of the floral disk was significantly heavier (10%) than seed from the inner half of the disk. The lightest seed were located at the center of the disk (Table 1). The kernel to pericarp ratio, however, did not vary significantly across the diameter of the disk which confirm the earlier finding of the independence of these two traits (Table 1).

FIGURE 1. Relationship between plant population and inflorescence diameter in sunflower (Plants $M^{-2} \times 10^3$ = plants ha^{-1})

$$Y = 209.4 - 22.5x + 1.36x^2$$

$$r^2 = 0.74 \quad (P < 0.001)$$

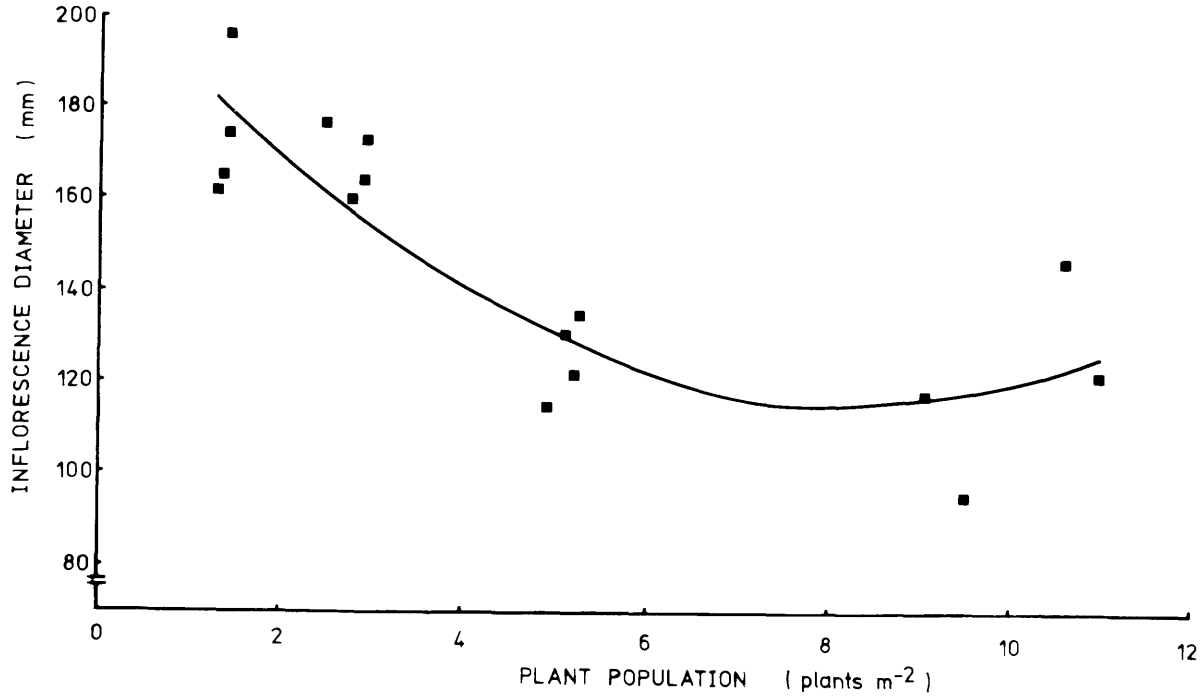


FIGURE 2. Relationship between inflorescence diameter and seed number per inflorescence in sunflower.

$$Y = -89.0 + 4.84x$$

$$r^2 = 0.64 \ (P < 0.001)$$

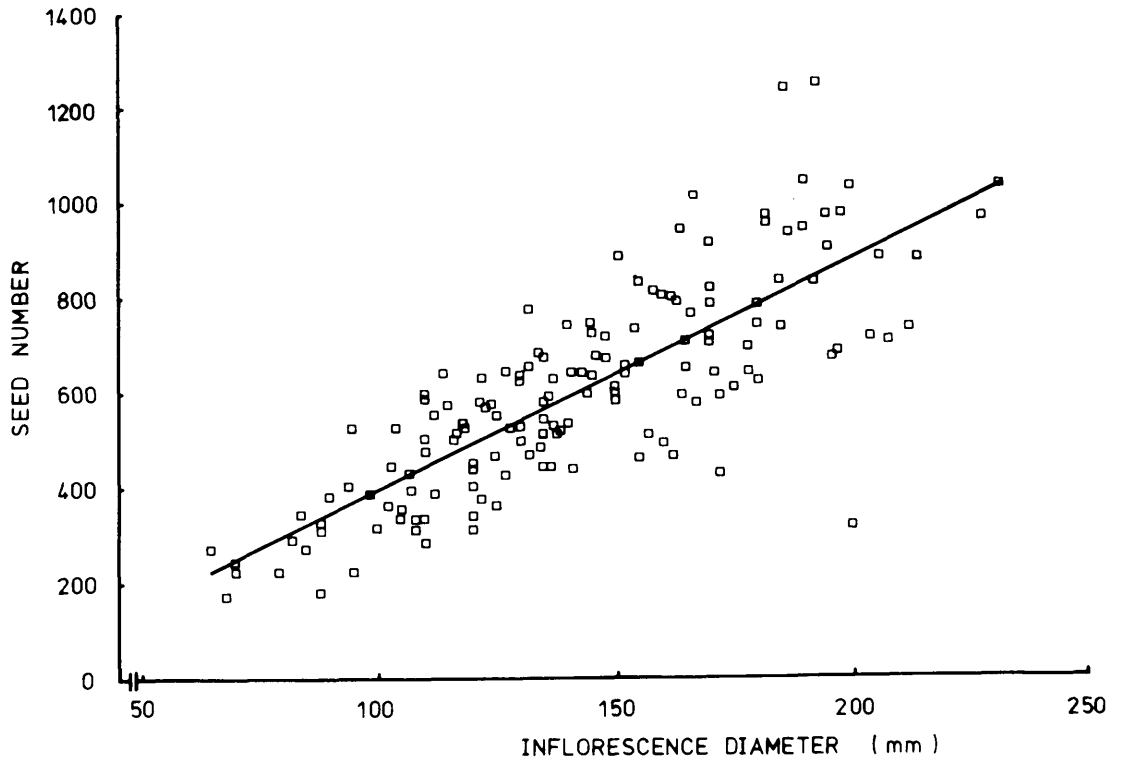


FIGURE 3. Relationship between Inflorescence diameter and mean seed weight in sunflower.

$$Y = -13.91 + 0.78x - 1.65 \times 10^{-3} x^2$$

$$r^2 = 0.43 \ (P < 0.001)$$

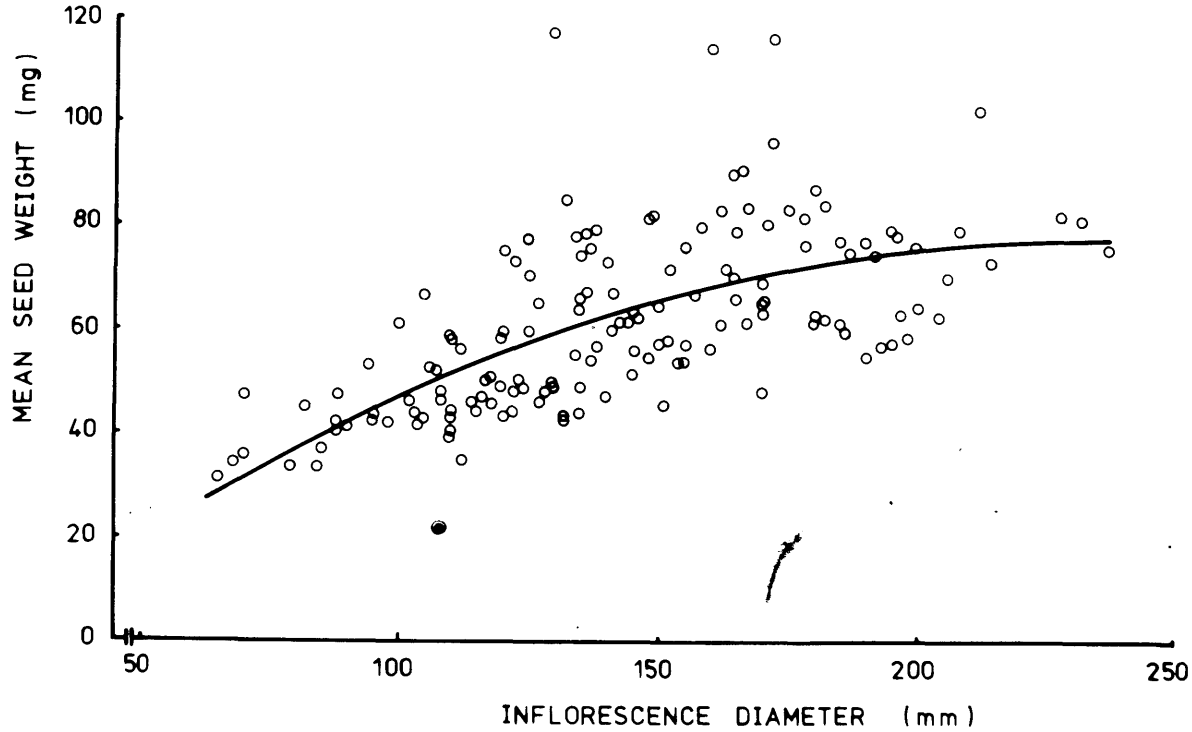


FIGURE 4. Relationship between inflorescence diameter and the ratio of kernel to pericarp weight.

$$Y = 1.595 + 0.0218x - 9.49 \times 10^{-5} x^2$$

$$r^2 = 0.22 \ (P < 0.05)$$

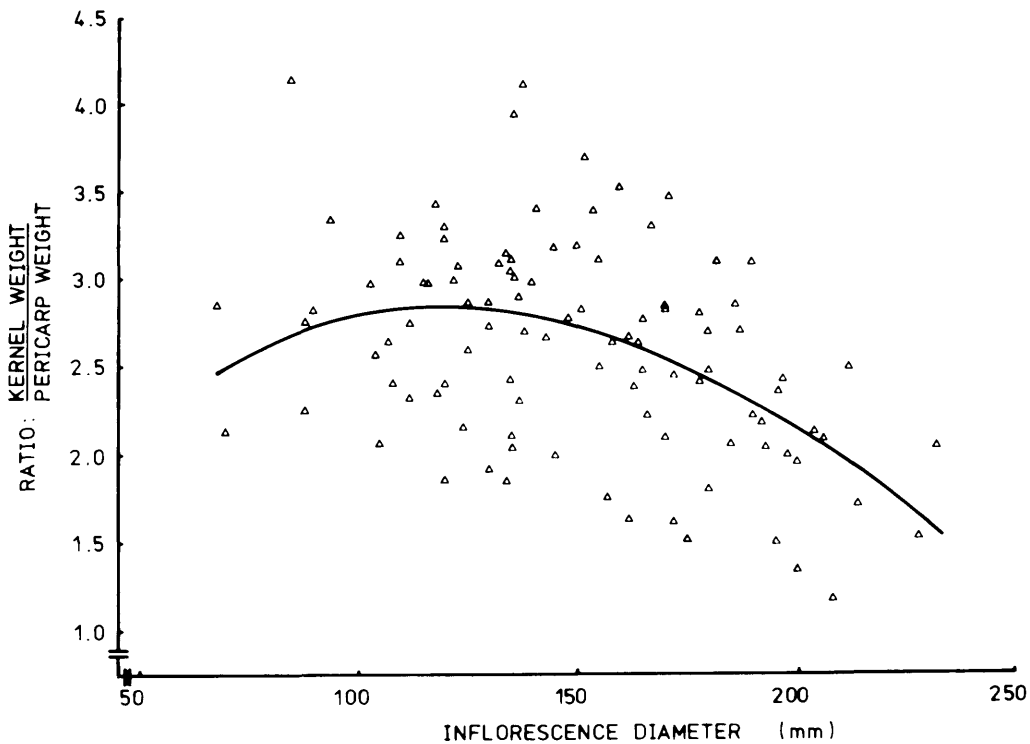


TABLE 1. Influence of Position on The Inflorescence Disk on Mead Seeds Weight and Kernel/Pericarp Ratio

Character	Zone of Floral Disk			
	Outer 25%	Mid-outer 25%	Mid-Inner 25%	Inner 25%
Mean seed weight (mg)	0.751_{A}*	0.745_{A}	0.698_{B}	0.651_{C}
Kernel/Pericarp (Weight Ratio)	3.6_{A}	3.7_{A}	3.4_{A}	3.5_{A}

*Values with the same letter are not significantly different using Duncan's Multiple Range Test.

Oil Content

There was very little relationship between the oil content of the seed and the size of the inflorescence from which it was harvested (Figure 5). The small reduction in the kernel to pericarp ratio found in the larger inflorescence was not sufficient to influence the oil content of the seed from these inflorescences. The oil content of seeds was also virtually independent of seed weight within the range of seed weights sampled in this trial, with the regression accounting for only 18% of the variation observed.

The only property of the seed which showed a significant correlation with the oil content was kernel weight when expressed as a percentage of the total seed weight (Figure 6). Considerable variation exists in the relative weight of the kernel, which as shown earlier, is largely independent of the size of the inflorescence and the weight of the seed. In this study the kernel weight varied from 55 to 80% of the total seed weight and as the kernel contains 96.5% of the oil in the seed (data from this study), it follows that it will have the dominant influence on the oil content of the seed. Despite this, the fact that kernel percentage only explained 57% of the variation found in oil content (Figure 6) suggests that other factors, both environmental and genetic, must account for the remaining variability.

Further evidence for this can be seen in the results of a separate study in which the kernel percentage and oil content was measured on samples of seeds from twenty-seven sunflower breeding populations made up from diverse parental material varying widely in oil content. The relationship between kernel percentage and oil content for these populations is illustrated in Figure 7. The regression accounted for 86% of the variation indicating that kernel percent can give a very reliable prediction of the oil content of seeds between, as well as within populations of sunflower.

Conclusions

Two factors of major importance in maximizing the yield of sunflower oil are the weight of seed per unit area of crop and the oil content of that seed.

FIGURE 5. Relationship between inflorescence diameter and the oil content of the seed

$$Y = 35.04 + 0.153x - 0.741 \times 10^{-3} \; x^2$$

$$r^2 = 0.25 \; (P < 0.01)$$

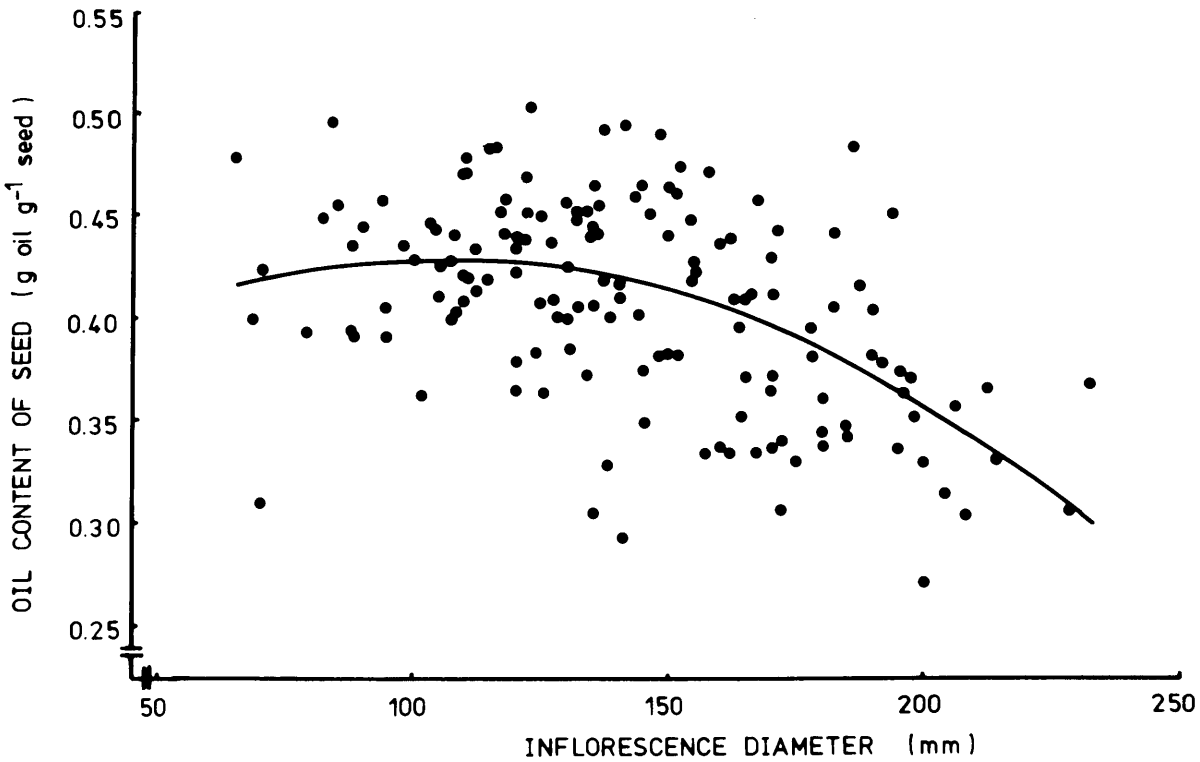


FIGURE 7. Relationship between the kernel weight, as a percentage of the total seed weight and the oil content of seed from twenty-seven sunflower breeding populations

$$Y = -23.87 + 0.90x$$

$$r^2 = 0.862 \quad (P < 0.001)$$

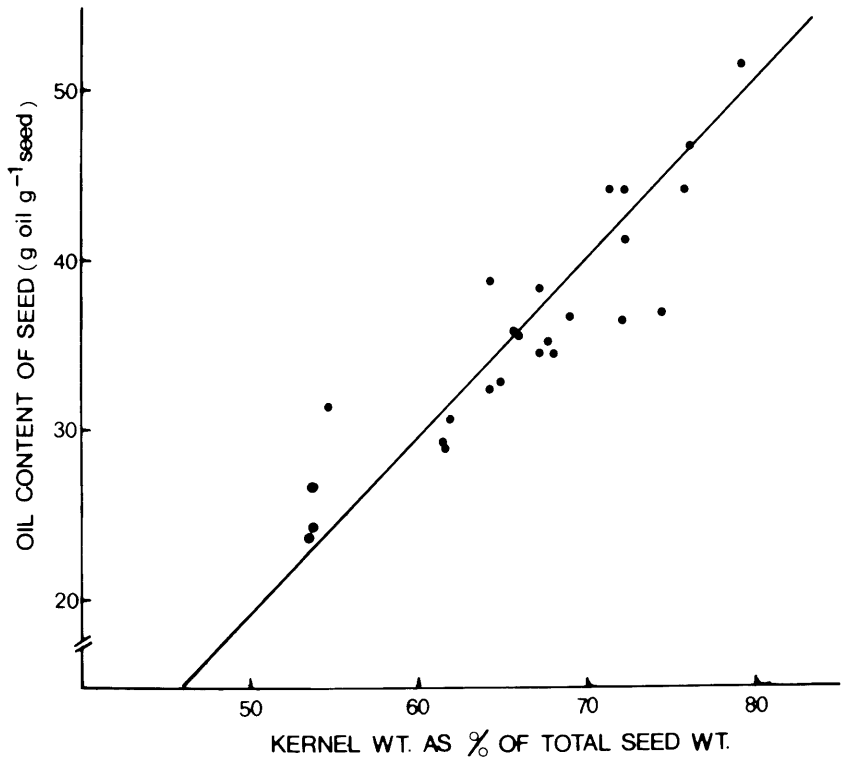
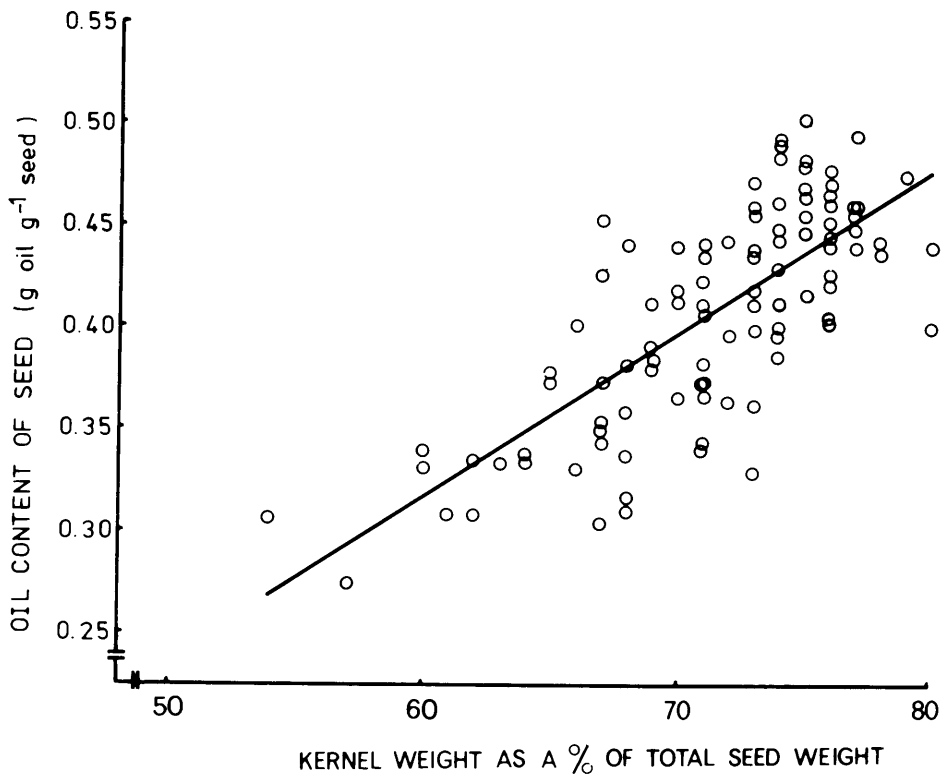


FIGURE 6. Relationship between kernel weight as a percentage of the total seed weight and the oil content of the seed of the variety Peredovik (Sunfola 68)

$$Y = -16.41 + 80.17x$$

$$r^2 = 0.57 \ (P < 0.001)$$



This study has been concerned with the latter issue and the findings suggest that changes in the plant population with associated effects on inflorescence size will have virtually no effect on the final oil content of the seed.

Apart from genetic variation and other environmental factors such as heat moisture stress and disease which have been shown to reduce oil yield (Canvin 1965; Fick and Zimmerman 1973; Harris et al 1978; Muriel and Downe 1974; Talha and Osman 1975; Zimmer and Zimmerman 1972), the important factor appears to be the proportion of the seed weight accounted for by the kernel. Past selection for higher oil yield in sunflower undoubtedly increased the relative weight of the kernel but in heterozygous open pollinated varieties such as Peredovik, there still appears to be considerable variation for this trait and hence good opportunities to select for genotypes with a higher kernel percentage.

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EFFECT OF CLIMATIC FACTORS - AIR TEMPERATURE AND HUMIDITY - ON BIOLOGICAL CHARACTERS OF SUNFLOWER

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Summary

Research objective was to determine the extent of changes in biological characters of sunflowers as affected by air temperature and humidity, as well as to establish whether certain developmental phases require the same temperature sums or the sums change from year to year.

We studied effects of air temperature and humidity on biological characters of sunflower grown in four ecological regions situated between 35th and 40th degree geographic latitude. The research, which lasted for five years (1970-1974), included the following nine cultivars: VNIIMK 8931, Mayack, Peredovic, No. 317, No. 61, Chernyanka 66, Armavirsky 3497, VNIIMK 6540 and Armavirec. The size of basic plot was 25.2 m.sq. There were five replications. Leaf area size was measured at 20 plants by the formula of Montgomery. Plant height was measured at 100 plants. Oil content was calculated by the method of Soxlet.

There are favorable and limiting factors in each region. In the first tested region, the limiting factor was a low humic content (1%), in the second, third, and fourth region unfavorable air temperatures and humidity. In spite of a low soil fertility in the first region, the highest average seed yield of the nine cultivars (32.0 mtc/ha) was obtained there. The average seed yields in the second, third, and fourth region were 30.9 mtc/ha, 31.5 mtc/ha, and 28 mtc/ha, respectively.

Oil content in absolutely dry seed was 49% in the first region (five-year average of the nine cultivars), 44.1% in the second, 44.6% in the third, and 45.0% in the fourth. These results show that the oil content in the first region was higher by 4-4.9% than the contents in the other three regions. It was also found that individual cultivars had highest oil contents in the first region. What does bring differences in oil contents? During the phase of oil synthesis, the mean daily temperatures in the first region were 26°C in July and 23.3°C in August (five-year average), in the second region 27°C in both months, in the third region 24°C in July and 26°C in August, and in the fourth region 25°C in July and 26°C in August. These figures indicate that high mean daily temperatures alone, without other adverse climatic factors, do not reduce oil contents. In those ecological conditions, however, in which high maximum temperatures (36-40°C) are accompanied by a high relative humidity (90-100%) during the phase of seed filling, oil content is reduced by 4-5%. It may also be noticed that sunflower plants endure easily such adverse climatic conditions if they occur before flowering. Our results show that sunflower plants, during the last 10-14 days of seed filling, are incapable of enduring such climatic