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The influence of land management and date of planting on physical properties of *Safid e Paisaye* onion (*Allium cepa L.*)

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ABSTRACT

Onion botanically named *Allium cepa* L. is a major crop of *Alliaceae* family. It is one of the largest commercially grown vegetables in the world including Afghanistan. This crop originated from Afghanistan and large number of its wild varieties are observed in the country. Local variety named *Safid e Paisaye* was selected for this investigation due to its capacity of longer storage and higher demand in the market. Very less research efforts are made to improve its bulb quality and share in the market. This investigation is carried out at Kabul university agriculture research farm in coordination with Amity University Uttar Pradesh, to study the effect of land management and planting date on bulb physical properties of onion. The parameters studied in this investigation include bulb width (cm), length (cm), thickness (cm), geometric mean diameter, arithmetic mean diameter, shape index, sphericity, roundness, ellipsoid ratio, frontal surface, cross sectional area, total area, number of scales, equatorial firmness (Kg/cm^2) and polar firmness (Kg/cm^2). The data is collected using required tools and was analyzed using R statistical analysis software. The results showed significant effect of planting date on physical properties of onion bulb. The first planting date (10th May) recorded the largest bulb width (6.95 cm), length (4.42 cm), thickness (6.75 cm), geometric mean diameter (5.91 cm), arithmetic mean diameter (6.04 cm), frontal surface (24.26 cm^2), cross sectional area (28.84 cm^2) and total area (110.63 cm^2). The same planting date recorded the lowest values for bulb shape index (0.64) and sphericity (0.85). Land management practices did not have significant effect on physical properties of onion bulb. None of the studied factors had significant effect on bulb roundness, ellipsoid ratio, number of scales, equatorial firmness and polar firmness. Conclusions: early planting of *Safid e Paisaye* onion seedlings can increase bulb size and improve bulb physical characteristics. This also helps to maintain the flat and round shape of onion bulb. Land preparation method and plough depth do not have significant influence on physical properties of onion bulb.

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1. Introduction

Onion botanically named *Allium cepa* L. is a major crop of *Alliaceae* family. It is one of the largest commercially grown vegetables in the world including Afghanistan. During 2019, Afghanistan produced 352,725 metric tons onions for export and local consumption [1]. The major importing countries of Afghan onion are India and Pakistan. During year 2019, Afghanistan exported 49,320 and 79,170 metric tons onion to India and Pakistan respectively. During this year the global export value of Afghan onion reached USD 38.15 million [2]. Onions are originated from Afghanistan [3] and large number of its wild varieties are observed in the country. *Safid e Paisaye* variety is largely grown in *Ghorband* valley of Parwan province in central Afghanistan. "*Safid e Paisaye*" is a local name means "white coin-like", this is selected based on white color of bulb and its flat round shape. The onion of this variety has the capacity of longer storage and also has higher demand in the market due to its unique shape [4].

The onions are reach source polysaccharides, vitamins such as B1, B2 and C, minerals like potassium and selenium, essential oils, phenolic compounds, flavonoids and large number of sulfur compounds. Due to its reach chemical composition the onion has the potential anti-cholesterol, anti-inflammatory, anti-cancer, and antioxidant properties [5,6]. The flavonoid quercetin present in onions may protect against many chronic diseases including cardiovascular disease, and cancer. The organo-sulfur compounds in onions can lower blood pressure and cholesterol [7].

The transplanting dates of onion seedlings vary widely among regions, confirming the influence of environmental conditions on onion growth, yield, and quality of bulbs. The identification of optimum planting dates are crucial for obtaining higher yield and quality bulbs [8–10].

Caruso et al. [11] evaluated the effects of planting date and crop density on growth, productivity and bulb quality indicators of onion cultivar "Ramata di Montoro." He reported that crop yield, mean weight of bulb, and bulb diameters decrease significantly with delay in transplanting date. He further stated that the plant density does not influence onion productivity substantially, but the most spaced crop produces the largest bulbs. Khokhar [12] reported that photoperiod plays an important role in bulb development and adaptation of a specific region. He

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mentioned that long days and high temperatures promote onion bulb formation. He further adds that bulb formation is regulated more by temperature (determined by growing degree days) as compared to photoperiod.

Aboukhadrah et al. [13] reported that early planting and wide furrows planting method significantly increases vegetative growth, yield and quality of onion. The finding of his investigation shows that early transplanting (15th December) in wide furrows planting method with the plant density of 45 plants/m^2 can lead to achieve the most economic yield in the North Delta of Egypt.

Early planting leads to increased plant height, number of leaves, leaf length, leaf width, bulb diameter, fresh bulb weight and yield of onion crop [14].

Prasad et al. [15] studied the effect of planting date and mulching on quality and yield of onion in rabi season at Lucknow, UP, India. He reported that the highest plant height, number of leaves per plant, length of leaves, neck thickness, polar bulb diameter, equatorial bulb diameter, number of scales per bulb and TSS are obtained with wheat straw mulching and transplanting date on 1st December.

Gronle et al. [16] evaluated the performance of pea and oat under shallow plough (7-10 cm) and deep plough (25-30 cm). They found that shallow plough results in greater penetration resistance in the 14–28 cm soil layer compared to deep plough. They further stated that the plough depth did not affect pea and oat grain yield. They concluded that shallow plough reduces the risk of poor crop performance due to heavy field traffic and can be an alternative to deep ploughing.

Minimal tillage slightly increases bulk density of the soil layer below the cultivated one. Minimal and no-tillage causes decrease in soil temperature, especially the top layer of soil (0–10 cm). The reduction of soil tillage depth and number leads to decrease in soil temperature [17].

Tillage depth does not have significant effect on population of sugar-beet and yield and sucrose content of its root. The tillage depth enhances physical quality of soil including bulk density, water content and soil penetration resistance but has less effect on yield and quality of sugar-beet [18].

Ewis et al. [19] studied the effect of planting methods on productivity, storability and crop-water relations of onion. They reported that water consumption is reduced in raised bed planting methods compared to the flat-bed planting method. They recorded the highest plant height, number of leaves per plant, bulb length, number of days to maturity and TSS (%) for planting onion on ridges of 60 cm width. The highest bulb diameter, plant weight and dry matter (%) were recorded for planting onion on raised bed. The raised bed planting method also recorded the highest number of marketable onions, total yield and bulb weight.

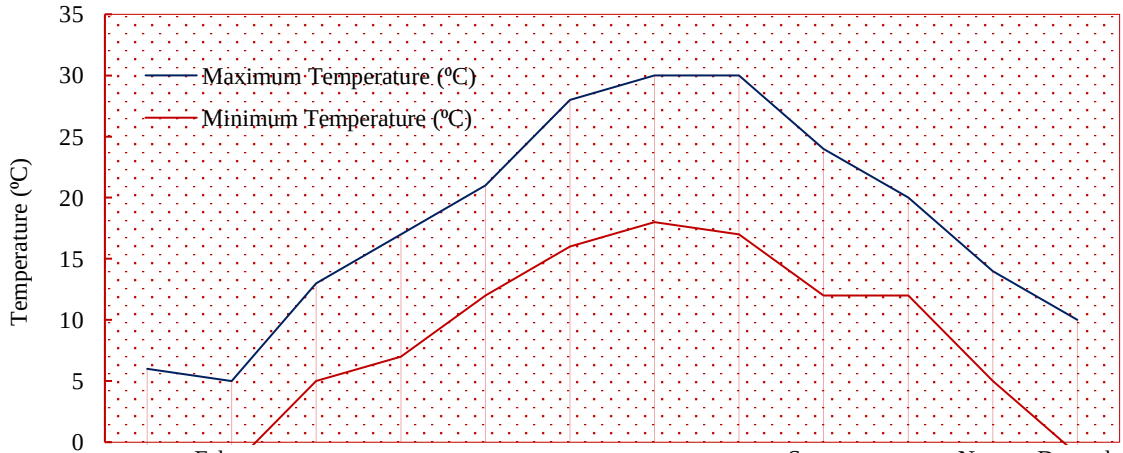
The highest onion yield and maximum yield attributes including plant height, number of leaves per plants, diameter of bulb, bulb mass and total bulb yield were recorded with nitrogen application at the rate of 135 kg/ha and 112.2 kg/ha in ridge planting. The highest economic return was recorded for nitrogen application at the rate of 112.5 kg/ha in ridge planting [20].

The main problem of *Safid e Paisaye* onion is small size of bulb which ultimately leads to lower productivity. The studies show that, tillage depth, land preparation and date of planting influence the physical properties of onion bulb. Considering the long storability, flat shape, and attractive color, this variety may occupy large share in onion market with small improvements.

The study objective was to find the optimum depth of plough, method of land preparation, and date of planting for better bulb quality and physical properties of *Safid e Paisaye* onion.

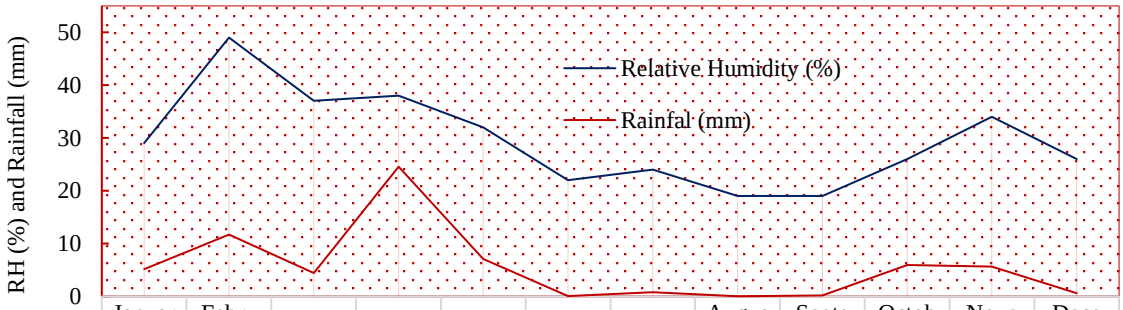
2. Methodology

The investigation was conducted during 2018 at agriculture research farm of Kabul University to study the optimum depth of plough, method of land preparation and date of planting for improved bulb quality and physical properties of *Safid e Paisaye* variety of onion. The investigation field (Kabul) has dry temperate climate with hot summer and cold winter. The common growing season in Kabul starts in April and extends till November. The monthly average weather data on temperature (°C), relative humidity (%) and rainfall (mm) and sunshine (hours) for the cropping season (2018) is presented in Figure 1. Figure 2. and figure 3., respectively.



	January	February	March	April	May	June	July	August	September	October	November	December
Maximum Temperature (ºC)	6	5	13	17	21	28	30	30	24	20	14	10
Minimum Temperature (ºC)	-2	-2	5	7	12	16	18	17	12	12	5	-1

Figure 1. Monthly average temperature (^{0}C) in Kabul, Afghanistan [21].



	January	February	March	April	May	June	July	August	September	October	November	December
Relative Humidity (%)	29	49	37	38	32	22	24	19	19	26	34	26
Rainfal (mm)	5.13	11.7	4.41	24.55	7.1	0.04	0.76	0	0.19	5.9	5.6	0.6

Figure 2. Average monthly relative humidity and rainfall in Kabul, Afghanistan [21].

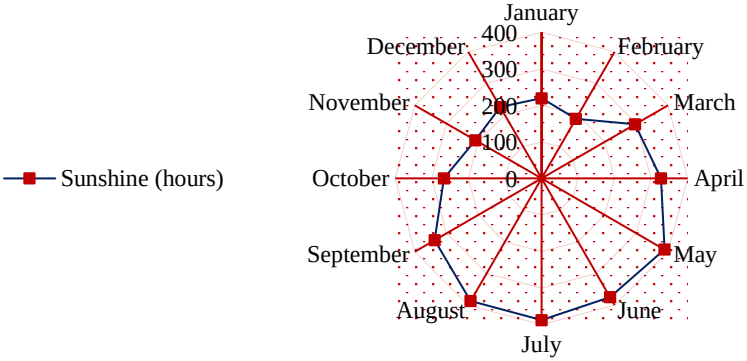


Figure 3. Average monthly sunshine hours in Kabul, Afghanistan [21].

The study was laid out in Split-Split Plot Randomized Complete Block Design (RCBD) with eighteen treatments, each replicated three times. The depth of plough at two level (25 cm and 10 cm) was allocated to mail plots. The methods of land preparation at three-level (flat bed, 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 depths of 10 cm and 25 cm. The beds of the plots were prepared in the form of 1) flat bed, 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 sown in nursery for 8 weeks prior to transplanting in the field. In other words, for the transplanting dates 10th May, 1st June, and 20th June, the seeds were sown in nursery on 10th March, 1st April, and 20th April, respectively.

The recommended dosage of chemical fertilizer (nitrogen at 90 kg/ha, phosphorus at 60 kg/ha and potassium at 45 kg/ha) and farm yard manure (at 15 Mt/ha) 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 the spacing of 20 cm between two rows and 12-15 cm between two plants. The weeds were controlled mechanically by hand weeding method. To prevent fungal diseases especially powdery mildew, the leaves were sprayed with 0.2 % Mancozeb fungicide solution, especially during the rainy season.

When 50% leaves dried, the bulbs were harvest and then cured for one month under ventilated conditions. The bulbs were then used for recording data of different physical properties.

The bulb width (largest equatorial diameter), length (polar diameter) and thickness (smallest equatorial diameter) were recorded in centimeters with the help of calipers. The number of scales were physically counted on cross cut bulbs. The fresh bulb weight in grams was recorded using digital weighing balance and the bulb volume in cubic centimeters was recorded using the water displacement method. Equatorial firmness (Kg/cm^2) and polar firmness (Kg/cm^2) were recorded using penetrometer (13 kg). Other parameters including geometric mean diameter (D_{gm}), arithmetic mean diameter (D_{am}), shape index (SI), sphericity (S), roundness (R), ellipsoid ratio (ER), frontal surface area (A_{FS}), cross sectional area (A_{CS}) and total area (A_T) of the bulbs were calculated using the following formulas (W, L and T represents width, length and thickness respectively) [22–25].

$$D_{gm} = \sqrt[3]{W*L*T} \quad (1)$$

$$D_{am} = (W + L + T)/3 \quad (2)$$

$$SI = L/\sqrt{W*T} \quad (3)$$

$$S = D_{gm}/W \quad (4)$$

$$R = T/W \quad (5)$$

$$ER = W/T \quad (6)$$

$$A_{FS} = \frac{\pi}{4}(W*L) \quad (7)$$

$$ACS = (\frac{\pi}{4})\,((W + L + T)^2/9) \quad (8)$$

$$A_T = \pi(D_{gm})^2 \quad (9)$$

The obtained data was statistically analyzed with the help of R software for statistical analysis. Least Significant Difference (LSD) at p=0.05 was used to find the differences among treatments.

3. Results and discussion

3.1. Buld diameters

The influence of plough depth, land preparation methods, and date of planting and their interactions on bulb width (cm), length (cm), thickness (cm), geometric mean diameter (cm) and arithmetic mean diameter (cm) of *Safid e Paisaye* onion are presented in table 1. Plough depth and land preparation had non-significant influence on bulb width, length, thickness, geometric mean diameter and arithmetic mean diameter. The date of planting had highly significant effect on bulb width, length, thickness, geometric mean diameter and arithmetic mean diameter. The highest bulb width (6.95 cm), length (4.42 cm), thickness (6.75 cm), geometric mean diameter (5.91 cm) and arithmetic mean diameter (6.04 cm) were observed in the first planting date (10th May) and the lowest bulb width (5.29 cm), length (3.73 cm), thickness (5.15 cm), geometric mean diameter (4.66 cm) and arithmetic mean diameter (4.72 cm) were observed in the third planting date (20th June). Suitable climate conditions and higher day length can play a role in bulb development. Khokhar [12] also reported that long days and high temperatures promote onion bulb formation. The authors [13–15,18,20] reported similar results.

Table 1: The effect of plough depth, land preparation and date of planting on bulb width (cm), length (cm), thickness (cm), geometric mean diameter (cm), and arithmetic mean diameter (cm) of *Safid e Paisaye* onion.

Treatment	Bulb width (cm)	Bulb length (cm)	Bulb thickness (cm)	Geometric mean diameter (cm)	Arithmetic mean diameter (cm)
Plough Depth (A)					
Deep plough (25 cm)	6.18	4.12	6.02	5.35	5.44
Shallow plough (10 cm)	6.09	3.97	5.94	5.23	5.33
F-test	NS	NS	NS	NS	NS
Land Preparation (B)					
Flat bed	6.37	4.15	6.21	5.47	5.58
Single row raised bed	5.98	3.91	5.83	5.15	5.24
Double row raised bed	6.06	4.07	5.89	5.25	5.34

F-test	NS	NS	NS	NS	NS
Planting Date (C)					
10th May	6.95 a	4.42 a	6.75 a	5.91 a	6.04 a
1st June	6.18 b	3.98 b	6.04 b	5.29 b	5.40 b
20th June	5.29 c	3.73 c	5.15 c	4.66 c	4.72 c
F-test	**	**	**	**	**
Interaction					
A×B	NS	NS	NS	NS	NS
A×C	NS	NS	NS	NS	NS
B×C	NS	NS	NS	NS	NS
A×B×C	NS	NS	NS	NS	NS

** and NS: highly significant, and non-significant, respectively. Means in same column for each factor having the same letter are not significantly different based on LSD at 0.05 level.

3.2. Buld area

The effect of plough depth, land preparation and date of planting and their interactions on bulb frontal surface area (cm^2), cross sectional area (cm^2) and total area (cm^2) of *Safid e Paisaye* onion is presented in Table 2. The effect of plough depth and land preparation methods was non-significant on bulb frontal surface area, cross-sectional area and total area. The effect of planting date was highly significant on bulb frontal surface area, cross sectional area and total area. The highest bulb frontal surface area (24.26 cm^2), cross-sectional area (28.84 cm^2) and total area (110.63 cm^2) were recorded for the first planting date (10th May) and the lowest bulb frontal surface area (15.55 cm^2), cross-sectional area (17.62 cm^2) and total area (68.63 cm^2) were recorded for third planting date (20th June). Suitable climatic conditions and longer day length during the bulb enlargement stage of onion could be the reason for larger bulbs with higher surface area. Authors [4,11,13,20,26] reported that, early planted onion produces larger bulbs.

3.3. Bulb firmness and number of scales per bulb

Table 3 shows the influence of plough depth, land preparation and date of planting and their interactions on number of scales per bulb, equatorial firmness (Kg/cm^2) and polar firmness (Kg/cm^2) of *Safid e Paisaye* onion. The effect of all three studied factors (depth of plough, methods of land preparation and date of planting) and their interactions was not significant on number of scales per bulb, equatorial firmness and polar firmness of onion bulb. Authors [4,27] also reported similar results.

Table 2: The effect of plough depth, land preparation and date of planting on frontal surface area (cm^2), cross sectional area (cm^2) and total area (cm^2) of bulbs of *Safid e Paisaye* onion.

Treatment	Frontal surface area (cm^2)	Cross sectional area (cm^2)	Total area (cm^2)
Plough Depth (A)			
Deep plough (25 cm)	20.3	23.7	91.5
Shallow plough (10 cm)	19.17	22.64	87.05
F-test	NS	NS	NS
Land Preparation (B)			
Flat bed	20.91	24.77	95.09
Single row raised bed	18.63	21.88	84.38
Double row raised bed	19.67	22.86	88.34
F-test	NS	NS	NS
Planting Date (C)			
10th May	24.26 a	28.84 a	110.63 a
1st June	19.40 b	23.05 b	88.55 b
20th June	15.55 c	17.62 c	68.63 c
F-test	**	**	**
Interaction			
A×B	NS	NS	NS
A×C	NS	NS	NS
B×C	NS	NS	NS
A×B×C	NS	NS	NS

** and NS: highly significant and non-significant, respectively. Means in same column for each factor having the same letter are not significantly different based on LSD at 0.05 level.

Table 3: The effect of plough depth, land preparation and date of planting on number of scales per bulb, equatorial firmness (kg/cm^2) and polar firmness (kg/cm^2) of bulbs of *Safid e Paisaye* onion.

Treatment	Number of scales per bulb	Equatorial firmness (Kg/cm^2)	Polar firmness (Kg/cm^2)
Plough Depth (A)			
Deep plough (25 cm)	11.59	10.05	10.97
Shallow plough (10 cm)	11.88	10.85	10.13
F-test	NS	NS	NS
Land Preparation (B)			
Flat bed	11.61	10.63	10.58
Single row raised bed	11.94	10.39	10.24
Double row raised bed	11.66	10.34	10.83
F-test	NS	NS	NS
Planting Date (C)			
10th May	11.27	10.36	10.14
1st June	11.83	10.51	10.92

20th June	12.11	10.49	10.59
F-test	NS	NS	NS
Interaction			
A×B	NS	NS	NS
A×C	NS	NS	NS
B×C	NS	NS	NS
A×B×C	NS	NS	NS

NS: Non-significant

3.4. Bulb shape

The effect of plough depth, land preparation methods and date of planting and their interactions on shape index, sphericity, roundness and ellipsoid ratio of *Safid e Paisaye* onion bulbs is presented in Table 4. The effect of plough depth and land preparation was found non-significant on shape index, sphericity, roundness and ellipsoid ratio of onion bulbs. The planting date had a highly significant influence on both shape index and sphericity whereas its effect on roundness and ellipsoid ratio of onion bulbs was non-significant. The lowest value for both shape index (0.64) and sphericity (0.85) were recorded for the first planting date (10th May) and the highest value for shape index (0.71) and sphericity (0.88) were recorded for the third planting date (20th June). The lower values for shape index and sphericity show that the bulbs have flat shape, which is one of the criteria of variety *Safid e Paisaye.* Suitable climatic conditions and longer growing seasons may have allowed the bulbs to reach their proper maturity and obtain its morphological characters. Authors [11,14,15,18,20] reported similar results.

Table 4: The effect of plough depth, land preparation and date of planting on shape index, sphericity, roundness and ellipsoid ratio of bulbs of *Safid e Paisaye* onion.

Treatment	Shape index	Sphericity	Roundness	Ellipsoid ratio
Plough Depth (A)				
Deep plough (25 cm)	0.68	0.86	0.97	1.02
Shallow plough (10 cm)	0.66	0.86	0.97	1.02
F-test	NS	NS	NS	NS
Land Preparation (B)				
Flat bed	0.66	0.86	0.97	1.02
Single row raised bed	0.66	0.86	0.97	1.02
Double row raised bed	0.68	0.87	0.97	1.02
F-test	NS	NS	NS	NS
Planting Date (C)				
10th May	0.64 b	0.85 b	0.97	1.03
1st June	0.65 b	0.85 b	0.97	1.02
20th June	0.71 a	0.88 a	0.97	1.02
F-test	**	**	NS	NS
Interaction				
A×B	NS	NS	NS	NS
A×C	NS	NS	NS	NS
B×C	NS	NS	NS	NS
A×B×C	NS	NS	NS	NS

** and NS: highly significant and non-significant, respectively. Means in same column for each factor having the same letter are not significantly different based on LSD at 0.05 level.

4. New findings

The findings of the study reveal that, under the dry temperate climate of Kabul – Afghanistan, the *Safid e Paisaye* onion sown early in March and transplanted early in May produces larger bulbs and bulb size reduces with delay in planting date. Early planting help to maintain the proper shape of onion bulb. Physical properties of onion bulb are not influenced by the depth of plough and methods of land preparation. Since the depth of plough and land preparation methods do not have a significant effect on bulb size and physical properties, shallow plough and flat bed can be followed for production of *Safid e Paisaye* onion.

5. Conclusion

It is concluded that, early planting of *Safid e Paisaye* onion can significantly increase bulb size and improve bulb physical characteristics. This also helps to maintain the flat and round shape of onion bulb. Land preparation method and plough depth do not have significant influence on physical properties of onion bulb. Based on this investigation's findings, the farmers are recommended to follow the early nursery raising (early March) and early transplanting (early May) for improved quality and larger bulb size of *Safid e Paisaye* onion. The shallow plough and flat bed may further allow the farmers to reduce the operational costs and decrease the risk of soil degradation.

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