SAARC J. Agric., 21(2): 251-261 (2023) *DOI: https://doi.org/10.3329/sja.v21i2.69780*

EFFECT OF PLANT SPACING AND MULCHING ON GROWTH, YIELD AND QUALITY OF SQUASH

M.A. Hossen[1*], M.N. Islam[1], M.J. Rahman[1], M.M. Uddin[2], H.M.M.T. Hossain[3] and S. Akther[4]

[1]Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh
[2]Bangladesh Agricultural Research Institute, Gazipur, Bangladesh
[3]Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh
[4]Agronomy Division, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh

ABSTRACT

An experiment was conducted at the Vegetable Research field of Horticulture Research Centre Division, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh, during October 2018 to February 2019to find out the effect of plant spacingand mulchon yield and yield attributes of squash. The experiment comprised two sets of treatments viz., (a) Plant spacing:(i) 1 m × 0.8 m (S_1); (ii) 1 m × 1 m (S_2) and 1m × 1.5 (S_3) and (b)Mulch: (i) No mulch (M_1); (ii) Straw mulch(M_2) and (iii)Polythene mulch (M_3) in a randomized complete block design (RCBD) with three replications. The variety BARI squash-1 was used in this experiment. The results showed that 1m × 1.5 plant spacing showed significantly the highest yield attributes and quality parameters but 1m × 1 m plant spacing showed significantly the highest yield ha^{-1}. Polythene mulch showed significantly the highest fruit $plant^{-1}$, yield $plant^{-1}$ and yield ha^{-1}. Fruit size, individual fruit weight and quality parameter did not show any significant difference irrespective of mulching. The interaction between plant spacing and mulch was significant for yield and quality parameters. Based on the study results it is concluded that maximum yield (50.20 t ha^{-1}) was achieved through 1m × 1 m plant spacing with polythene much but higher TSS and vitamin C was found through 1m × 1.5 m plant spacing with polythene much.

Keywords: Squash, Plant spacing, Mulch, Yield and Quality.

INTRODUCTION

Squash (*Cucurbita pepo* L.) is a cucurbit vegetables crop. It is widely cultivated in the world. This crop is relatively new in Bangladesh, but it is gaining popularity day by day as well as growing in economic significance, both in terms of generating cash

* Corresponding author: afzalhossen@gmail.com

Received: 07.05.2023 *Accepted: 22.12.2023*

and providing nutritional value. It is commonly known as zucchini. It is also known as marrow, courgette, baby marrow, summer squash, bush squash etc. Squash has various health benefits to human as well as medicinal potentials (Mohammad et al., 2011). It contains a variety of vitamins, minerals, amino acids, carbohydrates, and minerals, especially potassium, as well as phenolics, flavonoids, β-carotene, vitamin A, vitamin B_2, α-tocopherol, vitamin C, and vitamin E. It has various medicinal effects comprising anti-diabetic, anti-hypertensive, anti-tumor, anti-mutagenic, immune modulating, anti-bacterial, anti-hypercholestero-lemic, intestinal anti-parasitic, antalgic, and anti-inflammation effects, and utilization possibilities of Cucurbitaceous crops have been reported (Kostalova et al., 2009).

Plant density is an important parameter affecting yield. As a principle, inter-species competition always decreases yield at excessive high populations. However, environmental parameters including light, space, water and soil are not optimally used at excessively low populations and so, the yield decreases (Cormark & Smith, 1998; Rassam et al., 2007). Plants compete on the resources of atmosphere and soil. Optimum plant density depends on different factors such as: the attributes of the plant, growth period, sowing date and method, soil fertility, plant size, available moisture, solar radiation, planting pattern and weeds (Ameri et al., 2007). Optimum plant spacing is one of the major factors in fruitful crop production; it permits plant to grow to their full potential above and under the ground. Optimum spacing also reduces competition between plants for water, sunlight, nutrition and fertilizers. Therefore, plant population can directly or indirectly affect the yield.

Mulches play an important role by reducing soil erosion, improving soil structure, regulating soil temperature, conserving soil moisture and controlling the weed population. Continuous use of organic mulches is also helpful in improving the organic matter content, microbial flora and better soil aeration. Maintaining optimum soil moisture in the root zone of the plants could increase its growth and yield besides conserving precious irrigation water. Mulch is a protective layer that covers the soil's surface and is made up of both organic and inorganic components (Jafarnia and Homayi, 2006). Since the 1960s, plastic mulches have been used commercially to grow vegetables (Lamont, 2005). The application of mulches helped the crop to mature 7-15 days earlier and it also contributed significantly to the plant’s height, leaf area index, and dry matter, while the application of plastic mulch treatment improved the yield and efficiency of water usage in comparison to the mulch-free treatments (Zhao et al., 2012). Mulching reduces the deterioration of soil by the way of preventing the runoff and soil loss, minimizes the weed infestation and checks the water evaporation (Kumar and Lal, 2012). Plastic mulch is very popular for its ability to maintain soil moisture (Orzolek and Murphy, 1993).

Squash cultivation has a great opportunity in Bangladesh as a quick growing vegetable. There is limited information on how plant spacing and mulch affect summer squash (*Cucurbita pepo* L.), a newly introduced crop in Bangladesh. So the present study was conducted to find out the effect different plant spacing and mulching on yield and quality of squash in Bangladesh.

MATERIALS AND METHODS

Research Location

The research work was conducted at Vegetable Research field of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh during the period of October 2018 to March 2019. The experimental site is located at 24.0° N latitude and 95.25° E longitude, respectively (UNDP, 1988) at an elevation of 8.4 meters from the sea level (Anon., 1995). Top soil was sandy clay loam in texture having a pH around 6.0. The selected plot was medium high land. Plenty of sunshine and moderately low temperature prevails during experimental period. The weather data during the study period are presented in Table 1.

Table 1. Monthly mean weather data during the crop growing periods at BARI, Gazipur

Year	Month	Temperature (°C)			Relative humidity (%)		Sunshine (hr./day)	Total rainfall (mm)
		Maximum	Minimum	Average	9 am	2 pm		
2018	October	32.10	23.17	27.64	80.16	64.06	5.89	67.4
	November	30.87	18.67	24.77	76.20	54.87	7.38	42
	December	27.08	14.79	20.94	78.61	55.26	6.10	9.2
2019	January	28.14	13.25	20.70	77.32	46.84	7.23	0
	February	29.41	15.39	22.40	78.25	49.36	7.08	93.4
	March	32.00	19.43	25.72	72.39	52.29	7.39	126

Source: Physiology Division, Bangladesh Rice Research Institute, Joydebpur, Gazipur, Bangladesh.

Experimental Design

The experiment consisted of two factors. Factor A: Plant spacing (3) *viz*. (i) 1m × 0.8m (S_1); (ii) 1m × 1m (S_2) and 1m × 1.5m (S_3) and (b) Mulch (3): (i) No mulch (M_1); (ii) Straw mulch (M_2) and (iii) polythene mulch (M_3). The experiment was conducted in a randomized complete block design (RCBD) with three replications. The variety BARI squash-1 was used in this experiment. The layout of the experiment was prepared for distributing the combination of growing conditions and different planting dates. The 9 treatment combinations of the trail were assigned at arbitrary into 27 plots. The size of each unit plot 3m × 2m (= 6 m^2). The distance between block to block 1.0m and plots to plot distance was 0.5m.

Raising of seedlings and crop management

The seeds of BARI Squash-1 were collected from Olericulture Division, Horticulture Research Centre (HRC), BARI, Gazipur. Squash seeds were sown on 28 October 2018 in poly bags at net house of Olericulture division of BARI. Seeds were sown in polybags which were filled with loose friable, dead roots free, sandy loam soil previously mixed with well rotten cowdung. Eighteen days old seedlings were transplanted in the experimental plots. One fourth of cowdung (20 t ha^{-1}) and all of gypsum (100 kg ha^{-1}) zinc (12.5 kg ha^{-1}) and borax (10 $kgha^{-1}$), ½ TSP (175 kg ha^{-1}) and 1/3rd MoP (150 kg ha^{-1}) are to be applied, respectively during final land preparation. Cowdung @ 10 kg, TSP @ 60 g, MoP @ 50 g and Magnesium Oxide @ 8 g are to be applied each pit 7-10 days before planting. Urea @ 30 g is to be top dressed each pit at 4 split applications and MoP @ 25g to be applied 10-15 days after planting according to Krishi Projukti Hatboi (BARI, 2015). Healthy and uniform sized 18 days old seedlings were taken from the net house and were transplanted in the main field on 1 November, 2018. Plants were spaced 1m × 0.8m, 1m × 1m, 1m × 1.5m according to treatments. This operation was carried out during late hour of afternoon. The seedlings were watered after transplanting. The insects were controlled successfully by spraying Malathion 57 EC @ 2 ml/L water. The insecticide was sprayed fortnightly from a week after transplanting to a week before first harvesting. Squash fruits were harvested during maturity stage. Harvesting was started from 6 January and completed by 20 February, 2019. Harvesting was done in the morning. The harvested squashes of each plot collect separately, tagged and taken to laboratory for data collection.

Data collection and analysis method

The following data were collected from the experiment

Fruit length:

The length of the fruit was measured with a meter scale in centimeter from the neck of the fruit to the bottom of the fruit. It was measured from each plot and their average was calculated in centimeter.

Fruit diameter:

The diameter of individual fruit was measured in several directions from five selected fruits with slide calipers and the average of all directions was finally recorded and expressed in centimeter (cm).

Individual fruit weight:

From first harvest to last harvest total fruit number was counted and total fruit weight was measured from each plant of each plot to determine individual fruit weight and expressed in kilogram (kg).

Yield plant^{-1}:

Weight of matured fruits harvested from each picking in the tagged plants in each replication was recorded till final harvest and total yield of fruits per plant computed in kilogram.

Yield ha^{-1}:

After collection of fruit per plot, it was converted to ton per hectare by the following formula:

$$\text{Yield (ton ha}^{-1}\text{)} = \frac{\text{Fruit yield plot}^{-1}\text{ (kg)} \times 10000\text{ m}^2}{\text{Plot size (m}^2\text{)} \times 1\,000\text{ kg}}$$

TSS:

Total Soluble Solids (TSS) content was determined by a refractometer by placing of drop of pulp on its prism. TSS obtained from direct reading of the refractometer.

Vitamin-C content:

The reagent used for the estimation vitamin C were as follows

a) Metaphosphoric acid solution (3%)

b) Standard ascorbic solution

c) Dye solution

For estimation of vitamin C were as follows

Five ml of Standard ascorbic solution was taken in conical flask and 5 ml metaphosphoric acid (HPO_3) was added to it and shaken.

A micro burette was filled with dye solution then the mixed solution was titrated with dye using phenolphthalein as indicator solution to a pinked coloured end point, which persisted at least for 15 seconds. Dye factor was calculated using to the following formula-

$$\text{Dye factor} = \frac{0.5}{\text{Titre}}$$

Preparation of sample

10 g of sample was taken and transferred to 250 ml volumetric flask and the volume was made up to the mark with metaphosphoric acid.

Titration

Five ml of metaphosphoric acid extracted sample was taken in an aliquot and titrated with standard dye solution, using phenolphthalein as indicator to a pink coloured end point which persisted at least for 15 seconds.

Vitamin C content was calculated using to the following formula-

$$\text{Vitamin C content (mg/100 g sample)} = \frac{T \times D \times V_1}{V_2 \times W} \times 100$$

Where,

T = Titre

D= Dye factor

V_1= Volume made up

V_2= Volume of extract taken for estimation

W= Weight of sample taken for estimation

Virus incidence (%):

Incidence of virus disease recorded during the cropping period. Virus incidence was calculating by counting number of virus infected plants out of total number of plants assessed on two/three dates at 15 days interval, 30 days, 45 days and 60 days after transplanting. Percent data related to virus disease incidence is further subjected to angular transformation.

$$\text{Virus incidence (\%)} = \frac{\text{Number of virus infected plant}}{\text{Total number of pants assessed}} \times 100$$

Statistical analysis of data:

The recorded quantitative data were analyzed statistically by using MSTAT-C a computer based program to find out the variation among different treatments, treatment combinations and their interactions. Treatment means were compared by Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Effect of plant spacing

The result presented in Table 2 show that significant effect of plant spacing on fruit plant^{-1}, individual fruit weight, fruit length, yield plant^{-1} and yield ha^{-1}. Plant spacing did not play any significant impact on fruit diameter. The maximum number of fruits plant^{-1} (4.67) was obtained from S_3 (1m × 1.5m) while S_1 (0.8m × 1m) gave minimum number of fruits plant^{-1} (3.76). Wetzel and Stone (2019) who reported higher fruit number with lower population density. The highest individual fruit weight (1.36 kg) was found from S_3 while the lowest individual fruit weight (1.16 kg) was found from S_2 (1m × 1m). Aniekwe and Anike (2015) also observed similar result with the present sutdy and reported that widest plant spacing resulted higher single fruit weight compared to closest plant spacing. The longest fruit (52.58 cm) was observed from S_3 and shortest (48.77 cm) fruit was found from S_2. The highest yield plant^{-1}

(6.24 kg) was recorded from S_3 but the highest yield ha^{-1} (48.40 t) was recorded from S_2. The lowest yield $plant^{-1}$ (4.34 kg) was recorded from S_1 and lowest yield ha^{-1} (42.19 t) was recorded from S_3.

The result presented in Table 3 show that there was significant effect of plant spacing on total soluble solid (TSS) and vitamin C content. The highest total soluble solid (TSS) (6.01%) and maximum vitamin C content (14.01 mg/100g) was recorded from S_3 and the lowest TSS (5.51%) vitamin C content (12.83 mg/100g) was recorded from S_1.

Table 2. Yield parameters of squash as influenced by different plant spacing

Plant spacing	Yield parameters					
	Fruit $plant^{-1}$ (no.)	Individual fruit weight (kg)	Fruit length (cm)	Fruit diameter (cm)	Yield $plant^{-1}$ (kg)	Yield (t ha^{-1})
S_1	3.76 c	1.18 b	49.63 b	8.20	4.34 c	48.03 a
S_2	4.03 b	1.16 b	48.77 b	8.13	4.73 b	48.40 a
S_3	4.67 a	1.36 a	52.58 a	8.43	6.24 a	42.19 b
Level of significance	*	*	*	NS	*	*
CV (%)	1.38	6.38	7.93	8.66	2.40	2.12

In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability by DMRT.

S_1= 1m × 0.8m, S_2= 1m × 1m, S_3= 1m × 1.5m

Table 3. Quality parameters regarding TSS and vitamin C content of squash as influenced by different plant spacing

Plant spacing	Quality parameters	
	TSS (%)	Vitamin C content (mg/100g)
S_1	5.51 c	12.83 c
S_2	5.68 b	13.13 b
S_3	6.01 a	14.01 a
Level of significance	*	*
CV (%)	2.86	1.55

In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability by DMRT.

S_1= 1m × 0.8m, S_2= 1m × 1m, S_3= 1m × 1.5m.

Effect of mulch

The result presented in Table 4 shows that significant effect of mulching on fruit plant^{-1}, yield plant^{-1} and yield ha^{-1}. Mulching did not differ significantly on individual fruit weight, fruit length and fruit diameter. The maximum number of fruits plant^{-1} (4.41), highest yield plant^{-1} (5.24 kg) and yield ha^{-1} (47.90 t) were found from M_3 (polythene mulch) whereas the minimum number of fruits plant^{-1} (3.89), lowest yield plant^{-1}(4.98 kg) and yield ha^{-1} (44.53 t) were found from M_1 (no mulch).

The result presented in Table 5 showed that there was no significant effect of mulching on total soluble solid (TSS) and vitamin C content.

Table 4. Yield parameters of squash as influenced by different mulching

Mulch	Yield parameters					
	Fruit plant^{-1} (no.)	Individual fruit weight (kg)	Fruit length (cm)	Fruit diameter (cm)	Yield plant^{-1} (kg)	Yield (t ha^{-1})
M_1	3.89 c	1.19	49.70	8.05	4.98 b	44.53 c
M_2	4.17 b	1.23	50.05	8.28	5.09 b	46.19 b
M_3	4.41 a	1.28	51.23	8.43	5.24 a	47.90 a
Level of significance	*	NS	NS	NS	*	*
CV (%)	1.38	6.38	7.93	8.66	2.40	2.12

In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability by DMRT

M_1 = No mulch (Control), M_2 = Straw mulch, M_3 = Polythene mulch

Table 5. Quality parameters regarding TSS and vitamin C content of squash as influenced by different mulches

Mulch	Quality parameters	
	TSS (%)	Vitamin C content (mg/100g)
M_1	5.57	13.16
M_2	5.73	13.30
M_3	5.90	13.51
Level of significance	NS	NS
CV (%)	2.68	1.55

In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability by DMRT

M_1 = No mulch (Control), M_2 = Straw mulch, M_3 = Polythene mulch

Interaction effect of growing condition and planting date

Interaction effect of plant spacing and mulch date showed significant effect on fruit plant^{-1}, individual fruit weight, fruit length, yield plant^{-1} and yield ha^{-1} (Table 6) but fruit diameter did not differ any significantvariation. The maximum number of fruits plant^{-1} (5.0) was found from S_3M_3 whereas the minimum number of fruits plant^{-1} (3.53) was found from S_1M_1. The highest individual fruit weight (1.43 kg) was observed from S_3M_3 but the lowest individual fruit weight (1.12 kg) was observed from S_2M_1. The longest fruit (52.83 cm) was produced from S_3M_3 and the shortest fruit (48.07 cm) was produced from S_2M_2. The highest yield plant^{-1} (6.43 kg) was found from S_3M_3 and the lowest yield plant^{-1} (4.22 kg) was found from S_1M_1. Although the treatment combination S_3M_3 gave the highest value of all yield contributing parameters but the maximum yield ha^{-1} (50.20 t) were observed from S_2M_3 whereas the minimum yield ha^{-1} (41.03 t) were observed from S_3M_1. It might be due to higher number of plant population.

Table 7 presented interaction effect of plant spacing and mulch had significant effect on total soluble solid (TSS) and vitamin C content. The highest total soluble solid (TSS) (6.27%) and maximum vitamin C content (14.10 mg/100 g) were recorded from S_3M_3 but the lowest TSS (5.40%) and vitamin C content (12.78 mg/100 g) were recorded from S_1M_1.

Table 6. Yield parameters of squash as influenced by different plant spacing and mulch

Plant spacing ×Mulch	Yield parameters					
	Fruit plant^{-1} (no.)	Individual fruit weight (kg)	Fruit length (cm)	Fruit diameter (cm)	Yield plant^{-1} (kg)	Yield (t ha^{-1})
S_1M_1	3.53 f	1.15 de	48.13 b	8.24	4.22 f	46.07 d
S_1M_2	3.75 e	1.19 cd	49.50 ab	8.21	4.35 ef	48.03 bc
S_1M_3	4.00 d	1.22 c	51.27 ab	7.95	4.45 de	50.00 a
S_2M_1	3.82 e	1.12 e	48.13 b	7.76	4.63 cd	46.50 cd
S_2M_2	4.06 d	1.17 cde	48.07 b	8.17	4.73 c	48.50 ab
S_2M_3	4.23 c	1.20 cd	50.10 ab	8.66	4.83 c	50.20 a
S_3M_1	4.32 c	1.30 b	52.33 a	8.15	6.10 b	41.03 f
S_3M_2	4.70 b	1.35 b	52.58 a	8.45	6.20 b	42.03 ef
S_3M_3	5.00 a	1.43 a	52.83 a	8.68	6.43 a	43.50 e
Level of significance	*	*	*	NS	*	*
CV(%)	1.38	6.38	7.93	8.66	2.40	2.12

In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability by DMRT

S_1= 1m × 0.8m, S_2= 1m × 1m, S_3= 1m × 1.5m

M_1 = No mulch (Control), M_2 = Straw mulch, M_3 = Polythene mulch

Table 7. Quality parameters regarding TSS and vitamin C content of squash as influenced by different plant spacingand mulch

Plant spacing ×mulch	Quality parameters	
	TSS (%)	Vitamin C content (mg/100g)
S_1M_1	58.10 a	37.20 cd
S_1M_2	56.57 c	38.10 bc
S_1M_3	57.50 ab	39.30 b
S_2M_1	57.03 bc	36.53 d
S_2M_2	56.70 c	38.10 bc
S_2M_3	57.60 ab	38.93 b
S_3M_1	56.50 c	38.03 bc
S_3M_2	57.03 bc	37.97 bcd
S_3M_3	56.33 c	40.80 a
Level of significance	*	*
CV(%)	1.40	2.06

In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability by DMRT

S_1= 1m × 0.8m, S_2= 1m × 1m, S_3= 1 m × 1.5m

M_1 = No mulch (Control), M_2 = Straw mulch, M_3 = Polythene mulch

CONCLUSION

From the study, it may be concluded that, yield, quality and yield contributing characters of squash can be effectively manipulated by different plant spacing and mulching. Squash planted 1m × 1.5m with polythene mulch produced significantly the highest number of fruits plant^{-1}, individual fruit weight, fruit length and yield plant^{-1}. The highest total soluble solid (%) and vitamin C content (mg/100 g) also found from this treatment combination but the highest yield ha^{-1} produced from 1m × 1m with polythene mulch due to higher number of plant population.

REFERENCES

Ameri, A., Nassiri, M. and Rezvani, P. (2007). Effects of different nitrogen levels and plant density on flower, essential oils and extract production and nitrogen use efficiency of Marigold (*Calendula officinalis*). *Iranian Journal of Field Crops Research*. 5:315-325.

Aniekwe, N.L. and Anike, N.T. (2015). Effects of different mulching materials and plant densities on the environment, growth and yield of cucumber. *IOSR Journal of Agriculture and Veterinary Science. (IOSR-JAVS)*. 8(11- II): 64-72.

Anonymous, (1995). Agro-climatological data. Agromet Division, Bangladesh Meteorological Department, Joydebpur, Gazipur. Pp. 35-65.

Cormark, H.T.H. and Smith, J.M. (1998). *Calendula officinalis*, production potential and crop agronomy in southern England. Industrial Crops Products. **7**:223-229.

Jafarnia, S. and Homayi, M. (2006). A comprehensive guide to the greenhouse cultivation of cucumber and tomato. Sokhan Gostar Press, Tehran. pp.49-50.

Kostalova, Z., Hromadkova, Z. and Ebringerova, A. (2009). Chemical evaluation of seeded fruit biomass of oil pumpkin (*Cucurbita pepo* L.). *Chemical Paper*. 63:406-413.

Krishi Projukti Hatboi (2015). Seventh edition, Bangladesh Agricultural Research Institute, Gazipur-1701. Bangladesh.

Kumar, S.D. and Lal, B.R. (2012). Effect of mulching on crop production under rainfed condition: A Review. *International Journal of Research in Chemistry and Environment*. 2(2):8-20.

Lamont, W.J. (2005). Plastics: Modifying the microclimate for the production of vegetable crops. *Hort Technology.* 15(3)**:**477-481.

Mohammad, B.E., Ehsan, R. and Amin, A. (2011). Climatic suitability of growing summer squash (*Cucurbita pepo* L.) as a medicinal plant in Iran. *Notulae Scientia Biologicae.* 3(2): 39-46.

Orzolek, M.D. and Murphy, J.H. (1993). The effect of colored polyethylene mulch on yield of squash and pepper. *Proceeding National Agriculture Plasticulture Congress*. 24: 157-161.

Rassam, G., Naddaf. M. and Sefidcon, F. (2007). Effect of planting date and plant density on yield and seed yield components of anise (*Pimpinella anisum* L.). Pajouhesh Sazandegi. 75:127-133.

UNDP (1988). Land resources appraisal of Bangladesh for agricultural development. Food and Agriculture Organization of the United Nations, Rome, Report 3, Vol. 1, pp. 33-48.

Wetzel, J. and Stone, A. (2019). Yield response of winter squash to irrigation regime and planting density. *Journal of Horticultural Sciences*. 54(7): 1190–1198.

Zhao, H., Xiong, Y.C., Li, F.M., Wang, R.Y. and Qiang, S.C. (2012). Plastic film mulch for half growing season maximized WUE and yield of potato via moisture-temperature improvement in a semi-arid agro ecosystem. *Agricultural Water Management.*104:68-78.