Middle East Journal of Agriculture Research
Volume: 11 | Issue: 04| Oct. – Dec.| 2022

EISSN: 2706-7955 ISSN: 2077-4605
DOI: 10.36632/mejar/2022.11.4.70
Journal homepage: www.curresweb.com
Pages: 1091-1102

Impact of different rates and dates of phosphorus applications on growth parameters, yield and quality in Egyptian clover

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Received: 15 Oct. 2022 **Accepted:** 07 Nov. 2022 **Published:** 15 Nov. 2022

ABSTRACT

Phosphorus (P) rates and its date of application is considered some of the most important factor affecting crop growth, yield and nutritive value in Egyptian clover. Two field experiments were conducted at Sids Agriculture Research Station, Bani Sweif Governorate. ARC, Egypt, during the winter growing seasons of 2018/2019 and 2019/2020 to study the impact of use different rates and date of phosphorus applications on growth parameters, forage yield and quality in Egyptian clover (var. Giza 6). The experimental treatments were arranged in a split plot design with three replicates. The main plots represented three different rates of phosphorus (A1=100, A2=150 and A3=200 kg fed^{-1} superphosphate), whereas the sub-plots included the three dates of phosphorus applications (B1= one dose before planting, B2= two equal doses before planting and the second before first irrigation and B3= two equal doses one before first irrigation and the second before second irrigation). The main obvious results of this study could be summarized as follows; the rates of phosphorus applications had a significant effect on all traits under study of clover crop and maximum values were obtained with A3 treatment but it was on a par with A2 treatment. On the contrary, minimum values for the corresponding respective characters were recorded with A1 treatment. It could be stated that all traits were gradually increased due to applying the assessed rates of phosphorus. Whilst, in case of the dates of phosphorus application, data indicated that B2 treatment were superior compared with the other treatments for all traits. The highest values of interaction were obtained with A3 treatment and B2 treatment for growth parameters, yield and quality. Besides that, a feasibility study proved that Egyptian clover is economically advisable under treatment (200 kg fed^{-1}) superphosphate added at two equal doses the first before planting and the second before first irrigation, where the maximum total revenue, net return and net return per one invested recorded (37705.5, 26185.5, 2.27 L.E.), respectively. In nutshell, optimization of P fertilization and attention to the time of addition improves the productivity and quality of the forage in Egyptian clover.

Keywords: Phosphorus application, Egyptian clover, forage yield and quality.

1. Introduction

Egyptian clover (*Trifolium alexandrinum* L.) is a winter annual legume widely grown in several countries for fresh fodder, hay and silage and is the most important forage crop for irrigated areas in Egypt where plays a vital role in the sustainability of agriculture production (Azab *et al.,* 2010). It is ranked as the first forage crop in Egypt, particularly the multi cut type which is the most important toproviding fodder for a long duration. It is considered as the most important rab, fodder crop and the most potential crop from productivity, better forage quality, high digestibility and palatability as well as maintenance of soil fertility (Singh *et al.,* 2019).

In Egypt, the most limiting factor for animal wealth development is the lack of local feed due to the wide gap between the consumed and available local feed sources (ACSAD, 2008). Therefore, Egyptian clover is not only endogenous to Egypt but also the principal forage crop and occupying about 2.0– 2.8 million Fadden (El-Nahrawy, 2005).

Fodder crops play a vital role in agriculture because, the supply of nutritious fodders in sufficient amount is a basic requirement for livestock to fulfill the increasing demand of milk, butter and other

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dairy by products for utilization by human beings (Godara *et al.,* 2016). Besides that, the animal wealth development is depending mainly on berseem in the winter season because most of the animal protein requirement is fulfilled with feeding on berseem (ACSAD, 2008). It is considered a principal source of animal feed for the most whole year specifically the smallholders due to its high yielding and quality potential.

Fertilizer application is considered to be a major limiting factor (Sainju *et al.,* 2019) where the correctand judies fertilizer application can enhance yield up to 50 % and can also improve the quality of fodder (Roy *et al.,* 2015). Among all the primary nutrients, phosphorus is one of the key mineral nutrients for developing root system which helps in absorption of nutrients, which supported better yield, is very important where water is not abundant under rained condition (Azab *et al.,* 2010).

Gaballah (1996& 2001) noticed that number of stem/ plant, straw and seed yield and their attributes were significantly increased by increasing P rates from 15.5 to 46.5 kg P_2O_5 ha^{-1}. Virender (1999) reported that the application of 80 P_2O_5 /ha. Significantly increased fodder and seed yield of Egyptian clover over control. Also, Nadiam *et al.,* (2005) reported that the dry mass of shoots and roots of Egyptian were significant increased by phosphorus application. On the other hand, Singh (1979) found the application of 120 kg P_2O_5 ha^{-1} had no significant effect on yield productions. Also, (Aly 1989) reported that the differences among phosphorus rates (0, 15.5 and 31.0 kg P_2O_5 ha^{-1}) applied to berseem were not significant.

Phosphorus deficiency significantly reduces the plant growth (Marschner 1997) where phosphorus plays an important role in photosynthesis and the synthesis of nucleic acids, lipid, proteins and other important compound (Guinn 1984) and (Arredondo *et al.,* 2014). The phosphorus is immobile in the soil and due to its immobility the unused phosphorus applied as fertilizer that remains in the soil to be available for the next crops (Read *et al.,* 1973) and (Raghothama 1999).

Berseem clover is highly nutritive forage contains 15.8-26.7 % crude protein, 14.9-28.3 % crude fiber, 1.4-3.0 % ether extract, 1.4 - 2.58 % calcium and 2.22 - 2.46% phosphorus content (Mohsen *et al.,* 2011). Also, forage quality is of great importance in terms of animal production, it is determined by the content of different nutrients such as minerals, crude protein and fiber component.

The application of phosphorous is important and directly contributes to the quality as several researchers have reported that phosphorus fertilization increases crude protein, crude fiber, ether extract and ash while the contents of dry matter and NFE tended to decrease with increasing phosphorus fertilization levels Tongel and Albayrak (2006); Türk *et al.,* (2007) and Satpal *et al.,* (2020). Tongel and Albayrak (2006) studied the effect of four different phosphorus rates (0, 5, 10 and 15 kg da^{-1}) for quality and determined of highest quality in the parcels having 10 kg da^{-1} phosphorus application but there were no difference among 5 and 10 kg da^{-1} phosphorus application.

According to Hamid and Sarwar (1977), the crop uses only 15- 33 % of the applied P. So dividing the fertilizer dose of phosphorus application tent to increases the utilization at different stage of growing plants. The yield of clover is highly affected by environmental factors making farmers look for solutions for stability in production. According, an experiment was done to determine the best quantity and date to maximize the fertilizer use efficiencies of phosphate application which may gave high yield and quality of Egyptian clover.

Keeping the views of the above aspects, the present research is undertaken to identify the effect of use phosphorus fertilizer at different doses and dates on forage yield and quality of berseem.

2. Materials and Methods

Two field trials were conducted at Sids Agricultural Research Station, ARC, during 2018/2019 and 2019/2020 winter seasons to study the effect of different rates of phosphorus and dates of application on productivity and quality of Egyptian clover var. Giza 6. A representative soil samples were collected from the top 20 cm layer in the experimental fields, air-dried and sieved through a 2 mm screen. The main physical and chemical properties were determined using the methods described by Piper (1950), Cottenie *et al.,* (1982), Page *et al.,* (1982) and Amanullah and Khan, 2010); coarse sand 6.44%, fine sand 20.14%, silt 32.07, clay 41.35, soil texture class was clay, pH 7.71, organic matter 0.83%, EC 1.18 dSm^{-1}, $CaCO_3$ 5.62%, available N, P, K was 46.11, 5.32 and 176 mg kg^{-1}, respectively.

The experimental design was a split plot with three replicates, plot size was 16 m^2 (4 x 4 m). Phosphorus treatments were assigned to main plots; whereas dates of application were assigned to sub-plots. The following treatments were tested:

EISSN: 2706-7955 ISSN: 2077-4605 *DOI: 10.36632/mejar/2022.11.4.70*

A- Main plots represented the rates of phosphorus application in form of superphosphate (15.5 % P_2O_5) as follows:

A_1- 100 kg fed^{-1} superphosphate.
A_2- 150 kg fed^{-1} superphosphate.
A_3- 200 kg fed^{-1} superphosphate.

B- Sub plots represented the dates of phosphorus application as follows:
B_1- One dose before planting (control).
B_2- Two equal doses (the first before planting, the second before first irrigation).
B_3- Two equal doses (the first before first irrigation and the second before second irrigation).

Nitrogen fertilizer 30 kg fed^{-1} was applied in the form of urea (46.5 % N) before the first irrigation.

Seeding rate was 20 kg fed^{-1}. Sowing date was 17th and 20th October in 2018/2019 and 2019/2020 seasons, respectively. Recommended cultural practices were followed throughout the growing season.

2.1. Data recorded

2.1.1. Growth parameters and yields.

- Plant height (cm).
- Leaves/ stem ratio.
- Fresh and dry yields at each cut and total fresh and dry yields (ton fed^{-1}).

2.1.2. Chemical constituent:

Samples of forage were dried to constant weight using a forced air oven at 70 °C. Dry forage was ground by hummer mill and kept in labeled plastic bags for chemical analysis. Mixed plant samples from the five cuts were analyzed at the forage lab at Giza Research Station to determine:

- Crude protein (CP%): Total nitrogen was determined in the dry matter by using the modified micro-kjeldahl method as described in A.O.A.C. (2000), the crude protein content was calculated by multiplying the total nitrogen percentage by the factor of 6.25.
- Crude fibers (CF %) and ash % were estimated according to the method described in the A.O.A.C. (2000).
- Ether Extract (EE %) was extracted using petroleum ether (40-60°C boiling point) in a soxhlet apparatus provided with cold water condenser for 9 hours at a rate of 6 siphons/hour (A.O.A.C., 2000).
- Organic matter (OM %) was estimated by using the following equation: OM % =100 – (Ash %).
- Nitrogen Free Extract (NFE) content was estimated by subtracting the sum of the contents of crude protein, crude fiber, ash and ether extract out of 100.

$$NFE\ \% = 100 - (CP\ \% + CF\ \% + EE\ \% + Ash\ \%)$$

- Total digestible nutrients (TDN) was estimated according to Adams *et al.,* (1964), using the following equation: $TDN = 74.43 + 0.35\ CP - 0.73\ CF$.
- Digestible crude protein (DCP) was calculated according to Bredon *et al.,* (1963) using the following equation:

$$DCP = 0.9596\ CP - 3.55.$$

- Phosphorus (P %) was analyzed and determined according to the A.O.A.C. (2000).

2.2. Economic evaluation

Economic study involved the following parameters:

- Mean values of input variables and the total costs of crop production including fertilizer treatments and cultural practices applied during the vegetative stages of berseem.
- Net farm income of crop for various fertilization treatments.
- Net farm return of crop production as affected by applied treatments.

It's calculated as the difference between the forage yield value (according to the actual price) and the total costs. All fertilizers and seed prices as well as the costs of all farm operations were assigned based on the official and the actual market prices determined by the Egyptian Ministry of also reported by Galbiatti *et al.,* (2011). Total costs included all values of production inputs and other general or different costs.

2.3. Statistical Analysis

Data were statistically analyzed according to Snedecor and Cochran (1990) and treatment means were compared by least significant difference test (LSD) at 0.05 level of significance. Bartlett's test was done to test the homogeneity of error variance. The test was not significant for all assessed traits, so, the two seasons data were combined.

3. Results and Discussion

Mean values of the growth parameters and forage yield for Egyptian clover as affected by rates of phosphorus applications, dates of phosphorus applications and the interactions are presented in Tables (1 &2). The improvement in growth and yield traits owing to the pivotal impact of phosphorus on plant process, cell growth metabolism and root elongation in the plant tissues (Wissuwa *et al.,* 2009).

3.1. Growth parameters

Plant height (cm) and leaves/stem ratio (%) at different cuts of berseem as combined were illustrated in Table 1. Analysis of variance showed significant differences among all treatments under study, but there were no significant differences between A2 and A3 treatments in plant height and leaves/ stem ratio.

Table 1: Effect of rates and dates of phosphorus applications on plant height and leaves/stem ratio of Egyptian clover (combined across the two seasons).

Treatments	Plant height (cm)						Leaves/stem ratio					
	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Mean	Cut1	Cut2	Cut 3	Cut 4	Cut 5	Mean
Rates of phosphorus applications (Kg fed^{-1})												
A_1	65.93	68.11	75.03	72.49	79.81	72.27	0.403	0.572	0.939	0.741	1.049	0.741
A_2	68.34	70.63	77.61	75.04	82.45	74.81	0.463	0.635	1.04	0.791	1.165	0.818
A_3	70.66	72.99	79.85	77.39	84.65	77.11	0.505	0.679	1.08	0.826	1.204	0.859
L.S.D $_{0.05}$	2.38	2.45	2.31	2.49	2.45	2.49	0.053	0.049	0.054	0.049	0.064	0.064
Dates of phosphorus applications												
B_1	68.60	70.88	77.87	75.33	82.71	75.08	0.474	0.649	1.012	0.802	1.152	0.818
B_2	69.34	71.64	78.61	76.07	83.34	75.80	0.488	0.662	1.096	0.809	1.187	0.848
B_3	66.98	69.20	76.01	73.51	80.86	73.31	0.410	0.575	0.945	0.748	1.078	0.751
L.S.D $_{0.05}$	0.68	0.54	0.65	0.49	0.59	0.65	0.009	0.007	0.021	0.005	0.028	0.006
Interaction												
A_1X B_1	66.85	69.17	76.12	73.58	80.96	73.34	0.439	0.614	0.981	0.767	1.071	0.774
A_1 X B_2	67.19	69.45	76.46	73.92	81.30	73.66	0.452	0.627	0.994	0.78	1.154	0.801
A_1 X B_3	63.75	65.71	72.52	69.98	77.16	69.82	0.319	0.474	0.841	0.677	0.921	0.646
A_2 X B_1	68.62	70.88	77.89	75.35	82.73	75.09	0.465	0.64	0.997	0.793	1.167	0.812
A_2 X B_2	68.95	71.21	78.22	75.68	83.06	75.42	0.477	0.652	1.119	0.805	1.179	0.846
A_2 X B_3	67.45	69.79	76.72	74.08	81.56	73.92	0.447	0.612	0.989	0.775	1.149	0.794
A_3 X B_1	70.34	72.60	79.61	77.07	84.45	76.81	0.517	0.692	1.059	0.845	1.219	0.866
A_3X B_2	71.89	74.25	81.16	78.62	85.65	78.31	0.535	0.706	1.177	0.843	1.227	0.898
A_3 X B_3	69.75	72.11	78.78	76.48	83.86	76.20	0.463	0.638	1.005	0.791	1.165	0.812
L.S.D $_{0.05}$	2.02	1.85	2.11	2.34	1.92	2.07	0.043	0.059	0.045	0.031	0.048	0.035

A1= 100 kg fed $^{-1}$ superphosphate A2= 150 kg fed $^{-1}$superphosphate A3= 200 kg fed $^{-1}$superphosphate B1= one dose before planting B2 = two equal doses before planting and the second before first irrigation B3= two equal doses one before first irrigation and the second before second irrigation.

A Result of A3 treatment recorded 77.11 cm and 0.859 % in plant height and leaves/ stem ratio as means over all cuts, followed by A2 treatment which recorded 74.81 cm and 0.818 % for the same traits, respectively, while the lowest mean values were obtained with treatment A1 (72.27 cm and 0.741%) respectively. Similar effect of P fertilizer on clustar bean was reported by Ayub *et al.,* (2012 and 2013). The development and rapid growth of plant with the highest rate of P was reported by Chintapalli *et al.,* (2012) who mentioned that the potential cause might be due to that soils low in P, so it will adsorb large amounts from its, when P was applied at the highest level was helped plants of berssem to attain maximum growth parameters.

Akram *et al.,* (2022) recorded a highly significant effect with the increasing level of phosphorus on plant height of berseem. Besides that, Roy *et al.,* (2015) and Godara *et al.,* (2016) reported that the highest significant plant height and leaves/stem % of berseem with 100 kg P_2O_5 ha^{-1} but it was on a par with 80 kg P_2O_5 ha^{-1}. Although the difference between 150 kg fed^{-1} and 200 kg fed^{-1}superphosphate rates not reach to a large extent, so we can use 150 kg fed^{-1} treatment to provide fertilizer.

Results in Table (1) showed that plant height and leaves/stem ratio of Egyptian clover was significantly affected by dates of applying phosphorus. Where, the treatment of B2 was superior in plant height and leaves/ stem ratio, recording 75.80 cm and 0.848 % as mean values over all cuts, followed by the treatment of B1 that recorded 75.08 cm and 0.818 % for the same traits respectively.

In comparison, B3 treatment had the lowest values (73.31 cm and 0.751%) for growth parameters under study.

Application of phosphorus fertilizers before sowing increased vegetative growth of Egyptian clover compared to late application. These results are comparable with Amanullah *et al.,* (2010) who stated that the increase in the plant height and leaves/stem ratio might be due to available phosphours utilization and more assimilation during the growth period. This might be due to P fixation in the soil and reduced its availability when applied too earlier from planting, therefore adequate P should be applied at nearly sowing to reduce P fixation.

The effect of the interaction between rates and dates of phosphorus applications was significant on the investigated traits (Table 1). The maximum values were obtained by the interaction between A3 treatment and B2 followed by A3 and B1 treatment which recorded (78.31 and 76.81 cm) for plant height and (0.898 and 0.866%) for leaves/ stem ratio, respectively. On the other hand, A1and B3 treatment recorded the minimum values for plant height and leaves/ stem ratio (69.82cm and 0.646%), respectively. These results agree with those reported by Singh *et al.,* (1981) and Chaudhary *et al.,* (1987) who found that application of P_2O_5 at the dates of planting was high significant efficient in berseem for growth parameters.

3.2. Fresh and dry yields

Rates of phosphorus applications, its application dates and interaction had a significant effect at each cut and total for fresh and dry yields of Egyptian clover (Table 2). Perusal of the data reveals that fodder yield increased with increasing levels of phosphorus from 100 to 200 kg superphosphate fed^{-1}. Among different P levels, the highest total fresh yield (82.07 ton fed^{-1}) and total dry yield (12.37 ton fed^{-1}) were recorded with the application of A3 treatment which was significantly superior to the lower phosphorus levels. Similar results were obtained by Devi and Satpal (2019) who observed that highest green fodder yield and dry matter yield were recorded with application of 100 P_2O_5 kg /ha followed by 80 P_2O_5 kg /ha but significantly superior to 60 P_2O_5 kg /ha. In this study, the analysis of variance between A2 and A3 treatments had no significant differences in fresh and dry yield ton fed^{-1}. Whilst, A1 treatment revealed the lowest values for total fresh and dry yields (75.22 and 11.33 ton fed^{-1}) respectively. The researchers also reported that the highest green and dry yields of berseem with 90 P_2O_5 kg/ha but was equivalent to 60 P_2O_5 kg /ha (Saeed *et al.,* 2011) and (Mahmooda *et al.,* 2018). Also, Akram *et al.,* (2022) concluded that applying 100 kg/ha of phosphorous fertilizer to berseem we can easily obtain the maximum green fodder yield (92.33 t/ha).

Since the state of P during the early stages of crop development is important in determining possible crop yield, Results in Table (2) demonstrate highly significant for fresh and dry yields at each cut and total by dates of applying phosphorus. Data revealed that B2 treatment had the highest total values for fresh yield (80.32 ton fed^{-1}) and dry yield (12.35 ton fed^{-1}), followed by B1 treatment which recorded (78.89 and 12.07 ton fed^{-1}) respectively for the same traits. These results were consistent with the finding of Chaudhary *et al.,* (1987) and Amanullah *et al.,* (2010). However, the lowest values were obtained at B3 treatment which recorded 77.59 and 11.32 ton fed^{-1} for total fresh and dry yield. Earlier application of phosphorous may have reduced the availability and its uptake by berssem and resulted in lowest yield. The increase in yield with the application of P by sowing may be lead to great values of plant height and leaves/ stem ratio. Singh *et al.,* (1981) pointed to increasing in the forage and seed yields at the time of sowing for phosphorus application.

Table 2: Effect of rates and dates of phosphorus applications on fresh and dry yields (ton fed^{-1}) of Egyptian clover (combined across the two seasons).

Treatments	Fresh yield (ton fed^{-1})						Dry yield (ton fed^{-1})					
	Cut 1	Cut2	Cut 3	Cut4	Cut 5	Total	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Total
						Rates of phosphorus applications (Kg fed^{-1})						
A_1	9.14	15.70	16.81	18.43	15.15	75.22	1.88	2.11	2.34	2.99	2.01	11.33
A_2	9.92	16.75	17.59	19.24	16.00	79.51	2.00	2.23	2.46	3.22	2.13	12.04
A_3	10.42	17.24	18.09	19.86	16.46	82.07	2.05	2.28	2.51	3.35	2.18	12.37
L.S.D $_{0.05}$	0.632	0.781	0.635	0.594	0.692	3.11	0.093	0.078	0.067	0.167	0.085	0.523
						Dates of phosphorus applications						
B_1	9.82	16.57	17.49	19.14	15.86	78.89	2.01	2.24	2.47	3.23	2.14	12.07
B_2	10.05	16.93	17.72	19.46	16.16	80.32	2.05	2.28	2.51	3.32	2.18	12.35
B_3	9.61	16.20	17.28	18.93	15.58	77.59	1.87	2.1	2.33	3.02	2.00	11.32
L.S.D $_{0.05}$	0.061	0.073	0.065	0.056	0.056	0.195	0.026	0.029	0.027	0.038	0.024	0.189
						Interaction						
A_1X B_1	9.19	15.92	16.86	18.51	15.13	75.61	1.92	2.15	2.38	3.14	2.05	11.64
A_1 X B_2	9.38	16.21	17.05	18.61	15.42	76.67	1.95	2.18	2.41	3.17	2.08	11.79
A_1 X B_3	8.85	14.96	16.52	18.17	14.89	73.39	1.77	2.00	2.23	2.67	1.9	10.57
A_2 X B_1	9.93	16.76	17.60	19.25	16.07	79.61	2.02	2.25	2.48	3.24	2.15	12.14
A_2 X B_2	10.11	16.94	17.78	19.43	16.25	80.51	2.09	2.32	2.55	3.31	2.22	12.49
A_2 X B_3	9.73	16.56	17.40	19.05	15.67	78.41	1.89	2.12	2.35	3.11	2.02	11.49
A_3 X B_1	10.35	17.03	18.02	19.67	16.39	81.46	2.08	2.31	2.54	3.3	2.21	12.44
A_3X B_2	10.67	17.63	18.34	20.34	16.81	83.79	2.12	2.35	2.58	3.48	2.25	12.78
A_3 X B_3	10.24	17.07	17.91	19.56	16.18	80.96	1.95	2.18	2.41	3.27	2.08	11.89
L.S.D $_{0.05}$	0.095	0.074	0.080	0.074	0.074	1.64	0.016	0.023	0.011	0.014	0.023	0.231

A1= 100 kg fed $^{-1}$ superphosphate A2= 150 kg fed $^{-1}$ superphosphate A3= 200 kg fed $^{-1}$ superphosphate B1= one dose before planting B2 = two equal doses before planting and the second before first irrigation B3= two equal doses one before first irrigation and the second before second irrigation.

Data presented in Table (2) revealed that the interaction effect between rates and dates of phosphorus applications for fresh and dry yields was significant, as the rates and dates of phosphorus applications led to a significant increase in fresh and dry yields under the three investigated time of phosphorus applications to different extents. The highest total values were obtained by the interaction between A3 and B2 treatment followed by A3 and B1 treatment which recorded (83.79, 81.46 and 12.78, 12.44 ton fed^{-1}) for total fresh and dry yields, respectively. Likewise, the application of P_2O_5 at the time of planting was high significant effective for maximum fodder yield in berseem (Chaudhary *et al.,* 1987). On the other hand, the lowest values were obtained by A1 treatment with B3 treatment that recorded (73.39 and 10.57 ton fed^{-1}) for total fresh and dry yields, respectively.

3.3. Chemical constituent

Results of CP%, CF%, ash %, EE%, OM% and P% contents for Egyptian clover as affected by rates and dates of phosphorus applications and the interaction between them are presented in Table 3. Results indicated significant differences between rates of phosphorus applications. The highest values were obtained by using A3 treatment as revealed 19.77 % for CP, 29.62% for CF, 14.34 % for ash %, 3.34 % for EE and 2.59 % for P. On contrary, the lowest value was obtained by A1 treatment for CP (18.46%), CF (28.22%), ash (13.02%), EE (2.47%) and P (1.63%) except OM % where recorded the highest value 86.98%. Similar results were reported by (Mohsen *et al.,* 2011), (Seif and Saad 2014) and (Morsy and Awadalla 2017) who found that CP, CF, ash and EE % increased significantly with increasing phosphorous fertilization levels from 0 to 22.5 and even 45 kg P_2O_5 fed^{-1}. These results indicated the effect of phosphorous in enhancing the CP content of clover leaves as a major source of energy transfer in all vital physiological activities and metabolic function. Also, Ayodele and Oso (2014) found that P application at planting would remain available to enhance efficient P use as indicated by the higher percentage of P in the index leaf on cowpea.

Regarding to dates of phosphorus application, combined analysis revealed significant differences in CP%, CF%, ash %, EE%, OM% and P% content. The treatment B2 ranked first for CP (19.44%), CF (29.25%), ash (14.00%), EE (3.07%) and P (2.29%) followed by B1. However, the lowest values were obtained by B3 treatment for CP%, CF%, ash %, EE% and P% except OM% that recorded the highest value with B3 treatment. Increase in forage quality due to time of phosphorus application was well documented by many authors Türk *et al.,* (2007) and Sürmen *et al.,* (2011). Beside that Ayodele and Oso (2014) found that P application at planting would remain available to enhance efficient P use as indicated by the higher percentage of P in leaves.

Combined analysis indicated significant interaction effect of the imposed factors under study on CP%, CF%, Ash %, EE%, OM% and P% content. The maximum values were obtained by the interaction among A3 treatment and B2 for all forage quality traits under study except OM% that recorded highest value for A1 with B3, whilst the minimum values were recorded with the interaction between A1 and B3 treatment for CP%, CF%, ash %, EE% and P%.

Table 3: Effect of rates and dates of phosphorus applications on CP%, CF%, Ash %, EE%, OM% and P% of Egyptian clover (combined across the two seasons).

Treatment	CP%	CF%	Ash %	EE%	OM%	P %
Rates of phosphorus applications (Kg fed^{-1})						
A_1	18.46	28.22	13.02	2.47	86.98	1.63
A_2	19.26	29.08	13.82	3.12	86.18	2.35
A_3	19.77	29.62	14.34	3.34	85.67	2.59
L.S.D $_{0.05}$	0.713	0.643	0.625	0.361	0.693	0.156
Dates of phosphorus applications						
B_1	19.17	28.91	13.73	2.96	86.27	2.18
B_2	19.44	29.25	14.00	3.07	86.00	2.29
B_3	18.88	28.78	13.45	2.90	86.55	2.11
L.S.D $_{0.05}$	0.083	0.069	0.079	0.048	0.132	0.041
Interaction						
A_1X B_1	18.54	28.29	13.10	2.43	86.90	1.60
A_1X B_2	18.74	28.38	13.31	2.59	86.69	1.76
A_1X B_3	18.10	27.99	12.67	2.38	87.33	1.54
A_2X B_1	19.29	29.02	13.86	3.11	86.14	2.35
A_2X B_2	19.51	29.32	14.07	3.19	85.93	2.43
A_2X B_3	18.97	28.90	13.54	3.06	86.46	2.29
A_3X B_1	19.67	29.47	14.23	3.34	85.77	2.59
A_3X B_2	20.07	30.03	14.64	3.43	85.36	2.69
A_3X B_3	19.57	29.43	14.14	3.26	85.86	2.50
L.S.D $_{0.05}$	0.124	0.165	0.218	0.046	0.147	0.019

A1= 100 kg fed $^{-1}$ superphosphate A2= 150 kg fed $^{-1}$ superphosphate A3= 200 kg fed $^{-1}$ superphosphate B1= one dose before planting B2 = two equal doses before planting and the second before first irrigation B3= two equal doses one before first irrigation and the second before second irrigation.

This trend of the presented increasing order of CP%, CF%, ash % and EE% contents phosphorus levels increase was recorded with significant differences of various magnitudes Kulik (2009), Devi and Satpal (2019) and Satpal *et al.,* (2020).

Data presented in Table (4) showed NFE%, TDN% and DCP% contents of Egyptian clover as affected by rates and dates of phosphorus applications and the interaction, regarding phosphorus rates, it is obviously clear that the TDN% and DCP% increased as phosphorus rates increased from 100 to 150 and up to 200 kg fed^{-1} respectively. The respective values were 59.73, 59.94 and 60.29% for TDN, 14.16, 14.93 and 15.42% for DCP, while NFE% decreased as phosphorus rates increased recorded 37.83, 34.72 and 32.93%, respectively. Our results confirm the finding of Türk *et al.,* (2009), Sürmen *et al.,* (2011). The TDN refers to the nutrients that are available for livestock and are related to the CF concentration of the forage (Sürmen *et al.,* 2011).

From the combined analysis of dates of phosphorus application, data cleared that the treatment B3 had the highest values of NFE (35.99%). While, no significant differences were found between the treatment B1 and B3 in the content of TDN%, on the other hand DCP % gave the highest value at treatment B2 recorded 15.10%. These results agree with those reported by Singh *et al.,* (1981).

Results indicated significant interaction effects on NFE%, TDN% and DCP% contents. The highest values were obtained by the interaction A1 with B3 treatment that recorded 38.85 % for NFE%. While, TDN% gave the highest value by the interaction between treatment A3 and B3 recorded 60.33%. Whilst, DCP% gave the highest value by the interaction between treatment A3 and B2 recorded 15.71%. The findings are in harmony with the results Seif and Saad (2014) and Satpal *et al.,* (2020).

Table 4: Effect of rates and dates of phosphorus applications on NFE%, TDN% and DCP% of Egyptian clover (combined across the two seasons).

Treatment	NFE%	TDN%	DCP%
Rates of phosphorus applications (Kg fed^{-1})			
A_1	37.83	59.73	14.16
A_2	34.72	59.94	14.93
A_3	32.93	60.29	15.42
L.S.D $_{0.05}$	1.90	0.274	0.575
Dates of phosphorus applications			
B_1	35.24	60.04	14.84
B_2	34.25	59.88	15.10
B_3	35.99	60.03	14.57
L.S.D $_{0.05}$	0.643	0.021	0.079
Interaction			
A_1X B_1	37.64	59.85	14.24
A_1X B_2	36.98	59.53	14.43
A_1X B_3	38.85	59.80	13.82
A_2X B_1	34.70	60.00	14.97
A_2X B_2	33.90	59.85	15.17
A_2X B_3	35.53	59.97	14.66
A_3X B_1	33.36	60.27	15.32
A_3X B_2	31.83	60.27	15.71
A_3X B_3	33.60	60.33	15.23
L.S.D $_{0.05}$	0.267	0.021	0.139

A1= 100 kg fed $^{-1}$ superphosphate A2= 150 kg fed $^{-1}$ superphosphate A3= 200 kg fed $^{-1}$ superphosphate B1= one dose before planting B2 = two equal doses before planting and the second before first irrigation B3= two equal doses one before first irrigation and the second before second irrigation.

3.4. Economic evaluation

Results in Table (5& 6) revealed that the economic returns for applying different rates and time of phosphorus application and the interaction between them. The total revenue and net return values for different rates of phosphorus application ranged from (33849 and 22489 L.E.) for A1 treatment to (36931.5 and 25411.5 L.E.) for A3 treatment, respectively. Meanwhile, the total revenue and net return values for time of phosphorus application ranged from (34915.5 and 23475.5 L.E.) to (36144 and 24704 L.E.) for B3 and B2 treatments, respectively (Table 5). These results are in harmony with those reported by Satpal *et al.,* (2020). For the total revenue and net return values to interaction ranged from (33025.5 and 21665.5 L.E.) to (37705.5 and 26185.5 L.E.), respectively. Data reveal that the maximum total revenue (37705.5 L.E.), net return (26185.5 L.E.) and net return per one invested (2.27 L.E.) was mine for A3 with B2 treatment followed by A3 with B1 (36657 L.E total revenue), (25137 L.E. net return) and (2.18 L.E. net return per one invested). On the other hand, the minimum total revenue, net returns and net return per one invested was (33025.5, 21665.5 and 1.91 L.E.), respectively recorded by A1 with B3 (Table 6).Similar results were obtained by Kumawat and Khinchi (2017) and Akram *et al.,* (2022).

Table 5: Estimates of costs for inputs farm operations and economic return of Egyptian clover as affected by rates and dates of phosphorus applications (combined across the two seasons).

Costs of production inputs	Treatments					
	A1	A2	A3	B1	B2	B3
Land preparation						
Tillage	600	600	600	600	600	600
Planting	300	300	300	300	300	300
Seeds	600	600	600	600	600	600
Irrigation	500	500	500	500	500	500
Land rent	8000	8000	8000	8000	8000	8000
Mineral fertilizers						
Urea (46.5 % N)	300	300	300	300	300	300
Superphosphate (15.5 % P_2O_5)	160	240	320	240	240	240
Hoeing and weeding	300	300	300	300	300	300
Harvesting	600	600	600	600	600	600
Total variable cost	11360	11440	11520	11440	11440	11440
Price ton^{-1} (Total fresh yield)	450	450	450	450	450	450
Yield ton fad^{-1}	75.22	79.51	82.07	78.89	80.32	77.59
Total revenue	33849	35779.5	36931.5	35500.5	36144	34915.5
Net return	22489	24339.5	25411.5	24060.5	24704	23475.5
Return of invested L. E.	2.98	3.13	3.21	3.10	3.16	3.05
Net return of invested L. E.	1.98	2.13	2.21	2.10	2.16	2.05

A1= 100 kg fed $^{-1}$ superphosphate A2= 150 kg fed $^{-1}$ superphosphate A3= 200 kg fed $^{-1}$ superphosphate B1= one dose before planting B2 = two equal doses before planting and the second before first irrigation. B3= two equal doses one before first irrigation and the second before second irrigation. Net return (L.E. fad -1) = Total revenue- Total variable costs Return of invested L. E. = Total revenue/Total variable costs Net return of invested L. E. = Return of invested L.E.-1

Table 6: Estimates of costs for inputs farm operations and economic return of Egyptian clover as affected by interaction among rates and dates of phosphorus applications (combined across the two seasons).

Costs of production inputs	Interaction								
	A1XB1	A1XB2	A1XB3	A2XB1	A2XB2	A2XB3	A3XB1	A3XB2	A3XB3
Land preparation									
Tillage	600	600	600	600	600	600	600	600	600
Planting	300	300	300	300	300	300	300	300	300
Seeds	600	600	600	600	600	600	600	600	600
Irrigation	500	500	500	500	500	500	500	500	500
Land rent	8000	8000	8000	8000	8000	8000	8000	8000	8000
Mineral fertilizers									
Urea (46.5 % N)	300	300	300	300	300	300	300	300	300
Superphosphate (15.5 % P_2O_5)	160	160	160	240	240	240	320	320	320
Hoeing and weeding	300	300	300	300	300	300	300	300	300
Harvesting	600	600	600	600	600	600	600	600	600
Total variable cost	11360	11360	11360	11440	11440	11440	11520	11520	11520
Price ton^{-1} (Total fresh yield)	450	450	450	450	450	450	450	450	450
Yield ton fad^{-1}	75.61	76.67	73.39	79.61	80.51	78.41	81.46	83.79	80.96
Total revenue	34024.5	34501.5	33025.5	35824.5	36229.5	35284.5	36657	37705.5	36432
Net return	22664.5	23141.5	21665.5	24384.5	24789.5	23844.5	25137	26185.5	24912
Return of invested L. E.	3.00	3.04	2.91	3.13	3.17	3.08	3.18	3.27	3.16
Net return of invested L. E.	2.00	2.04	1.91	2.13	2.17	2.08	2.18	2.27	2.16

A1= 100 kg fed $^{-1}$ superphosphate A2= 150 kg fed $^{-1}$ superphosphate A3= 200 kg fed $^{-1}$ superphosphate B1= one dose before planting B2 = two equal doses before planting and the second before first irrigation B3= two equal doses one before first irrigation and the second before second irrigation. Net return (L.E. fad -1) = Total revenue- Total variable costs Return of invested L. E. = Total revenue/Total variable costs Net return of invested L. E. = Return of invested L.E.-1

EISSN: 2706-7955 ISSN: 2077-4605 DOI: 10.36632/mejar/2022.11.4.70

4. Conclusion

Based on the indications of results, Egyptian clover responded to applying different rates and dates of phosphorus application and the interaction between them. In case of phosphorus rates, A3 treatment (200 kg fed^{-1} superphosphate) found to be the optimum dose for better growth parameters, yield, quality and economic values of Egyptian clover but the difference between 150 kg fed^{-1} and 200 kg fed^{-1} superphosphate rates not reach to a large extent, so 150 kg fed^{-1} treatment could be used to provide fertilize**r.** For the time of phosphorus application, B2 treatment (two equal doses before planting and the second before first irrigation) produced highest significant for all traits under study. Thus, it is recommended to use this application. Generally, it could be stated that to increase forage production and its quality of Egyptian clover, 150 kg fed^{-1} superphosphate with two equal doses before planting and the second before first irrigation under clay soil conditions.

5. Acknowledgment

The authors wish to express their sincere appreciation to staff of the Department of Economics, Central laboratory for statistical analysis for great effort and helpful assistance in the Economic study.

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