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Research Article

Effect of Some Chemical and Biological Fertilizers on Productivity of Medicinal Flax (*Linum usitatissimum*) Plant

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ABSTRACT: A field experiment was carried out at the Experimental Station, Faculty of Agriculture, Trbiat Modares University, during spring season of 2009-2010, to study the effect of some chemical and biological fertilizers containing macro nutrients (*i.e* 100 kg/ha Urea as the source of N, 100 kg/ha calcium super phosphate as the source of P, 150 kg/ha Potassium sulphate as the source of K and 150 kg/ha N.P.K (10–15–10) fertilizer as the source of macro complete fertilizer, combination of 50 kg/ha + 50 ton/ha animal manure and 100 ton/ha animal manure) on yield and its components of medicinal flax plant. The earliest and latest flowering date of plants were achieved by applying N.P.K fertilizer and 100 ton/ha animal manure, respectively. The highest plant height in the full flowering stage was obtained by application of 100 ton/ha animal manure. Seeding date of plants was also significantly affected by applied fertilizers; 100 ton/ha animal manure and N.P.K treatment caused the latest and the earliest seeding date of plants, respectively. The lowest seed index was obtained in control treatment, whereas N.P.K fertilizer caused the highest 1000-seed weight. Seed yield, seed oil percentage and oil yield reached the highest values by adding 150 kg/ha potassium sulphate. Meanwhile oil compositions of the extracted oils were significantly different because of applying different fertilizers, and linoleic acid had the highest amount in all of the tested samples. Ultimately, 100 ton/ha animal manure showed its leading impact on the protein content of seeds.

KEYWORDS: Fertilizer, Flax, *Linum Usitatissimum* L., Medicinal Plants

INTRODUCTION

Flax (*Linum usitatissimum* L.) is one of the most important of medicinal plants, and its production goes back to the ancient times.[1] Today's products of the flax plant have grown in number and importance, and there is also an increased demand for them, therefore human consumption of the flax is increasing rapidly for its food and industrial benefits.[2]

As a result of limited flax production, a gap between the production and consumption has been increased. This gap could be minimized by increasing flax yield/unit area, through planting high yielding varieties and optimizing agricultural practices. Proper fertilization is among numerous factors involved in this concern. Doubtless, application of fertilizers containing macro nutrients (*i.e.* N.P.K) plays an important role to obtain high flax yield.[3]

Many researchers have revealed the effect of N, P and K fertilizers, on the flax growth and yield: Kineber et al.[4] studied the effects of S and N on yield, its related characteristics, and quality of flax cultivars Sakha 1, Giza 8 and imported Belinka, and chemical properties of soil after harvest. Two rates of elemental S were tested, *i.e.* 100 and 200 kg/fed., respectively. The N treatments comprised 45 and 60 kg N/fed. as anhydrous ammonia (82.0%); 45 kg N/fed. as ammonium sulfate (20.6%); or 30 kg N as anhydrous ammonia+15 kg N/fed. as ammonium sulfate. The addition of S to alkali soil decreased the pH value and improved the chemical properties of the soil besides improving the yield and

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its related characteristics. The highest S level (0.02%) had the best effect on technical stem length, number of capsules per plant, number of seeds per plant, seed yield/fed., fiber length and fiber fineness. Application of N at 60 kg/fed. in the form of anhydrous ammonia could improve technical stem length, straw yield/fed., number of capsules per plant, number of seeds per plant, seed yield per plant and per fed., and fibre quality characteristics. Application of N at 30 kg/fed. as anhydrous ammonia+15 kg N/fed. as ammonium sulfate gave the highest value for fruiting zone length and oil percentage. The cultivars were differed significantly in all characteristics. Imported Belinka was the leading cultivar with regard to technical length, straw yield per plant and fiber yield/fed., fiber length and fiber fineness. Sharief et al.[3] through their study on response of two flax cultivars namely Giza 8 and Blanka to different levels of two macro nutrients of N and P in Egypt in two consecutive years found that Giza cv. Surpassed Blanka in number of fruit branches plant^{-1}, number of capsules plant^{-1}, 1000 seed weight, weight of seeds plant^{-1} as well as seed and straw yields ha^{-1}. Blanka surpassed Giza 8 in stem diameter in the first season, plant height, technical length and straw yield in both seasons. Increasing nitrogen levels from 70 to 120 and 170 kg N ha^{-1} significantly increased plants height, technical length, stem diameter, number of fruit branches plant^{-1}, number of capsules plant^{-1}, number of seeds capsule^{-1}, 1000 seed weight, seed and straw yield plant^{-1} and ha^{-1}. Nitrogen level of 170 kg N ha^{-1} was the recommended level to increase seed and straw yields ha^{-1}. The application of 70 kg P+60 kg K ha^{-1} induced a marked increase and surpassed other studied PK combinations regarding all studied characters. The highest seed yield ha^{-1} was produced by Giza 8 when fertilized with 170 kg N ha^{-1}. Yadav et al.[5] illustrated that increasing rates of N and P improved seed index (1000-seed weight). Seed oil percentage increased with increasing P rates, but it was not affected by N rates. The optimum rates of N and P_2O_5 were 78 and 25 kg/ha, respectively. Sarode and Naphade[6] found that seed yield of linseed increased with increasing P up to 10 kg while seed oil content was slightly increased by P application. Moreover, Chaubey and Dwivedi[7] reported that P application increased seed yield by 17.3 % and 14.1 % in two growing seasons. Kadar et al.[8] reported that P and K did not significantly increase the yield. The optimum N rate was 100 kg/ha. Excessive NP treatments reduced the oil content by 3%, seed yield by 25–30%, and oil yield by 30–40%. The seed yield ranged from 1.2 to 2.0 t/ha, the oil content varied from 38 to 41%, and the oil yield ranged from 453 to 789 kg/ha. The seed oil contained an average of, 3.8% stearic acid, 6.6% palmitic acid, 13.2% linoleic acid, 21.4% oleic acid and 54.9% linolenic acid. The amount of linoleic acid was enhanced by P but was reduced by N; the opposite effect was recorded for oleic acid content. Dubey[9] in india found that the highest seed yield and net return of flax CV. JLS-23 came from the application of 60 kg N and 30 kg P_2O_5/ha. Abd El-Samie and El-Bially[10] reported that there was a significant increase in plant height, technical length, number of fruiting branches/plant, number of capsules/plant, number of seeds/capsule, 1000-seed weight and yield of seeds and straw fad^{-1} with each increase in the applied nitrogen at the rate 30, 40 and 60 kg fad^{-1}. They also found a marked increase in oil yield with increasing nitrogen rates from 30 to 60 kg fad^{-1}. Salama[11] showed that application of N fertilizer at 60 or 80 kg N fad^{-1} did not induce marked increases in the studied characteristics and stated that N fertilizer level should not exceed 40 kg N fad^{-1} for flax production, in Mansoura region. Haniyat El-Nimr et al.[12] reported that increase of nitrogen levels from 45 to 70 kg fad^{-1} caused a significant increase in the most of the studied characters (*i.e* number of capsules/plant, straw, fiber and seed yield/fad). Application of 95 kg N fad^{-1} decreased the values of seed index, seed oil percentage and oil yield fad^{-1}. On the other hand, technical length was increased as nitrogen level increased from 45, 70 to 95 kg N fad^{-1}. Increasing the nitrogen fertilizer levels up to 60 kg N fad^{-1} increased total plant height, technical length, stem diameter, number of upper branches, straw yield fad^{-1}, number of capsules/plant, number of seed capsul^{-1}, seed index and seed yield fad^{-1}.

MATERIALS AND METHODS

A field experiment was conducted at the Experimental Station, Faculty of Agriculture, Tarbiat Modares University, during the spring season of 2009–2010. The aim of this investigation was the study of effect of some chemical and biological NPK containing fertilizers on yield and its component of a medicinal flax plant, under Tehran district conditions.

The field experiment was laid out in a Randomized Complete Blocks design, with 3 replications. The experimental plot size was 2 meters long and 2 meters width, occupying an area of 4 m^2 . Nitrogen fertilizer in the form of urea (46% N) was applied in 3 equal portions (before first irrigation, 30 and 60 days after sowing, respectively). Phosphorus in the form of calcium superphosphate (46% P_2O_5) and potassium in the form of potassium sulphate (50% K2O) were applied, at the rate previously mentioned. In this study the combination of 50 kg/ha urea+50 ton/ha animal (cow) manure and 100 ton/ha

Table 1: Soil sample analysis of experimental site

Characteristic	Amount
Sand (%)	59
Silt (%)	17
Clay (%)	24
Soil Texture	Clay-Sand
EC	1.89 mmho/cm
pH	7.68
Available K(ppm)	328
Available P(ppm)	19.184
Total N (%)	0.2
Organic C (%)	2.28

animal manure as the biological fertilizer Treatments were also employed.

The experimental field was well prepared. Sowing was done in rows during first week of March. Seeds were hand drilled in 5 rows 15 cm apart. Physical and chemical soil analysis is presented in Table 1. Irrigation was done on the day of sowing. Other irrigations performed approximately at 7 days intervals. Weeds were controlled by hand. The normal cultural practices for growing flax plant were practiced.

Studied Characters

At the full seed maturing stage, 10 guarded plants were chosen at random from each plot for the determination of yield and its components as follows: Germination date of seeds with counting days after sowing (DAS), 4-Leaf stage (DAS), Stemming stage (DAS), Flowering date of plants (DAS), Seeding date of plants (DAS), Full maturity stage time of seeds (DAS), Seed index (1000-seed weight in grams), Seed yield in kg/ha, Seed oil percentage (It was determined using Soxhlet apparatus according to AOCS[13]), Oil yield in kg/ha (It was estimated by multiplying oil percentage by seed yield/ha), Oil compositions (It was determined using Gas Chromatography.[14])

Statistical analysis

All data were statistically analyzed according to the technique of analysis of variance (ANOVA) for Complete Randomized Blocks design as published by Yazdi Samadi et al. [15] All statistical analyses were performed using the facility of computer, MINITAB.14 and MSTAT-C computer softwares.

Table 2: Animal manure characteristics

N (%)	K (%)	P (%)	Organic Matter (%)	Dry Matter (%)	EC (ds/m)	pH
0.9	1.37	0.54	79.85	34.26	15.8	7.3

RESULTS AND DISCUSSION

Data in Table 3 revealed that all of the evaluated characters of the flax plants with the exceptions of seed germination date and 4-Leaf and stemming stage were markedly varied as a result of applying different chemical and biological fertilizers. 100 ton/ha was the leading treatment in the case of the date of stemming stage (10.33 DAS) while, control was ranked in the lowest position (11.33 DAS). Moreover, no significant differences observed among the other treatments. Height of plants at the full flowering stage was also severely under the influence of 100 ton/ha animal manure and the maximum height in the treated plants achieved by applying this treatment (44.867 cm), so that the most of the treated plants had an obvious tendency for lodging. Treatments of macro complete fertilizer (41.167 cm), combination of animal manure+urea (40.833 cm) and K containing fertilizer (40.833 cm) were respectively ranked after the superior treatment. Although, the shortest plants (38.933 cm) were placed in control, but showed no significant difference to the phosphorus containing treatment. Adding 150 kg/ha N.P.K fertilizer was the most effective treatment for accelerating flowering (103.6 DAS) and seeding date (107.6 DAS) of plants, whereas applying 100 ton/ha animal manure postponed these characters (110.33 DAS, 116.33 DAS) significantly more than the other treatments (Table 3). That was no significant difference between K containing fertilizer (104.67 DAS, 109.33 DAS) and the leading treatment. N.P.K also caused a significant effect on increasing seed index (1000-seed weight) and was the most effective treatment for increasing this characteristic (4.67 gr.). The lowest seed index (3.68 gr.) achieved in the control treatment (Table 3).

Seeds ripening stage was markedly under the influence of the applied treatments; the control (121.3 DAS) and 100 ton/ha animal manure (131.3 DAS) caused the shortest and the longest seeds ripening date after sowing, respectively. The obtained data showed that the source of potassium was the most effective treatment for increasing seed yield (1378 kg), seed oil percentage (27.933 %) and oil yield (385.1 gr). These findings are in contrast to those obtained by Salma[11] and Leilah.[16]

Although all of the oil samples contained the same compositions (Table 4) of linolenic acid, palmitic acid, stearic acid and oleic acid, the samples differed in oil compositions percentage. The main fatty acid in all of the tested samples was linoleic acid.

The highest content of linoleic acid found in combination of 50 kg/ha urea and 50 ton/ha animal manure treatment

Table 3: Comparison of means for the evaluated traits of flax

Treatment	Stemming date	height in full blooming stage	Flowering date	Seeding date	Seed ripening date	1000-Seed weight	Seed yield	Seed oil	Oil yield	Seed protein
	Day after sowing	cm	Day after sowing	Day after sowing	Day after sowing	g	Kg.ha^{-1}	(%)	Kg.ha^{-1}	(%)
T1†	11.333A*	38.933C	105.00B	110.00BC	121.33D	3.680B	781.5C	18.733B	146.28C	21.433A
T2	11.000AB	40.833AB	104.67BC	109.33C	122.00D	4.313AB	1378A	27.933A	385.1A	18.200C
T3	11.000AB	40.167BC	103.33B	110.0BC	125.00C	4.293AB	1246.3A	22.067B	274.97B	18.167C
T4	11.000AB	41.167AB	103.67C	107.67D	125.00C	4.676A	1054.6B	26.500A	279.7B	18.567C
T5	10.333B	44.867A	110.33A	116.33A	131.33A	4.453AB	884.5BC	22.000B	194.8C	24.567A
T6	11.000AB	40.833AB	105.33AB	112.00AB	129.00B	4.530A	1340.6A	21.33B	288.1B	20.733B

†T1, T2… T6: Control, Potassium fertilizer, Phosphorus fertilizer, Macro complete fertilizer, Animal manure and Combination of animal manure+Nitrogen fertilizer treatments

*: In each column, means followed with the same letters are not significantly different at 5% level of probability.

Table 4: Comparison of means for linseed oil components

Treatment	Linoleic acid %	Linolenic acid %	Oleic acid %	Stearic acid %	Palmetic acid %
T1†	39.793C*	14.653A	7.487A	6.592B	29.037A
T2	43.790A	13.680AB	7.293A	6.012B	27.892B
T3	41.130B	14.447A	7.490A	7.225A	29.597A
T4	40.740B	13.163AB	7.557A	7.093A	28.031AB
T5	41.610B	15.620A	7.337A	7.282A	29.717A
T6	44.377A	15.343A	4.697B	7.199A	27.010B

† T1, T2… T6: Control, Potassium fertilizer, Phosphorus fertilizer, Macro complete fertilizer, Animal manure and Combination of animal manure+Nitrogen fertilizer treatments.

* : In each column, means followed with the same letters are not significantly different at 5% level of probability.

(44.377%) and the lowest one achieved by control (39.793%). As we expected, the highest protein content of seeds was measured in the 100 ton/ha animal manure (24.567%). Although, no significant difference was observed among the phosphorus (18.167%), potassium (18.200%) and macro complete fertilizer (18.567%). However, these treatments showed the minimum values, respectively. 100 ton/ha animal manure (24.567%) and control (21.433%) ranked the maximum positions, respectively.

CONCLUSIONS

Having no significant effect of the applied treatments on the two characters of date of germination and 4-leaf stage may be due to the fact that germination and initial growth of the plants is directly depended on viability of seeds, and the rate of growth and development in this stage is not (at least directly) under the influence of applying such nutritional sources. Using and sowing Vigorous seeds surely will result in the subsequent thriving growth of the plantlets at the initial stages of their growth and development, with the minimum requirement to the nutritional additives. Regarding the animal manure characteristics showing the high values of nitrogen and phosphorus content, we concluded that the appropriate vegetative appearance of plantlet treated with animal manure is due to the high amounts of the mentioned elements. Especially high values of nitrogen may cause an accelerated vegetative growth of plantlets and their height as well. Flax has showed high sensitivity to lodging, and this may be intensified by applying high level of nitrogen to the plantlets. Tendency of plantlets to lodging is directly related to the amount of the nitrogen uptake available in animal manure. Results of Reineri[17] followed by our findings confirmed the sensitivity of flax to the high levels of N uptake.

Results of the soil analysis revealed poor nutritional level of the experimental site; considering the low rate of growth and development of the plants placed in control treatment and subsequently their short recorded heights revealed the direct impact of adding nutritional elements on the rate of growth and developments of flax plants. The most important elements of N.P.K in the productive growth of any crop were simultaneously provided when soil treated with the complete macro fertilizer; resulted in the fastest flowering date of plantlets and the highest 1000-seed weight. It has been so long widely accepted that nitrogen accelerates/enhances the vegetative growth and the reverse, decreases/postpones the productive growth. Since, the vegetative and the productive growth of plants have a reverse proportion so, a marked delay in full flowering stage of plants treated with 100 ton/ha animal manure shows that the high amount of available nitrogen directly increased the productive growth of plants and subsequently impacted the height of plants positively, and full flowering date from the sowing day, negatively.

Moreover, K_2SO_4 as the source of potassium caused an increase in oil content of seeds. Since, the rule of sulphur is well-known and there are a number of researchers which have reported the effect of this element in synthesis/increase of fatty acids in oily plants such as flax;[18] therefore, sounds, an interaction between solphur and potassium available in the mentioned fertilizer was the main cause for the markedly increase in fatty acids content of seeds. Our results are in accordance to those revealed by Kineber et al.[4] which emphasize on the impact of sulphur in improve oil content of oily crops.

In the other hands, regarding the substantial rule of N in synthesis of amino acids and therefore protein in living organisms,[19] that was not unexpected to find the impact of nitrogen containing fertilizers namely 100 ton/ha animal manure as the most effective treatment in increasing protein content of seeds. The low content of fatty acids in plants treated with the mentioned fertilizer, plus to the high values of nitrogen caused a considerable increase more than the other treatments in protein content of seeds.

Taking all these into account, it was generally concluded that yield and its component of flax plant are widely affected by applying chemical and biological fertilizers. However, some characteristics such as germination date of seeds are not under the influence of fertilizing the cultivated plants.

In general, the increase in growth and development of plants is closely related to the amount of the applied nitrogen, phosphorus and potassium, which led to the increase in seed index, seed yield, seed oil percentage and oil yield that are considered as the main components of growth and development of any crop.

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