DETERMINING THE BEST RATE AND TIME OF NITROGEN FERTILIZATION FOR SUSTAINABLE PRODUCTION OF SUNFLOWER

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ABSTRACT: *Nitrogen fertilization at proper stage is considered a key to the crop yield, balance application of nutrients can fill the demands of the agricultural lands for sustainable crop production and livestock. This research study explored to determine the best rate and time of nitrogen fertilization for sustainable production of sunflower. The experiment was arranged in randomized complete block design, consisted of four nitrogen rates (00, 50, 100 and 150 kg N ha^{-1}) and five timings of nitrogen application at different stages (Full N at sowing (S), ½ N at sowing (S) + ½ N at first irrigation (FI), ½ N at sowing (S)+ ½ N at flowering stage (FS), ½ N at first irrigation (FI) + ½ N at flowering stage (FS), 1/3 N at sowing (S) + 1/3 N at first irrigation (FI) + 1/3 N at flowering stage (FS)). A dose of 100 kg N ha^{-1} followed by 150 kg N ha^{-1} was highest for most of the growth and yield traits of sunflower with an increase over control of leaf area 6%, seeds head^{-1} 52%, 1000 seed weight 42%, yield 30% and oil content 7%. Most of the traits of sunflower were highest in three splits (1/3 at S+ 1/3 at FI+ 1/3 at FS), followed by the nitrogen application timing in two equal splits (½ at S and ½ at FS) and (½ at FI and ½ at FS). It was found that 100 kg N ha^{-1} was superior in producing most of the growth and yield contributing traits, while most of the growth and yield contributing characteristics were enhanced where nitrogen was applied in three equal splits (1/3 N at S+ 1/3 N at FI+ 1/3 N at FS). The significant interactive effect revealed that the sunflower behaved differently at 100 kg N ha^{-1} × three equal splits of nitrogen fertilization.*

Key words: Application timings, Growth, Nitrogen, Sunflower, Yield.

INTRODUCTION

The Sunflower (*Helianthus annuus* L.) is an important oilseed crop worldwide, contains oil, protein and crude fiber. Sunflower is the one of the key oil seed crop of Pakistan due to its major contribution in oil production. According to the statistics 2009-10, the production was expected about 0.680 (million tons) whereas 1.246 (million tons) of edible oil was imported by paying huge cost and 872 (thousand acres) land is under sunflower cultivation in Pakistan, 554 and 211 thousand tons under seed and oil production, respectively [9]. The plant growth and reproductive stages require protein to enhance crop yield, further formation of the protein is dependent upon available nitrogen used by plant activities [13, 19]. Higher N application rates controlled to rapid leaf area expansion, prolonged the life of leaves, and increase crop assimilation rate resulting increase in crop yield [24]. Nitrogen fertilizer has significant role not only in crop production as well as other crop growing activities. Limited supply of N reduces plant growth and developmental processes. Moreover, the nitrogen application enhanced all dry matter along with nitrogen accumulation and separating into several growth parts of crops, and other developments [15]. Sunflower has strong and well developed root system, and maintains their stomata under high evaporation rates demands that usually prevail in tropical and semi-tropical regions. Profound, judicious, and timely application of N fertilizers at different growth stages to sunflower can play vital role seed production and oil content [2, 3]. The farming practices, i.e., kind, time, amount of N fertilizer and interaction among nutrients are significant factors that standardize the quality and yield in sunflower crop [3], beside the other factor imbalanced and inadequate supply N is a major yield limiting factor in sunflower production. Proper amount and timely application of N fertilizer is considered a crucial for bumper crop [1, 10, and 13]. The most consistent techniques to increase the N availability is to apply N when it is required by the crop [14]. Use of N fertilizer through a appropriate method is that at the time when it is efficiently used by the crop. Nitrogen efficiency (NE) can be enhanced by corresponding the N application rate and the method of application with respect to plant anxieties [8, 21, and 16]. Suzur [23] has reported that appropriate fertilization is important for getting a high yield per hectare, and N deficiency is the most restrictive nutritional syndrome to sunflower. Adequate soil fertility is also necessary for the profitable sunflower production and that N is the most stress full nutrient for its yield production [17]. High rates of N application generally favour crop assimilation, hence contributing to enhance seed yield (17, 19]. Ishaque [12] found that 125 kg ha^{-1} twisted number of heads, increase seed head^{-1}, 1000-grain weight and enhance seed yield in comparison to high doses of N at 190 and at 250 kg ha^{-1}. Keeping these facts in mind, the present study was carried out with the hypothesis that the efficiency of nitrogen can be enhanced through suitable application rate of N in proper amounts and at proper growth stages of sunflower for sustainable production. The specific objectives were, (1) to identify best nitrogen rates and time of application on the growth and yield of field grown sunflower (2) To determine the relationship between the nitrogen application timings and yield of sunflower.

MATERIALS AND METHODS

This field study was conducted at Oil Seed Section, Agriculture Research Institute (ARI), Tandojam during 2012-2013. This study was arranged in randomized complete block design with two factors in three repeats using a plot area of 4m × 5m = (20 m^2). The field was prepared by first applying two dry ploughings than by land leveller. Later, the field remain in soaking doze, when field came in normal conditions two ploughings with cultivator followed by planking was applied to attain the better seed bed preparation. There were two factors (A and B), Factor (A), (nitrogen levels) NL_1=0, NL_2=50, NL_3=100 and NL_4=150 kg N ha^{-1} and Factor (B) = (N application times), (Full N at sowing (S), ½ N at sowing (S) + ½ N at first irrigation (FI), ½ N at sowing (S)+ ½ N at flowering stage (FS), ½ N at first irrigation (FI) + ½ N at flowering stage (FS), 1/3 N at sowing (S) + 1/3 N at first irrigation (FI) + 1/3 N at flowering stage (FS)). Plant growth and yield traits were recorded, i.e., plant length (cm), leaf area (cm^2), head diameter (cm), seeds $head^{-1}$, seed index, yield (kg ha^{-1}) and oil content (%). The crop was sown by dibbling method on a well prepared seedbed. The sunflower (HO-1) variety was sown by maintaining a plant spacing of 1.0 ft. The rows were kept 1.5 ft. apart. All the required cultural and management practices were applied during the study period. The recommended doses of phosphorus (90 kg ha^{-1}) and potassium (75 kg ha^{-1}) was applied in the form of potassium sulphate (50% K_2O) and phosphorus as (DAP (18% N and 46% P_2O_5). For recording the observation on different agronomic parameters five plant were selected randomly from each plot and tagged properly. Statistical analysis was carried out using Statistix ver. 8.1. The difference in the means was described by (least significant difference <0.05).

RESULTS AND DISCUSSIONS

Nitrogen (N) is the one of the key constituent of proteins and is essentially utilized throughout the life span from vegetative to harvesting stage. It is reviewed from the literature that one of the main reasons of low yield is imbalanced fertilization of the required nutrients. Proper amount, method and time of N fertilization is necessary for better crop growth and seed yield for sustainable crop production [13]. The most logical approach to increase nitrogen availability is to apply N when it is used by the crop, because without the management of especially N fertilization is the consumption of N fertilization in field and reduction in profit [14].

The key findings of the present research depicted that the plant height was significantly (P< 0.01) affected due the different application times and nitrogen doses. It is clear from the results (Table 1) that the maximum plant height of 208. cm was noted, where the N was applied at a dose of 150 kg N ha^{-1} followed by the 0 kg N ha^{-1} 199.4 cm. However, the plant height of 205.6 cm was recorded, where the nitrogen application times were applied 1/3 N at S + 1/3 N at FI + 1/3 N at FS followed by the N applied at ½ at S and ½ at FI at the rate of 150 kg N ha^{-1}, whereas their interaction was non-significant (P> 0.05). The maximum leaf area, seeds per head, 1000 seed weight and seed yield, oil content of 364.8 cm^2, 668.4, 63.2 g, 2137.7 kg ha^{-1}, 41.6 %, respectively, was noted at a dose of 100 kg N ha^{-1} followed by the 150 kg N ha^{-1} 364.1, 660.6, 54.63 g, 2123.2 kg ha^{-1}, 41.1 %, respectively. Higher response was observed at 1/3 N at S + 1/3 N at FI + 1/3 N at FS followed by the N applied at ½ at S and ½ at FS (Table 1 & 2). The significant interactive result revealed that the sunflower behaved differently for their leaf area at different nitrogen application times and nitrogen levels (Table 1 & 2). However, sunflower did not behave differently for oil content% at different nitrogen application times and nitrogen doses. Maximum head diameter increased at the rate of 150 kg N ha^{-1} followed by the 100 kg N ha^{-1} 25.7 cm, it responded more to N fertilization times 1/3 N at S + 1/3 N at FI+ 1/3 N at FS followed by the N applied at ½ at S + ½ at FS and its interaction was non-significant (Table 1).

Table 1. Plant height, leaf area, head diameter and seeds per head of sunflower as affected by different nitrogen levels and application timings

	N	Plant height (cm)	Leaf area (cm^2)	Head diameter (mm)	Seeds $head^{-1}$
Full N at S (control)	N0	192.23	334.85	22.82	415.00
	N50	190.00	340.83	23.79	473.33
	N100	191.33	355.30	24.46	626.67
	N150	205.38	352.86	26.57	625.44
Mean		194.73 c	345.96 e	24.41 c	535.11 e
½ N at S + ½ N at FI	N0	202.45	340.41	23.15	418.00
	N50	200.04	350.86	23.49	486.00
	N100	197.71	355.19	25.00	643.67
	N150	209.17	354.19	27.66	644.30
Mean		202.34 ab	350.16 d	24.83 bc	547.99 d
½ N at S + ½ at FS	N0	198.49	352.79	25.71	446.33
	N50	198.00	362.28	26.49	532.33
	N100	199.67	368.37	25.66	679.67
	N150	209.82	368.00	26.26	667.00

Mean		201.50 ab	362.86 b	26.03 ab	581.33 c
½ at FI + ½ at FS	N0	199.08	349.37	25.01	446.33
	N50	199.28	361.20	25.45	574.00
	N100	199.15	366.97	26.42	678.00
	N150	205.42	367.97	25.45	666.15
Mean		200.73 b	361.38 c	25.58 abc	591.12 b
1/3 at S + 1/3 at FI + 1/3 at FS	N0	204.77	362.77	25.46	467.67
	N50	204.51	372.87	27.07	599.67
	N100	203.07	378.30	27.46	714.00
	N150	210.30	377.22	26.13	700.67
Mean		205.66 a	372.79 a	26.53 a	620.50 a

Table 2. Seed index, seed yield and oil content of sunflower as affected by different nitrogen levels and application timings

	N	Seed index	Seed yield (kg ha^{-1}	Oil content (%)
Full N at S (control)	N0	39.00	1519.19	38.15
	N50	48.83	1786.67	39.48
	N100	57.00	2069.56	40.61
	N150	48.84	2052.71	40.16
Mean		50.29 d	1857.03 e	39.60 c
½ N at S + ½ N at FI	N0	41.45	1602.09	38.32
	N50	52.00	1800.78	39.57
	N100	58.00	2105.23	41.00
	N150	52.01	2099.00	40.72
Mean		52.41 c	1901.78 d	39.90 c
½ N at S+ ½ at FS	N0	46.12	1695.00	39.32
	N50	56.00	1901.34	40.69
	N100	66.33	2156.93	41.62
	N150	56.12	2136.00	41.58
Mean		58.28 b	1972.32 c	40.81 b
½ at FI + ½ at FS	N0	47.00	1701.23	39.08
	N50	55.19	1946.67	40.44
	N100	65.33	2151.67	40.99
	N150	59.34	2132.15	40.74
Mean		58.46 b	1982.93 b	40.31 bc
1/3 at S + 1/3 at FI + 1/3 at FS	N0	49.67	1756.60	40.23
	N50	59.63	2001.67	41.01
	N100	69.33	2205.01	43.90
	N150	61.34	2196.15	42.25
Mean		61.91 a	2039.86 a	41.85 a

Shortly in this study, A dose of 100 kg N ha^{-1} followed by 150 kg N ha^{-1} was highest for most of the growth and yield traits and Most of the traits of sunflower were highest in three splits (1/3 at S+ 1/3 at FI+ 1/3 at FS), followed by the nitrogen application timing in two equal splits (½ at S and ½ at FS) and (½ at FI and ½ at FS). Reasons might that the balanced use of nitrogen fertilizer at te proper growth stage increased the most of growth traits and might be increased nitrogen use efficiency corresponding to an application rate and the method of application. Furthermore, in our opinion the proper amount and application method is a key for crop production, it should be supplied when it is required by the crop. These findings are with agreements of [22, 11] who found the significant effects of N on te head diameter of the sunflower. It is well reported that N fertilization has increased the achene yield of sunflower hybrids [4]. It is also reported that the numbers of achenes per head is an important contribution in achene seed yield [5]. The results of [18] endorsed that where N was supplied in different splits produced the highest seed yields of 2446 kg nitrogen ha and 2370 kg nitrogen ha^{-1}. The findings of [7] witnessed that 120 kg nitrogen ha^{-1}provided more outputs for all the traits in comparison to control. Nitrogen timings did not influence the total dry matter, crop growth rate, oil content and protein though, where N was applied in two splits (½ at N sowing + ½ at N flowering) increased seed yield than full dose of nitrogen at sowing. [19] Investigated that 180 kg nitrogen per hectare produced more yield in comparison to other nitrogen rates (0, 60, 120, 240 kg ha^{-1}) during the study period. Nasim [13] Found that 120 kg nitrogen ha^{-1} increased most of the grain yield and most of the yield contributing traits, where N was applied in split increased grain weight in comparison to te single split application. The findings of [20] the results

were influenced by N rates, application method and interaction of N rates × N timing method.

CONCLUSIONS

The results concluded that 100 kg N ha^{-1} was found to be the best rate for producing most of the growth and yield traits of the sunflower, followed by the 150 nitrogen kg ha^{-1}. All the traits of sunflower were highest in case of where nitrogen was applied in three equal splits (1/3 N at S + 1/3 N at FI + 1/3 N at FS), followed by two equal splits of nitrogen application timing method (½ N at S and ½ N at FS) and (½ at FI and ½ at FS). Therefore, we can minimize the imbalanced use of nitrogen fertilizer, by adapting best application timings strategy. Furthermore, the proper amount and application method is a key for crop production, it should be supply when it is required by the crop.

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