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Path-coefficient and Stepwise Regression Analyses Under Different Sowing Dates in Alfalfa (*Medicago sativa*)

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Abstract

The current work was carried out at Agronomy Department Farm, Faculty of Agriculture, Assiut University, Egypt, to study the direct and indirect effects and stepwise regression of yield attributes on forage and seed yields of ten alfalfa genotypes. Two experiments were carried out as experiment I (2017-2019) and experiment II (2018-2020). The experiments were laid out in a split block design with three replications. Five sowing dates at 10th October (D1), 10th November (D2), 10th December (D3), 20th March (D4) and 20th April (D5) were used. Fifteen cuts were taken from each sowing date in two years, while, seed yield was taken in the second year which take in the first week of March, April and May for the studied sowing date. The obtained results of path analysis, show that, fresh forage yield has the greatest influence on protein forage yield in each sowing date. However, its indirect effects were negative *via* mean dry matter percentage or negligible *via* protein percentage in both experiments. Also, the number of pods/plant and number of seeds/pod contributed to most direct effect on seed yield/plant for each sowing dates. Meantime, the results of stepwise regression analysis showed that, the model no.2 which included two independent traits i.e. dry forage yield and protein percentage resembled the fit model for protein yield. Also, the model no.2 which possessed two independent traits i.e. number of seeds/plant and 1000-seed weight has strong contribution to seed yield/plant.

Keywords: *Alfalfa, Path-analysis, Stepwise regression, Sowing dates, Protein and Seed yield*

Introduction

Alfalfa or Lucerne (*Medicago sativa* L.) is a highly productive forage legume of global importance. Being a long-lived perennial, it's had been called "The king of the Forages". It is one of the most important forage species in many countries for its high production. In Egypt, the total cultivated area of alfalfa was about 73321 feddan (one feddan = 4200 m^2) with an estimated productivity of about 1953422 tons of green fodder (B.A.S, 2018). Because alfalfa can fix nitrogen and synthesize protein, it is a very useful for farmers, who have grown alfalfa as a protein-rich fodder for cows, goats, sheep, chickens and others. It is cultivated over a wide range of climatic and edaphic conditions ranging from the semi-arid regions to the humid areas. Therefore, this crop plays a significant economic role in animal feed market (i.e., hay, dehydrated forage, pellets, and silage). A great effort has been made to improve alfalfa forage quality.

In Egypt, the production of forage crops did not satisfy the feeding requirements of animal, especially in summer season which are suffering from serious feed shortage and the receiving than their maintenance. It is very important to increase the alfalfa productivity through, improving agricultural practices and selecting adapted varieties through suitable plant breeding program.

The current changes in the climatic conditions all over the world towards warming and especially in Egypt are expected to increase the heat during the alfalfa growth period. It was desirable to change the planting date of alfalfa to avoid the high or low temperature effects at the beginning of each season. Few workers practiced that matter. Seed yield of alfalfa was found to depend on several factors i.e. weather condition and insect's activity during the period of blooming (Martiniello *et al*., 1999).

Less information is available in Egypt regarding the influence of change in climatic conditions resulting from different planting dates on forage and seed yields of alfalfa.

Relationships between yield and yield contributing traits also play an important role (Diz *et al*., 1994). Environmental conditions during seed development, genetic characteristics and agronomic techniques have considerable effect on seed yield and components of yield through their effect on plant reproductive.

Path analysis is used to determine the amount of direct and indirect effects of the causal components on the effect component. As previous studies, plant breeders could find well qualified varieties with certain characteristics by using path analysis at the terminal selection stage of breeding. Suleyman and Meryem (2006) found positive direct effect of number of pods per raceme and number of seed per raceme on seed yield of alfalfa and suggested that these yield components may be good selection criteria to improve seed yield of alfalfa cultivars. In contrast, Kowithayakorn & Hill (1982) and Askarian *et al*., (1995) found that the number of seeds/pod was an unimportant yield component.

The effects of different temperatures on the performance (forage and seed yields) of the current ten verities under different sowing dates were published previously (Bakheit *et al.,* 2021a and b).

Therefore, the objectives of current study were design to study the nature of association between forage protein yield, seed yield and their contributing variables via correlation coefficient and path-coefficient procedure, besides stepwise regression analysis for protein yield, seed yield/plant and seed yield per/m^2.

Materials and Methods

This work was carried out at the Agronomy Department Experimental Farm, Faculty of Agriculture, Assiut University, Assiut, Egypt (27.19 N, 31.16 E; clay soil) during three years from 2017 to 2020 in two experiments. The aim of this work was to study the effect of temperature resulting from six different sowing dates on forage and seed yields and their components of ten alfalfa genotypes (*Medicago sativa* L.).

The physical and chemical properties of the experimental soil were sand (25.9%), silt (24.7%), clay (49.4), soil pH (7.80), organic matter (1.62%), total nitrogen (0.09%) and $CaCO_3$ (1.2%). Materials for this study included nine genotypes from Egypt, Ismailia-1, Nubaria-1, Ramah-1, Populations from F.R.S., Kharja, El-Dahlia, Farafra, Aswan and Balady, beside one introduced genotype from U.S.A (Cuf 101).

Two experiments were carried out as experiment I (2017-2019) and experiment II (2018-2020), each experiment include two parts, the first for forage yield and its components and the second for seed yield and its components. Treatments involved three autumn sowing dates, i.e. 10th October (D_1), 10th November (D_2) and 10th December (D_3) and three spring sowing dates, i.e. 20th March (D_4), 20th April (D_5) and 20th May (D_6), Also, ten alfalfa genotypes were included in each experiment. The sowing date of 20th May (D6) in both experiments did not germinated under Assiut condition, consequently, the other five sowing dates improved across the two experiments.

Each experiment included all autumn and spring sowing dates. A split block design with three replications was used in both experiments. Sowing dates were arranged in vertical strips and the genotypes in horizontal strips. Plot size was one square meter (one-meter-long x one meter apart). Alfalfa seed were broadcasted by hand at the rate of six and five g/m^2 (plot) for forage and seed yields, respectively. Phosphorus and all other cultural practices were maintained at optimum level for maximum alfalfa productivity. Fifteen cuts were taken in the two years from each sowing date for each experiment (experiment I, 2017 and 2019 and experiment II, 2018 and 2020). In the second year for each sowing date, the plants were left for flowering and seed production in the first week of each of March for D_1 and D_4, April for D_2 and D_5 and May for D_3 in the two experiments.

The following data were recorded;

A- Forage yield and its attributes:

Data of the following traits were recorded at the time of each cut for each sowing date:

1- Mean plant height, (PH) cm
2- Mean leaves/stems ratio (LS)
3- Total fresh forage yield, (kg) (FFY): The total of the fifteen cuts were considered for each sowing date in each experiment.
4- Mean dry matter percentage (DMP): after drying in an oven at 70°C until weight constancy. The mean of the fifteen cuts were considered for each experiment.
5- Total dry forage yield (DFY): estimated by using green forage yield of each plot x mean dry matter percentage.
6- Mean protein percentage (PP): The protein percentage was determined by micro-Kjeldahl method as outlined by Baur and Ensminger (1977) to estimate the total nitrogen. Nitrogen percentage was multiplied by 6.25 to obtained crude protein.
7- Protein yield (m^2) (PY): estimated by using dry forage yield/m^2 x protein percentage.

B- Seed yield and its attributes:

At seed maturity stage the following data were recorded on a sample of 10 plants randomly collected from the center of each plot for each sowing dates ; for number of inflorescences (NIP), number of pods/plant (NPP), number of seeds/pod (NSD), number of seeds/plant (NSP), 1000 seed weight (seed index) and seed yield/plant, g (SYP). Moreover, seed yield/plot, g (SYW) was estimated.

Climatic data during growing seasons included maximum and minimum daily temperature from sowing date to date of physiological maturity in each experiment . The total growing degree days (GDD), (base= 7) was calculated (Table 1) for each sowing date according to Saeed and Francis (1984) as follows:

Total growing degree days (GDD) =

Σ[((Maximum + Minimum temperature)/2)-7]

Where, 7= point zero growth three values were estimated for total of fifteen cuts, and for seed yield at the second year from March for D_1 and D_4, April for D_2 and D_5, and May for D_3 until seed maturity (Table 1)

Path coefficient analysis:

Path coefficient analysis was done according to the procedure suggested by Dewey and Lu (1959) for forage yield and its components as well as seed yield and its components, as following:

a- Protein forage yield and its components:

First order components of protein yield in alfalfa (Y) were:

1- fresh forage yield (f), 2- mean dry matter percentage (m), and 3- mean protein percentage (t) as well as the residual factors (x) for each sowing date as shown in Figure 1. The correlation coefficients were partitioned into direct and indirect effects as following:

$$1 - r_{y1} = P_{y1} + r_{12}\, P_{y2} + r_{13}\, P_{y3}$$
$$2 - r_{y2} = P_{y2} + r_{13}\, P_{y1} + r_{23}\, P_{y3}$$
$$3 - r_{y3} = P_{y3} + r_{13}\, P_{y1} + r_{23}\, P_{y2}$$
$$1 = P_x^2 + P_{y1}^2 + P_{y2}^2 + P_{y3}^2 + 2P_{y1}\, r_{12}\, P_{y2} + 2P_{y1}\, r_{13}\, P_{23} + 2P_{y2}\, r_{23}\, P_{y3}$$

Where, r is the correlation coefficient between variables, P is the path coefficient measuring the direct effects and other is the measure of the indirect effects of one variable upon another. The path-coefficients in this particular instance were obtained by the simultaneous solution of the above equations.

b- Seed yield/plant and its components

In the same manor, the diagram could be similar for seed yield and its components (Figure 2).

Variables of seed yield/plant which were considered to contribute to seed yield/plant (S) were; 1- number of pods/plant, 2- number of seeds/pod, and 3- seed index (1000 seed weight) as well as the residual factors (x).

$$1 - r_{S1} = P_{S1} + r_{12}\, P_{S2} + r_{13}\, P_{S3}$$
$$2 - r_{S2} = P_{S2} + r_{12}\, P_{S1} + r_{23}\, P_{S3}$$
$$3 - r_{S3} = P_{S3} + r_{13}\, P_{S1} + r_{23}\, P_{S2}$$
$$1 = P_{sx}^2 + P_{s1}^2 + P_{s2}^2 + P_{s3}^2 + 2P_{s1}\, r_{12}\, P_{s2} + 2P_{s1}\, r_{13}\, P_{s3} + 2P_{s2}\, r_{23}\, P_{s3}$$

Stepwise regression analyses

SPSS-PC program Ver. 10 of Nie *et al.,* (1975) was used to estimate stepwise multiple regression across the two experiments *i.e.* 2017-2019 and 2018-2020 for dependent factors i.e. protein yield (PY), seed yield/plant (SYP) and seed yield/plot (SYW). Also, coefficient of determination (R^2) was calculated for all models derived from stepwise analysis. Ten genotypes in five sowing dates produced 50 treatments.

Results and Discussion

A- Path-coefficient analysis

A- 1. Path-coefficient analysis for forage yield and its components

Path-coefficient analysis was used to determine the direct and indirect effects of the total fresh forage yield, mean dry matter percentage and mean protein percentage on forage total protein yield under each of the five sowing dates and over dates in experiment I and II as presented in Table 2.

Concerning each sowing date, the total fresh forage yield had the greatest influence on total forage protein yield as indicated by phenotypic correlation as well as path-coefficient analysis. The path-coefficient analysis revealed that the total fresh forage yield contributed to most direct effect in all sowing dates in the two experiments (Table 2). The direct effect of fresh forage yield on protein yield recorded a high positive values of 0.71, 1.08, 0.764, 0.699, 0.378, and 1.025 for D1, D2, D3, D4, D5 and overall sowing dates in experiment I, respectively. While in experiment II, the respected values were 1.22, 0.877, 0.719, 0.557, 0.394 and 0.686, respectively. Negative or positive negligible indirect effects were found for dry matter and protein percentages *via* fresh forage yield for all sowing dates in both experiments. All these negligible values ranged from -0.0965 to 0.2130 (Table 2). This might indicate that the fresh forage yield has the major effect as direct contribution toward total forage protein yield.

Mean dry matter percentage has a low positive direct effect on protein yield with values of 0.205, 0.372 in D1, 0.186, 0.311 in D2, 0.202, 0.336 in D3, 0.195, 0.163 in D4, 0.364, 0.260 in D5 and 0.096, 0.145 overall sowing dates in experiments I and II, respectively. But dry matter percentage was of negative or negligible indirect effect *via* fresh forage yield and protein percentage for all sowing dates in both experiments (Table 2).

Moreover, mean protein percentage has a positive and high direct effect in both experiments, where, recorded values of 0.668, 0.791 in D1, 0.843, 0.982 in D2, 0.663, 0.473 in D3, 0.701, 0.676 in D4, 0.668, 0.776 in D5 and 0.222, 0.457 in overall sowing dates for experiment I and II, respectively. But, mean protein percentage revealed negative or positive negligible indirect effect *via* fresh forage yield and *via* dry matter percentage in values ranged from -0.672 to 0.289 (Table 2).

In general, the path coefficient analysis revealed that the fresh forage yield, dry matter percentage and protein percentage contributed to mainly to and most direct effects on forage protein yield under that current study.

It could be concluded that, the fresh forage yield, dry matter and protein percentages were important traits for selecting of high total forage protein yield in alfalfa depending on results of direct effects in path-coefficient analysis (Table 2). With this respect, Julier *et al.*, (2000) reported that forage yield and its quality are complex traits whose expression is influenced by genetic constitution of a plant as well as environmental factors. Because of the mentioned reasons, determining the genetic potential of the alfalfa ecotypes and the interrelation among traits are of high importance. Monirifar (2011) found that plant dry weight had a positive relation with all other yield components. Also, these results are in line with those reported by Bakheit *et al.*, (2017) in Egyptian clover who found that seasonal fresh forage yield had the highest positive direct effect on seasonal protein forage yield (0.84) followed by mean dry matter percentage (0.46) and protein percentage (0.172). Also, Abd El-Rady (2018) indicated that the fresh forage yield had the greatest influence on protein forage yield, but its indirect effects via mean dry matter percentage were negative and via protein percentage were -0.830, -0.008 and 0.035 for first, second and third sowing dates, respectively. Thereby fresh forage yield, dry matter and protein percentages are important traits for selection of high protein forage yield.

On the other hand, the residual effect of the current path-coefficient was negligible in most sowing dates and experiments, indicating that there are no other effecting traits on protein values that were recorded in that recent research (Table 2).

A-2. Path-coefficient analysis for seed yield/plant and its components

The partitioning of phenotypic correlation between seed yield/plant and yield components into direct and indirect effects by path analysis under the five sowing dates and over dates in the two experiments was carried out as in Table 3. Path-coefficient analysis was used to determine the direct and indirect effect of the number of pods/plant, number of seeds/pod, and seed index (1000-seed weight) on seed yield/plant across all sowing dates of both experiments (Table 3).

Results in Table 3 showed that the relative importance of the primary seed yield components were different from sowing date to another and from experiment to another. On the other hand, in this study path-coefficient analysis showed complex interrelations among seed yield components because number of pods/plant, number of seeds/pod and 1000-seed weight were all important in determining seed yield in alfalfa.

To sum, seed yield/plant of alfalfa could be generally a function of number of pods/plant, number of seeds/pod and 1000-seed weight. Also, the path coefficient analysis revealed that the number of pods/plant and number of seeds/pod contributed most direct effect for each sowing date in the two experiments (Table 3). For example, the high direct effects for number of pods/plant were 1.075, 0.774, 0.716, 1.03, 0.907 and 0.990, in D1, D2, D3, D4, D5 and overall sowing dates in experiment I, respectively. Also, the values were 0.667, 1.24, 0.843, 0.893, 1.347 and 0.711 in the same manner in experiment II, respectively.

But, the values were negative or positive and negligible for indirect effect via number of seeds/pod and 1000-seed weight in both experiments for most sowing dates (Table 3). For example, the indirect effects via number of seeds/pod and 1000-seed weight were (0.279, 0.010), (-0.109, -0.007), (-0.042, 0.009), (-0.349, 0.032), (-0.055, 0.017) and (-0.224, -0.016) in D1, D2, D3, D4, D5 and overall sowing dates in experiment I, respectively. While, the values were (0.193, -0.056), (-0.496, 0.114), (-0.210, 0.007), (-0.019, 0.022), (-0.773, -0.070) and (-0.183, -0.011) in the same manner in experiment II, respectively.

Mean number of seeds/pod had a high and positive direct effect in experiments I and II with values of 1.248, 0.902 in D1, 0.525, 0.565 in D2, 0.713, 0.777 in D3, 0.807, 0.441 in D4, 0.418, 1.008 in D5 and 0.619, 0.803 overall sowing dates, respectively. But, the number of seeds/pod were negative or negligible indirect effect via number of pods/plant and 1000-seed weight for each sowing date in experiment I and II (Table 3).

Moreover, 1000-seed weight had a low positive direct effect in experiments I and II recording values of 0.328, 0.298 in D1, 0.055, 0.257 in D2, 0.135, 0.048 in D3, 0.175, 0.057 in D4, 0.125, 0.302 in D5 and 0.130, 0.163 overall sowing dates, respectively.

Meanwhile, 1000-seed weight expressed a negative or positive and negligible indirect effect via number of pods/plant and number of seeds/pod for each sowing date in both experiments. For example, the indirect effect via number of pods/plant and number of seeds/pod in experiment I were 0.033 and -0.224; -0.095 and 0.099; 0.049 and -0.017; 0.189 and -0.30; 0.124 and 0.183 and -0.125 and 0.053 in D1, D2, D3, D4, D5 and overall sowing dates, respectively. While, in experiment II were -0.125 and -0.195; 0.553 and -0.240; (0.117 and 0.193; 0.347 and -0.030; -0.313 and 0.418 and -0.048, -0.002 in the same manner, respectively (Table 3).

In general, the results of path coefficient analysis exhibited that the number of pods/plant, number of seeds/pod and 1000-seed weight had the main and basic direct effects and contribution on seed yield/plant in the current research.

With this respect very little information was available on alfalfa seed yield associations with inflorescences level. A large genetic variation among and within variety of alfalfa for seed yield and its component was reported by Campbeil and He (1997). The seed yield components techniques (Sengul, 2006). Iannucci *et al.* (2002) reported complex interactions among seed yield components with inflorescence density, pods/inflorescence, seed/pod and 1000-seed weight.

These results are in line with those reported by Bakheit *et al.* (2017) in Egyptian clover. Also, Jafari *et al.*, (2012) found that pod yield had higher direct and total effects on seed yield. As well as, Abd El-Rady (2018) reported that direct effects of number of pods/plant on seed yield/ plant were 0.511, 0.390 and 0.823 in first, second and third sowing dates, respectively. While, the direct effects of number of seeds/pod on seed yield/plant were 1.186, 0.997 and 0.359, respectively. The direct effects of 1000-seed weight on seed yield/plant were 0.526, 0.359 and 0.141, respectively.

On the other hand, the residual effect of path-coefficient for seed yield trait was negligible in most sowing dates and experiments, indicating that there are no other traits recorded and affected seed yield/plant in the current research.

Finally, the results of the path-coefficient analysis suggested that selection for improving seed yield/plant may be carried directly through selection for number of seeds/pod, number of pods/plant and 1000-seed weight.

B- Stepwise regression analysis

B.1- Stepwise regression for protein yield (PY)

In experiment I (2017-2019), stepwise regression analysis for dependent trait of protein yield (PY) gave two fitted models, model 1 has only one independent trait of dry forage yield (DFY) and gave R^2 = 0.948, and model 2 with independent traits of dry forage yield (DFY) and protein percentage (PP) resembled to be the fit model and gave R^2 = 0.997 (Table 4). Also, in the experiment II (2018-2020), two fitted models were exerted for dependent trait of protein yield. These two models were the same as in experiment I and gave R^2 = 0.829 and 0.998, respectively (Table 4). It is clear that, model 2 which has two traits (dry forage yield and protein percentage) in both experiments revealed R^2 strongly closed to unity and resembled to the strong relationship between those two traits and protein yield, consequently they might be powerful traits to produce highest protein yield and should take strong place through the evaluation and selection for protein yield in alfalfa.

B.2- Stepwise regression for seed yield/plant (SYP)

In experiment I (2017-2019), stepwise regression analysis for dependent trait of seed yield/plant (SYP) revealed that two fitted models were obtained, model 1 gave only one independent trait of number of seeds/plant (NSP) with R^2 = 0.971, and model 2 possessed two independent traits of number of seeds/plant (NSP) and 1000 seed weight (SI) resembled to be the fit model and presented R^2 = 0.996 (Table 5). In the experiment II (2018-2020) two fitted models were exerted for dependent trait of seed yield/plant (SYP). These two models were the same as in exper.1 and gave R^2 = 0.983 and 0.995, respectively (Table 5). It is remarkable result that the model 2 which possessed two traits (number of seeds/plant and 1000 seed weight) in both experiments revealed strong R^2 closed to unity and excepted the strong contributions of those two traits in seed yield/plant, consequently it might be a powerful tool to enhance. Selection high of seed yield/plant and should take large place via the improvement of seed yield/plant in alfalfa.

B.3- Stepwise regression for seed yield/plot (SYW)

Stepwise regression analysis for dependent trait of seed yield/plot (SYW) revealed different picture comparing to seed yield/plant (SYP). In experiment I (2017-2019), stepwise regression analysis for dependent trait of seed yield/plot (SYW) revealed two models were obtained, model 1 gave only one independent trait of seed yield/plant (SYP) and weak R^2 = 0. 268, and model 2 possessed two independent seed yield/plant (SYP) and number of inflorescence/plant (NIP) with R^2 = 0. 340 (Table 6). In the experiment II (2018-2020) one different model was exerted for dependent trait of seed yield/plot (SYW) which included one independent trait of number of pods/plant (NPP) and gave very weak R^2 = 0.094 (Table 6). The obtained results concluded that the weak contributions of yielded traits in seed yield/plot under the current study. Therefore, more studies should be taken remarkable place to determine a powerful traits contributed to seed yield/plot in alfalfa.

B.4- Expected and actual values comparison

The expected values of all dependent traits i.e. protein yield, seed yield/plant and seed yield/plot for all produced fitted stepwise models were insignificant relative to the actual values in both experiments as revealed by t-test which tend to be less than unity or zero for all models. Moreover, the correlation coefficients (r) between expected and actual values were positive, very high and strongly closed to unity in all cases for protein yield and seed yield/plant and medium values for seed yield/plot. These results displayed the effectiveness of stepwise regression analysis in determining the contributions of strongest dependent trait/s to release a high yield of protein and seed in alfalfa.

Wenyue *et al*., (2011) found that, stepwise regression had different effects on different types of alfalfa. The hay production can be improved by increasing the specific leaf weight and decreasing the fresh/dry ratio and stem/leaf ratio. The density of branches of multifoliolate alfalfa is lower than trifoliolate alfalfa, therefore, hay yield of multifoliolate alfalfa can be enhanced by increasing number of branches, number and applying rational close planting. Moreover, Kakaei and Mazahery-Laghab (2015) noted that the stepwise regression for fresh forage yield as dependent variable showed that dry forage yield, dry matter percent and plant height in 10% flowering stage were respectively entered to the model and with 89.29% of cumulative contrast coefficient confirmed the most variations of fresh forage yield in alfalfa. In addition, Sharratt *et al*. (1986) indicated that, multiple regression analysis revealed that, relative importance of environmental variables in alfalfa spring dry matter production were dependent on stand age. Fall and winter period variables, notably precipitation and air temperature, were found to have a large effect on spring yields and thus should be considered in alfalfa growth models. Jafari *et al*. (2012) reported that the dry matter yield and pod yield had higher direct and total effects on seed yield of alfalfa.

Conclusion

In the recent study, the effect of protein component on forage yield was studied. Forage yield was found to contribute in increasing protein forage yield. In addition, number of pods/plant contributed in increasing seed yield. These traits help alfalfa breeder to improve conduct breeding programs, forage and seed yields. Based on stepwise regression analysis, two models were found and containing independent traits *i.e.* dry forage yield and protein percentage resembled to be the fit model for protein yield in both experiments. Based on stepwise regression for seed yield/plant two independent traits (number of seeds/plant and 1000-seed weight) had strong contributions for seed yield/plant in both experiments.

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Table 1. Mean of daily temperature (°C) during the period of alfalfa growth from 2017 to 2020 years.

Month	Average temperature (°C)								
	2017/2018			2018/2019			2019/2020		
	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
Oct.	31.93	16.90	24.42	32.13	18.13	25.13	33.20	19.53	26.37
Nov.	24.70	11.37	18.03	26.20	12.90	19.55	28.13	14.00	21.07
Dec.	22.53	9.17	15.85	20.53	8.30	14.42	21.07	8.47	14.77
Jan.	19.50	6.90	13.20	18.83	6.07	12.45	18.17	5.93	12.05
Feb.	25.57	11.87	18.72	21.33	7.83	14.58	23.37	7.70	15.53
Mar.	30.10	14.57	22.33	24.33	10.00	17.17	25.77	11.53	18.65
Apr.	32.07	16.30	24.18	29.57	14.13	21.85	29.77	15.17	22.47
May.	37.33	22.20	29.77	37.23	22.33	29.78	34.77	19.53	27.15
Jun.	38.23	22.80	30.52	38.53	25.10	31.82	38.13	23.07	30.60
Jul.	37.63	25.07	31.35	38.57	24.80	31.68	38.27	24.13	31.20
Aug.	36.80	25.10	30.95	35.03	25.57	30.30	38.07	23.67	30.87
Sept.	35.17	22.13	28.65	34.73	21.73	28.23	37.23	25.96	31.60

Table 2. Total growing degree days (GDD) for each sowing date.

Sowing date	Forage yield from sowing date until fifteen cuts		Seed yield at second years until seed maturity	
	2017/2019	2019/2020	2019	2020
10th October	7677	7395	1650	1592
10th November	7587	7181	2007	1917
10th December	7547	7260	2264	2215
20th March	8575	8373	1990	1954
20th April	8898	8773	2376	1917

Table 3. Path coefficient analysis of total protein forage yield and its components for the five sowing dates (D) and over them in each experiments Exp. I and Exp. II)

Effect		D1		D2		D3		D4		D5		Overall dates	
		Exp. I	Exp. II	Exp. I	Exp. II	Exp. I	Exp. II	Exp. I	Exp. II	Exp. I	Exp. II	Exp. I	Exp. II
1- Correlation between forage protein yield and fresh forage yield	r=	0.701	0.721	0.693	0.449	0.801	0.693	0.693	0.746	0.568	0.459	0.971	0.895
Direct effect	p_{14}=	0.710	1.222	1.089	0.877	0.764	0.720	0.700	0.557	0.378	0.394	1.026	0.686
Indirect effect via dry forage %	$r_{12}p_{24}$=	-0.064	-0.067	-0.091	-0.039	-0.031	0.070	-0.033	-0.024	0.065	0.101	-0.031	0.017
Indirect effect via protein %	$r_{13}p_{34}$=	0.055	-0.435	-0.305	-0.389	0.068	-0.097	0.026	0.213	0.125	-0.037	-0.024	0.192
2- Correlation between forage protein yield and dry matter %	r=	0.033	0.103	-0.537	0.060	-0.217	0.760	0.050	0.058	0.503	0.644	-0.249	0.269
Direct effect	p_{24}=	0.205	0.372	0.186	0.311	0.202	0.336	0.195	0.163	0.364	0.260	0.096	0.145
Indirect effect via fresh forage yield	$r_{12}p_{14}$=	-0.221	-0.219	-0.535	-0.111	-0.117	0.150	-0.118	-0.081	0.068	0.153	-0.334	0.081
Indirect effect via protein %	$r_{23}p_{14}$=	0.049	-0.050	-0.188	-0.140	-0.303	0.274	-0.027	-0.024	0.072	0.231	-0.011	0.043
3- Correlation between forage protein yield and protein %	r=	0.741	0.095	0.407	0.590	0.649	0.521	0.719	0.846	0.778	0.835	0.109	0.759
Direct effect	p_{34}=	0.668	0.791	0.843	0.982	0.663	0.473	0.701	0.676	0.668	0.776	0.222	0.457
Indirect effect via fresh forage yield	$r_{13}p_{14}$=	0.058	-0.672	-0.394	-0.347	0.078	-0.147	0.026	0.175	0.071	-0.019	-0.109	0.289
Indirect effect via dry forage %	$r_{23}p_{24}$=	0.015	-0.023	-0.041	-0.045	-0.092	0.195	-0.008	-0.006	0.039	0.077	-0.005	0.014
4- Residual effect		0.026	0.072	0.043	0.092	0.035	0.000	0.038	0.055	0.287	0.058	0.060	0.029

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Table 4. Path coefficient analysis of seed yield/plant and its components for the five the five sowing dates (D) and over dates in each experiments Exp. I and Exp. II).

Effect		D1		D2		D3		D4		D5		Overall dates	
		Exp. I	Exp. II	Exp. I	Exp. II	Exp. I	Exp. II	Exp. I	Exp. II	Exp. I	Exp. II	Exp. I	Exp. II
1- Correlation between number of pods/plant and seed yield/plant	r=	0.806	0.804	0.657	0.862	0.683	0.640	0.720	0.896	0.868	0.503	0.749	0.517
Direct effect	p_{14}=	1.075	0.667	0.774	1.244	0.716	0.843	1.038	0.893	0.907	1.347	0.990	0.711
Indirect effect via number of seeds/pod	$r_{12}p_{24}$=	-0.280	0.193	-0.110	-0.496	-0.043	-0.210	-0.350	-0.019	-0.056	-0.774	-0.225	-0.183
Indirect effect via 1000-seed weight	$r_{13}p_{34}$=	0.010	-0.056	-0.007	0.115	0.009	0.007	0.032	0.022	0.017	-0.070	-0.017	-0.011
2- Correlation between number of seeds/pod and seed yield/plant	r=	0.948	0.980	0.374	-0.634	0.667	0.562	0.293	0.398	0.353	0.101	0.271	0.640
Direct effect	p_{24}=	1.248	0.902	0.525	0.566	0.713	0.778	0.808	0.441	0.419	1.009	0.619	0.803
Indirect effect via number of pods/plant	$r_{12}p_{14}$=	-0.241	0.143	-0.162	-1.091	-0.043	-0.228	-0.449	-0.039	-0.121	-1.033	-0.360	-0.162
Indirect effect via 1000-seed weight	$r_{23}p_{14}$=	-0.059	-0.065	0.010	-0.109	-0.003	0.012	-0.065	-0.004	0.055	0.125	0.011	-0.001
3- Correlation between 1000-seed weight and seed yield/plant	r=	0.137	-0.023	0.059	0.571	0.168	0.359	0.065	0.375	0.433	0.407	0.057	0.113
Direct effect	p_{34}=	0.328	0.298	0.055	0.258	0.136	0.048	0.176	0.058	0.125	0.302	0.130	0.164
Indirect effect via number of pods/plant	$r_{13}p_{14}$=	0.033	-0.125	-0.096	0.554	0.049	0.117	0.190	0.347	0.124	-0.314	-0.126	-0.048
Indirect effect via number of seeds/pod	$r_{23}p_{24}$=	-0.225	-0.196	0.100	-0.240	-0.017	0.194	-0.300	-0.030	0.184	0.419	0.053	-0.002
4- Residual effect		0.000	0.000	0.540	0.374	0.110	0.077	0.070	0.052	0.106	0.312	0.288	0.317

Table 5. Stepwise regression analysis for protein yield (PY) via studied morphological traits (over 15 cuts of 10 genotypes and 5 sowing dates) in the two successive experiment

Experiment	Independent traits	Model No.	Fitted independent traits	R^2	Regression equation
Exp. I (2017/2019)	PH, FFY, DFY, LS, PP, DMP	Mod.1	DFY	0.948	$\hat{Y}$ = 0.041 + 0.211 DFY
		Mod.2	DFY, PP	0.997	$\hat{Y}$ = - 1.711 + 0.217 DFY + 0.079 PP
Exp. II (2018/2020)	PH, FFY, DFY, LS, PP, DMP	Mod.1	DFY	0.829	$\hat{Y}$ = -0.643 + 0.263 DFY
		Mod.2	DFY, PP	0.998	$\hat{Y}$ = - 2.096 + 0.208 DFY + 0.101 PP

Plant height (PH), Fresh forage yield (FFY), Dry forage yield (DFY), Protein yield (PY), leaves/ stem ratio (LS), Dry matter % (DMP, Protein % (PP).

Table 6. Stepwise regression analysis for seed yield/plant (SYP) via studied yielded traits (over 15 cuts of 10 genotypes and 5 sowing date in the two successive experiments.

Experiment	Independent traits	Model No.	Fitted independent traits	R^2	Regression equation
Exp. I (2017/2019)	NIP, NPP, NSD, NSP, SYW, SI	Mod.1	NSP	0.971	$\hat{Y}$ = 0.002 + 0.003 NSEEDP
		Mod.2	NSP, SI	0.996	$\hat{Y}$ = - 0.224 + 0.003 NSEEDP + 0.079 SI
Exp. II (2018/2020)	NIP, NPP, NSP, NSD, SYW, SI	Mod.1	NSP	0.983	$\hat{Y}$ = -0.001 + 0.003 NSEEDP
		Mod.2	NSP, SI	0.995	$\hat{Y}$ = - 0.362 + 0.003 NSEEDP + 0.143 SI

Number of inflorescence/plant (NIP), Number of pods/plant (NPP), Number of seeds/pod (NSD), Number of seeds/plant (NSP), Seed yield/plot (SYW), 1000 seed weight (SI).

Table 7. Stepwise regression analysis for seed yield/plot (SYW) via studied yielded traits (over 15 cuts of 10 genotypes and 5 sowing dates) in the two successive experiments.

Experiment	Independent traits	Model No.	Fitted independent traits	R^2	Regression equation
Exp.I (2017/2019)	NIP, NPP, NSD, NSP, SYP, SI	Mod.1	SYP	0.268	$\hat{Y}$ = 35.568 + 69.407 SYP
		Mod.2	SYP, NIP	0.340	$\hat{Y}$ = 47.545 + 79.238 SYP - 0.892 NINFP
Exp. II (2018/2020)	NIP, NPP, NSP, NSD, SYP, SI	Mod.1	NPP	0.094	$\hat{Y}$ = 25.033 + 0.107 NPODP

Number of inflorescence/plant (NIP), Number of pods/plant (NPP), Number of seeds/pod (NSD), Number of seeds/plant (NSP), Seed yield/plant (SYP), 1000 seed weight (SI).

Table 8. Actual and expected values of protein yield (PY) for all models of stepwise regression analysis across the two succession experiments.

Treatments Combination	Expr. I (2017-2019)			Expr. II (2018-2020)			Treatments combination	Expr. I (2017-2019)			Expr. II (2018-2020)		
	Actual values	Expected values Mod. 1	Mod. 2	Actual values	Expected values Mod. 1	Mod. 2		Actual values	Expected values Mod. 1	Mod. 2	Actual values	Expected values Mod. 1	Mod. 2
1	**1.86**	1.82	1.86	**2.56**	2.20	2.54	27	**1.69**	1.71	1.69	**2.00**	1.96	2.00
2	**1.56**	1.71	1.57	**2.73**	2.49	2.69	28	**1.86**	1.85	1.87	**2.26**	2.37	2.28
3	**1.95**	2.04	1.97	**2.46**	2.29	2.44	29	**1.99**	1.88	1.99	**1.86**	1.91	1.86
4	**2.16**	2.19	2.17	**2.99**	3.00	2.97	30	**1.74**	1.69	1.74	**1.77**	1.78	1.77
5	**2.27**	2.03	2.24	**2.46**	2.54	2.47	31	**2.02**	1.97	2.03	**1.61**	1.80	1.59
6	**2.10**	1.93	2.08	**2.63**	2.60	2.62	32	**1.80**	1.89	1.82	**1.74**	1.73	1.72
7	**1.89**	2.00	1.91	**2.60**	2.48	2.59	33	**2.19**	2.24	2.21	**1.75**	1.79	1.73
8	**2.01**	2.04	2.02	**2.56**	2.75	2.59	34	**2.23**	2.20	2.24	**2.30**	2.21	2.30
9	**1.85**	2.01	1.88	**2.88**	2.93	2.88	35	**2.19**	2.04	2.17	**1.87**	1.85	1.88
10	**1.88**	1.90	1.90	**2.66**	2.48	2.64	36	**1.96**	2.04	1.98	**1.71**	2.04	1.72
11	**1.27**	1.18	1.33	**1.94**	2.08	1.96	37	**2.32**	2.14	2.29	**1.67**	1.86	1.65
12	**1.10**	1.17	1.08	**1.92**	1.90	1.92	38	**2.13**	2.09	2.13	**1.75**	1.95	1.74
13	**1.17**	1.11	1.21	**1.82**	1.80	1.82	39	**2.00**	2.16	2.05	**1.87**	2.08	1.90
14	**1.09**	1.18	1.05	**2.18**	1.97	2.18	40	**2.12**	2.09	2.13	**1.60**	1.75	1.57
15	**1.15**	1.14	1.18	**1.82**	1.76	1.82	41	**1.29**	1.23	1.32	**1.71**	1.74	1.69
16	**1.24**	1.32	1.22	**1.81**	1.83	1.80	42	**1.07**	1.11	1.05	**1.67**	1.88	1.66
17	**1.23**	1.27	1.22	**2.06**	1.88	2.07	43	**1.26**	1.24	1.27	**1.80**	1.77	1.80
18	**1.25**	1.25	1.25	**2.00**	2.01	2.01	44	**1.28**	1.24	1.29	**1.71**	1.90	1.70
19	**1.27**	1.28	1.28	**1.92**	1.95	1.92	45	**1.30**	1.24	1.32	**2.00**	1.82	2.01
20	**1.19**	1.22	1.19	**1.91**	1.63	1.93	46	**1.19**	1.23	1.18	**2.18**	2.11	2.18
21	**2.01**	1.82	2.01	**1.76**	1.67	1.76	47	**1.18**	1.21	1.17	**1.98**	2.00	2.00
22	**1.53**	1.67	1.52	**1.81**	1.78	1.80	48	**1.21**	1.23	1.21	**1.83**	1.84	1.82
23	**1.93**	1.87	1.93	**1.79**	1.79	1.79	49	**1.27**	1.19	1.32	**1.74**	2.00	1.74
24	**1.91**	2.06	1.94	**2.17**	2.06	2.18	50	**1.20**	1.17	1.22	**1.65**	1.72	1.63
25	**1.74**	1.73	1.74	**1.94**	1.74	1.95	*r*	-	**0.974**	**0.999**	-	**0.911**	**0.999**
26	**1.77**	1.75	1.78	**2.09**	1.91	2.10	*t*		**0.82**	**0.04**		**0.92**	**0.24**

Table 9. Actual and expected values of seed yield/plant (SYP) for all models of stepwise regression analysis across the two succession experiments.

Treatments combination	Expr. I (2017-2019)			Expr. II (2018-2020)			Treatments combination	Expr. I (2017-2019)			Expr. II (2018-2020)		
	Actual values	Expected values Mod. 1	Mod. 2	Actual values	Expected values Mod. 1	Mod. 2		Actual values	Expected values Mod. 1	Mod. 2	Actual values	Expected values Mod. 1	Mod. 2
1	**0.28**	0.31	0.31	**0.28**	0.32	0.33	27	**0.19**	0.21	0.20	**0.22**	0.26	0.25
2	**0.16**	0.19	0.17	**0.55**	0.65	0.65	28	**0.20**	0.20	0.22	**0.43**	0.49	0.50
3	**0.24**	0.24	0.25	**0.20**	0.25	0.23	29	**0.14**	0.14	0.16	**0.33**	0.38	0.39
4	**0.12**	0.14	0.12	**0.55**	0.75	0.71	30	**0.19**	0.20	0.20	**0.16**	0.20	0.18
5	**0.10**	0.10	0.11	**0.73**	0.85	0.85	31	**0.28**	0.31	0.30	**0.16**	0.18	0.21
6	**0.21**	0.21	0.22	**0.51**	0.58	0.59	32	**0.23**	0.25	0.25	**0.16**	0.18	0.20
7	**0.19**	0.21	0.20	**0.41**	0.47	0.48	33	**0.19**	0.20	0.20	**0.11**	0.14	0.13
8	**0.25**	0.27	0.27	**0.48**	0.57	0.57	34	**0.38**	0.40	0.40	**0.22**	0.25	0.26
9	**0.31**	0.35	0.34	**0.78**	0.90	0.91	35	**0.43**	0.45	0.45	**0.18**	0.19	0.23
10	**0.18**	0.26	0.20	**0.57**	0.75	0.72	36	**0.28**	0.27	0.29	**0.10**	0.13	0.10
11	**0.22**	0.23	0.23	**0.38**	0.45	0.45	37	**0.24**	0.26	0.25	**0.17**	0.20	0.19
12	**0.22**	0.23	0.23	**0.34**	0.41	0.41	38	**0.23**	0.24	0.24	**0.10**	0.13	0.12
13	**0.35**	0.37	0.37	**0.59**	0.67	0.69	39	**0.23**	0.24	0.24	**0.19**	0.21	0.24
14	**0.26**	0.26	0.28	**0.51**	0.57	0.59	40	**0.28**	0.28	0.29	**0.31**	0.37	0.37
15	**0.41**	0.41	0.42	**0.85**	0.95	0.97	41	**0.26**	0.29	0.28	**0.23**	0.26	0.27
16	**0.35**	0.39	0.38	**0.42**	0.53	0.51	42	**0.23**	0.27	0.25	**0.22**	0.27	0.26
17	**0.27**	0.30	0.29	**0.49**	0.60	0.59	43	**0.36**	0.38	0.38	**0.15**	0.17	0.19
18	**0.24**	0.26	0.26	**0.77**	0.84	0.87	44	**0.17**	0.19	0.19	**0.15**	0.20	0.16
19	**0.33**	0.37	0.36	**0.55**	0.70	0.68	45	**0.34**	0.36	0.36	**0.20**	0.25	0.22
20	**0.25**	0.29	0.27	**0.56**	0.72	0.70	46	**0.23**	0.27	0.24	**0.24**	0.30	0.28
21	**0.11**	0.11	0.12	**0.15**	0.17	0.18	47	**0.36**	0.35	0.37	**0.23**	0.29	0.27
22	**0.15**	0.16	0.17	**0.22**	0.25	0.26	48	**0.30**	0.33	0.32	**0.31**	0.38	0.38
23	**0.09**	0.10	0.09	**0.22**	0.25	0.27	49	**0.43**	0.45	0.45	**0.30**	0.31	0.36
24	**0.17**	0.17	0.18	**0.24**	0.25	0.29	50	**0.46**	0.50	0.50	**0.27**	0.34	0.31
25	**0.09**	0.10	0.09	**0.20**	0.25	0.24	*r*	-	**0.986**	**0.999**	-	**0.992**	**0.998**
26	**0.14**	0.14	0.14	**0.60**	0.67	0.69	*t*		**1.5E-10**	**2.8E-21**		**8.0E-14**	**6.1E-16**

Table 10. Actual and expected values of seed yield/plot (SYW) for all models of stepwise regression analysis across the two succession experiments.

Treatments combination	Expr. I (2017-2019)			Expr. II (2018-2020)			Treatments combination	Expr. I (2017-2019)			Expr. II (2018-2020)		
	Actual	Expected values		Actual	Expected values			Actual	Expected values		Actual	Expected values	
	values	Mod. 1	Mod. 2	values	Mod. 1	-		values	Mod. 1	Mod. 2	values	Mod. 1	-
1	**71.14**	55.23	58.60	**36.11**	39.85	-	27	**55.03**	48.76	51.50	**26.41**	34.28	-
2	**45.16**	46.67	46.84	**51.29**	43.94	-	28	**56.85**	49.45	43.08	**41.58**	30.39	-
3	**58.60**	51.99	51.23	**34.52**	35.50	-	29	**46.92**	45.52	42.94	**40.24**	36.54	-
4	**44.64**	43.67	43.41	**51.73**	41.53	-	30	**55.53**	48.76	52.69	**21.24**	33.81	-
5	**43.38**	42.28	41.63	**65.38**	44.55	-	31	**73.45**	55.00	58.53	**51.56**	36.84	-
6	**54.17**	49.91	52.42	**47.33**	43.10	-	32	**60.13**	51.53	49.91	**51.74**	33.59	-
7	**49.08**	48.76	51.80	**41.24**	36.45	-	33	**57.46**	48.99	54.14	**49.28**	32.71	-
8	**64.02**	52.92	55.26	**45.02**	38.80	-	34	**74.35**	61.71	61.93	**75.40**	35.55	-
9	**73.78**	57.32	60.78	**66.68**	47.56	-	35	**85.69**	65.64	64.04	**66.50**	38.41	-
10	**46.02**	47.83	49.45	**58.30**	48.50	-	36	**65.81**	55.00	54.57	**45.56**	33.95	-
11	**19.15**	50.84	45.85	**18.94**	31.70	-	37	**60.82**	52.23	51.30	**54.94**	35.79	-
12	**25.88**	50.61	53.81	**17.91**	30.91	-	38	**59.96**	51.53	57.34	**42.18**	32.34	-
13	**54.18**	59.63	59.26	**30.12**	39.38	-	39	**59.30**	51.53	49.42	**75.15**	37.87	-
14	**44.77**	53.61	55.36	**27.05**	36.12	-	40	**63.64**	54.77	55.20	**79.02**	44.23	-
15	**58.22**	63.79	67.78	**35.52**	43.44	-	41	**47.42**	53.38	51.23	**25.24**	38.19	-
16	**49.27**	60.09	59.98	**21.05**	33.24	-	42	**45.66**	51.53	45.55	**24.33**	45.79	-
17	**45.25**	54.08	57.67	**27.01**	31.85	-	43	**56.24**	60.55	59.62	**15.49**	32.02	-
18	**36.83**	52.23	40.59	**32.14**	45.60	-	44	**32.77**	47.14	42.41	**21.76**	43.40	-
19	**46.55**	58.47	61.11	**27.87**	34.78	-	45	**52.50**	58.94	59.16	**23.46**	38.62	-
20	**42.24**	52.92	56.16	**29.65**	43.97	-	46	**45.06**	51.30	46.48	**26.14**	42.19	-
21	**45.41**	42.97	42.72	**19.25**	33.18	-	47	**60.10**	60.32	58.96	**24.77**	40.98	-
22	**51.14**	45.98	45.26	**27.75**	36.46	-	48	**47.51**	56.62	56.02	**31.72**	46.33	-
23	**36.04**	41.81	42.19	**28.50**	31.87	-	49	**60.29**	65.18	62.82	**31.47**	41.48	-
24	**53.39**	47.14	50.05	**31.59**	33.03	-	50	**61.73**	67.50	64.86	**31.01**	40.94	-
25	**45.31**	41.58	40.44	**21.43**	33.94	-	*r*	-	**0.523**	**0.588**	-	**0.307**	-
26	**45.64**	45.05	46.08	**42.11**	44.84	-	*t*		**0.97**	**0.95**		**0.99**	-

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تحليل معامل المرور والانحدار المتدرج تحت مواعيد زراعة مختلفة فى البرسيم الحجازى

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الملخص

تم اجراء هذه الدراسة بقسم المحاصيل بكلية الزراعة جامعة أسيوط خلال الأعوام ٢٠١٧ حتى ٢٠٢٠ في تجربتين وذلك لدراسة التأثيرات المباشرة وغير المباشرة وكذلك الانحدار المتدرج على المحصول العلفى والبذرى ومكوناتهم في عشائر من البرسيم الحجازي. وأقيمت لذلك تجربتين الأولى ٢٠١٧ – ٢٠١٩ والثانية ٢٠١٨-٢٠٢٠. وقد استخدم تصميم الشرائح المنشقة في ثلاث مكررات في كلا التجربتين. وتمت الزراعة في خمسة مواعيد منها ثلاثة مواعيد خريفية هي ١٠ أكتوبر ، ١٠ نوفمبر ، ١٠ ديسمبر، وأثنان ربيعية هما ٢٠ مارس ، ٢٠ أبريل. وتم أخذ خمسة عشر حشه من كل ميعاد زراعة ولكل تركيب وراثي لكلا التجربتين. بينما تم تسجيل المحصول البذري في السنة الثانية لكل تجربة في شهر مارس وأبريل ومايو حسب ميعاد الزراعة. أوضح تحليل معامل المرور أن لمحصول العلف الأخضر تأثيرا كبيرا على ناتج محصول البروتين العلفى لكل ميعاد زراعة بينما كانت القيمه غير المباشرة لنسبة المادة الجافة ونسبة البروتين سلبيه أو غير ذات قيمة لكل ميعاد زراعة في التجربتين. وكانت التاثيرات المباشرة لعدد القرون/ للنبات وعدد البذور في القرن ذو تاثير كبير على محصول البذور / النبات لكل ميعاد زراعة في التجربتين. ولكن التاثير غير المباشر لعدد البذور في / القرن ووزن ١٠٠٠ بذرة كان سالبا أو موجبا وذو قيمه مهملة على محصول البذور/ للنبات. ويتضح من نتائج معامل الانحدار المتدرج أن الموديل الثاني والذي يشمل صفتين مستقلتين وهما محصول العلف الجاف ونسبة البروتين هو أنسب موديل لمحصول البروتين. وكذلك كان الموديل الثانى والذي يشمل صفتين مستقلتين وهما عدد البذور/ للنبات ووزن ١٠٠٠ بذرة يساهم بقوة في محصول البذور/ النبات في كلا التجربتين.