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Evaluating Right Timing and Splitting Nitrogen Application Rates for Enhanced Growth and Yield of Sunflower

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Abstract:

The research was carried out for evaluating right timing and splitting nitrogen application rates for enhanced growth and yield of sunflower at oilseed section, Agriculture Research Institute, Tandojam. The experiment was laid out in three replicated randomized complete

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block design having net plot size of 20 m^2. Nitrogen rate of 100 kg ha^{-1} was applied either in full or splits. The treatments included; T_1= 100 kg ha^{-1}N (Full dose of N at the time of sowing, T_2= 1/2 N at sowing + 1/2 at first irrigation (two splits), T_3= 1/3rd N at sowing + 1/3rd at first irrigation + 1/3rd at 2nd irrigation (three splits). The observation was recorded on important growth and yield contributing characteristics.

The analysis of variance showed that spilt N application and its timing had significant effect on all the growth and yield parameters except days to 75% maturity, which showed non-significant effect. The maximum 84.3 days to 75% maturity were recorded in T_3 when N was applied in three splits whereas minimum 82.0 days to 75% maturity were recorded in T_1 when N was applied as full dose at the time of sowing. The maximum 95.0 days to 90% maturity were recorded in T_3 when N was applied in three splits whereas minimum 91.3 days to 90% maturity were recorded in T_1 when N was applied as full dose at the time of sowing. The maximum 210.0 cm plant height was recorded under T_3 whereas minimum 126.6 cm plant height was recorded under T_1. The maximum 11.3 cm stem girth was recorded under T_3 when N was applied in three splits while the minimum 6.3 cm stem girth was observed at T_1 where full dose of N was applied at the time of sowing. The maximum 26.0 cm head diameter, 60.0 g seeds $head^{-1}$ yield, 72.3 g seed index and 1414.0 kg yield ha^{-1} was observed under T_3 = 1/3rd N at sowing + 1/3rd at first irrigation + 1/3rd at 2nd irrigation (three splits) whereas the minimum 18.0 cm head diameter, 24.6 g seeds $head^{-1}$ yield, 43.6 g seed index and 859.0 kg yield ha^{-1} was recorded at T_1 = full dose of N at the time of sowing. It was further revealed and concluded that sunflower performed better in all parameters when N was applied in three splits and at different timings as compare to full N application at sowing time and N in two splits. Therefore, for better performance of sunflower production and optimum N use, N application in three splits is recommended.

Key words: Sunflower, Nitrogen, Timings, Nitrogen Use Efficacy, Yield.

INTRODUCTION

Pakistan is an agricultural country and has made a great progress in agriculture sector but it is still facing an acute shortage of edible oil. Sunflower (*Helianthus annus L.*) is a critical oilseed trim that positions the fourth alongside soybean, palm oil and canola as a wellspring of eatable oil on the planet (USDA, 2008). Sunflower is a vital oilseed crop which position third after soybean and shelled nut alongside other oilseed yield similar (cotton and canola) which pays extensively to palatable oil on the planet (Thava prakash *et al.,* 2002). Sunflower possesses a critical spot in oil seed crops in light of brief length of time in Pakistan, having capacity to adjust extensive variety of atmosphere and soil conditions (Thava prakash *et al*., 2003). Sunflower product has perfect spot in the present trimming framework yet because of a few requirements the normal produce is less than world's average. The major reason of lower yield than its yield potential is lack of production technology, particularly imbalanced use of fertilizers. The low profitability is for the most part because of poor richness of soils, absence of suitable creation innovation, distance of commitments, and showcasing troubles (Anwar-ul-Haq *et al*., 2006; Arshad *et al*., 2009).

Lack of nutrients and unfair nourishments use are major issues for low crop yield in Pakistan. Plants need an adequate amount of both macro and micro nutrients for plant growth and development. Among the nutrient elements required by plants, nitrogen (N) is most essential and is required in the largest amount from soil (Lewis, 1986). N is one of the significant supplements that upgrade the metabolic procedures that in light of protein, prompts increments in vegetative, regenerative development and yield of the harvest (Zubillaga *et al.,* 2002; Koutroubas *et al.,* 2008). Nitrogen performance an imperious part in enlargement of product

(Massignam *et al*.,2009) and builds the yield notwithstanding nature of whole harvests (Bell *et al*., 1995; Dreccer *et al*., 2000; Ullah *et al.,* 2010). Nitrogen is a fundamentally essential plant supplement and is the most habitually inadequate of all supplements (Tisdale *et al*., 2003). Nitrogen is a mobile element and can easily be lost through leaching, erosion; denitrification, *etc* render nitrogen regularly the maximum restricting supplement for plant development, change and achievement of yield potential (Heichel and Barnes, 1984). Outstanding to the better accessibility (Ahmad *et al.,* 1996) and critical contribution for improving crop production (Geleto *et al.,* 1995).

Sunflower like other crops requires balanced amount NPK fertilization. Nitrogen deficiency is generally the most limiting nutritional disorder affecting sunflower production. The yield of sunflower is controlled by a few components, including choice of suitable half breeds, legitimate creation innovation and administration rehearses particularly ideal plant populace in the field, reasonably utilization of manure, especially nitrogen and social and marketing systems (Ishfaq *et al*., 2009; Ali *et al*., 2011). Many growers believe that sunflower do not require as much applied fertilizer as cereals. Sunflower has an extensive root system which may help in efficient of residual soil nutrients. Increasing nitrogen rate resulted in increased seed and oil yields/ha Mojiri and Arzani, 2003). Sunflower crop responds positively to management factors and overall yield is correlated with nutrient uptake throughout its growth period.

Adequate soil fertility is one of the fundamental requirements for profitable sunflower production and that N is the most yields limiting nutrient for its production (Mortvedt *et al*., 2003). The effect of satisfactory N supply on the execution of sunflower has been widely portrayed and inspected. (Nasim *et al*. (2011) concluded that with the increase of nitrogen level, there is increment in the yield and yield components of sunflower. Increasing nitrogen rate resulted in increased seed and oil yield ha^{-1}. Mojiri and Arzani, 2003). With the increasing rates of nitrogen, growth, achene's yield and overall achene oil yield per unit area increased but grain oil contents decreased 19.4, 15.3 and 22.7 % yield reduction of hybrid sunflower due to deficiency of nitrogen, phosphorus and potash, respectively. Concluded that different combinations of NPK had significantly affected achene yield and oil content. Demonstrated that increasing nitrogen and phosphorus levels increased growth and yield in sunflower but increasing nitrogen rates decreased seed oil percentage. Significant responses to nitrogen fertilization have been reported that 40-80 kg N ha^{-1}. Mathers and Stewart (1981) reported that sufficient N for maximum sunflower yield was provided by 84 kg N ha^{-1}, while Monotti (1978) and Malligawad *et al.* (2004) stated that 100 kg N ha^{-1} was suitable for nitrogen fertilization of sunflower. In any case, nitrogen preparation is exceptionally variable and it relies on upon the measures of the component officially exhibit in the dirt and the potential yield of nature (Laureti *et al.*, 2007).

The synthetic manures are critical wellspring of promptly accessible nitrogen (N) to the yield and speak to a critical measure to right supplement insufficiencies and to supplant components uprooted in the items reaped. N treatment has been appeared to be especially compelling as for yield arrangement (Connor and Sadras 1992). Lægreid *et al.* (1999) has reported that the use of N fertilizer has been essential to increasing the productivity of agriculture, which in part is due to the increased use of N fertilizers. However, low recovery of fertilizer N has genuine biological results (Scheiner *et al.* 2002) and major constraint to crop production. Lower on farm N use efficiency (NUE) awareness of the commitment of N from the earth and the dirt, poor synchrony between harvest N request and N supply significant reason of inability to bring product yield potential into full play, and a failure to viably hinder N misfortunes. Reports have demonstrated that around half of connected N manure stays occupied to a harvest because of N misfortunes (Zafar and Muhammad, 2007). Legg and Meisinger (1982) likewise reported that not more than 50 to 60% of connected N is typically recuperated under normal field conditions, and effective timing and arrangement of N could build recuperation of connected N up to 70 or to 80 %. Legitimate N application timing and rates are basic for addressing product needs, and show extensive open doors for enhancing N use effectiveness (NUE) (Blankenau et al., 2002). Development phase of plants at the season of utilization decides NUE. Nitrogen use proficiency can be expanded by joining manure, soil, water, and administration. Two main approaches can be undertaken: increasing the use of N during crop growing season and decreasing the losses of N by applying optimum doses.

Appropriate fertilization is important for getting high yield per hectare, and N deficiency is the most limiting nutritional disorder to sunflower production (Suzer, 1998). Nitrogen use efficiency can be increased by combining fertilizer, soil, water, and management. Two main approaches can be undertaken: increasing the use of N during crop growing season and decreasing the losses of N by applying optimum doses. Appropriate N management that include proper N application timing and rates are critical for meeting crop needs, and indicate considerable opportunities for improving N use efficiency (NUE) (Blankenau *et al.*, 2002). Efficient utilization of manure through applying at suitable timing, and causes is essential to increase and attain yield potential without damaging the soil and the environment (Quresh *et al.*, 1992). Elevated amounts of soaked fat utilization are related with expanded danger of coronary illness. Conventional sunflower oil has soaked unsaturated fat (SFA) content, which is viewed as low contrasted and most vegetables oils. Furthermore, it is important to abatement its soaked fat focus.

MATERIALS AND METHODS

The experiment was conducted during 2014-2015 at the experimental fields of Oilseed section, Agriculture Research Institute, Tandojam. The experiment was laid out in randomized complete block design with three replications using a net plot size of 4 x 5 m (20 m^2). The experiment involved of three treatments as given under:

Treatments:
T_1= Full amount of Nitrogen at the stage of planting
T_2= 1/2 N at sowing + 1/2 at 1^{st} irrigation
T_3= $1/3^{rd}$ N at sowing + $1/3^{rd}$ at 1^{st} irrigation + $1/3^{rd}$ at 2^{nd} irrigation

Cultural Practices

All the necessary cultural operations were adopted throughout the growing period according to the crop requirements uniformly in all the plots till the crop matured. The land were set by 2 cross wise dry plantings each charted by clod crushing and levelling to eradicated the weeds and equal distribution of irrigation water. Sunflower variety HO-1 sown during February, 2015. The seeds were drilled at a seed rate of 5kg ha^{-1} by single coulter hand drill at row spacing of 75 cm. The plant to plant space of 45 cm were maintained in the experimental area. Earthening were performed after first irrigation. N, P and K were practiced at 100-50-25 kg ha^{-1} in the form of urea, DAP and potassium sulphate. The whole phosphorus and potash were practiced at the period of planting while nitrogen were practiced at different times for each usage. The first irrigation were given thirty days after sowing and afterwards the crop

were irrigated at a regular interval of fifteen days. Crop were kept free of weeds by hand hoeing. Crop were harvested manually when attain maturity. Harvested crops were sun dried and threshed manually. Observations pertaining to different yield and yield contributing and quality traits of the crop was recorded by using standard procedures. Following observation was recorded.
The following observation were recorded:

Observations recorded

1. Days to 75% maturity
2. Days to 90% maturity
3. Plant height (cm)
4. Stem girth (cm)
5. Head diameter (cm)
6. Seeds head^{-1}
7. Seed index (1000 seed weight, g)
8. Seed yield (kg ha^{-1})

PROCEDURE FOR RECORDING OBSERVATIONS:

Plant height (cm)

Plant height was measured in centimetres from the base to tip of the randomly each selected plant with measuring tape.

Stem girth (cm)

The stem girth was measured by means of Vernier Caliper at maturity of the crop in labelled plants in each treatment and mean will be worked out.

Head diameter (cm)

For recording head diameter, measuring tape was used in all replications of each treatment and averages were worked out.

Seeds head^{-1}

Mature heads were harvested and the total number of seeds will be counted as seeds head^{-1}

Seed index (g)

Seed index (1000 seeds) from selected plants at maturity were obtained randomly and weighted in grams.

Seed yield (kg ha^{-1})

The harvested and cleaned seeds from each selected plant and each plot will be weighed (g) to obtain yield kg ha^{-1}.

Data Analytical Method

Statistical analysis was performed using computer software MSTAT-C. Treatment means were isolated utilizing Least Significant Difference test at alpha 0.05.

LAYOUT PLAN OF THE EXPERIMENT

Experimental Design = Randomize complete block design (Factorial)
Replications = 03
Plot Size (Area) = 4 m × 5 m (20 m^2).
Treatments = 03

Treatments:

T_1= Full amount of Nitrogen at the time of planting
T_2= 1/2 N at sowing + 1/2 at 1st irrigation
T_3= 1/3rd N at sowing + 1/3rd at 1st irrigation + 1/3rd at 2nd irrigation

RESULT

The results of mean performance of all the treatments achieved are presented in table 1-8 and their analysis of variance of

Appendix I to VIII. Results obtained for various parameters of sunflower are furnished here in the upcoming paragraphs.

Days to 75% maturity

The results regarding the days to 75% ripeness of sunflowers as affected by N doses and their different application timings are show in Table 1, while the examination of variance is shown as Appendix-I. The examination of variance revealed that the days to 75% maturity was not significant.

It has been shown in the results that the minimum days to 75% maturity (81.0 cm) was observed in T_3= 1/3rd N at sowing + 1/3rd at 1st irrigation + 1/3rd at 2nd irrigation followed by T_2= 1/2 N at sowing + 1/2 at 1st irrigation which gave (83.7) days to 75% maturity. The maximum days to 75% maturity (84.0 cm) was recorded at T_1= Full amount of at the stage of planting.

Table-1: Days to75% maturity sunflower as affected by right timing and splitting nitrogen application on rates.

Treatments	**R-I**	**R-II**	**R-III**	**Mean**
T1	85	87	80	84.0 **C**
T2	82	84	85	83.7 **B**
T3	78	82	83	81.0 **A**
Total	81.7	84.3	82.7	

Days to 90% maturity

The results regarding the days to 90% maturity of sunflowers as affected by nitrogen doses and their different application timings are presented in Table 2, while the exploration of variance is shown as Appendix-II. The examination of variance revealed that the days to 90% maturity was not significant.

It has been shown in the results that the minimum days to 90% maturity (91.3 cm) was observed in T_2= 1/2 N at sowing + 1/2 at 1st irrigation followed by T_3= 1/3rd N at sowing + 1/3rd at 1st irrigation + 1/3rd at 2nd irrigation which gave (92.7 cm) days to 90% maturity. The maximum days to 90% maturity (94.7cm) was recorded at T_1= Full amount of Nitrogen at the stage of planting.

Table-2: Days to 90% maturity sunflower as affected by right timing and splitting nitrogen application rates.

Treatments	RI	RII	RIII	Mean
T1	95	92	97	94.7 **C**
T2	90	95	89	91.3 **A**
T3	92	90	96	92.7 **B**
Total	92.3	92.3	94.0	

Plant height (cm)

The results regarding the plant height (cm) of sunflowers affected by nitrogen doses and their different application timings is presented in Table 3, while the examination of variance is shown as Appendix-III. The examination of variance revealed that the plant height was not significant.

It has been shown in the results that the maximum plant height (263.3 cm) was recorded at T_2= 1/2 N at sowing + 1/2 at 1st irrigation, followed by T_3= 1/3rd N at sowing + 1/3rd at 1st irrigation + 1/3rd at 2nd irrigation which gave (163.3 cm) plant height. The minimum plant height (159.1 cm) was observed in T_1= Full amount of Nitrogen at the stage of planting.

Table-3: Plant height (cm) of sunflower as affected by right timing and splitting nitrogen application rates.

Treatments	R-I	R-II	R-II	Mean
T1	171.7	145.7	160.0	159.1 **C**
T2	183.0	160.0	447.0	263.3 **A**
T3	170.0	158.3	161.7	163.3 **B**
Total	174.8	154.7	256.2	

Stem girth (cm)

The results regarding the stem girth (cm) of sunflowers as affected by nitrogen doses and their different application timings are presented in Table 4, while the examination of variance is shown as Appendix-IV. The examination of variance revealed that the stem girth was not significant. It has been shown in the results that the maximum stem girth (8.9 cm) was recorded at T_2= 1/2 N at sowing + 1/2 at 1st irrigation followed by T_3= 1/3rd N at sowing + 1/3rd at 1st irrigation + 1/3rd at 2nd irrigation which gave (8.3 cm) stem girth. The minimum stem girth (7.7 cm) was observed in T_1= Full amount of Nitrogen at the stage of planting.

Table-4: Stem girth (cm) of sunflower as affected by right timing and splitting nitrogen application rates.

Treatments	**R-I**	**R-II**	**R-III**	**Mean**
T1	8.3	7.0	7.7	7.7 **C**
T2	8.0	9.7	9.0	8.9 **A**
T3	9.0	8.0	8.0	8.3 **B**
Total	8.4	8.2	8.2	

Head diameter (cm)

The results regarding the head diameter (cm) of sunflowers as affected by nitrogen doses and their different application timings is presented in Table 5, while the examination of variance shown as Appendix-V. The investigation of variance revealed that the head diameter was significantly.

It has been shown in the results that the maximum head diameter (31.4 cm) was recorded at T_3= 1/3rd N at sowing + 1/3rd at 1st irrigation + 1/3rd at 2nd irrigation followed T_1= Full level of N at the stage of sowing which gave (28.0). The minimum head diameter (27.1 cm) was observed in T_2= 1/2 Nitrogen at sowing + 1/2 at 1st watering.

Table-5: Head diameter (cm) of sunflower as affected by right timing and splitting nitrogen application rates.

Treatments	R-I	R-II	R-III	Mean
T1	29.0	29.0	26.0	28.0 **B**
T2	28.7	29.0	23.7	27.1 **B**
T3	33.3	31.0	30.0	31.4 **A**
Total	30.3	29.7	26.5	

Seeds head $^{-1}$

The results regarding the seeds head^{-1} (cm) of sunflowers affected by nitrogen doses and their different application timings are presented in Table 6, while the examination of variance shown as Appendix-VI. The study of variance revealed that the seeds head^{-1} were not significant.

It has been shown in the results that the maximum seeds head^{-1} (71.3 cm) were recorded in T_3= 1/3rd N at sowing + 1/3rd at 1st irrigation + 1/3rd at 2nd irrigation, followed by T_1= Full dose of N at the time of sowing which gave (57.3) seeds head^{-1}. The minimum seeds head^{-1} (51.0 cm) were observed in T_2= 1/2 Nitrogen at planting + 1/2 at 1st watering.

Table-6: Seeds head^{-1} yield (gm) of sunflower as affected by right timing and splitting nitrogen application rates.

Treatments	RI	RII	RIII	Mean
T1	38	94	40	57.3 **B**
T2	48	75	30	51.0 **C**
T3	46	124	44	71.3 **A**
Total	44.0	97.7	38.0	

Seed index (gm)

The results regarding the seed index (gm) of sunflowers affected by nitrogen doses and their different application timings are presented in Table 7, while the examination of variance shown as Appendix-VII. The study of variance revealed that the seed index (gm) were not significant.

It has been shown in the results that the maximum seed index (51.3 g) was recorded at T_3= 1/3rd N at planting + 1/3rd at

1st watering+ 1/3rd at 2nd watering followed by T_2= 1/2 Nitrogen at planting + 1/2 at 1st watering, which gave (51.0 gm). The minimum seed index (46.7 gm) was observed in T_1= Full level of Nitrogen at the stage of planting.

Table-7: Seed index weight in (gm) sunflower as affected by right timing and splitting nitrogen application rates.

Treatments	RI	RII	RIII	Mean
T1	42	59	39	46.7 **B**
T2	47	64	42	51.0 **A**
T3	46	65	43	51.3 **A**
Total	45.0	62.7	41.3	

Yield ha^{-1} (kg)

The results regarding the yield ha^{-1} (kg) of sunflowers affected by nitrogen doses and their different application timings are presented in Table 8, while the exploration of variance shown as Appendix-VIII. The analysis of variance revealed that the yield ha^{-1} (kg) was significant.

It has been shown in the results that the maximum yield ha^{-1} (1102.0 kg) were recorded in T_3= 1/3rd N at sowing + 1/3rd at 1st irrigation + 1/3rd at 2nd irrigation, followed by T_1= Full dose of N at the time of sowing which gave (1009.3 kg) yield ha^{-1}. The minimum yield ha^{-1} (928.0 kg) were observed in T_2= 1/2 N at sowing + 1/2 at 1st irrigation.

Table-8: Yield ha^{-1} (kg) sunflower as affected by right timing and splitting nitrogen application rates.

Treatments	R-I	R-II	R-III	Mean
T1	966	1015	1042	1009.3 **B**
T2	959	855	970	928.0 **C**
T3	1100	1056	1150	1102.0 **A**
Total	1008.3	975.3	1055.7	

DISCUSSION

Nitrogen is the vast majority of most imperative essential of plant protein and is required all through the yield development period from vegetative point to ensuing gathering. One of the main cause of low yield is imbalanced and inadequate supply of nutrients. Proper amount and time of fertilizer application is considered a key to the pumper crop (Jan *et al.*, 2007). The most legitimate way to deal with expanding nitrogen manure use effectiveness is to supply N while it is required in the yield (Keeney, 1982).

The finding of present research showed that analysis of variance was meaningfully ($P<0.01$) affected by right scheduling of nitrogen request and its splitting rates for producing head diameter in (cm) and yield ha^{-1} in (kg). While the right timing of nitrogen application and its splitting rates were not significant ($P<0.01$) for producing days to 75% maturity, days to 90% maturity, plant height in (cm), stem girth (cm), Seeds $head^{-1}$ (gm) and seeds index (gm).

The current research displayed that the T_2 = 1/2 N at sowing + 1/2 at 1^{st} irrigation resulted in taking minimum days to 90% maturity (91.33) and maximizing the values (263.33 cm) for plant height (cm) and (8.89 cm) for stem girth. When crop was fertilized with N at 3 splits in T_3 = $1/3^{rd}$ N at sowing + $1/3^{rd}$ at 1^{st} irrigation + $1/3^{rd}$ at 2^{nd} irrigation, it maximized the values for (81.00) for days to 75% maturity, (31.44 cm) head diameter, (71.33) seeds $head^{-1}$, (1102.00 kg ha^{-1}) seeds yield. Maximum seed index (51.33) and (51.00) was observed at T_3 = $1/3^{rd}$ N at sowing + $1/3^{rd}$ at 1^{st} irrigation + $1/3^{rd}$ at 2^{nd} irrigation and T_2 = 1/2 N at sowing + 1/2 at 1^{st} irrigation, respectively. When crop was given full dose of N at the time of sowing in T_1, it presented simultaneous decline in crop performance of head diameter (28.00 cm), seeds $head^{-1}$ (57.33), yield in kg ha^{-1} (1009.33), seed index (46.66) but this same treatment showed minimum values for days to 75% maturity, days to 90% maturity, plant height (cm) and stem girth (cm) and T_2 = 1/2 N at sowing + 1/2 at 1st irrigation also exposed the minimum values for head diameter (cm), seeds head^{-1} and yield ha^{-1}. It was concluded that the all the traits were highest in T_3 where nitrogen was applied in three splits (1/3rd N at sowing + 1/3rd at 1st irrigation + 1/3rd at 2nd irrigation) except days to 90% maturity, plant height (cm) and stem girth (cm) followed by T_2 where nitrogen was given in two splits (1/2 N at sowing + 1/2 at 1st irrigation). The minimum result was found in T_1 where full dose of N at the time of sowing was applied. The discoveries of the study have further been confirmed by many past researchers and scientists. Fatih Killi. (2004) found that seeds head^{-1}, 1000–seeds weight and seed yield of sunflowers was increased when N was at applied in two splits. Munir *et al.* (2007) reported that all the quality traits were significantly affected with the application of nitrogen in splits. The highest yield characteristics were obtained when nitrogen was connected in three equivalent parts at sowing, at first watering system and at blossoming. Hassan *et al.* (2010) stated that the treatment of three splits of N fertilizer at a total rate of 140 kg ha^{-1} applied significantly increased stem girth on maize crop. Nasim *et al.* (2011) applied 180 kg nitrogen ha^{-1} in three splits viz. 1/3rd dose of N at the season of sowing, while remaining 2/third of N was utilized as a part of two parts; first rest at first watering system and second nap of N at the blooming stage got higher yield from Hysun-38 sunflower hybrid. The study of Özer *et al.* (2004) determined that nitrogen applied as divided into 2 requests, half with planting and the remaining half at the start of stem elongation influenced all plant parameters by applied nitrogen fertilizer rates. Ali *et al.* (2014) supported application of 150 kg nitrogen ha^{-1} into three splits viz. 1/3rd dose at the time of sowing and remaining 2/3rd two splits, by first irrigation and flowering stage for getting higher phonological duration.

CONCLUSION

The results concluded that the all the traits were highest in T_3 where nitrogen was applied in three splits (1/3rd N at sowing + 1/3rd at 1st irrigation + 1/3rd at 2nd irrigation) except days to 90% maturity, plant height (cm) and stem girth (cm) followed by T_2 where nitrogen was given in two splits (1/2 N at sowing + 1/2 at 1st irrigation). The minimum result was found in T_1 where full dose of N at the time of sowing was applied.

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