Research Article

Yield Performance of Summer Season Sunflower under N-Rate by Change in Climate of Northwest of Pakistan

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Abstract | Sunflower (*Helianthus annuus* L.), a non-conventional oil seed crop, can successfully be fit in the cropping system as spring or summer season crop. However, its planting in summer is at risk of the moon-soon outbreak duration in the season. Present study was aimed to quantify delay-sowing response with increasing N-rate on crop productivity at Agronomy Research Farm, University of Agriculture Peshawar Pakistan. Sunflower (cv. Hysun-33) was planted on different dates i.e. Jul. 1, 11 and 21 treated with different N-rates starting from 40 kg ha^{-1} with a 40 kg increment to the maximum of 160 (kg ha^{-1}) including a control treatment in a randomized complete block (RCB) design in four replications. Sowing date (SD) were main plot and N-rate subplot treatments. Mean results of replications revealed a significant reduction in days to flowering and maturity by delay SD. However, positive responses were observed by increase in N-rate. Early planting showed maximum biomass and yield at 120 kg N ha^{-1} which was due to reflecting higher leaf area, plant height and stem diameter (cm). Traits e.g. the head diameter, grain head^{-1} and grains weight were indicators contributing towards grain yield by early sowing compare to late sowing or increasing N-rate (40 to 120 kg ha^{-1}). The oil content and oil yield was naturally contributed well to early sowing date in season. However, a decrease in oil content with increasing N was observed. Oil yield (kg ha^{-1}), the net returns per unit area, is of interest of the crop cultivation and observed the maximum at 120 kg N ha^{-1}. The study suggests that delay sowing of summer sunflower crop in the region either by monsoon rains or any other circumstances decreased production drastically. Moreover, an increase of N from 120 kg ha^{-1} is not of much value under these circumstances but have the potential to investigate for increasing production of the sunflower crop in the region.

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Introduction

Sunflower (*Helianthus annuus* L.), a newly introduced hybrid oil seed crop, ranks at position three in world oil seed crop production (Thavaprakash et al., 2002; Khan, 2014). Pakistan is acute deficient in local edible oil production and depends on the import of edible oil since its independence (Munir et al., 2007; Khan, 2014) and situation is becoming worse with the uncontrolled growing population today and in the expected future (Asif et al., 2001; Iqbal et al., 2007). Focus is to curtail import bill of the existing edible oil. Sunflower suits best with the climate to grow with potential to be grown 2-3 times a year due to seasonal favourability. The recent climate changes also favours its production in the area's where other rain fed crops can be replaced and or it can be introduced as high yielding crop to narrow down the space of domestic demands and local oil production (Hu et al., 2008; Akmal et al., 2014). Sunflower is extensively distributed crop with high oil content (Allam et al., 2003; Nasim et al., 2011) and oil can easily be extracted using local traditional existing technology. Its cultivation has not gain momentum since its introduction in 1960 due to completion with the traditional grain crops. However, expected climate change in region is establishing opportunity for its cultivation. Rainfall amount and distribution is emerging challenge of future agriculture. It is expected to drastically vary in Pakistan and Khyber Pakhtunkhwa (KP) with expectation that rainfall will increase in spring and summer and reduction in autumn (Hanif and Ali, 2014; Khan, 2014). This shift in seasonal rainfall may disturb existing crop since cultivation and/or creates opportunity for new crops to grow in region. Increase in precipitation has an effect on soil N-content and use of N-fertilizer application rates and timings. Sunflower cultivation from spring to end of summer may create space in the cropping system for cultivation on rain fed land or land that is under wheat cultivation remained uncultivated due to delay in seasonal precipitation (Akmal et al., 2014; Khan, 2014). Crops that fail to plant in time by high rain or drought have to create space for an alternative crop in the cropping system. Sunflower could be the best option to grow due to its contribution in annual import bill and relatively longest growing season (Khan, 2014).

Decrease in yield due to late planting has already been reported for warmer crops and increase in plant biomass of stem. Likewise, cool temperature has decreased incident radiation at anthesis and adversely affects grain filling and grain weight (Ali et al., 2012a). Yield reduction relates to planting time of sunflower in subtropical conditions and biomass accumulation has affected intercepted radiation, radiation use efficiency which affects seed development of the crop. Ali et al. (2012b) has already reported that grain weight decreased by delay sowing due to unfavorable environment (Weiss, 2000). Nitrogen also plays an important role in plant growth (Dreccer et al., 2000; Ullah et al., 2010). Photosynthesis and net assimilation rate increase with increase in N-rate (Ahmad et al., 2009; Munir et al., 2007) that resulted higher yield (Ozer et al., 2004). Nitrogen is indispensable to increase edible oil (Nasim et al., 2011; Ali et al., 2012a) with increase in canopy leaf area (Oyinlola et al., 2010). The present study aims to compare yield and traits of sunflower in summer planted on different dates with increasing N-rates for future cultivation in KP.

Materials and Methods

Site and Experiment

Field experiment was conducted at Agronomy Research Farm, University of Agriculture Peshawar Pakistan, during summer 2014. Experimental site was located 359 m above sea level. The climatic conditions of research farm are semi-arid, subtropical with annual rainfall of less than 360 mm. Soil pH varies from 7.5 to 7.8, silty clay loam and deficient in total N (>0.5 g kg^{-1}). Sunflower hybrid (cv. Hysun-33) was used for two factors (a) the sowing date July 1, 11 and 21 with 10 days interval and (b) N-rates the control, 40, 80, 120 and 160 kg ha^{-1} in a randomized complete block design in split-plot arrangements. Sowing date was assigned to main plots and N-rates to subplot, each treatment replicated 4 times. Experimental unit was 4.0m long and 4.2m wide, accommodating six rows at 0.70 m distance. Seedbed was prepared uniformly in late June by harvesting wheat in May. Sunflower was planted on as per defined date using seed rate 6 kg ha^{-1}. Nitrogen as per treatment and Phosphorous (90 P_2O_5 kg ha^{-1}) was applied using urea and Triple Super Phosphate (TSP) manually broadcast at seedbed preparation. Remaining half N was applied 45 days after planting. Plant population was maintained by removing extra plants at emergence spaced 20cm within rows. Irrigation was applied as per crop water need. All other agronomic practices were kept uniform.

Measurements and Observation

Days to flowering were recorded by counting days taken from sowing to 90% plants produced flowers in an experimental unit. Likewise, days to maturity was recorded by counting days when 90% heads turned yellow and outer brackets turned brownish. Plant height (cm) was recorded on randomly selected 10 representative plants in central rows in an experimental unit a week before the crop harvest. Plant height was measured manually on individual plant from base to top edge at collar disc. Leaf area index was recorded at flowering stage with LI-2000 (LI-COR, USA). The machine was calibrated on sampling day with adjustment for a single mean reading of LAI from multiple samplings of one above and three below the

Table 1: *Parameters recorded during growth and development of sunflower planted on different dates and N-rate (kg ha⁻¹) as summer season crop in Peshawar*

Sowing date (SD)	Flowering (days)	Maturity	LAI	Plant height (cm)	Head diameter (cm)	Grain head^{-1} (Number)	Grain weight (000 g)
July 1	57.37 a	85.2 a	3.31 a	156.22 a	13.7 a	975.46 a	39.69 a
July 11	56.35 b	81.8 b	3.09 b	149.88 b	12.66 b	864.28 b	39.4 a
July 21	54.14c	79.1 c	2.99 c	142.57 c	11.72 c	807.44 c	36.10 b
LSD (p<0.05)	0.175	0.449	0.076	0.495	0.086	13.74	0.323
Nitrogen (kg ha^{-1}) N							
0	55.6 d	81.1 d	2.78 e	139.31 e	11.4 a	794.41 d	39.7 a
40	55.8 cd	81.6 c	2.90 d	145.65 d	12.2 a	836.41 c	38.6 b
80	56.0 bc	82.0 b	3.18 c	151.52 c	13.0 a	893.01 b	38.2 c
120	56.1 ab	82.5 a	3.46 a	155.39 b	13.5 a	955.56 a	37.9 d
160	56.2 a	82.9 a	3.33 b	155.91 a	13.3 a	932.57 a	37.5 e
LSD (p<0.05)	0.241	0.363	0.077	0.380	0.107	27.20	0.300
SDxN	NS	NS	NS	*	NS	NS	NS

Mean followed by different letters within a category and column are significantly different from each other (p<0.05) using Least Significant Difference (LSD) test

canopy at 11-13 h of the day. Plant population (m^{-2}) was recorded by counting existing plants in an experimental unit. Stem diameter of plant was recorded at flowering stage on ten randomly selected samples in a plot. The diameter was measured with a Vernier calliper at top, middle and bottom of a plant and averaged for plant stem diameter. Two central rows in an experimental unit were harvested; sun dried in field for two weeks and weighed on a spring balance for total biomass. Head diameter (cm) plant^{-1} was recorded by selecting 10 heads in a subplot, measured with the help of line gauge the centre of each head. Grains head^{-1} was counted manually on selected 10 samples. Grains were shelled from sunflower and subsequently counted at harvest. Thousand grains weight (g) was obtained from threshed clean grains in a treatment, taking random samples and counted manually for 1000 grains. Data for two central rows already harvested for biological yield in an experimental unit were subsequently used for grain yield. Potential yield was estimated on the desired population basis. Grain yield was recorded from plants harvested less mortality through wind and diseases. Oil content (%) was recorded through Nuclear Magnet Resonance (NMR) at Nuclear Institute for Food and Agriculture (NIFA) at Peshawar. NMR provides fast and precise determination of SFC (Solid Fat Content) on total grains basis. Oil yield was estimate from oil content multiplied with grain yield. Likewise, grain N-content was estimated by micro-Kjeldhal method.

Data significance were studied by analysis of variance (ANOVA) as the procedure referred by Steel et al. (1997) and treatment means, found significant, were compared using least significant difference (LSD) test ($p \leq 0.05$).

Results and Discussion

Phenology and growth

Emergence and days to emergence (m^{-2}) were not affected by treatments (data not shown). Days to flowering differed (p<0.05) with sowing date (SD) and N-rate (Table 1). Planting on July 1 took the maximum days, followed by July 11 with minimum by July 21. This shows that delay sowing limits crop vegetative period. Delay sowing in July. is associated to reduction in soil temperature which delay emergence (Khalifa et al., 2000; Ali and Norka, 2013). Every increase of N-rate has delayed flowering. Interaction SD x N were non-significant (p<0.05) for days to flowering. Days to maturity also showed difference (p<0.05) with lowest for late sowing and the highest for early planting. Increased N-rate has also delayed days to maturity with the maximum days were taken by N 160 kg ha^{-1}. Interaction SD x N were non-significant for days to maturity. Nitrogen is one of the highly consumed nutrients and its mobility in soil further accelerates its demand in soils that are irrigated by flood irrigation system and/or fields that are subjected to heavy rainfall in crop growth season

(Oyinlola et al., 2010; Hanif and Ali, 2014). This experiment is heavily exposed to seasonal rainfall in July and August (Moon-soon out beak) and is a potential threat to adjust the optimum N-rate for crops in cultivation (Akmal et al., 2014; Hanif and Ali, 2014). Plant height (cm) differed ($p<0.05$) by SD and N-rate with highest for July 1 that significantly decreased by delay sowing till July 21. Increase N significantly increased plant height with maximum for N 160 kg ha^{-1}, followed by N 120 and the minimum for control. Interaction SD x N showed linear increases for all SD with increase in N-rate, however, with clear differences for July 1, 11 and 21 at N-rate from 40 to 120 kg ha^{-1} (Figure 1). Nitrogen 120 and 160 kg ha^{-1} did not show any clear changes for any SD. Data on leaf area index also showed a change ($p<0.05$) with altering SD or N-rate. Results revealed a decrease in LAI by delay sowing and/or reduced N-rates. Nitrogen 120 and 160 kg ha^{-1} were almost alike. Interaction SD x N did not change ($p<0.05$) crop LAI. Plant height is subjected to growth duration avail by the crop. Late sown crop naturally have less days with a decreasing trend in both daily temperatures from sowing to the crop followed every next vegetative growth stage has to show a reduction in height, leaf number and its total or averaged area per plant basis (Osman and Awed, 2010; Nasim et al., 2012).

($p<0.05$) for N 160 but decreased for reduction in N-rate with minimum for control. Interaction SD x N was non-significant for head diameter. Grain $head^{-1}$ was significant with highest for July 1 and lowest for July 21 SD. Highest grain $head^{-1}$ was noted for N 120 that were not changed for N 160 kg ha^{-1} but decreased thereafter with reduction in N to the minimum at control. Grain per head was not varied for SD x N. The 1000 grain weight (g) affected ($p<0.05$) by SD and N-rate with maximum for July 1 minimum for July 21. Increasing N from control has significantly decreased 1000 grain weight. Interaction SD x N was non-significant for 1000 grain weight. Stem diameter (cm), the most important parameter affects lodging at crop maturity when head weight exceeds that total biomass, differed by SD (Table 2). Results reported the highest diameter for July 1, followed by July 11 and July 21. Correspondingly the N-rate affected stem diameter with highest for N 160 kg ha^{-1}, followed by every reduction in N-rate to minimum at control. Interaction SD x N-rate was significant for stem diameter with a linear increase for all sowings (Figure 2). By increasing N from 0 to 160 with marked differences for July 1 than rest of the two SD. Capitulum size is the most important character of productivity that decreased by delay sowing due to rational biomass of the plant (Nasim et al., 2012; Khan, 2014).

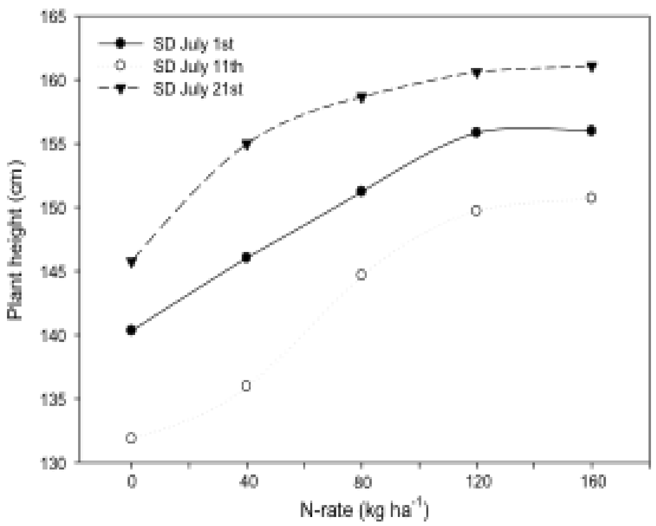

Figure 1: *Interactive effect of treatments Sowing date x N-rate on plant height of sunflower*

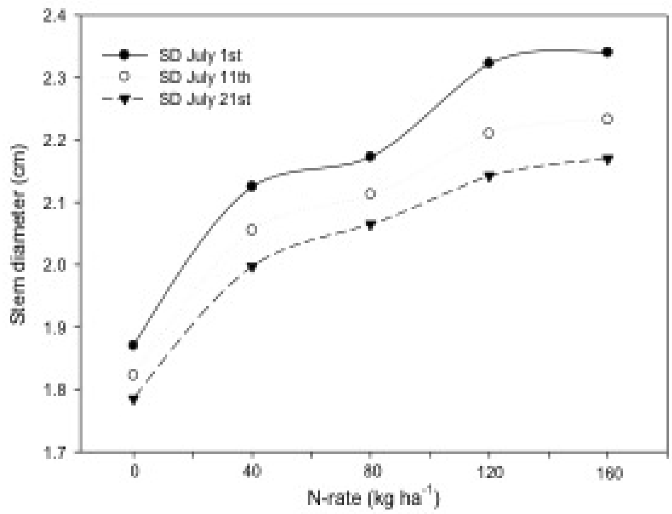

Figure 2: *Interactive effect of treatment Sowing date x N-rate on stem diameter of sunflower*

Yield traits

Head diameter (cm) was differed ($p<0.05$) by SD and N-rate (Table 1). The maximum head diameter was reported for July 1 sowing, followed by July 11 and the minimum for July 21. Likewise, N 120 kg ha^{-1} showed the maximum head diameter with no change

Decrease in head diameter also decreased grain number and its weight by the cooler season effects of total life cycle. Likewise, a reduction in N-rate also decreased both size i.e. diameter with grain number and weight by limiting N-rate or delay sowing date. It is of the interest to note that delay sowing and condition

Table 2: *Parameters recorded during growth and development of sunflower planted on different dates and N-rate (kg ha^{-1}) as summer season crop in Peshawar*

Sowing date (SD)	Stem diameter (cm)	Biomass (kg ha^{-1})	Grain yield (kg ha^{-1})	Oil-content (%)	Oil yield (kg ha^{-1})	N-content (%)	N-uptake (kg ha^{-1})
July 1	2.17 a	7215.44 a	1545.33 a	35.94 a	553.82 a	3.63 c	56.57 a
July 11	2.09 b	6640.52 b	1404.79 b	35.34 b	429.21 b	3.72 b	52.63 a
July 21	2.03 c	6300.99 c	1257.45 c	34.14 c	428.17 c	3.86 a	48.83 b
LSD (p<0.05)	0.017	0.409	22.52	0.393	7.38	0.055	1.12
Nitrogen (kg ha^{-1}) N							
0	1.83 e	6367.67 e	1052.29 e	35.88 a	378.30 e	3.52 e	36.97 e
40	2.06 d	6500.77 d	1216.31 d	35.52 b	432.98 d	3.63 d	44.03 d
80	2.12 c	6758.26 c	1411.05 c	35.21 c	497.72 c	3.74 c	52.60 c
120	2.23 b	7017.37 a	1681.22 a	34.73 d	584.47 a	3.81 b	64.00 b
160	2.25 a	6950.87 b	1651.73 b	34.37 e	568.55 b	3.99 a	65.79 a
LSD (p<0.05)	0.013	0.416	28.45	0.304	10.82	0.066	1.59
SDxN	*	*	NS	NS	NS	NS	NS

Mean followed by different letters within a category and columns are significantly different from each other (p<0.05) using Least Significant difference (LSD) test

of the soil and climate of the areas supports N 120 kg ha^{-1} for the crop. Addition of N exceeded from 120 does not bring any change in yields are indicators to concentrate on other nutrients in the soils and/or crop uptake potential to get advantage of the additional N supply in terms of yield and oil content (Osman and Awed, 2010; Soleymani et al., 2013; Asim et al., 2014).

Biomass and Yield

Biological yield (kg ha^{-1}) was statistically differed for SD with highest for July 1 and lowest for July 21 (Table 2). Response of N on biomass was also significant with maximum for N 120 kg ha^{-1}. The N 120 and 160 kg ha^{-1} did not change plant biomass. Interaction SD x N indicated a linear increase for July 1 and 11, under increasing N from 0 to 120 kg ha^{-1} with a no change or slightly decline response thereafter for 120 and 160 kg ha^{-1} (Figure 3). Grain yield (kg ha^{-1}) indicated significant (p<0.05) differences for SD and N-rate. Delay planting from July 1 to 21, has decreased (p<0.05) grain yield (Nasim et al., 2012; Awais et al., 2013). Similarly, the grain yield was highest at N 120 kg ha^{-1}, followed by N 160, 80 and 40 with lowest at control. A non-significant response observed in grain yield for SD x N interaction. Biomass is products of plant height and leaf number with area. Delay sowing decreased biomass due to limited stem with leaf number and area and similarly did by the N-rates (Oyinlola et al., 2010). Yield is products of traits that have been influenced by SD and N-rates. The decrease in head diameter, seed number and its weight was clear indicator of decreasing yield by delay sowing and limiting N-rate to the crop (Soleymani et al., 2013; Asim et al., 2014).

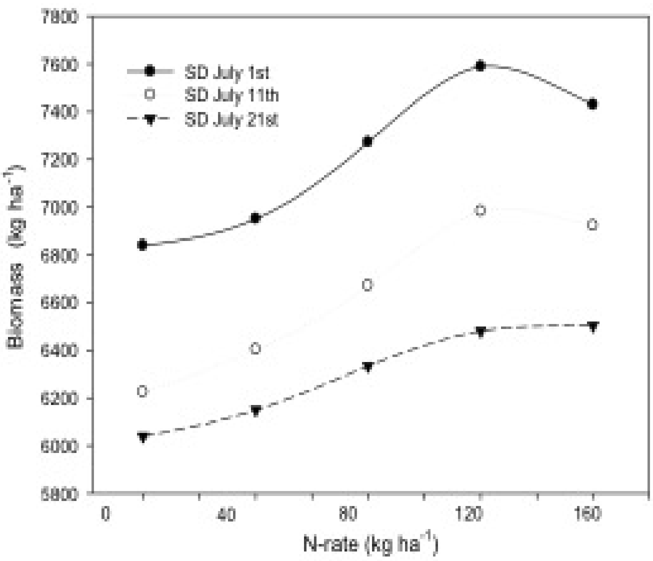

Figure 3: *Interactive effect of treatments Sowing date x N-rate on biomass of sunflower*

Oil- & N-content and N-uptake

Oil content (%) influenced (p<0.05) by SD and N-rate. July 1 SD showed highest oil content which decreased by delay in SD. Delay sowing crop was subjected to relatively low mean daily temperatures which might have decreased its yield and oil content (Ozer et al., 2004; Abdel-Motagally and Osman, 2010; Abdou et al., 2011). Likewise, control showed highest oil content that gradually decrease when N supply increased to 120 kg ha^{-1}. Interaction SD×N was non-significant for grain oil content. Nitrogen in higher concentration has shown an adverse effect on oil content which might be that N is promoting growth and the healthy growth of plant traits by dilution effects showed a reduction in oil content but not in oil yield (Khan et al., 2014). Oil yield (kg ha^{-1}) was significant ($p<0.05$) for SD and N-rate. Delay planting sunflower in season has reduced oil yield. The maximum oil yield was reported for N 120, followed by 160, 80 and 40 kg ha^{-1} and the minimum in control plots. A non-significant response was observed in oil yield for interaction SD x N. Nitrogen content (%) was significantly differed by SD with a decreasing trend for the delay sowing in summer. Likewise, N-content increased with increasing N with highest reading for N 160 followed by 120, 80 and 40 kg ha^{-1} with lowest for control. SD x N for grain N-content was non-significant. Grain N uptake (kg ha^{-1}) also decreased by delay sowing and increased with increase N-rate to crop. The highest N uptake was observed for N 160 kg ha^{-1}. Interaction SD x N was non-significant for grain N-uptake.

Conclusion and Recommendations

From results it can be concluded that sunflower grain yield (kg ha^{-1}) and oil contents (%) decrease by delay sowing in season with a week or more due to any unavoidable circumstance e.g. outbreak of moon-soon rains which are common in the area. Farmers have to plant the crop early or adopt measures avoiding any delay in planting in season. Nitrogen 120 kg ha^{-1} is, under specific circumstances, the optimum N-rate for sunflower. Its uptake efficiency could be increased through further study of the N-management under the prevailing circumstances by application and management with timing and rates and/or balancing with other nutrients management keeping the soil condition for consideration.

Authors' Contribution

Ilham Ullah carried out the research and prepared the draft of the manuscript. G. Arjumand contributed in editing and replied to comments of the referees. N. Ali helped in data verification, tabulation and analysis while M. Akmal designed the research, helpeds in manuscript preparation and editing.

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