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HARVEST INDEX AND GRAIN/STRAW RATIO OF OIL SEED RAPE UNDER DIFFERENT NITROGEN LEVELS AND PLANT DENSITIES

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ABSTRACT

Two field experiments were conducted in two successive seasons to study the variation of harvest index and grain /straw ratio and some related traits of two different genotypes under different nitrogen levels and plant population densities. Highly significant effects were detected for nitrogen level, plant population density and genotypes for most studied traits. The results showed, the highest seed yield m^{-2}, biological yield m^{-2} and straw yield m^{-2} were obtained under the higher nitrogen level. Simple linear relationships were observed between nitrogen levels and each of biological yield, straw yield and seed yield. On the other hand, quadratic relationships were observed between nitrogen levels and each of harvest index and grain/straw ratio. Based on standard deviation, standard error, coefficient of variability and coefficient of skewness and kurtosis, harvest index showed more efficient selection criterion as compared to grain/straw ratio. The higher values of standard deviation, standard error, coefficient of variability and coefficient of skewness and kurtosis resulted under the higher level of nitrogen. High significant positive correlation coefficients were observed between seed yield and each of biological yield, straw yield, harvest index and grain/straw ratio.

Key words: ***Oil seed rape, Harvest index, Grain/straw ratio, CV%., Skewness, Kurtosis coefficient***

INTRODUCTION

Harvest index is a widely used parameter in crop science and plant breeding, Diepenbrock (2000) mentioned biological yield as the product of growth rate and duration of the growing period, both of which indicate the potential for improvement in yield. Likewise, greater harvest index leads to a higher seed yield.

The results of many experiments indicate, harvest index could be applied as a effective selection criterion (Bhatt 1977 and Huehn 1991). The efficiency of a trait such as harvest index, used as selection criterion is mainly detrmined by the numerical magnitude of the correlation between this trait and seed yield. Beside harvest index such other traits as grain/straw ratio with high stability to varying environmental condition are high interest in the field of plant breeding.

In many experiments with different crop species, harvest index showed pronounced stability with regard to varying environmental conditions (Blast 1982) In several investigations, coefficient of variation of harvest index were mostly considerably smaller than respective values for grain yield and for biomass (Huehn *et al* 1991). Moreover, Huehn (1993) reported a clear advantage in the use of the ratio of harvest index compared to the application of grain/straw ratio.

With nitrogen uptake of 330 Kg N/ha, rape crops produced up to 20 t DM/ha, at seed yield of 3.3 t DM/ha, harvest indices varied from 0.14-0.23% (Aufhamer *et al* 1994). Kler *et al* (1992 a), showed that application of 90 kg N/ha compared with 60 kg N/ha increased all vegetative parameters. Shukla and Kumar (1997) examined six varieties of Indian mustard to study the effect of nitrogen fertilization on yield attributes, they mentioned the differences among varieties to be non-significant for seed weight and harvest index but N-application at rate 120 kg ha^{-1} significantly increased seed yield and harvest index.

Under four levels of nitrogen 0, 40, 80, and 120 Kg N ha^{-1} *B. carinata* had significant grater number of pods $plant^{-1}$ as compared to *B. juncea* or *B. napus*. while *B. juncea* recorded significantly greater values for 1000 seed weight and seeds $plant^{-1}$ than other species, resulting in significantly higher seed yield and harvest index. Moreover, values of yield components increased with increasing N rate, the significant response for most yield components was up to 80 Kg N ha^{-1}. There was a quadratic response in *B. juncea* and linear relationship in *B. carinata* and *B.napus* between N levels and seed yield (Prakash *et al* 1999).

Seventy genotypes of oil seed rape were evaluated under three level of nitrogen 0, 100, and 220 Kg. N ha^{-1}, hybrid genotypes had the highest seed yield even under reduced N-supply. Genotypic variation was significant under all N-levels for seed and straw. A breeding strategy for improved N-efficiency can therefore, be based on selection for high N harvest index by reducing N-yield of straw (Kessle *et al* 1999). In the same context. Mishra and Kurchania (2001) mentioned increasing nitrogen up to 120 Kg/ha caused a corresponding increase in crop biomass, seed yield and harvest index

Plant population density governs the components of yield and, thus, the yield of individual plants. A uniform distribution of plants per unit area is a prerequisite for yield stability (Diepenbrock 2000). Abuzeid and Wilcockson (1989) showed that harvest index ranged from 25 to 40%. Moreover, increasing plant density from 2.22 to 6.66 plants m^{-2} advanced and increasing maximum LAI and total bud dry weight m^{-2}. On the other side Roy and Paule (1993) showed harvest index to decrease with increase in plant population density.

Under four plant population densities of 100000, 400000, 700000 and 1000000 plants ha^{-1} given 0, 60, 120 and 180 Kg N/ha Ali *et al* (1997) showed , harvest index and seed yield increased with increasing N-rate up to 120 Kg ha^{-1}. Increasing plant density up to 400000 plants ha^{-1} significantly increased harvest index, which were positively correlated with high seed yield.

This investigation aimed to: 1) study the variation of harvest index compared to the variation of grain/ straw ratio under different conditions by using some statistical parameters i.e., standard deviation standard error, coefficient of variation, coefficient of skewness and coefficient of kurtosis .2) study the nature of correlation of each harvest index and grain/straw ratio and some studied traits.

MATERIAL AND METHODS

Two spring oil seed rape cultivars Canola 103 (G1) and Semu 249/84 (G2) which are quite different in many morphological and physiological traits, have been grown and tested in a field trial at the Agricultural Experiment and Research Center, Faculty of Agriculture Cairo University during two successive seasons (2000-2001) and (2001-2002).

The experimental treatments were arranged in a split-split plot as a randomize complete block design with three replications. The four nitrogen levels (40, 60, 80 and 100 Kg N/feddan) occupied the main plots, the two genotypes the subplots and the plant population density (20, 30, 40 plants m^{-2}) in sub-sub plot.

Each plot consisted of five rows 4 m long with 50 cm between rows and 5, 7.5, 10 cm between plants to give different plant densities 40 (PD1), 30 (PD2) and 20 (PD3) plants m^{-2}, respectively Seeds were drilled in the rows and thinning was done 30 days after sowing according to plant distances. Different nitrogen levels were added after thinning All the agricultural practices were done according to the recommended methods.

At maturity seed yield and total dry matter (TDM) g m^{-2} from interior area of the rows were determined by sampling one m^{-2} of each plot (border rows were discarded to prevent inter plot interference between row spacing and cultivars). Oven drying to constant weight at 60 C^{0} for seed yield m^{-2} and dry matter was done.

The two parameters harvest index (HI) and grain/straw ratio (GR) were calculated as follows,

HI= (seed yield/ total biological yield) m^{-2}

GR=(seed yield/ straw yield) m^{-2}

The data were analyzed as a split-split plot design for the five studied traits (biological yield g m^{-2}, straw yield g m^{-2}, seed yield g m^{-2}, harvest index and grain/straw ratio) by analysis of variance with means separation according to LSD. The error variance of both experiments were homogeneous (Barttlet' test), therefore, combined analysis of variance over the two seasons was done.

The best fit curves were used to determine the linear and/or quadratic relationships between nitrogen levels and each of biological yield, straw yield, seed yield, harvest index and grain/straw ratio.

RESULTS AND DISCUSSION

Results in Table (1) showed, biological yield m^{-2}, straw yield m^{-2}, seed yield m^{-2} , harvest index and grain/straw ratio were significantly affected by nitrogen level, plant population densities and genotypes with two exception cases in respect to the effect of plant population density and genotypes on grain/straw ratio and harvest index. These results reflected the important role of nitrogen, plant density and genotypes on the different traits. Insignificant effects for most first and second order interactions were detected. Meanwhile, some first order interactions of (year x genotypes) have significant effect on straw yield, grain/straw ratio and harvest index. Straw yield was affected significantly by (plant density x genotypes). Biological yield showed significant response by (year x plant density).

However, insignificant effect of plant population densities on both harvest index and grain/straw ratio (Table 1), (Table 2) showed, increasing plant population density caused reduction in harvest index and grain/straw ratio as compared to lower plant population density 20 plants m^{-2}

Highest biological yield (1509 g m^{-2}) was obtained from G2 under 30 plant m^{-2} and highest level of nitrogen (100 kg feddan^{-1}), while G1 exhibited the highest biological yield (1303 g m^{-2}) under 20 plants m^{-2} and (100 kg N feddan^{-1}) (Table 3)

In respect to straw yield, highest straw yield (1221 g m^{-2}) was obtained from G2 under 30 plant m^{-2} and highest level of nitrogen (100 Kg feddan^{-1}). On the other hand, G1 showed highest straw yield (1060 g m^{-2}) under 20 plants m^{-2} with the highest level of nitrogen (100 kg N feddan^{-1}) (Table 3).

Table 1. Analysis of variance of biological yield, straw yield, seed yield, harvest index and grain/straw ratio of two oilseed rape genotypes grown under three plant densities and four levels of nitrogen.

S.O.V.	d.f.	Biological yield	Straw yield	Seed yield	Grain/ straw ratio	Harvest index
Years (Y)	1	Ns	Ns	**	**	**
Rep/ (Y)	4	Ns	Ns	Ns	Ns	Ns
Nitrogen (N)	3	**	**	**	**	**
Y x N	3	Ns	Ns	Ns	Ns	Ns
Plant density (D)	2	**	**	**	Ns	Ns
Y x D	2	*	Ns	Ns	Ns	Ns
N x D	6	Ns	Ns	Ns	Ns	Ns
Y x N x D	6	Ns	Ns	Ns	Ns	Ns
Genotypes (G)	1	*	*	*	Ns	Ns
Y x G	1	Ns	*	Ns	*	**
N x G	3	Ns	Ns	Ns	Ns	Ns
D x G	2	Ns	*	Ns	Ns	Ns
N x D x G	6	Ns	Ns	Ns	Ns	Ns
Y x D x G	2	Ns	Ns	Ns	Ns	Ns
Y x N x G	3	Ns	Ns	Ns	Ns	Ns
Y x N x D x G	6	Ns	Ns	Ns	Ns	Ns

Ns, *,**insignificant, significant mean square at the 0.05 and 0.01 probability levels, respectively

Table 2. Mean performance of studied traits under studied factors.

		Biological yield	Straw yield	Seed yield	Grain/ straw ratio	Harvest index
N levels Kg feddan^{-1}	40	906.0	722.0	184.0	0.260	0.200
	60	1011.0	796.0	215.7	0.280	0.220
	80	1041.0	792.0	249.1	0.320	0.240
	100	1299.0	1042.0	256.6	0.250	0.200
$LSD_{0.05}$		175.9	132.0	47.5	0.03	0.023
Genotypes	G1	1007.4	796.4	216.1	0.273	0.220
	G2	1117.3	879.9	237.2	0.283	0.216
$LSD_{0.05}$		93.0	62.9	20.1	Ns	Ns
Plant densities m^{-2}	40	945.5	743.8	201.7	0.276	0.214
	30	1125.1	894.8	230.3	0.265	0.207
	20	1123.8	876.7	247.1	0.293	0.223
$LSD_{0.05}$		108.2	84.8	23.1	Ns	Ns

Table 3. Biological yield, straw yield, seed yield, grain/straw ratio and harvest index related to genotypes, plant population densities and nitrogen levels

PD	N-level	Biological yield (g m^{-2})		Straw yield (g m^{-2})		Seed yield (g m^{-2})		Grain/straw ratio		Harvest index	
1		G1	G2	G1	G2	G1	G2	G1	G2	G1	G2
	1	684	922	555	744	129	178	0.23	0.25	0.19	0.19
	2	1078	834	847	644	232	190	0.28	0.30	0.22	0.23
	3	926	811	726	612	200	199	0.29	0.32	0.23	0.25
	4	1039	1271	805	1017	234	254	0.29	0.25	0.22	0.20
	Mean	931	959	733	754	198	205	0.27	0.27	0.22	0.22
2	1	879	967	693	789	186	178	0.27	0.23	0.21	0.18
	2	1011	1096	812	864	199	231	0.24	0.27	020	0.22
	3	935	1389	695	1072	239	317	0.35	0.30	0.26	0.24
	4	1213	1509	1008	1221	205	288	0.20	0.25	0.17	0.20
	Mean	1009	1241	802	987	207	253	0.27	0.27	0.21	0.21
3	1	970	1020	764	788	206	231	0.27	0.30	0.21	0.23
	2	1020	1031	791	816	228	215	029	0.27	0.23	0.21
	3	1096	1093	804	844	292	249	0.36	0.30	0.27	0.23
	4	1303	1461	1060	1144	243	317	0.23	0.28	0.19	0.22
	Mean	1096	1151	854	898	242	253	0.29	0.29	0.23	0.22
LSD	DG	NS		109.0		NS		NS		NS	

Higher seed yield m^{-2} (317 g) was obtained by G2 under 20 plant m^{-2} and highest level of nitrogen (100 Kg N feddan^{-1}). On the other hand, G1 showed the highest seed yield m^{-2} (292 g) under 20 plant m^{-2} and (80 Kg N feddan^{-1}). In respect to grain/straw ratio and harvest index the results in Table (3), showed, the higher value of grain/straw ratio for G1 and G2 were resulted from 80 Kg N feddan^{-1} for PD1 , PD2 and PD3 .

The results in Table (1) showed significant effect of nitrogen levels for all studied traits, so any increase in nitrogen level would cause an increase in biological yield, straw yield and seed yield. Results in Table (2) showed, application of 100 kg N feddan^{-1} had increased biological yield from 906 to 1299 g m^{-2} (about 43%), and increased straw yield from 722.3 to 1042 g m^{-2} (about 44%), and increased seed yield from 184 to 256.6 g m^{2} (about 39%). Fig. (1) showed, for all plant densities linear relationships were detected between nitrogen levels and each of biological yield, straw yield and seed yield these results are in harmony with those obtained by Prakash *et al* (1999).

In respect to the effect of nitrogen level on grain/straw ratio and harvest index, quadratic relationships were detected between nitrogen level and each of harvest index and grain/straw ratio Fig (1) and Table (2). Harvest index increased gradually by increasing nitrogen level reaching its maximum for G1 (0.22, 0.24 and 0.26) under (81.6, 68.6 and 69.2 Kg N feddan^{-1} for PD1, PD2 and PD3 , respectively. In respect to harvest index of G2, it reached its maximum values (0.23, 0.23 and 0.24) under nitrogen

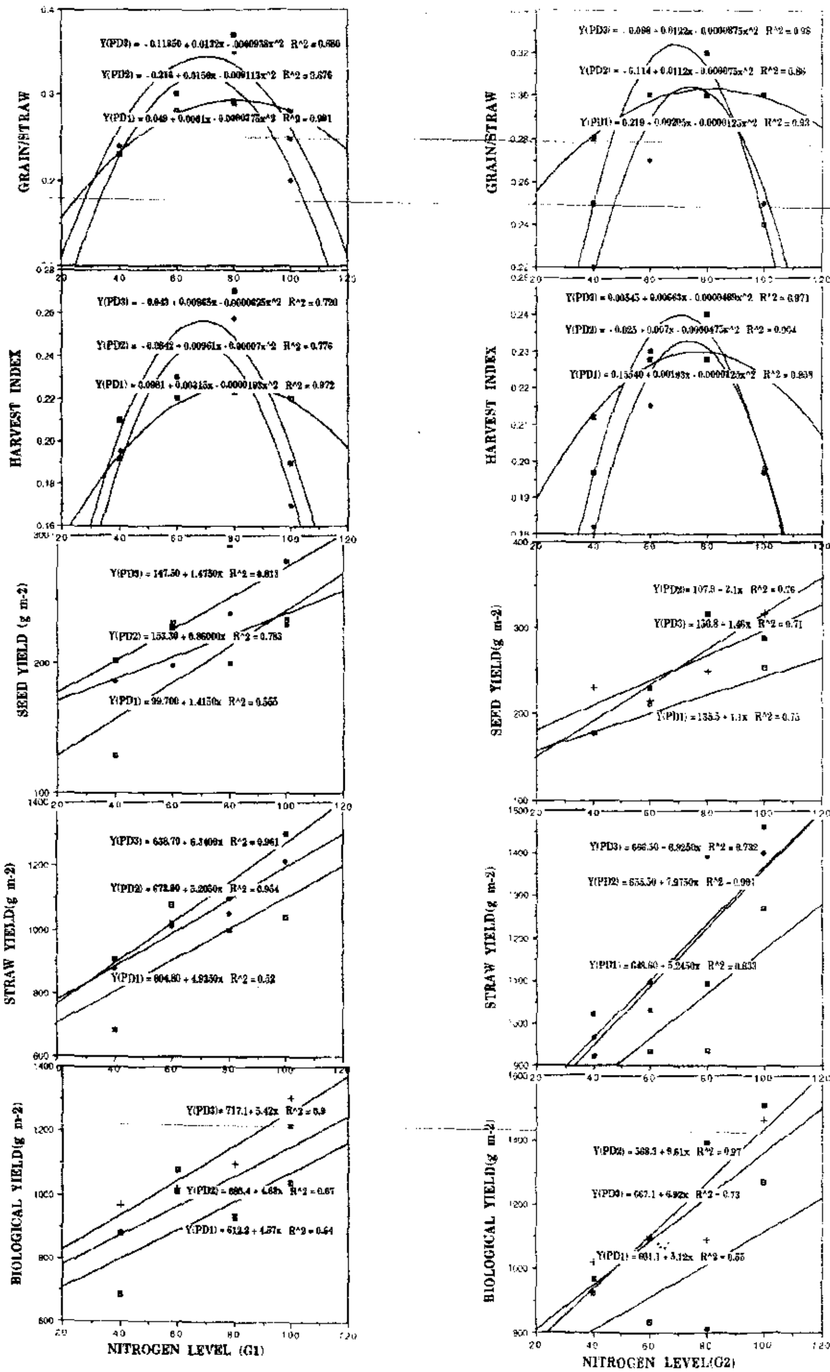

Fig. 1. Relationship between nitrogen levels and the five studied traits.

levels of (73.7, 77.2 and 70.7 kg feddan^{-1}) at PD1, PD2 and PD3, respectively. In respect to grain/straw ratio, it reached to its maximum (0.30, 0.32 and 0.35) under nitrogen level of (81.3, 69.0 and 70.4 kg feddan^{-1}) for the three plant densities, respectively in G1. In the same context, G2 showed the maximum grain/straw ratio (0.30, 0.31 and 0.33) under (82, 74.4 and 69.7 Kg N feddan^{-1}) for the three plant population densities, respectively.

The results in Table (1) showed significant effect of plant density on biological, straw and seed yield m^{-2}. Increasing plant population density to 40 plant m^{-2} caused a reduction (about 15 %) in biological yield of G1 as compared to 20 plants m^{-2}. In respect to G2 the reduction reached to about 22.7 % under higher plant population density (40 plant m^{-2}) as compare to 30 plant m^{-2}. In respect to straw yield, the higher plant population density caused reduction in straw yield as compared to lower plant density by about (14 and 23.6 %) for G1 and G2, respectively. In the same context, by increasing plant density, seed yield decreased by 18 and 19 % for G1 and G2, respectively under higher plant density (40 plant m^{-2}) as compared to 20 plants m^{-2} (Table 3).

Regression coefficients of G1 were, 4.57, 4.63 and 5.42 in biological yield, 4.94, 5.2 and 6.34 in straw yield and 1.42, 0.86 and 1.48 for seed yield under the three plant population density, respectively Fig (1). For G2

the regression coefficients were 5.12, 9.61 and 6.92 for biological yield, 5.25, 7.97 and 6.93 in straw yield and 1.1, 1.46 and 2.1 in seed yield under 40,30 and 20 plants^{-2}, respectively. From these results it could be concluded that, the amount of change under higher population density was lower as compared to the amount of change under lower plant population density which may be due to the greatest ability of oil seed rape plants to adapt to different conditions i.e, it could give more fruiting branches under lower plant density which cause higher biological yield and seed yield.

From the previous results it could be concluded higher mean values of biological yield, straw yield and seed yield were obtained under the highest nitrogen level. On the other hand and with respect to harvest index and grain/straw ratio, the maximum values were under third level of nitrogen (80 kg N feddan^{-1}) which may be due to, the amount of change in straw yield exceed the amount of change in seed yield. For example G1 showed higher regression coefficient "b" (4.93, 5.2 and 6.34) for straw yield as compared to the values of "b" of seed yield (1.41, 0.86 and 1.48) under the three plant population densities, . In the same context G2 showed higher "b" values (5.25, 7.97 and 6.93) for straw yield as compared to (b=1.1, 1.46 and 2.1) of seed yield for the three plant densities, respectively.

The results in Table (4) showed, standard error, standard deviation and the coefficients of variation (CV%), skewness and kurtosis for all studied traits under the four levels of nitrogen across years, genotypes and plant population densities. In respect to standard error, the results showed, for all studied traits, higher values of standard error were observed under the higher level of nitrogen. That is may be due to, the oil seed rape plant showing high different responses to various conditions. The higher level of nitrogen, encourage the of oil seed plant variability which reflect on the coefficient of standard error. With respect to coefficient of kurtosis and coefficients of skewness, the results showed, for all studied traits that higher level of nitrogen especially 80 Kg N feddan^{-1} showed the greatest values of each skewness and kurtosis coefficients. In the same context, for all studied traits coefficient of variability reached the highest values under the higher nitrogen levels.

Table 4. Standard error, standard deviation CV.%, skewness and kurtosis coefficients of the five studied traits

	N	Standard error	Standard deviation	C.V %	Skewness	Kurtosis
Biological yield g m-2	1	39.3	235.4	25.97	0.18	2.32
	2	36.5	218.8	21.60	0.03	2.93
	3	54.4	326.4	31.30	0.80	4.08
	4	54.0	32.4.2	25.00	0.53	3.58
Straw yield g m-^{2}	1	31.8	190.8	26.40	0.25	2.39
	2	31.3	188.1	23.60	0.026	2.39
	3	44.8	268.6	33.90	1.21	5.82
	4	44.7	267.9	25.70	0.42	3.29
Seed yield g m-2	1	10.3	61.6	33.50	0.42	2.52
	2	9.57	57.4	26.60	0.21	2.73
	3	13.7	80.2	33.00	0.58	3.32
	4	14.1	84.6	33.00	0.59	2.96
Grain/straw ratio	1	0.01	0.06	23.00	0.42	2.71
	2	0.015	0.09	32.14	0.95	4.22
	3	0.013	0.08	25.40	0.23	5.95
	4	0.01	0.07	28.00	0.65	4.66
Harvest index	1	0.007	0.04	20.00	0.076	2.30
	2	0.008	0.05	22.70	0.07	0.85
	3	0.008	0.05	20.80	0.08	2.72
	4	0.008	0.05	25.00	0.44	2.48

The results in Table (4) showed, harvest index had the lower values of coefficient of variability, standard error, coefficient of kurtosis and coefficient of skewness as compared to grain/straw ratio, biological yield, straw yield and seed yield/plant.

Figure (2) showed relative frequency distribution of the all studied traits over replication and seasons (n=24). The results showed, harvest index

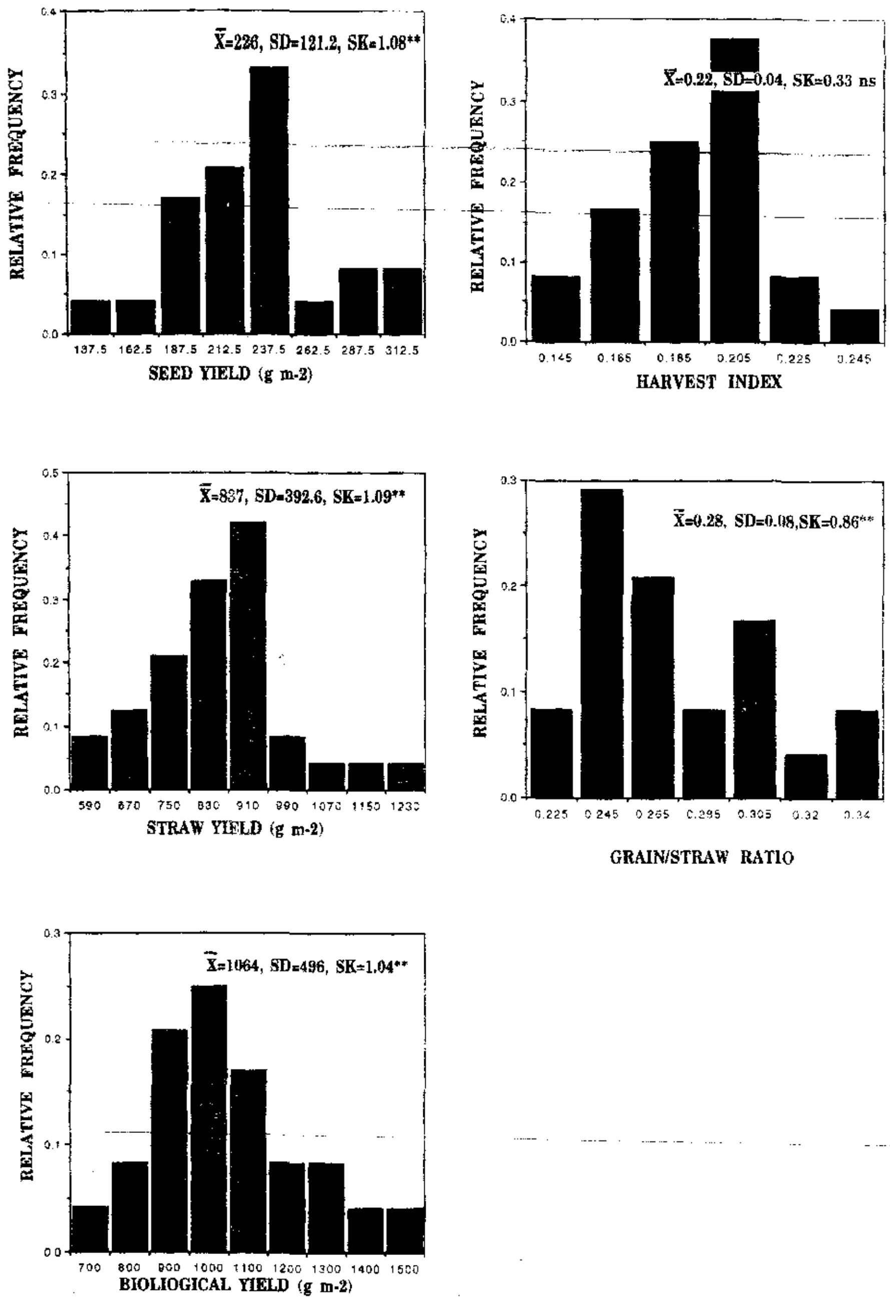

Fig. 2. Relative frequency distribution of the five studied traits.

exhibited the lowest values of each standard deviation (SD=0.04) and coefficient of skewness (Sk=0.33) as compared to the other traits. Grain/straw ratio exhibited slightly more differentiated standard deviations (SD=0.08) and significant positive skewness coefficient values (Sk=0.86**) as compared to harvest index. Highly significant positive skewness coefficient values were detected to biological yield (Sk=1.04**), seed yield (Sk=1.08**), and straw yield (Sk=1.09**). From these results it could be concluded that, harvest index is more stability and less affected by the change in different conditions, The " b" values of harvest index under different plant densities and genotypes were smaller as compared to other traits .Fig (1).

The individual harvest indices fluctuated from 0.10 to 0.39 and they, therefore, exhibit a considerable range of variation. On the other hand, the individual grain/straw,ratio vary from 0.11 up to 0.64. They therefore, show a clearly enlarged range of variation as compared to the individual harvest indices (data not presented).

Many experimental investigations with quite different agricultural crops have been published demonstrating a pronounced stability of the harvest index with regard to varying environmental conditions. Huhen (1993) showed, such " stable" traits to be of particular interest in the field of plant breeding, and can be used as selection criteria.

Simple correlation coefficients between all possible pairs combinations of all five studied traits are presented in Table (5). The results showed, highly significant positive correlation coefficients between seed yield and each of biological yield(r=0.97**), straw yield (r=0.95**), harvest index(r=0.47*) and grain/straw ratio(r=0.44*) indicating the important role of dry matter accumulation on seed yield. These results are in harmony with those obtained by Shrief (1989), Huehn (1991), Kler *et al* (1992 b) and Shrief and Mahrous (1998). The higher correlation coefficient value between harvest index and seed yield as compared to correlation coefficient between grain/straw ratio and seed yield reflect the important role of harvest index as a selection criterion as compared to grain/straw ratio.

Table 5. Simple correlation coefficients between all possible pairs of the five studied traits

	Biological yield	Straw yield	Seed yield	Harvest index
Grain/straw ratio	0.11	0.04	0.44*	0.96**
Harvest index	0.16	0.10	0.47*	
Seed yield	0.97**	0.95**		
Straw yield	0.99**			

Also, significant positive correlation coefficients were observed between biological yield and straw yield ($r=0.97^{**}$). In the same context, significant positive correlation coefficient was observed between harvest index and grain/straw ratio ($r=0.96^{**}$).

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دليل الحصاد ونسبة البذور للقش لمحصول السلجم تحت مستويات مختلفة من النيتروجين والكثافات النباتية

سعيد عبد الرحمن شريف

قسم المحاصيل-كلية الزراعة-جامعة القاهرة

أجرى هدا البحث بهدف دراسة تأثير بعض العوامل (النيتروجين والكثافات النباتية) على الاختلافات بالنسبة لدليل الحصاد ونسبة البذور الى القش وبعض الصفات الأخرى (الحاصل البيولوجى الكلى، وزن القش، محصول البذور للمتر المربع) لصنفين من لفت الزيت.

أظهرت النتائج وجود تأثير معنوى لعوامل الدراسة ودلك على اغلب الصفات المدروسة. حيث تم الحصول على أعلى حاصل بيولوجى وقش ومحصول بذرة للمتر المربع ودلك تحت أعلى مستوى من النيتروجين (١٠٠ كجم/فدان). كما أظهرت النتائج وجود علاقة خطية بين مستوى النيتروجين المضاف وكلا من الحاصل البيولوجى الكلى ، و محصول القش ومحصول البذرة. على جانب آخر أظهرت النتائج ان

هناك علاقة من الدرجة الثانية بين مستويات النيتروجين المضافة وصفتى دليل الحصاد ونسبة البذرة للقش. أظهرت صفة دليل الحصاد كفاءة عالية كصفة انتخابية مقارنة بـ نسبة البذور للقش . تم الحصول على اعلى القيم للمقاييس الإحصائية المستخدمة والتى تمثلت فى الانحراف المعيارى، الخطأ القياسى،معامل الاختلاف، ومعاملى الالتواء والتفرطح تحت المستويات العالية من النيتروجين. أظهرت النتائج وجود ارتباط معنوى موجب بين صفة المحصول والحاصل البيولوجي الكلى ووزن القش ودليل الحصاد ونسبة البذرة للقش.

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