Agronomy Research **19**(4), 1914–1928, 2021
https://doi.org/10.15159/AR.21.154

Responses of onion growth and yield to different planting dates and land management practices

H. Salari[1,*], R.S. Antil[2] and Y.S. Saharawat[3]

[1]Amity University Uttar Pradesh, Amity Institute of Horticulture Studies and Research, Amity Road, Sector 125, Noida, IN 201301 Uttar Pradesh, India
[2]Amity University Uttar Pradesh, Amity Food and Agriculture Foundation, Amity Road, Sector 125, Noida, IN 201301 Uttar Pradesh, India
[3]ICAR - Indian Agriculture Research Institute, Department of Soil Science, Pusa road, New Delhi, IN 110012 Delhi, India
[*]Correspondence: h.salari@yahoo.com

Received: September 10th, 2021; Accepted: November 3rd, 2021; Published: November 15th, 2021

Abstract. Local varieties of *onion* (*Allium cepa* L.) are believed to be well adopted to agroecological conditions of their respective growing region but their lower productivity is a concern to be addressed. The variety '*Safid e Paisaye'* was selected for this investigation due to its long storability and higher market demand. The present study was carried out at Agriculture Research Farm of Kabul University to study the influence of land management practices and planting dates on growth and yield of onion. Different agronomic traits including number of leaves per plant, leaf length, leaf area per plant, leaf area index, normalized difference vegetation index (NDVI), maturity period, marketable yield and total yield were studied in these trials. The recorded data were statistically analysed with R software. The planting dates had significant influence on growth and yield of onions. At 90 days after sowing, the highest number of leaves per plant (7.18), leaf length (30.07 cm), leaf area per plant (277.43 cm^2), leaf area index (0.93) and NDVI (0.29) were recorded for the first planting date (10th May). Similarly, the longest maturity period (176.44 days) and highest marketable yield (37.01 t ha^{-1}) and total yield (40.08 t ha^{-1}) were also observed under the first planting date. Land management practices did not have significant effect on growth and maturity period of onions. However, the marketable yield was influenced by tillage depth and land preparation. The deep tillage and flatbed recorded highest marketable yield of 38.58 t ha^{-1} and 26.9 t ha^{-1}, respectively. The results of the study indicate that, early planting was more appropriate to get vigorous and high yielding onions. The deep ploughed flatbeds were appropriate to get higher marketable yield of onions.

Key words: *Allium cepa* L., growth response, Normalized Difference Vegetation Index (NDVI), planting date, tillage depth, yield response.

INTRODUCTION

Onion (*Allium cepa* L.) is a biennial herbaceous plant belonging to the *Alliaceae* family. Local varieties are believed to be well adopted to agroecological conditions of their respective growing region, but their lower productivity is a concern to be addressed.

Central Asia comprising Afghanistan is thought to be the origin of onion crop (Salari et al., 2020). Both improved and local varieties of onions are commercially grown in different parts of the country. *Safid e Paisaye* is a local onion variety grown in central region of Afghanistan especially in *Ghorband* valley. The bulbs of this variety are white-coloured and has flat round shape (Salari et al., 2020). This variety is famous for its long storability and high demand in the local market (Salari et al., 2020). The main problem of *Safid e Paisaye* onion is small size of bulb which causes lower productivity.

Land preparation and planting date determine the growth and yield of agricultural crops. Tillage depth alone do not have significant influence on growth and yield of onions (Jabro et al., 2010; Gronle et al., 2015) however, deep tillage in combination with other agricultural practices increases the yield (Gami et al. (2013). In several regions, commercial onions are produced on raised beds (Shanmugasundaram & Kalb, 2007). The raised beds are efficient in saving irrigation water but its influence on yield and quality of onions is not significant (Hatterman-Valenti & Hendrickson, 2006).

The planting date of onion vary widely among regions, this reflects the differential environmental conditions of the growing regions. It is important to identify the optimum planting dates for onion in order for it to express its full agronomic potentials (Kerpauskas et al., 2009; Deepak et al., 2014; Horváth et al., 2021). The onions grown in early planting dates produces vigorous plants and larger bulb with higher fresh weight and neck and bulb diameters (Bosekeng & Coetzer, 2013; Bosekeng & Coetzer, 2015; Ali et al., 2016; Aboukhadrah et al., 2017; Singh & Singh, 2000).

The previous studies showed that, land preparation and planting date influenced the growth and yield of onions. How these factors influence the growth and yield of *Safid e Paisaye* is yet to be determined. Consequently, the present study was conducted to find the optimum depth of tillage, land preparation method and date of planting for improved plant growth and yield of onion variety *Safid e Paisaye*.

MATERIALS AND METHODS

These trials were carried out at the Agriculture Research Farm of Agriculture Faculty of Kabul University during year 2018/19 and 2019/20 cropping seasons. The trial field falls under dry temperate climatic zone of Afghanistan (Salari et al., 2020). The common growing season in Kabul is from April to November. The average monthly weather data on temperature (°C), relative humidity (%), day length (hours) and rainfall (mm) during the experimental period is presented in Table 1.

The study was laid out in Split-Split Plot Randomized Complete Block Design (RCBD) with eighteen treatments each replicated three times. The depth of tillage at two level (25 cm and 10 cm) was allocated to main plots. The methods of land preparation at three level (flatbed, single row raised bed, double row raised bed) were allotted in sub plots. The dates of planting at three level (10th May, 1st June and 20th June) were applied randomly in sub-sub plots.

Considering the details of experiment, the plots were ploughed to the depths of 10 cm and 25 cm. The beds of the plots were prepared in form of 1) flatbed, 2) raised beds with the height and width of 10 and 20 cm respectively - a single row of onion plants was cultivated on top of raised bed and 3) raised beds with the height and width of 10 and 40 cm respectively - two rows of onion plants were cultivated on top of it. The seeds were raised in nursery for 8 weeks prior to transplanting to the field. For the

transplanting dates 10 May, 1 June, and 20 June, the seeds were sown in nursery on 10 March, 1 April, and 20 April, respectively.

Table 1. Average monthly weather data of Kabul, Afghanistan During 2018 and 2019 ('POWER Data Access Viewer' n.d.) and *('Sunrise and Sunset in Afghanistan' n.d.)

Month	Maximum Temperature (ºC)			Minimum Temperature (°C)			Relative Humidity (%)			Day length (hours)*			Rainfall (mm)		
	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
January	6.9	2.2	4.5	-4.0	-8.7	-6.4	33.0	61.8	47.4	10.1	10.1	10.1	6.5	92.7	49.6
February	7.3	1.0	4.2	-3.7	-9.9	-6.8	50.3	72.8	61.5	11.0	11.0	11.0	27.7	69.7	48.7
March	14.9	7.4	11.2	1.4	-3.5	-1.0	45.6	66.4	56.0	11.6	11.6	11.6	17.4	51.2	34.3
April	19.7	17.3	18.5	4.4	4.1	4.3	38.1	60.8	49.4	13.1	13.1	13.1	13.8	40.5	27.2
May	21.8	21.4	21.6	6.4	5.5	6.0	37.0	42.8	39.9	14.0	14.0	14.0	22.3	29.1	25.7
June	28.2	25.2	26.7	10.9	8.4	9.6	23.7	32.6	28.2	14.3	14.3	14.3	3.6	4.2	3.9
July	30.8	31.1	31.0	13.1	13.4	13.2	20.9	25.5	23.2	14.2	14.2	14.2	4.0	8.4	6.2
August	28.7	29.1	28.9	10.8	11.8	11.3	23.1	24.7	23.9	13.3	13.3	13.3	7.8	12.7	10.2
September	25.0	27.2	26.1	7.7	9.3	8.5	24.2	21.7	23.0	12.3	12.3	12.3	18.3	0.9	9.6
October	17.4	18.2	17.8	2.7	4.3	3.5	34.1	38.6	36.3	11.2	11.2	11.2	12.1	16.7	14.4
November	11.7	9.6	10.7	-0.6	-1.7	-1.2	41.8	51.8	46.8	10.3	10.3	10.3	7.5	39.9	23.7
December	7.5	7.4	7.5	-4.5	-3.8	-4.2	38.5	43.2	40.9	9.5	9.5	9.5	33.8	7.1	20.5

The recommended dosage of inorganic fertilizer (nitrogen at 90 kg ha^{-1}, phosphorus at 60 kg ha^{-1} and potassium at 45 kg ha^{-1}) and farm yard manure at 15 t ha^{-1} were applied to all the plots. The plots were irrigated using common flood irrigation. Considering the climatic conditions, the frequency of irrigation was decided once in each 7–10 days. The plants were grown with rows spaced 0.2 m apart and an in-row plant distance of 0.12–0.15 m. The weeds were controlled manually by hand weeding. To control fungal diseases especially powdery mildew, the leaves were sprayed with 0.2% Mancozeb fungicide solution especially during the rainy season.

The data on growth parameters was recorded at 90 and 120 days after sowing. The numbers of leaves per plant in the selected three plants were counted in each treatment. The length of the leaf was measured in cm from the base to tip of the leaf. Leaf area was recorded from randomly labeled three plants in each treatment and was presented as square centimeter per plant. Leaf area index (LAI) was estimated by dividing the actual leaf area per plant by land area occupied by the same plant (spread of the plant) by using the formula (1) as given by Watson, (1952).

$$LAI = \frac{\text{Leaf area per plant (cm}^2\text{)}}{\text{Land area occupied by each plant (cm}^2\text{)}} \quad (1)$$

The Normalized Difference Vegetation Index (NDVI) for each treatment was recorded using green seeker. For maturity period, the number of days from sowing to harvest for each treatment were counted and presented in days. Marketable yield and total yield were recorded in kg per plot and presented in metric tons per hectare.

At maturity, the bulbs were harvested and then cured for one month under ventilated conditions, which, were then used for recording the yield data.

The recorded data were statistically analyzed with R software. ANOVA was calculated according to split-split plot RCBD and main effects were separated using Least Significant Difference (*LSD*) at $P = 0.05$. The results are explained for significant interactions.

RESULTS AND DISCUSSION

Number of leaves per plant

Tillage depth, land preparation, date of planting and their interactions affected number of leaves per plant at 90 and 120 days after sowing (Table 2).

Table 2. Number of leaves per plant as effected by depth of tillage, land preparation and date of planting of Safid e Paisaye onion

Treatment	Days after sowing					
	90			120		
	2018	2019	Mean	2018	2019	Mean
Tillage Depth (A):						
Deep tillage (25 cm)	6.57 ± 0.20	5.78 ± 0.19	6.18 ± 0.19	10.48 ± 0.26	10.60 ± 0.21	10.54 ± 0.15
Shallow tillage (10 cm)	6.62 ± 0.17	5.69 ± 0.18	6.16 ± 0.17	10.97 ± 0.30	10.72 ± 0.2	10.85 ± 0.18
F-test	NS	NS	NS	NS	NS	NS
Land Preparation (B):						
Flatbed	6.61 ± 0.26	5.80 ± 0.25	6.21 ± 0.25	10.03 ± 0.29	10.85 ± 0.25	10.44 ± 0.17
Raised bed - Single row	6.72 ± 0.24	5.78 ± 0.24	6.25 ± 0.24	11.22 ± 0.39	10.70 ± 0.27	10.96 ± 0.23
Raised bed - Double row	6.45 ± 0.17	5.63 ± 0.18	6.04 ± 0.17	10.92 ± 0.32	10.43 ± 0.23	10.68 ± 0.19
F-test	NS	NS	NS	NS	NS	NS
Planting Date (C):						
10th May	7.59 ± 0.16 a	6.76 ± 0.16 a	7.18 ± 0.16 a	9.90 ± 0.26 b	11.24 ± 0.19 a	10.57 ± 0.18 b
1st June	6.06 ± 0.12 b	5.22 ± 0.12 b	5.64 ± 0.12 b	11.00 ± 0.26 a	9.50 ± 0.13 b	10.25 ± 0.15 b
20th June	6.13 ± 0.17 b	5.22 ± 0.15 b	5.68 ± 0.16 b	11.27 ± 0.42 a	11.24 ± 0.15 a	11.26 ± 0.21 a
F-test	**	**	**	**	**	**
LSD	0.41	0.39	0.38	0.67	0.54	0.41
CV (%)	9	9.9	9	9.1	7.3	5.5
Interaction: A×B	NS	NS	NS	NS	NS	NS
A×C	NS	NS	NS	*	NS	NS
B×C	NS	NS	NS	**	NS	**
A×B×C	NS	NS	NS	NS	NS	NS

**, * and NS indicate highly significant, significant and non-significant respectively. Each value is the mean ± *SE*. Values with the common letter in the same column for each factor do not differ significantly, as per *LSD* at 0.05 level.

However, the interaction between tillage depth and planting date was found to be significant at 120 days after sowing. The planting date had highly significant effect

($P < 0.01$) on number of leaves per plant. Based on mean values, the highest number of leaves per plant (7.18) at 90 days after sowing were recorded for first planting date (10th May) and the lowest (5.64) for second planting date (1st June). However, after 120 days of sowing the third planting date (20th June) recorded the highest number of leaves per plant (11.26) and the lowest (10.25) for second planting date (1st June). The combination of shallow tillage and third planting date recorded the highest number of leaves per plant (11.96) while the lowest (9.67) were recorded for the combination of deep tillage and first planting date (Fig. 1).

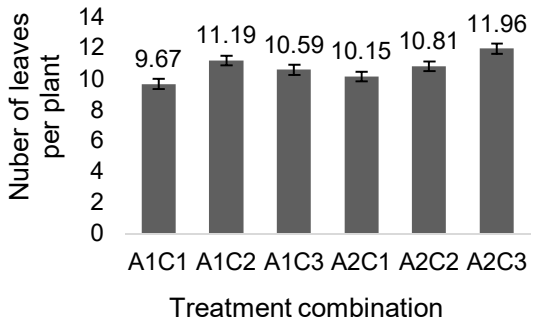

Figure 1. The number of leaves per plant of Safid e Paisaye onion as influenced by significant interaction between tillage depth (A) and planting date (C) at 120 days after sowing during season 2018.

The combination of single row raised bed and third planting date (20th June) recorded the highest number of leaves per plant and the combination of flatbed and second planting date (1st June) recorded the lowest number of leaves per plant (Fig. 2).

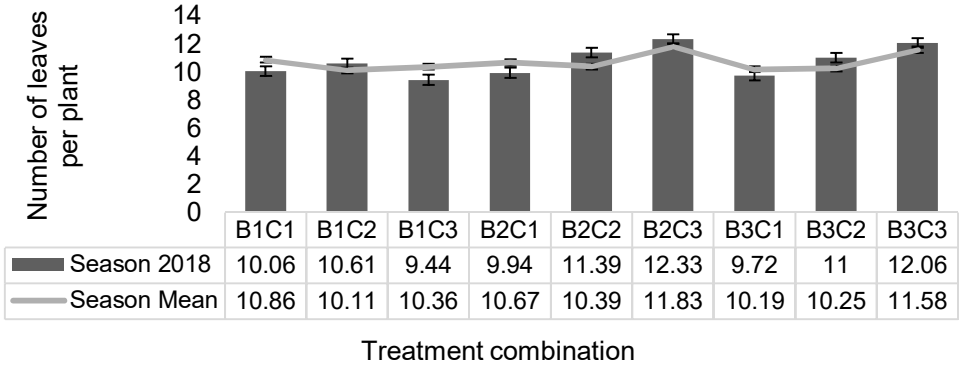

Figure 2. The number of leaves per plant of Safid e Paisaye onion as influenced by significant interaction between land preparation methods (B) and planting date (C) at 120 days after sowing.

Onion has shallow root system which might be the cause for non-significant effect of tillage depth and land preparation methods on number of leaves per plant. Jabro et al., 2010; Parvin et al., 2014 and Feitosa et al., 2020 also reported non-significant effect of tillage depth and land preparation on plant growth. Previous studies (Khokhar, 2017; Sekara et al., 2017) show that, onion growth is influence by weather conditions specially temperature and day length. The increase number of leavers per plant in first and third planting date might be associated with the ideal weather for plant growth. Because, during the month of March the seedling for first planting date were produced under plastic tunnel and hence the ideal weather was ensured. The transplants for second and third planting dates were produced in open field and they produced the lowest number

of leaves. Authors (Ali et al., 2016 and Prasad et al., 2017) also reported that onion plants grown in early dates produced more leaves per plant.

Raised bed planting method reduces water losses and shallow tillage decreases the soil temperature which both leads to increased water use efficiency. The efficient use of irrigation water under the combinations of shallow tillage and third planting date and single row raised bed and third planting date might be the possible reason for increased number of leaves per plant. The authors (Aboukhadrah et al., 2017; Ewis et al., 2017 and Peter & Miglena, 2020) reported similar findings.

Leaf length

The effect of planting date on leaf length was highly significant ($P < 0.01$) at 90 days after sowing. The highest leaf length (30.07 cm) was recorded for first planting date (10th May) and lowest for third planting date (20th June) (Table 3).

Table 3. The leaf length (cm) of onion variety Safid e Paisaye as effected by depth of tillage, land preparation and date of planting

Treatment	Days after sowing					
	90			120		
	2018	2019	Mean	2018	2019	Mean
Tillage Depth (A):						
Deep tillage (25 cm)	26.76 ± 0.97	23.60 ± 0.92	25.18 ± 0.94	38.03 ± 0.77	32.96 ± 1.14	35.50 ± 0.66
Shallow tillage (10 cm)	25.48 ± 1.01	22.87 ± 0.89	24.18 ± 0.95	36.09 ± 0.90	33.84 ± 1.22	34.97 ± 0.71
F-test	NS	NS	NS	NS	NS	NS
Land Preparation (B):						
Flatbed	25.61 ± 1.03	23.00 ± 0.91	24.31 ± 0.97	37.8 ± 0.96	34.31 ± 1.64	36.06 ± 0.66
Raised bed - Single row	26.97 ± 1.31	23.98 ± 1.26	25.48 ± 1.28	35.7 ± 1.08	33.19 ± 1.50	34.44 ± 0.99
Raised bed - Double row	25.77 ± 1.33	22.73 ± 1.14	24.25 ± 1.22	37.7 ± 1.06	32.69 ± 1.20	35.20 ± 0.82
F-test	NS	NS	NS	NS	NS	NS
Planting Date (C):						
10th May	31.72 ± 0.94 a	28.41 ± 0.85 a	30.07 ± 0.89 a	38.81 ± 1.03	30.56 ± 0.99	34.69 ± 0.61
1st June	24.25 ± 0.81 b	21.51 ± 0.67 b	22.88 ± 0.73 b	36.03 ± 1.07	34.40 ± 1.60	35.22 ± 1.11
20th June	22.39 ± 0.44 b	19.80 ± 0.39 b	21.10 ± 0.39 b	36.35 ± 0.95	35.23 ± 1.48	35.79 ± 0.73
F-test	**	**	**	NS	NS	NS
LSD	2.37	2.12	2.21			
CV (%)	13.2	13.3	13.1			
Interaction: A×B	NS	NS	NS	NS	NS	NS
A×C	NS	NS	NS	NS	NS	NS
B×C	NS	NS	NS	NS	NS	NS
A×B×C	NS	NS	NS	NS	NS	NS

** and NS indicate highly significant and non-significant respectively. Each value is the mean ± *SE*. Values with the common letter in the same column for each factor do not differ significantly, as per *LSD* at 0.05 level.

The shallow root system of onion crops could be the possible reason for its neutral response to tillage depth and land preparation method. The authors (Khokhar, 2017; Sekara et al., 2017 and Ikeda et al., 2020) reported that short day length encourages vegetative growth of onion while longer day lengths encourage bulb formation in onion. The suitable weather especially shorter day lengths during initial three months of plant growth for the first plant date might be the cause for longer leaf length. The onion in third planting date is less exposed to short days and they tend to produce bulbs instead of completing vegetative growth. Similar results were reported by(Ali et al., 2016; Aboukhadrah et al., 2017 and Prasad et al., 2017).

Leaf area per plant

The effect of planting date on leaf area per plant was highly significant ($P < 0.01$) at 90 days after sowing (Table 4).

Table 4. The leaf area per plant (cm^2) of onion variety Safid e Paisaye as effected by depth of tillage, land preparation and date of planting

Treatment	Days After Sowing					
	90			120		
	2018	2019	Mean	2018	2019	Mean
Tillage Depth (A):						
Deep tillage (25 cm)	184.97 ± 18.30	151.51 ± 17.03	168.24 ± 17.60	862.85 ± 41.82	560.72 ± 25.41	711.79 ± 22.13
Shallow tillage (10 cm)	181.73 ± 17.54	150.56 ± 16.43	166.15 ± 16.90	826.28 ± 51.08	615.36 ± 28.76	720.82 ± 30.31
F-test	NS	NS	NS	NS	NS	NS
Land Preparation (B):						
Flatbed	177.77 ± 18.57	144.15 ± 16.32	160.96 ± 17.33	808.62 ± 47.05	601.82 ± 31.17	705.22 ± 27.10
Raised bed - Single row	196.15 ± 25.67	165.72 ± 25.05	180.94 ± 25.27	816.11 ± 62.6	608.73 ± 38.52	712.42 ± 32.76
Raised bed - Double row	176.12 ± 21.37	143.24 ± 19.28	159.68 ± 20.26	908.97 ± 59.65	553.57 ± 30.81	731.27 ± 37.5
F-test	NS	NS	NS	NS	NS	NS
Planting Date (C):						
10th May	297.43 ± 15.81 a	257.42 ± 14.92 a	277.43 ± 15.09 a	839.30 ± 66.00	577.52 ± 29.17	708.41 ± 33.37
1st June	134.11 ± 5.75 b	104.89 ± 5.28 b	119.50 ± 5.29 b	846.17 ± 47.24	543.37 ± 31.52	694.77 ± 30.89
20th June	118.50 ± 6.05 b	90.80 ± 5.43 b	104.65 ± 5.63 b	848.23 ± 58.89	643.22 ± 36.93	745.73 ± 32.95
F-test	**	**	**	NS	NS	NS
LSD	28.84	25.24	26.37			
CV (%)	22.9	24.3	22.9			
Interaction: A×B	NS	NS	NS	NS	NS	NS
A×C	NS	NS	NS	NS	NS	NS
B×C	NS	NS	NS	NS	NS	NS
A×B×C	*	NS	*	NS	NS	NS

**, * and NS indicate highly significant, significant and non-significant respectively. Each value is the mean ± *SE*. Values with the common letter in the same column for each factor do not differ significantly, as per *LSD* at 0.05 level.

The interaction between tillage depth, land preparation and date of planting was significant for leaf area per plant at 90 days after sowing. The highest leaf area per plant (277.43 cm^2) was recorded for first planting date (10th May) and the lowest (104.65 cm^2) for third planting date (20th June).

The combination of deep tillage, single row raised bed and first planting date (10th May) recorded the highest leaf area per plant. The lowest leaf area per plant was recorded for the combination of shallow tillage, flatbed and third planting date (Fig. 3).

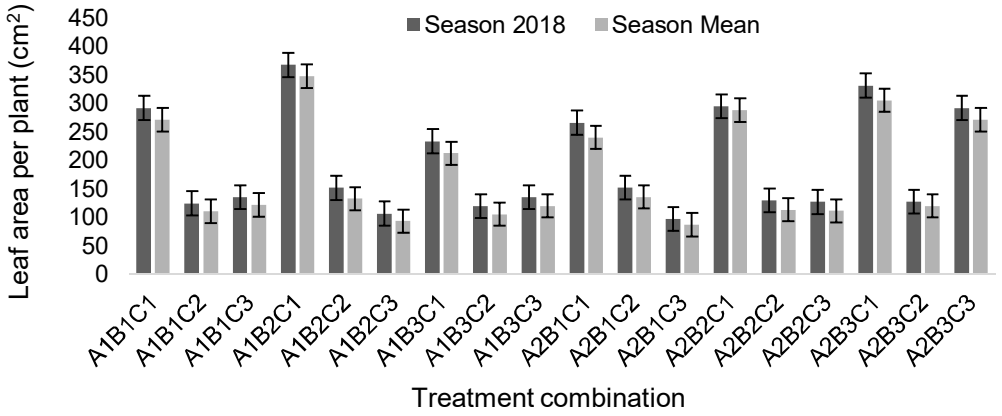

Figure 3. The leaf area per plant of Safid e Paisaye onion as influenced by significant interaction between tillage depth (A), land preparation (B) and planting date (C) at 90 days after sowing.

Leaf area per plant is dependent on number of leaves per plant, leaf length and leaf diameter. Since both leaf number and leaf length at 90 days after sowing were recorded higher for first planting date thereby it is obvious that, leaf area per plant would also be higher for the same planting date. The suitable climatic conditions in first planting date might be the possible cause for increased leaf area per plant. The improved water use efficiency under combination of deep tillage, single row raised bed and first planting date might be the reason for increase leaf area per plant. Similar results are recorded by (Hatterman-Valenti & Hendrickson, 2006; Aboukhadrah et al., 2017; Ahmed et al., 2017 and Ewis et al., 2017).

Leaf area index

The effect of planting date on leaf area index was highly significant ($P < 0.01$) at 90 days after sowing. The interaction between tillage depth, land preparation and date of planting was significant for leaf area index at 90 days after sowing. The highest leaf area index (0.93) at 90 days after sowing was recorded for first planting date (10th May) and the lowest (0.35) for third planting date (20th June) (Table 5).

The combination of deep tillage, single row raised bed and first planting date (10th May) recorded the highest leaf area index at 90 days after sowing. The lowest leaf area index after 90 days of sowing was recorded for the combination of shallow tillage, flatbed and third planting date (Fig. 4).

Table 5. Leaf area index of Safid e Paisaye onion as effected by depth of tillage, land preparation and date of planting

Treatment	Days after sowing					
	90			120		
	2018	2019	Mean	2018	2019	Mean
Tillage Depth (A):						
Deep tillage (25 cm)	0.62 ± 0.06	0.51 ± 0.06	0.57 ± 0.06	2.87 ± 0.14	1.87 ± 0.08	2.37 ± 0.07
Shallow tillage (10 cm)	0.61 ± 0.06	0.50 ± 0.05	0.56 ± 0.06	2.75 ± 0.17	2.05 ± 0.10	2.4 ± 0.10
F-test	NS	NS	NS	NS	NS	NS
Land Preparation (B):						
Flatbed	0.59 ± 0.06	0.48 ± 0.05	0.54 ± 0.06	2.69 ± 0.16	2.01 ± 0.10	2.35 ± 0.09
Raised bed – Single row	0.65 ± 0.08	0.55 ± 0.08	0.60 ± 0.08	2.72 ± 0.21	2.03 ± 0.13	2.38 ± 0.11
Raised bed – Double row	0.59 ± 0.07	0.48 ± 0.06	0.54 ± 0.07	3.02 ± 0.20	1.85 ± 0.10	2.44 ± 0.12
F-test	NS	NS	NS	NS	NS	NS
Planting Date (C):						
10th May	0.99 ± 0.05 a	0.86 ± 0.05 a	0.93 ± 0.05 a	2.79 ± 0.22	1.93 ± 0.10	2.36 ± 0.11
1st June	0.45 ± 0.02 b	0.35 ± 0.02 b	0.40 ± 0.02 b	2.82 ± 0.16	1.81 ± 0.11	2.32 ± 0.10
20th June	0.40 ± 0.02 b	0.30 ± 0.02 b	0.35 ± 0.02 b	2.82 ± 0.20	2.14 ± 0.12	2.48 ± 0.11
F-test	**	**	**	NS	NS	NS
LSD	0.1	0.08	0.09			
CV (%)	22.9	24.3	23.0			
Interaction: A×B	NS	NS	NS	NS	NS	NS
A×C	NS	NS	NS	NS	NS	NS
B×C	NS	NS	NS	NS	NS	NS
A×B×C	*	NS	*	NS	NS	NS

**, * and NS indicate highly significant, significant and non-significant respectively. Each value is the mean ± *SE*. Values with the common letter in the same column for each factor do not differ significantly, as per *LSD* at 0.05 level.

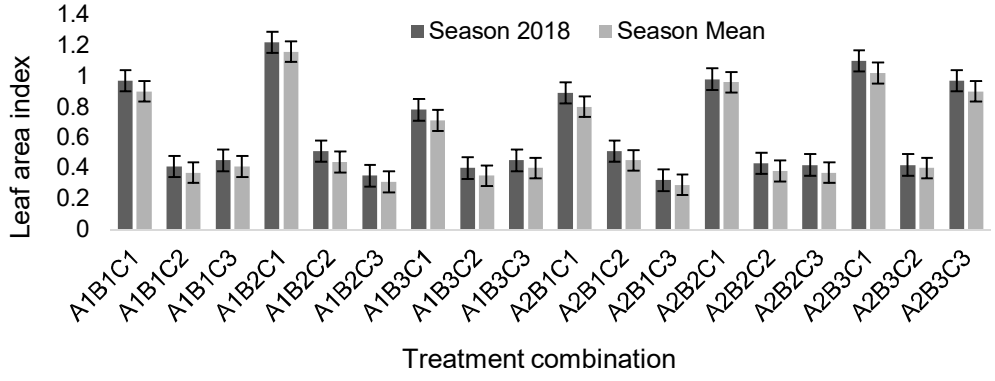

Figure 4. The leaf area index of Safid e Paisaye onion as influenced by significant interaction between tillage depth (A), land preparation (B) and planting date (C) at 90 days after sowing.

The leaf area index, shows that land is most efficiently used under first planting date as compare to later planting dates. Ali et al. (2016), Aboukhadrah et al. (2017) and Prasad et al. (2017) also reported higher plant growth for early planting of onion.

Normalized difference vegetation index (NDVI)

The effect of tillage depth on NDVI was significant at 120 days after sowing. The highest NDVI (0.493) was recorded for deep tillage and the lowest (0.474) for shallow tillage (Table 6). Planting date had highly significant ($P < 0.01$) effect on NDVI at both 90 and 120 days after sowing. The highest NDVI (0.29) at 90 days after sowing was recorded for first plating date and the lowest (0.13) for second planting date. At 120 days after sowing the highest NDVI (0.49) was recorded for second planting date which was on par with third planting date (0.47) (Table 6).

Table 6. Normalized Difference Vegetation Index (NDVI) as effected by depth of tillage, land preparation and date of planting of Safid e Paisaye onion

Treatment	Days after sowing					
	90			120		
	2018	2019	Mean	2018	2019	Mean
Tillage Depth (A):						
Deep tillage (25 cm)	0.24 ± 0.02	0.19 ± 0.02	0.22 ± 0.02	0.49 ± 0.01 a	0.44 ± 0.02	0.47 ± 0.01
Shallow tillage (10 cm)	0.22 ± 0.01	0.17 ± 0.01	0.20 ± 0.01	0.47 ± 0.01 b	0.45 ± 0.02	0.46 ± 0.01
F-test	NS	NS	NS	*	NS	NS
LSD				0.01		
CV (%)				2.3		
Land Preparation (B):						
Flatbed	0.24 ± 0.02	0.18 ± 0.02	0.21 ± 0.02	0.50 ± 0.01	0.44 ± 0.02	0.47 ± 0.01
Raised bed – Single row	0.23 ± 0.02	0.18 ± 0.02	0.21 ± 0.02	0.46 ± 0.01	0.46 ± 0.02	0.46 ± 0.01
Raised bed – Double row	0.23 ± 0.02	0.18 ± 0.02	0.21 ± 0.02	0.49 ± 0.01	0.43 ± 0.02	0.46 ± 0.01
F-test	NS	NS	NS	NS	NS	NS
Planting Date (C):						
10th May	0.31 ± 0.02 a	0.26 ± 0.01 a	0.29 ± 0.01 a	0.48 ± 0.01	0.37 ± 0.01 b	0.43 ± 0.01 b
1st June	0.16 ± 0.01 c	0.10 ± 0.00 c	0.13 ± 0.00 b	0.50 ± 0.01	0.49 ± 0.02 a	0.49 ± 0.01 a
20th June	0.23 ± 0.01 b	0.17 ± 0.01 b	0.20 ± 0.01 c	0.47 ± 0.01	0.47 ± 0.02 a	0.47 ± 0.01 a
F-test	**	**	**	NS	**	**
LSD	0.04	0.03	0.03		0.05	0.03
CV (%)	22.1	25.4	23.1		15.3	8.6
Interaction: A×B	NS	NS	NS	NS	NS	NS
A×C	NS	NS	NS	NS	NS	NS
B×C	NS	NS	NS	NS	NS	NS
A×B×C	NS	NS	NS	NS	NS	NS

**, * and NS indicate highly significant, significant and non-significant respectively. Each value is the mean ± *SE*. Values with the common letter in the same column for each factor do not differ significantly, as per *LSD* at 0.05 level.

The NDVI is dependent on vegetation in the field which increases with increase in plant growth. Feng et al. (2019) and Tan et al. (2020) also reported similar results.

Maturity period

Planting date had highly significant ($P < 0.01$) effect on maturity period. Onions produced in first planting date (10th May) took longer period (176.44 days) to reach maturity and those in third planting date took shortest period (153.83 days) (Table 7).

The hot and dry weather during later planting dates may accelerates the plant growth and development and decrease the maturity period. Potopová et al. (2015), Sekara et al. (2017), Yoon & Choi (2020) reported that early planting of crops in spring increases the length of growing season.

Table 7. Maturity period (days) of onion variety Safid e Paisaye as effected by depth of tillage, land preparation and date of planting

Treatment	Year		
	2018	2019	Mean
Tillage Depth (A):			
Deep tillage (25 cm)	154 ± 2.88	174.96 ± 1.87	164.65 ± 1.97
Shallow tillage (10 cm)	154 ± 3.03	172.74 ± 1.70	163.54 ± 2.01
F-test	NS	NS	NS
Land Preparation (B):			
Flatbed	154 ± 3.76	173.56 ± 2.38	163.81 ± 2.59
Raised bed – Single row	155 ± 3.66	173.67 ± 1.65	164.14 ± 2.18
Raised bed – Double row	154 ± 3.57	174.33 ± 2.54	164.33 ± 2.61
F-test	NS	NS	NS
Planting Date (C):			
10th May	173 ± 0.38 a	180.33 ± 1.30 a	176.44 ± 0.66 a
1st June	155 ± 0.28 b	169.28 ± 2.19 b	162.00 ± 1.12 b
20th June	136 ± 0.28 c	171.94 ± 2.10 b	153.83 ± 1.05 c
F-test	**	**	**
LSD	1.05	6.08	4.03
CV (%)	1	5.1	2.7
Interaction: A×B	NS	NS	NS
A×C	NS	NS	NS
B×C	NS	NS	NS
A×B×C	NS	NS	NS

** and NS indicate highly significant and non-significant respectively. Each value is the mean ± *SE*. Values with the common letter in the same column for each factor do not differ significantly, as per *LSD* at 0.05 level.

Yield

The depth of tillage had significant ($P < 0.05$) influence on marketable yield. The deep tillage recorded higher marketable yield (38.58 t ha^{-1}) as compare to shallow tillage (35.10 t ha^{-1}) (Table 8). The land preparation method significantly ($P < 0.05$) influenced the marketable yield. The highest (26.9 t ha^{-1}) and lowest (22.51 t ha^{-1}) marketable yield was recorded under flatbed and single row raised bed respectively (Table 8). The effect of planting date was highly significant ($P < 0.01$) on both marketable and total yield. The highest marketable yield (37.01 t ha^{-1}) and total yield (40.08 t ha^{-1}) were produced under first planting date (10 May) and the lowest marketable yield (23.21 t ha^{-1}) and total yield (24.22 t ha^{-1}) under third planting date (20 June) (Table 8).

Table 8. The marketable yield (t ha^{-1}) and total yield (t ha^{-1}) as effected by depth of tillage, land preparation and date of planting of Safid e Paisaye onion

Treatment	Marketable yield (t ha^{-1})			Total yield (t ha^{-1})		
	2018	2019	Mean	2018	2019	Mean
Tillage Depth (A):						
Deep tillage (25 cm)	25.50 ± 1.31	38.58 ± 2.28 a	32.04 ± 1.74	26.95 ± 1.34	40.98 ± 2.45	33.97 ± 1.81
Shallow tillage (10 cm)	23.43 ± 1.87	35.10 ± 2.36 b	29.26 ± 1.61	24.95 ± 1.89	38.56 ± 2.89	31.76 ± 1.87
F-test	NS	**	NS	NS	NS	NS
LSD		0.68				
CV (%)		1.6				
Land Preparation (B):						
Flatbed	26.90 ± 2.04 a	36.42 ± 2.08	31.66 ± 1.68	28.49 ± 2.09	38.62 ± 2.37	33.56 ± 1.77
Raised bed – Single row	22.51 ± 1.91b	34.06 ± 2.18	28.29 ± 1.86	23.97 ± 1.92	38.62 ± 3.19	31.30 ± 2.30
Raised bed – Double row	23.99 ± 1.95 ab	40.04 ± 3.89	32.02 ± 2.54	25.39 ± 1.96	42.07 ± 4.10	33.73 ± 2.67
F-test	*	NS	NS	NS	NS	NS
LSD	3.15					
CV (%)	16.7					
Planting Date (C):						
10th May	32.54 ± 1.55 a	41.48 ± 2.77 a	37.01 ± 1.7 a	34.25 ± 1.56 a	45.90 ± 3.30 a	40.08 ± 1.81 a
1st June	24.19 ± 1.43b	39.28 ± 2.68 a	31.74 ± 1.75b	25.61 ± 1.40 b	42.97 ± 2.68 a	34.29 ± 1.72 b
20th June	16.67 ± 0.58 c	29.75 ± 2.41b	23.21 ± 1.24 c	18.00 ± 0.58 c	30.44 ± 2.66 b	24.22 ± 1.38 c
F-test	**	**	**	**	**	**
LSD	3.93	6.23	3.84	3.7	6.93	4.04
CV (%)	23.4	24.6	18.2	20.7	25.3	17.9
Interaction: A×B	NS	NS	NS	NS	NS	NS
A×C	NS	NS	NS	NS	NS	NS
B×C	NS	NS	NS	NS	NS	NS
A×B×C	NS	NS	NS	NS	NS	*

**, * and NS indicate highly significant, significant and non-significant respectively. Each value is the mean ± *SE*. Values with the common letter in the same column for each factor do not differ significantly, as per *LSD* at 0.05 level.

The total yield was significantly influenced by combination of tillage depth, land preparation and planting date. The highest total yield (41.44 t ha^{-1}) was recorded under combination of deep tillage, single row raised bed and first planting date (10th May) and the lowest (20.87 t ha^{-1}) under the combination of shallow tillage, single row raised bed and third plating date (20th June) (Fig. 5).

Jabro et al. (2010) reported that deep tillage reduces soil bulk density, increases water intake, improves aeration, and improves response to nitrogen uptake which might be the possible reason for increased marketable yield under deep tillage conditions. The optimum soil type (silty loam) might be the reason for proper bulb enlargement on flatbeds. The genotype and onion bulb shape are also important factors which determines the response of onion variety to environment including soil management. The variety

used in this research is flat and round in shape and its equatorial diameter is almost double of its polar diameter. The bulb shape of this variety might be the possible reason for its better response to flatbed, because small raised beds may not provide enough soil coverage to the bulb.

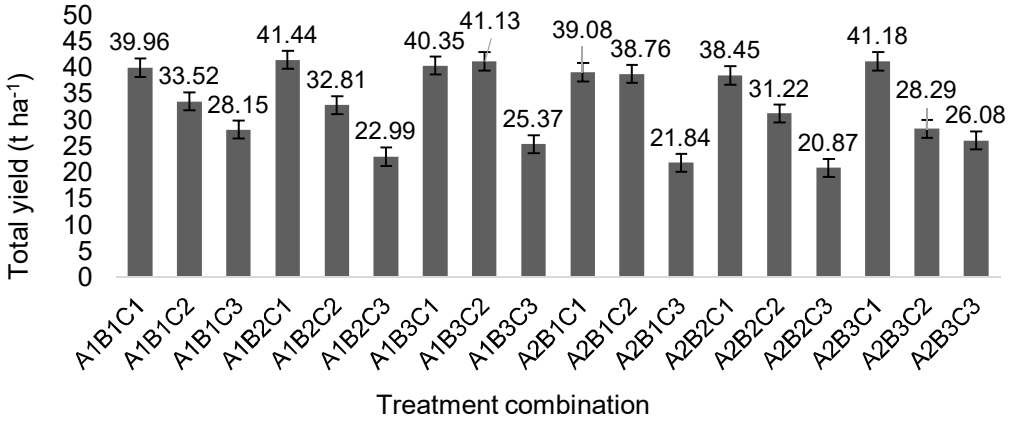

Figure 5. Total yield (t ha^{-1}) of Safid e Paisaye onion as influenced by significant interaction between tillage depth (A), land preparation (B) and planting date (C) during mean of season 2018 and 2019.

The ideal weather might be the possible reasons for higher yield of onion under early planting dates. The authors (Singh & Singh, 2000; Abdulsalam & Hamaiel, 2004; Bosekeng & Coetzer, 2013 and Caruso et al., 2014) reported that delay in planting date reduces yield of onion. Improved soil structure, better water use efficiency and ideal weather might be the possible reason for increased marketable yield under combination of deep tillage, single row raised bed and first planting date. Similar results were also reported by (Singh & Singh, 2000; Jabro et al., 2010; Caruso et al., 2014 and Ewis et al., 2017).

CONCLUSIONS

The tillage depth does not influence the total yield of onion however, deep tillage enhanced the marketable yield. Flatbed increased the marketable yield of *Safid e Paisaye* onions as compare to raised beds. Delay in planting date significantly reduced plant growth and yield and early planting date was more appropriate to get vigorous plants and higher yield of onion variety *Safid e Paisaye*.

REFERENCES

Abdulsalam, M.A. & Hamaiel, A.F. 2004. Effect of planting dates and compound fertilizers on growth, yield and quality of hassawi onion under Al-Hassa Oasis conditions. *Scientific Journal of King Faisal University (Basic and Applied Sciences)*, **5**(1), 65–79.

Aboukhadrah, S., Abdul Alsayed, Labib Sobhy, & Abdelmasieh, W. 2017. Response of onion yield and quality to different planting date, methods and density. *Egyptian Journal of Agronomy* **39**(2), 203–19. https://doi.org/10.21608/agro.2017.1203.1065

Ahmed, K., Nawaz, M.Q., Hussain, S.S., Rizwan, M., Sarfraz, M., Wainse, G.M. & Jamil, M. 2017. Response of onion to different nitrogen levels and method of transplanting in moderately salt affected soil. *Acta Agriculturae Slovenica* **109**(2), 303–13. https://doi.org/10.14720/aas.2017.109.2.13

Ali, J., Abdurrab, H.M., Ali, M., Rashid, A., Shakoor, A., Khan, A., Khan, J., Jamal, A. & Khan, H. 2016. Effect of sowing dates and phosphorus levels on growth and bulb production of onion. *Pure and Applied Biology* **5**(3), 406–17. https://doi.org/10.19045/bspab.2016.50053

Bosekeng, G. & Coetzer, G. 2013. Response of onion (Allium Cepa L.) to sowing dates. *African Journal of Agricultural Research* **8**(22), 2757–64. https://doi.org/10.5897/AJAR2013.7035

Bosekeng, G. & Coetzer, G. 2015. Response of onion (Allium Cepa L.) to sowing date and plant population in the Central Free State, South Africa.' *African Journal of Agricultural Research* **10**(4), 179–87. https://doi.org/10.5897/AJAR2013.8071

Caruso, G., Conti, S., Villari, G., Borrelli, C., Melchionna, G., Minutolo, M., Russo, G. & Amalfitano, C. 2014. Effects of transplanting time and plant density on yield, quality and antioxidant content of onion (Allium Cepa L.) in Southern Italy. *Scientia Horticulturae* **166**, 111–20. https://doi.org/10.1016/j.scienta.2013.12.019

Deepak Misra, A.D., Kumar Ashok, & Ingo, M.W. 2014. Effect of spacing and planting time on growth and yield of onion. *Indian Journal of Horticulture* **71**(2), 207–10.

Ewis, M., Abd, K., Marey, R. & Khaled, A. 2017. Improving yield, storability and water productivity for some onion cultivars by different planting methods. *Fayoum J. Agric. Res. & Dev.* **34**(1), 31–49.

Feitosa, Jardênia R., Fernandes, Haroldo C., Cecon, Paulo R., Leite, Daniel M., Nery, Filipe M.T. & Pereira, Janielle S. 2020. Onion yield as a function of soil tillage system and soil water content. *Revista Brasileira de Engenharia Agrícola e Ambiental* **24**(2), 115–20. https://doi.org/10.1590/1807-1929/agriambi.v24n2p115-120

Feng, Wei, Yapeng Wu, Li He, Xingxu Ren, Yangyang Wang, Gege Hou, Yonghua Wang, Wandai Liu & Tiancai Guo. 2019. An optimized non-linear vegetation index for estimating leaf area index in winter wheat. *Precision Agriculture* **20**(6), 1157–76. https://doi.org/10.1007/s11119-019-09648-8

Gami, M.R., Arvadia Patel, D.D., Patel, M.K., Patel, T.U., Patel, H.M. & Patel, A.J. 2013. Evaluation of different tillage depths and FYM levels on onion (Allium cepa L.) bulb crop. *AGRES – An International e-Journal* **2**(1), 20–27.

Gronle, A., Lux, G., Böhm, H., Schmidtke, K., Wild, M., Demmel, M., Brandhuber, R., Wilbois, K.-P. & Heß, J. 2015. 'Effect of Ploughing Depth and Mechanical Soil Loading on Soil Physical Properties, Weed Infestation, Yield Performance and Grain Quality in Sole and Intercrops of Pea and Oat in Organic Farming.' *Soil and Tillage Research* **148**(May): 59–73. https://doi.org/10.1016/j.still.2014.12.004

Hatterman-Valenti, M. Harlene & Hendrickson, P.E. 2006. Companion Crop and Planting Configuration Effect on Onion. *HortTechnology* **16**(1), 12–15. https://doi.org/10.21273/HORTTECH.16.1.0012

Horváth, É., Gombos, B. & Széles, A. 2021. Evaluation phenology, yield and quality of maize genotypes in drought stress and non-stress environments. *Agronomy research* **19**(2), 408–422. https://doi.org/10.15159/AR.21.073

Ikeda, H., Yamamoto, T., Kinoshita, T., Tsukazaki, H. & Yamasaki, A. 2020. A comparative study on the growth and bulb development of several onion (Allium cepa L.) cultivars sown in spring in the northeast region of Japan. *The Horticulture Journal* **89**(5), 586–92. https://doi.org/10.2503/hortj.UTD-200

Jabro, J.D., Stevens, W.B., Iversen, W.M. & Evans, R.G. 2010. Tillage depth effects on soil physical properties, sugarbeet yield, and sugarbeet quality. *Communications in Soil Science and Plant Analysis* **41**(7), 908–16. https://doi.org/10.1080/00103621003594677

Kerpauskas, P., Sirvydas, A.P., Vasinauskienė, R. & Tamošiuna, A. 2009. Influence of thermal effect duration on onion yield. *Agronomy Research* **7**(Special issue 1), 323–327.

Khokhar, K.M. 2017. Environmental and genotypic effects on bulb development in onion – a Review.' *The Journal of Horticultural Science and Biotechnology* **92**(5), 448–54. https://doi.org/10.1080/14620316.2017.1314199

Parvin, N., Parvage, M.M. & Etana, A. 2014. Effect of mould-board ploughing and shallow tillage on sub-soil physical properties and crop performance. *Soil Science and Plant Nutrition* **60**(1), 38–44. https://doi.org/10.1080/00380768.2013.847779

Peter, Y. & Miglena, D. 2020. Effect of different types of soil tillage for sunflower on some soil physical characteristics. Part II: bulk density and soil temperature. *Helia* **43**(73), 133–49. https://doi.org/10.1515/helia-2020-0013

Potopová, V., Zahradníček, P., Türkott, L., Štěpánek, P. & Soukup, J. 2015. The effects of climate change on variability of the growing seasons in the Elbe River lowland, Czech Republic. *Advances in Meteorology* 2015 (October), 1–16. https://doi.org/10.1155/2015/546920

'POWER Data Access Viewer.' n.d. https://power.larc.nasa.gov/data-access-viewer/. Accessed 16.2.2021.

Prasad, B., Maji, S. & Meena, K.R. 2017. Effect of date of transplanting and mulching on growth, yield and quality of onion (Allium Cepa L.) Cv. Nasik Red. *Journal of Applied and Natural Science* **9**(1), 94–101. https://doi.org/10.31018/jans.v9i1.1156

Salari, H., Hansra, B.S. & Saharwat, Y.S. 2020. Effect of cultural practices on quality and yield of onion (Allium Cepa L. Var. Safid e Paisaye). *Journal of Ecoscience and Plant Revolution* **1**(1), 9–14. https://doi.org/10.37357/1068.jepr.1.1.02

Sekara, A., Pokluda, R., Vacchio, L.D., Somma, S. & Caruso, G. 2017. 'Interactions among genotype, environment and agronomic practices on production and quality of storage onion (Allium Cepa L.) - A Review.' *Horticultural Science* **44**(1), 21–42. https://doi.org/10.17221/92/2015-HORTSCI

Shanmugasundaram, S. & Kalb, T. 2007. AVRDC Training guide: suggested cultural practices for onion. *AVRDC - The World Vegetable Center.* 2007. https://worldveg.tind.io/record/35054

Singh, A.K. & Singh, V. 2000. Interaction effect of agronomical practices on kharif onion (Allium Cepa L.)' *New Botanist* **27**(1/4), 115–18.

'Sunrise and Sunset in Afghanistan.' n.d. https://www.worlddata.info/asia/afghanistan/sunset.php. Accessed 16.2.2021

Tan, C.W., Zhang, P.P., Zhou, X.X., Wang, Z.X., Xu, Z.Q., Mao, W., Li, W.X., Huo, Z.Y., Guo, W.S. & Yun, F. 2020. Quantitative monitoring of leaf area index in wheat of different plant types by integrating NDVI and beer-lambert law.' *Scientific Reports* **10**(1), 929. https://doi.org/10.1038/s41598-020-57750-z

Watson, D.J. 1952. The physiological basis of variation in yield. *Advances in Agronomy* **4**, 101–45. https://doi.org/10.1016/S0065-2113(08)60307-7

Yoon, P.R. & Choi, J.Y. 2020. Effects of shift in growing season due to climate change on rice yield and crop water requirements. *Paddy and Water Environment* **18**(2), 291–307. https://doi.org/10.1007/s10333-019-00782-7