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Effect of cultural practices on quality and yield of onion (Allium cepa L. Var. Safid e Paisaye)

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ABSTRACT

Onion (Allium cepa L.) is among the most cultivated vegetable crops in the world. Afghanistan is thought to be the origin as several local and wild varieties are found in different parts of the country. *Safid e Paisaye* is a local variety grown in central parts of Afghanistan in the *Ghorband* valley. This variety has long storability and high market demand among restaurants in the region, but little research has been done to increase the quality and its availability to the market to increase its market share in Afghanistan. Conducted under supervision of Amity University Uttar Pradesh, Noida, India, at Agriculture Faculty Research Farm of Kabul University, this investigation looks at plough depth, land preparation methods, and planting date on quality and yield of onion bulb; it also studied other cultural practices including irrigation and fertilization dose and frequency. The parameters studied in this investigation include neck diameter (cm), bulb diameter (cm), neck to bulb ratio, bulb weight (gr), bulb volume (cm^3), bulb density (gr/cm^3), Total Soluble Solids (TSS) (Brix), firmness (Kg/cm^2), marketable yield (MT/Ha), and total yield (MT/Ha). The data revealed that planting date has significant influence on bulb quality and yield of onion. The highest bulb diameter (6.95 cm), bulb weight (121 gr), bulb volume (128 cm3), marketable yield (32.54 MT/Ha), and total yield (34.24 MT/Ha) and the lowest neck to bulb ratio (0.04) were recorded for the first planting date (seed sown in nursery on 10 March - seedlings planted in field on 10 May). Land preparation methods only had significant influence on marketable yield; the highest marketable yield (26.90 MT/Ha) was recorded for flat bed land preparation method. Plough depth had no significant influence on onion quality and yield. Bulb density, TSS,and firmness were not significantly influenced by factors studied in this investigation. Conclusions: early sowing and planting of onion variety *Safid e paisaye* can significantly increase yield and productivity. Flat bed land preparation method is more suitable for higher productivity of onion variety *Safid e Paisaye* as compared to raised beds.

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1. Introduction

Onion (Allium cepa L.) is a major bulbous crop among the cultivated vegetables in the world. This crop is widely grown in Afghanistan with different qualities and levels of yield. In Afghanistan during year 2017, onion production reached to 212,000 metric tons for both local consumption and export [1]. Afghanistan is thought to be the origin for this crop [2], and several local varieties are grown in different parts of the country. The Safid e Paisaye variety is grown in central parts of the country especially in the Ghorband valley located around 80 km away from Kabul. Safid e Paisaye means "white coin-like", which refers to its white color and a flat round bulb of medium size. The onion has long storability and high demand in the market as it is preferred in regional restaurants making a special local dish named "Do Piaza".

The onion is globally well-known for its nutritional and medicinal value. It contains phenolic compounds and flavonoids that have potential anti-inflammatory, anti-cholesterol, anti-cancer, and antioxidant properties. Onions contain vitamins (B1, B2 and C), minerals (potassium, selenium), polysaccharides (fructosans, saccharose, peptides and flavonoids), essential oils, and a large number of sulfur compounds (thiosulfinates and thiosulfonates, cepaenes, sulfur-oxides, sulfur-dioxides, mono-sulfides, di-sulfides, tri-sulfides and sulfoxides) [3,20], Onions are usually cooked as a vegetable or part of a dish, or they can be eaten raw or used to make pickles or chutneys.

Gami et al. [4] noticed in field experiments that tillage depth significantly affects onion quality. A plough depth of 22.5 cm significantly increased growth parameters, yield attributes, and bulb yield which resulted in higher remuneration compared to 15 cm and 7.5 cm tillage depths. Varying widely among regions, transplanting dates of onion seedlings reflects the effect of environmental conditions on growth, bulb yield, and bulb quality. It is critical to identify the optimum transplanting dates for maximum quality and quantity [5–7]. Cultivation method dictates the effective utilization of water irrigation. Wide furrows may lead to saving irrigation water while maintaining satisfactory levels of production. Research is needed to study reducing water losses and improve management of irrigation water for local farmers [8–10]. Significant decrease in total yield of onion was noticed when soil water stress increased below -50 kPa [11]. Sumalatha et al. [12] looked at seasonal devastation caused by pests during field experiments at Parbhani, Maharashtra, India.

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These investaigators looked at seasonal infestation threats of onion thrips on the Kharif onion which could impact the ladybird beetle (coccinellids) population (which prey on thrips) and onion bulb yield. The highest number of thrips was noticed between October to December 2016. Non-significant correlation was observed between weather parameters and thrips population. The ladybird beetle population tracked the thrips population, and a maximum count was obtained during November when pest abundance was high. However, the population of coccinellids was negatively influenced with temperature, wind velocity, and evaporation. These studies concluded that the lower population of thrips was noticed in crops transplanted between 20 July and 30 July as seedlings. The highest population of thrips was recorded in seedlings transplanted between 20 August and 10 September.

Small bulb size remains the major problem of Safid e Paisaye variety. The previously mentioned studies shows that plough depth, land preparation method, and planting date influence the quality (including bulb size) and yield of onion. These studies also reveal that planting date influences the pest population on the onion crop which plays a vital role in final product quality. No work has been done to improve this onion variety's quality and yield in the market. Due to its long storability and high market demand, with small improvements, this variety can occupy a larger share of onion market in Afghanistan.

This objective of this investigation was to investigate the optimal plough depth (25 cm and 10 cm), land preparation methods (flat bed, single row raised bed, double row raised bed), and planting date (seeds sown in nursery on 10th March, 1st April and 20th April and seedlings transplanted in field on 10th May, 1st June and 20th June respectively) for improved quality and yield of the onion variety Safid e Paisaye.

2. Methodology

This study was carried out during the year 2018 at the research farm of the Agriculture Faculty of Kabul University to investigate the optimal plough depth, land preparation methods, and planting date for improved quality and yield of onion variety Safid e Paisaye. The climate of investigation field (Kabul) is dry temperate, and the common growing season is from April to November. The average monthly weather data on maximum and minimum temperature, relative humidity, sunshine hours, and rainfall during the cropping season are presented.

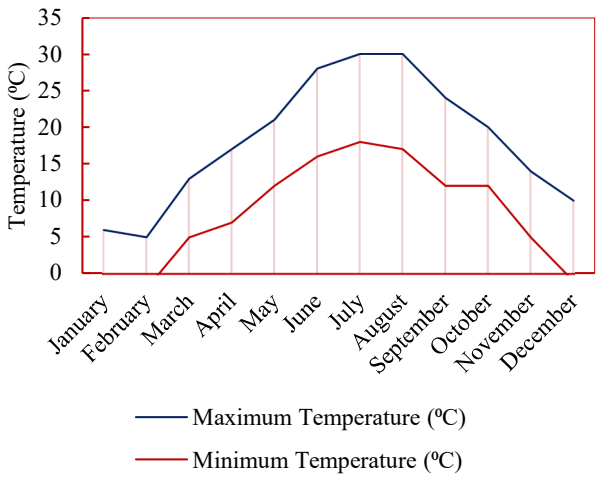

Figure 1. Average monthly temperature (ºC) in Kabul, Afghanistan [13].

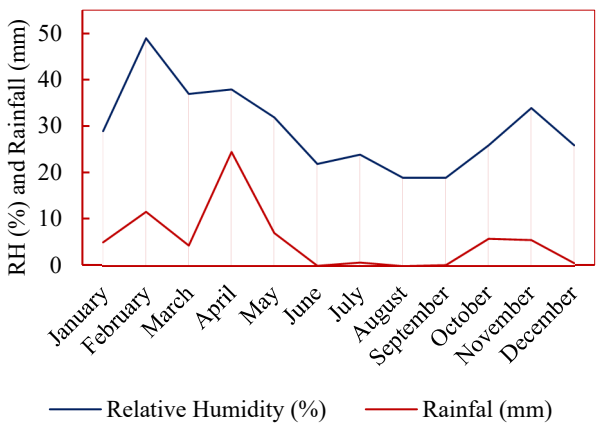

Figure 2. Average monthly relative humidity and rainfall in Kabul, Afghanistan [13].

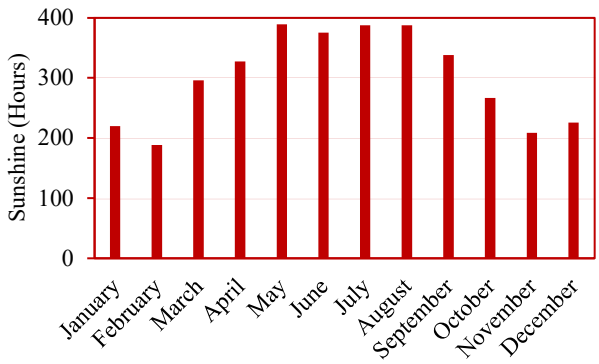

Figure 3. Average monthly sunshine hours in Kabul, Afghanistan [13].

Recommended cultural practices for nursery raising, field preparation, spacing, fertilization, irrigation, weeding, and plant protection were followed in order to obtain a successful crop.

1- Nursery raising: the seed for this onion variety was procured from a local farmer in the Ghurband valley located in Parwan province of Afghanistan. The seed was sown in a nursery for 8 weeks, and transplants were then moved to the field. Seeds were sown in nursery on 10 March, 1 April, and 20 April, and the seedlings were transplanted on 10 May, 1 June, and 20 June respectively.

2- Field preparation: the experimental plot were plowed twice followed by leveling and clod crushing. The plots were ploughed to depths of 10 or 25 centimeters. The plot beds were prepared in three different methods: flat bed, raised beds with the height of 10 cm and width of 20 cm with a single row of onion cultivated on the top of the raised bed, and raised beds with the height of 10 cm and width of 40 cm with two rows of onion cultivated on its top.

3- Fertilization: recommended doses of Farm Yard Manure (15 Mt/ha), nitrogen (90 kg/ha), phosphorus (60 kg/ha) and potassium (45 kg/ha) were applied to all the plots. Before planting, half of nitrogen in the form of urea (46% N), all phosphorus in form of Di-Ammonium Phosphate (46% P2O5), and all potassium in the form of Sulphate of Potash (50% K2O) were applied to the field. The remaining nitrogen was applied at the top, with two additional applications after 4 and 8 weeks of planting.

4- Irrigation: the flood irrigation method was used. Frequency of irrigation was decided based on climatic conditions (once in 7-10 days).

5- Spacing: the seedlings were planted with 20 cm between two rows and 12-15 cm between two plants in a row.

6- Weeding: experimental plots were kept free from weeds by mechanical weed control method (hand weeding).

7- Disease control: during rainy period, to prevent the growth of powdery mildew on the leaves, all crops were sprayed with 0.2 % Mancozeb fungicide solution.

The experiment is laid out in Split-Split Plot Randomized Complete Block Design (RCBD) with three replications. The main plots were designated for plough depth (25 cm and 10 cm). In subplots, the land preparation methods (flat bed, single row raised bed, double row raised bed) were randomly applied, and planting date (seeds sown in nursery on 10th March, 1st April and 20th April and seedlings transplanted in field on 10th May, 1st June and 20th June respectively) was allocated randomly in sub-subplots.

Figure 4. A view of study field.

The crop was harvested when 50% leaves dried. The bulbs were then cured for period of one month under ventilated conditions. The cured bulbs were used for recording data of different quality and yield parameters.

Marketable yield and total yield were recorded in kg/plot and presented in Metric Tons per Hectare. Neck diameter (cm) and equatorial bulb diameter (cm) were measured with calipers, and neck-to-bulb ratio was calculated. A digital weighing balance (g) was used for bulb weight. Bulb volume (cm3) was measured based on the water displacement method. Bulb density (g/cm3) was calculated as ratio of bulb weight to bulb volume. TSS (Brix) was recorded with the help of hand refractometer (0-32 ^{0}B), and the firmness (Kg/cm2) was measured with the help of penetrometer (13 kg).

The data for all parameters was recorded from three randomly selected bulbs from each treatment. The data obtained was statistically analyzed using R statistical analysis software. After calculation of ANOVA, Least Significant Difference (LSD) is calculated to find the difference among treatments. Level of significance used is at p=0.05.

3. Results and discussion

3.1. Yield parameters

The effects of plough depth, land preparation, and planting date and their interactions on marketable yield (MT/Ha) and total yield (MT/Ha) of onion variety Safid e Paisaye are shown in table 1. Plough depth had no significant effect on both marketable and total yield. Land preparation method was found to be significant on marketable yield but non-significant on total yield; the highest marketable yield (26.90 MT/Ha) was observed in flat bed, and the lowest (22.51 MT/Ha) was observed in single row raised beds. Planting date had highly significant effect on both marketable yield and total yield. The highest marketable yield (32.54 MT/Ha) and total yield (34.25 MT/Ha) were recorded for the first planting date (nursery on 10 March and transplanted on 10 May) and the lowest marketable yield (16.67 MT/Ha) and total yield (18.00 MT/Ha) were observed in third planting date (nursery on 20 April and transplanted on 20 June).

Suitable climate conditions could play a role during bulb growth and development stages. Similar results are reported by the Authors [10,14–16].

Table 1: Marketable yield (MT/Ha) and total yield (MT/Ha) as influenced by plough depth, land preparation method, and planting date of *Safid e paisaye* onion.

Treatment	Marketable Yield (MT/Ha)	Total Yield (MT/Ha)
Plough Depth (A)		
Deep plough (25 cm)	25.50	26.95
Shallow plough (10 cm)	23.43	24.95
F-test	N.S.	N.S.
Land Preparation (B)		
Flat bed	26.90 a	28.49
Single row raised bed	22.51 b	23.97
Double row raised bed	23.99 ab	25.39
F-test	*	N.S.
Planting Date (C)		
10th May	32.54 a	34.25 a
1st June	24.19 b	25.61 b
20th June	16.67 c	18.00 c
F-test	**	**
Interaction		
A×B	N.S.	N.S.
A×C	N.S.	N.S.
B×C	N.S.	N.S.
A×B×C	N.S.	N.S.

*, ** and N.S.: significant, highly significant, and non-significant, respectively. Means within the same column for each factor followed by the same letter are not significantly different, according to LSD at 0.05 level.

Table 2: Bulb diameter (cm), neck diameter and neck-to-bulb ratio as influenced by plough depth, land preparation method and planting date of Safid e paisaye onion and their interactions.

Treatment	Bulb Diameter (cm)	Neck Diameter (cm)	Neck to Bulb Ratio
Plough Depth (A)			
Deep plough (25 cm)	6.18	0.29	0.05
Shallow plough (10 cm)	6.09	0.29	0.05
F-test	N.S.	N.S.	N.S.
Land Preparation (B)			
Flat bed	6.37	0.29	0.05
Single row raised bed	5.98	0.26	0.04
Double row raised bed	6.06	0.33	0.06
F-test	N.S.	N.S.	N.S.
Planting Date (C)			
10th May	6.95 a	0.28	0.04 a
1st June	6.18 b	0.32	0.05 b
20th June	5.29 c	0.28	0.05 b
F-test	**	N.S.	**
Interaction			
A×B	N.S.	N.S.	N.S.
A×C	N.S.	N.S.	N.S.
B×C	N.S.	**	*
A×B×C	N.S.	N.S.	N.S.

*, ** and N.S.: significant, highly significant and non-significant, respectively. Means within the same column for each factor followed by the same letter are not significantly different, according to LSD at 0.05 level.

3.2. Quality parameters

Table 4 presents the effects of plough depth, land preparation method, and planting date and their interactions on bulb weight (g), bulb volume (cm3), bulb density (g/cm3), TSS (Brix) and firmness (Kg/cm2) of onion variety Safid e Paisaye. Bulb density, TSS and firmness were not significantly influenced by any of investigation factors and their interactions. Planting date had significant effect on both bulb weight and volume while plough depth and land preparation method did not. The highest bulb weight (121 g) and bulb volume (128.07) were recorded for the first planting date (nursery on 10 March and transplanted on 10 May) and the lowest bulb weight (60.38 g) and bulb volume (64.07) were recorded for third planting date (nursery on 20 April and transplanted on 20 June). Suitable climatic conditions during bulb growth stage might be the possible reason for this. Authors are also reported that delay in sowing date reduces bulb weight [10,16,17].

Table 3: Lowest values of neck diameter (cm) and neck-to-bulb ratio of *Safid e paisaye* onion as affected by significant interaction among the experimental factors.

Variable	Lowest Values	Treatment
Neck Diameter (cm)	0.23	1st June × Flat bed
Neck to Bulb Ratio	0.03	1st June × Flat bed

3.3. Diameters

The effect of plough depth, land preparation method and planting date and their interactions on bulb diameter (cm), neck diameter (cm) and neck to bulb ratio of onion variety *Safid e Paisaye* is shown in table 2. Plough depth and land preparation methods were not significant on bulb diameter, neck diameter and neck-to-bulb ratio. Planting date was significant for bulb diameter and neck-to-bulb ratio but not significant for neck diameter. The highest bulb diameter (6.95 cm) and lowest neck to bulb ratio (0.04) were recorded for the first planting date (nursery on 10 March and transplanted on 10 May) and the lowest bulb diameter (5.29 cm) and highest neck to bulb ratio (0.05) were recorded for third planting date (nursery on 20 April and transplanted on 20 June). The interaction between land preparation method and planting date was found to be highly significant for neck diameter and significant for neck-to-bulb ratio. The combination of second planting date (nursery on 1 April and transplanted on 1 June) and flat bed land preparation method recorded the lowest values 0.23 cm and 0.03 for neck diameter and neck-to-bulb ratio respectively (table 3). This might be due to suitable climate conditions during bulb enlargement stage of onion growth. Authors are [10,18,19] reported higher bulb diameters for early planting dates. Bosekeng and Coetzer [20] reported thinner neck diameters for later planting dates.

Table 4: Bulb weight (g), bulb volume (cm^3), bulb density (g/cm^3), TSS (Brix) and firmness (Kg/cm^2) as influenced by plough depth, land preparation method and planting date of *Safid e paisaye* onion and their interactions.

Treatment	Bulb Weight (g)	Bulb Volume (cm3)	Bulb Density (g/cm3)	TSS (Brix)	Firmness (Kg/cm2)
Plough depth (A)					
Deep plough (25 cm)	92.81	98.22	0.943	9.79	10.05
Shallow plough (10 cm)	87.11	92.41	0.944	10.16	10.85
F-test	N.S.	N.S.	N.S.	N.S.	N.S.
Land preparation (B)					
Flat bed	98.38	104.19	0.943	9.91	10.63
Single row raised bed	83.11	88.15	0.943	10.42	10.39
Double row raised bed	88.38	93.62	0.944	9.59	10.34
F-test	N.S.	N.S.	N.S.	N.S.	N.S.
Planting date (C)					
10th May	121.00 a	128.07 a	0.944	10.00	10.36
1st June	88.50 b	93.81 b	0.943	9.55	10.51
20th June	60.38 c	64.07 c	0.942	10.38	10.49
F-test	**	**	N.S.	N.S.	N.S.
Interaction					
A×B	N.S.	N.S.	N.S.	N.S.	N.S.
A×C	N.S.	N.S.	N.S.	N.S.	N.S.
B×C	N.S.	N.S.	N.S.	N.S.	N.S.
A×B×C	N.S.	N.S.	N.S.	N.S.	N.S.

*, ** and N.S.: significant, highly significant and non-significant, respectively. Means within the same column for each factor followed by the same letter are not significantly different, according to LSD at 0.05 level.

4. Discussion

The results of the investigation shows that early nursery sowing (10 March) of onion variety *Safid e Paisaye* seed and planting after 8 weeks (10 May) can significantly increase bulb size and yield. Flat bed preparation is more suitable for higher yield production compared to raised beds. Bulb quality (TSS, firmness and density) is not influenced by plough depth, land preparation method and planting date. Because planting depth has not significantly influenced bulb quality, size and yield, deep ploughing is not required for production of onion variety *Safid e Paisaye* likely due to its shallow root system.

5. Conclusion

We conclude that for higher productivity and better quality of onion variety *Safid e Paisaye*, the following cultural practices should be followed:

1- Nursery raising: sowing seed of this variety of onion in nursery should be scheduled early in March, and seedlings should be transplanted after 8 weeks.

2- Land preparation: Flat bed land preparation is more suitable for higher productivity of onion variety Safid e Paisaye as compared to raised beds. Deep ploughing is not required, and good productivity may occur with shallow (10 cm) ploughed fields.

3- Fertilization: recommended doses of Farm Yard Manure (15 Mt/ha), nitrogen (90 kg/ha), phosphorus (60 kg/ha) and potassium (45 kg/ha) should be applied to field. All farm yard manure, half of nitrogen, all phosphorus and all potassium should be applied during land preparation (before planting), and the remaining nitrogen should be applied after 4 and 8 weeks of planting.

4- Irrigation: flood irrigation method can be applied with a frequency of once in 7-10 days (depending on on climatic conditions).

5- Spacing: the seedlings are planted with 20 cm between two rows and 12-15 cm between two plants in a row.

6- Weeding: the field should be kept free from weeds by mechanical or hand weeding method.

7- Disease control: since powdery mildew may infect the leaves during rainy periods, the plants should be sprayed with 0.2 % Mancozeb fungicide solution.

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