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Effect of Inorganic Fertilizers (NPK) with Organic Sources (Biomix and Humic Acid) on the Bulb Quality and Storage Quality of Onions (*Allium cepa* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An investigation entitled "Effect of different levels of fertilizers with organic sources on growth, yield and quality of onion (*Allium cepa* L.)" was undertaken at the experimental farm, Department of Horticulture, VNMKV, Parbhani, Maharashtra, in the late *Kharif* season of 2020–21 and 2021–22. The present investigation was laid out in a factorial randomized block design (FRBD) with three different levels of recommended dose of fertilizers (RDF): F_1: RDF 80% (80:40:40 NPK kg/ha), F_2: RDF 100% (100:50:50 NPK kg/ha) and F_3: RDF 120% (120:60:60 NPK kg/ha) with six levels of organic sources, namely, S_0 : Control, S_1 : Biomix 10 kg/ha, S_2 : Biomix 12.5 kg/ha, S_3 : Biomix 15

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kg/ha, S_4 : Humic acid 05 kg/ha and S_5 : Humic acid 10 kg/ha comprising eighteen treatments and replicated thrice. The aim of this work is to study the effect of different levels of RDF and organic sources on the bulb quality and storage quality of onions (*Allium cepa* L.). The onion bulb produced under 120% RDF has recorded the higher mean values of the quality parameters, *viz.,* chlorophyll content (63.44 SPAD value), ascorbic acid content (11.71 mg/100 g), total soluble solids (12.23%), reducing sugar (2.33%), non-reducing sugar (5.27%) and total sugar (7.60%). Among the organic sources, humic acid at 10 kg/ha had the highest mean chlorophyll content (59.66 SPAD value), total soluble solids (11.91%), reducing sugar (2.29%), non-reducing sugar (5.03%), and total sugar (7.32%), with the exception of ascorbic acid (10.89 mg/100 g), which was highest at biomix 15 kg/ha. In five months of storage studies, the mean minimum physiological loss in weight (18.47%) at ambient storage was observed under 80:40:40 NPK kg/ha, and the maximum total soluble solids (%) were recorded at 120:60:60 NPK kg/ha. During a five-month storage study, the mean minimum PLW (18.55%) at ambient storage was recorded under biomix at 15 kg/ha. The mean maximum total soluble solids were found after humic acid treatment (10 kg/ha) in the fifth month of storage.

Keywords: Inorganic fertilizers; NPK; RDF; organic sources; biomix; humic acid; bulb quality; storage quality.

1. INTRODUCTION

Onion (*Allium cepa* L.) is a perennial (often biennial) monocotyledonous bulbous belonging to the Alliaceae family and one of the most important crops of vegetables and spices grown under a wide range of climatic conditions worldwide [1,2]. Recent molecular techniques that illustrated the relationships and phylogeny of the various species have largely established them [3,4]. The species of the *Allium* genus are among the ancient cultivated crops and have been commonly cultivated and used in Egyptian artefacts dating from 2700 B.C [4]. The current species, however, *Allium cepa* is known only from cultivation, but appears to have been primarily domesticated in the Central Asian Mountains by wild ancestors, especially in the Iran and Pakistan regions. In a variety of flavoured salads and soups, onion is used in both the green and mature stages for salad and spice. It is very popular in food and commonly used in almost all regions of the world for cooking, and has been used throughout history in various cultures and rituals; it is therefore called the "Kitchen Queen" [1].

In India, it is grown on an area of 1.64 million hectares with a production of 26.93 million MT and productivity of 16.43 MT per hectare [5]. In Maharashtra is also leading in total export of onion sharing almost 64% of the total produce exported from India. There is a lot of demand of Indian onion in the world, the country has exported 1,434,925 metric tons of fresh onion to the world for the worth of Rs. 2,49,668 lakh during the year 2021. The average yield per hectare of onion in India is 16.43 metric tonnes and that of Maharashtra 17.9 metric tons. Maharashtra state has the dominant position in respect of onion accounting for 25.90 per cent of the total area and 29.08 per cent of the total production of onion in India [5-8].

Over several years, numerous possible health and nutritional benefits resulting from onion consumption have been studied. Onions provide flavour and contain health-related properties of useful phytochemicals, including different sulphur-containing compounds such as Alkenyl cysteine sulphoxides, anti-oxidant compounds that are likely to be used to protect against fungi and insects, create the distinctive odour, flavour, and lachrymatory (tear stimulating) properties of onions along with their breakdown products [1]. Baswant -780: Bulbs are flattish round in shape, red in colour, medium to large in size and mildly pungent. Total soluble solids is 11 – 12%. Keeping quality is poor. Ready for harvest in 90 to 100 days after transplanting and average yield is 25 t/ha. Suitable for *kharif* season in Maharashtra [6].

Long term fertilizers trials have clearly shown the positive role of organic sources with chemical fertilizers in maintaining the productivity of soil by maintaining the soil fertility and important physical properties [9]. Fertilizer prices are increasing day by day so becoming unaffordable by small and marginal farmers, depleting soil fertility due to widening gap between nutrient removal and supplies, growing concern about environmental hazards and increasing threat to sustainable agriculture. Besides above facts, the long term use of biomix and humic acid is economical, eco-friendly, more efficient, productive and accessible to marginal and small farmers with chemical fertilizers.

Biomix is known fact that the bioagents are playing important role in plant disease management, pest management and boosting plant growth. Department of Pathology, VNMKV, Parbhani, introduced biocontrol in the region and developed experimental product in the year 2005 and he named as Biomix. A new Biomix was formulated by Dr. K.T. Apet adding some biofungicides, biopesticides and growth promoting bioagents. It contents *Trichoderma viride, Trichoderma harzianum, Asperillus niger, Pseudomonas fluorescens, Pseudomonas striata, Beauveria bassiana, Neumoria relyi, Metarhizium anisopliae, Gluconacetobactor, Paecilomyces lilacinus, Bacillus subtillis, verticillium lecanii, PPFM, Azospirillum brasilince* [10].

Humic acid is the dark "Humus" found in soil and made up of organic matter derived from microbial degradation. Humus, enriches the soil thereby allowing fertilizer chemicals to reach their maximum potential in promulgating plant growth. Humic acid typically, contains heterocyclic compounds with carboxylic, phenolic, alcoholic and carbonyl functional groups. It is extracted from lignite or low rank coals. It is complex with high molecular weight humic constituents containing plant growth stimulating substances [11]. Application of humic acid, enhances water retention and maintains air water relationship in the soil. It acts as absorbent for nutrients thereby prevents leaching losses and increases the porosity and cation exchange capacity of the soil. It helps in the formation of stable complexes with metal ions and there by increases the availability of nutrients to the plants. Sufficient information exists on the impact of humic acid on field crops like rice, groundnut, soybean etc. [11].

Applied nutrients are subjected to losses like leaching and volatilization resulting in economic loss to farmer. Balanced fertilization has to be made for different crops for attaining maximum yield and profit. There is meager information on the balanced use of chemical fertilizers with organic sources (Biomix and Humic Acid) for onion crop.

Postharvest losses in onion are a matter of serious concern throughout the world. While India is the world's second largest producer and exporter of onions, huge (25-30%) post-harvest losses include weight loss, sprouting and microbial decay limiting domestic supply and export [12]. During late kharif Seseaon the scarcity of high-yielding varieties to sustain quality also causes currency fluctuations in markets. Since onion biodiversity is found to be low, the excavation of accessible germplasm with appropriate markers is essential for an effective programme of crop improvement. The biochemical characteristics may be related to the ability to store onions, since they affect the sprouting and weight loss that influences the onion appropriate maintenance quality [13].

Lack of ample knowledge on the use of biomix and humic acid for onion vegetable crops paved the way for formulating the present research, whose objective was to study the effect of different levels of RDF and organic sources on the bulb quality and storage quality of onions (*Allium cepa* L.).

2. MATERIALS AND METHODS

The present experiment, entitled “Effect of different levels of fertilizers with organic sources on growth, yield and quality of onion (*Allium cepa* L.)” was conducted at the Department of Horticulture, VNMKV, Parbhani, in the late *Kharif* season during 2020-21 and 2021-22. There were two factors studied in this experiment one major factor A) Different levels of RDF (F_1: RDF 80% (80:40:40 NPK kg/ha), F_2: RDF 100% (100:50:50 NPK kg/ha) and F_3: RDF 120% (120:60:60 NPK kg/ha)) and sub factor B) Organic sources (S_0: Control, S_1: Biomix 10 kg/ha, S_2: Biomix 12.5 kg/ha, S_3: Biomix 15 kg/ha, S_4: Humic acid 05 kg/ha and S_5: Humic acid 10 kg/ha). The experiment was laid out in a factorial randomized block design (FRBD) with eighteen treatments and replicated thrice. The onions were transplanted with 15 cm row to row and 10 cm plant to plant spacing. In all, eighteen treatment combinations were tried. The details are presented in Table 1.

2.1Treatment Application

2.1.1 Different levels of RDF

Soil application of different levels of recommended dose of fertilizers as per the treatment for onions is: i. RDF 80% (80:40:40 NPK kg/ha), ii. RDF 100% (100:50:50 NPK kg/ha) and iii. RDF 120% (120:60:60 NPK kg/ha). Nitrogen was applied as per treatment through urea, half as a basal dose and the remaining half in two equal splits at 10 and 30 days after

Table 1. Treatment combinations

Sr. No.	Treatment	Treatment combination details
1.	F_1S_0	RDF 80%/ha (80:40:40 NPK kg/ha) + Control
2.	F_1S_1	RDF 80%/ha + Biomix 10 kg/ha
3.	F_1S_2	RDF 80%/ha + Biomix 12.5 kg/ha
4.	F_1S_3	RDF 80%/ha + Biomix 15 kg/ha
5.	F_1S_4	RDF 80%/ha + Humic acid 05 kg/ha
6.	F_1S_5	RDF 80%/ha + Humic acid 10 kg/ha
7.	F_2S_0	RDF 100%/ha (100:50:50 NPK kg/ha) + Control
8.	F_2S_1	RDF 100%/ha + Biomix 10 kg/ha
9.	F_2S_2	RDF 100%/ha + Biomix 12.5 kg/ha
10.	F_2S_3	RDF 100%/ha + Biomix 15 kg/ha
11.	F_2S_4	RDF 100%/ha + Humic acid 05 kg/ha
12.	F_2S_5	RDF 100%/ha + Humic acid 10 kg/ha
13.	F_3S_0	RDF 120%/ha (120:60:60 NPK kg/ha) + Control
14.	F_3S_1	RDF 120%/ha + Biomix 10 kg/ha /ha
15.	F_3S_2	RDF 120%/ha + Biomix 12.5 kg/ha
16.	F_3S_3	RDF 120%/ha + Biomix 15 kg/ha
17.	F_3S_4	RDF 120%/ha + Humic acid 05 kg/ha
18.	F_3S_5	RDF 120%/ha + Humic acid 10 kg/ha

transplanting. Phosphorus and potassium were applied through single super phosphate and muriate of potash, respectively, just before transplanting. Amounts of N, P, and K for each fertilizer used: 46% nitrogen for urea, 16% phosphorous for SSP, and 60% potassium for MOP.

2.1.2 Organic sources (Biomix and humic acid)

Soil application (drenching) of different levels of biomix, viz., i. biomix 10 kg/ha, ii. biomix 12.5 kg/ha, and iii. biomix 15 kg/ha; and humic acid is i. humic acid 5 kg/ha, and ii. humic acid 10 kg/ha for onions. Procedure for preparation of a biomix or humic acid solution for drenching: To make a solution for each plot, take 5 litres of water and add the necessary amount of biomix or humic acid.

2.2 Treatment Evaluation/Details of Observations Recorded

Different bulb quality parameters, *viz.,* chlorophyll content, ascorbic acid content, total soluble solids, reducing sugar, non reducing sugar, total sugar; and storage quality attributes, *viz.,* physiological loss in weight (%) and total soluble solids (TSS) during five months of storage period, were recorded and subjected to statistical analysis as per [14].

2.2.1 Quality parameters

2.2.1.1 Total chlorophyll content (SPAD Value)

The total chlorophyll content was estimated by using '*Chlorophyll Spade Meter' (Minolta SPAD 502, Konica Inc. Tokyo, Japan)* from the leaves of five selected observational plants and average mean was worked out.

2.2.1.2 Ascorbic acid content (mg/100 g)

Determination of ascorbic acid was done by 2,6 dichlorophenol indophenols dye method as described by [15]. A known quantity of onion juice or powder with 3% metaphosphoric acid (HPO3) to make the final volume 26 of 100 ml and then filtered. A known quantity of aliquot was titrated against 0.025%. 2,6 dichlorophenol indophenols dye to a pink colour end point. The ascorbic acid content of the sample was calculated taking into consideration the dye factor and expressed as mg ascorbic acid per 100 g juice extract.

$$\text{Dye factor} = \frac{0.5}{\text{Titrate reading}}$$

$$\text{Ascorbic acid}\left(\frac{\text{mg}}{100\text{g}}\right) = \frac{\text{Titrate} \times \text{Dye factor} \times \text{Vol. made up reading}}{\text{Aliquot extract} \times \text{Weight of sample taken for estimation}} \times 100$$

2.2.1.3 Total soluble solids (%)

Total soluble solids (TSS) percentage was determined with the help of hand refractometer at the time of harvesting of bulb. The average content was worked out from all the five selected observational plants (bulbs) and it was expressed in percentage.

2.2.1.4 Reducing sugars (%)

Reducing sugars (glucose) of bulb/juice were determined by method described by [15]. A known quantity of sample was taken in a volumetric flask, some distilled water added and dissolved. Thereafter, 2 ml of 45% basis lead acetate solution was added for clarification. After 10 minute, the solution was delayed by adding potassium oxalate crystals remained undisclosed and the volume made up to level with distilled water and filtrate was titrated against boiling standard Fehling's mixtures (5 ml of Fehling's solutions A and B each) till the blue colour appeared. Then, 1-2 drops of methylene blue indicator was added and the titration was continued till the content attained a brick red colour and titrate value was noted. The percentage of reducing sugar (glucose) was calculated according to following formula.

$$\text{Reducing sugars (\%)} = \frac{\text{Glucose equivalent x total volume made up}}{\text{Titrate value x weight of sample}} \text{ X } 100$$

2.2.1.5 Non reducing sugar (%)

Non Reducing sugars content was determined by using Benedict's method. It was expressed in percent. In this method the juice powder of onion was taken for analysis. In this method the juice extracted from bulb is inverted by boiling with mineral acid to obtain invert sugar solution. It is titrated against Benedict's reagent.

2.2.1.6 Total sugar (%)

Total sugars were determined by adding the value of reducing and non reducing sugars. It was expressed in per cent.

2.2.2 Storage study

Storage Condition: Freshly harvested, healthy onion bulbs of average size were selected for storage experiment as per treatment. The bulbs were grouped in sets of 5 for each replication (n=3) in each treatment set, and stored under ambient conditions. PWL% and TSS% recorded at monthly interval for five months with initial post-harvest analysis at the harvesting was considered the reference.

2.2.2.1 Physiological loss in weight (%)

Physiological loss in weight (%) was determined [16] by using following formula: Physiological loss in weight (%) = [(Initial weight – Final weight) / Initial weight] x 100

2.2.2.2 Total soluble solids (%)

Total soluble solids of the juice were recorded with the help of hand refractometer by taking a drop of juice of composite on prime of the refractometer and observing it against the light. The hand refractometer was calibrated with distilled water before use.

2.3 Statistical Analysis of Data

The statistical analysis of collected data was done by the standard procedure. The analysis of variance was carried out according to factorial randomized block design (FRBD). The significance of treatment differences was tested by 'F' test on the basis of null hypothesis. The appropriate standard error (S.E m.±) was computed in each case. Co-efficient of variance per cent was also worked out for all the characters. The results have been calculated at probability level 5 per cent according to [14].

3. RESULTS AND DISCUSSION

3.1 Effect of Different Levels of Fertilizers with Organic Sources on Quality Attributes

3.1.1 Chlorophyll content (SPAD value)

3.1.1.1 Effect of different levels of recommended dose of fertilizers kg/ha

Data presented in Table 2 and illustrated in Fig. 1 showed that, different levels of NPK kg/ha significantly affected on chlorophyll content of onion leaf. During the year 2020-21, 2021-22 and in pooled analysis data influenced by different levels of NPK kg/ha showed significantly maximum [(64.61), (62.27) and (63.44), respectively] chlorophyll content (SPAD value) of onion leaf was recorded with 120:60:60 NPK kg/ha, followed by 100:50:50 NPK kg/ha [(57.32), (54.35) and (55.84), respectively]. Whereas, minimum [(51.27), (50.43) and (50.85), respectively] chlorophyll content (SPAD value) of onion leaf was recorded with the treatment F_1 *i.e.* 80:40:40 NPK kg/ha.

Nitrogen application increased, chlorophyll a and b contents were enhanced that in turn recorded higher SPAD reading in onion [17], hence,

Table 2. Effect of different levels of RDF with organic sources on chlorophyll content (SPAD value at 60 days after transplanting) of onion

Treatment	Chlorophyll content (SPAD value)		
	2020-21	**2021-22**	**Pooled mean**
Main treatment: Different levels of RDF/ha (F)			
F_1: RDF 80% (80:40:40 NPK kg/ha)	51.27	50.43	50.85
F_2: RDF 100% (100:50:50 NPK kg/ha)	57.32	54.35	55.84
F_3: RDF120% (120:60:60 NPK kg/ha)	64.61	62.27	63.44
SE (m) $\pm$	0.85	0.88	0.86
CD @ 5%	2.51	2.62	2.55
Sub treatment: Organic sources/ha (S)			
S_0 : Control	54.83	52.86	53.85
S_1 : Biomix 10 kg/ha	56.62	54.19	55.41
S_2 : Biomix 12.5 kg/ha	57.56	55.54	56.55
S_3 : Biomix 15 kg/ha	58.98	56.95	57.97
S_4 : Humic acid 05 kg/ha	57.76	55.90	56.83
S_5 : Humic acid 10 kg/ha	60.66	58.66	59.66
SE (m) $\pm$	1.21	1.24	1.22
CD @ 5%	3.62	3.66	3.62
Interaction effect: Different levels of RDF/ha (F) with organic sources/ha (S)			
SE (m) $\pm$	2.09	2.14	1.96
CD @ 5%	NS	NS	NS

chlorophyll content significantly increased with the increased levels of NPK application. Especially nitrogen helped in vigorous vegetative growth and imparted deep green colour to the foliage which favoured photosynthetic activity of the plants.

Especially nitrogen helped in vigorous vegetative growth and imparted deep green colour to the foliage which favoured photosynthetic activity of the plants. These results were in line with [18,19].

3.1.1.2 Effect of organic sources kg/ha

During 2020-21, 2021-22 and in pooled analysis data influenced by different levels of organic sources showed significantly maximum [(60.66), (58.66) and (59.66), respectively] chlorophyll content (SPAD value) of onion leaf was recorded with S_5. However, it was statistically at par with S_2 [(57.56), (55.54) and (56.55), respectively], S_3 [(58.98), (56.95) and (57.97), respectively] and S_4 [(57.76), (55.90) and (56.83), respectively] during both years and in pooled analysis. Whereas, minimum [(54.83), (52.56) and (53.85), respectively] chlorophyll content (SPAD value) of onion leaf was recorded with the treatment S_0 *i.e.* Control.

The presence of humic substances in the nutrient solution produces an increase in the chlorophyll apparatus in tomato [20]. Chlorophyll pigments are essential constituent of leaf and act as a seat of photosynthesis. The total chlorophyll content of onion was highest recorded with humic acid 10 kg/ha at 60 days after transplanting. Soil application of humic acid was found to be more effective in increasing the total chlorophyll content. The increase might have been due to that stimulation activity of humic acid on the synthesis of chlorophyll precursor. This is in line with the earlier findings of [11] in onion.

3.1.1.3 Interaction effect

The interaction effect of different levels of recommended dose of fertilizers per hectare with organic sources per hectare on chlorophyll content (SPAD value) of onion leaf at 60 days after transplanting during both years of experiments (2020-21 and 2021-22) as well as pooled were found to be non-significant.

3.1.2 Ascorbic acid content (mg/100g)

3.1.2.1 Effect of different levels of recommended dose of fertilizers kg/ha

Data pertaining to the effect of different levels of NPK on ascorbic acid content of onion bulb are presented in Table 3 and graphically depicted in Fig. 2. Soil application of different levels of RDF had significant influence on ascorbic acid content in both years (2020-21 and 2021-22) of experiment as well as in the pooled analysis. The

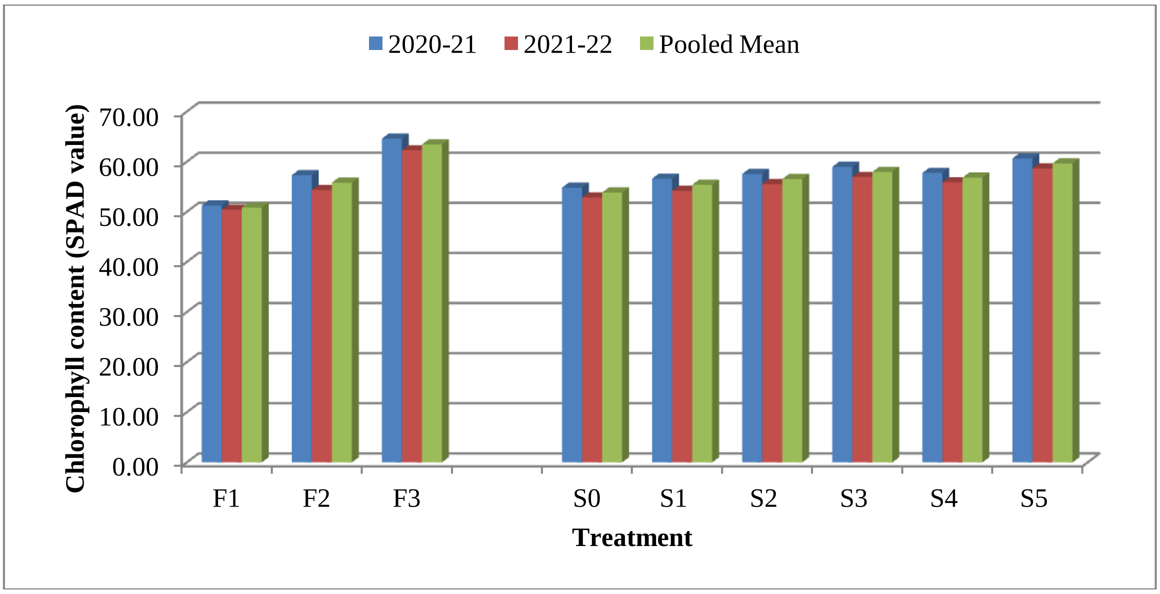

Fig. 1. Effect of different levels of RDF and organic sources on chlorophyll content (SPAD value at 60 days after transplanting) of onion

maximum [(11.92 mg/100g), (11.51 mg/100g) and (11.71 mg/100g), respectively] ascorbic acid content was recorded in F_3 *i.e.* 120:60:60 NPK per hectare. Followed by F_2 *i.e.* 100:50:50 NPK kg/ha [(10.60 mg/100g), (10.24 mg/100g) and (10.42 mg/100g). Whereas, minimum [(9.38 mg/100g), (9.00 mg/100g) and (9.19 mg/100g), respectively] ascorbic acid content was recorded in F_1 *i.e.* 80:40:40 NPK kg/ha.

The different quality parameters like vitamin C content varied with different doses of application of P and K [21]. Increasing the fertigation level from 80% to 120% NPK influenced the ascorbic content of onion due to be potassium, it is a quality nutrient that is highly responsible for carbohydrate metabolism and thus increases the ascorbic acid content. The similar result reported by [17] in onion.

3.1.2.2 Effect of organic sources kg/ha

The data indicated that the different organic sources levels significantly influence ascorbic acid content in onion bulbs. During 2020-21, 2021-22 and in pooled analysis data influenced by different levels of organic sources (biomix and humic acid levels) showed significantly maximum [(11.14 mg/100g), (10.63 mg/100g) and (10.89 mg/100g), respectively] ascorbic acid content of onion bulb was recorded with S_3 *i.e.* Biomix 15 kg/ha. However, it was statistically at par with S_2 [(10.88 mg/100g), (10.30 mg/100g) and (10.59 mg/100g), respectively] and S_5 [(10.75 mg/100g), (10.51 mg/100g) and (10.63 mg/100g), respectively] during both years and in pooled analysis but S_4 (10.21 mg/100g) during 2021-22. Whereas, minimum [(10.18 mg/100g), (9.84 mg/100g) and (10.01 mg/100g), respectively] ascorbic acid content of onion bulb was recorded with the treatment S_0 *i.e.* Control.

Biomix is known fact that the bioagents are playing important role in plant disease management, pest management and boosting quality of different vegetables [10]. The application of biomix at 15 kg/ha recorded higher ascorbic acid content in onion bulb. The reason might be due to the application of biomix increases the available nutrient status in soil, which decides the activity of ascorbicase enzyme, which is responsible for the production of ascorbic acid. The enzyme invertase activity was enhanced by biomix, which resulted in hydrolysis of sucrose to glucose and this might have increased the ascorbic acid content. These perceptions are in congruity/ conformity with [22] in lettuce.

3.1.2.3 Interaction effect

Data from Table 3 indicate that the interaction effect of different levels of NPK kg/ha with organic sources (biomix and humic acid levels) kg/ha on ascorbic acid content (mg/100g) of onion bulbs at harvesting during both years of experiments (2020-21 and 2021-22) as well as pooled mean analysis were found to be non-significant.

Table 3. Effect of different levels of RDF with organic sources on ascorbic acid content (mg/100g) of onion

Treatment	Ascorbic acid content (mg/100g)		
	2020-21	2021-22	Pooled mean
Main treatment: Different levels of RDF/ha (F)			
F_1: RDF 80% (80:40:40 NPK kg/ha)	9.38	9.00	9.19
F_2: RDF 100% (100:50:50 NPK kg/ha)	10.60	10.24	10.42
F_3: RDF120% (120:60:60 NPK kg/ha)	11.92	11.51	11.71
SE (m) ±	0.14	0.12	0.12
CD @ 5%	0.41	0.34	0.35
Sub treatment: Organic sources/ha (S)			
S_0 : Control	10.18	9.84	10.01
S_1 : Biomix 10 kg/ha	10.51	10.00	10.26
S_2 : Biomix 12.5 kg/ha	10.88	10.30	10.59
S_3 : Biomix 15 kg/ha	11.14	10.63	10.89
S_4 : Humic acid 05 kg/ha	10.30	10.21	10.26
S_5 : Humic acid 10 kg/ha	10.75	10.51	10.63
SE (m) ±	0.20	0.17	0.17
CD @ 5%	0.59	0.48	0.50
Interaction effect: Different levels of RDF/ha (F) with Organic sources/ha (S)			
SE (m) ±	0.35	0.29	0.30
CD @ 5%	NS	NS	NS

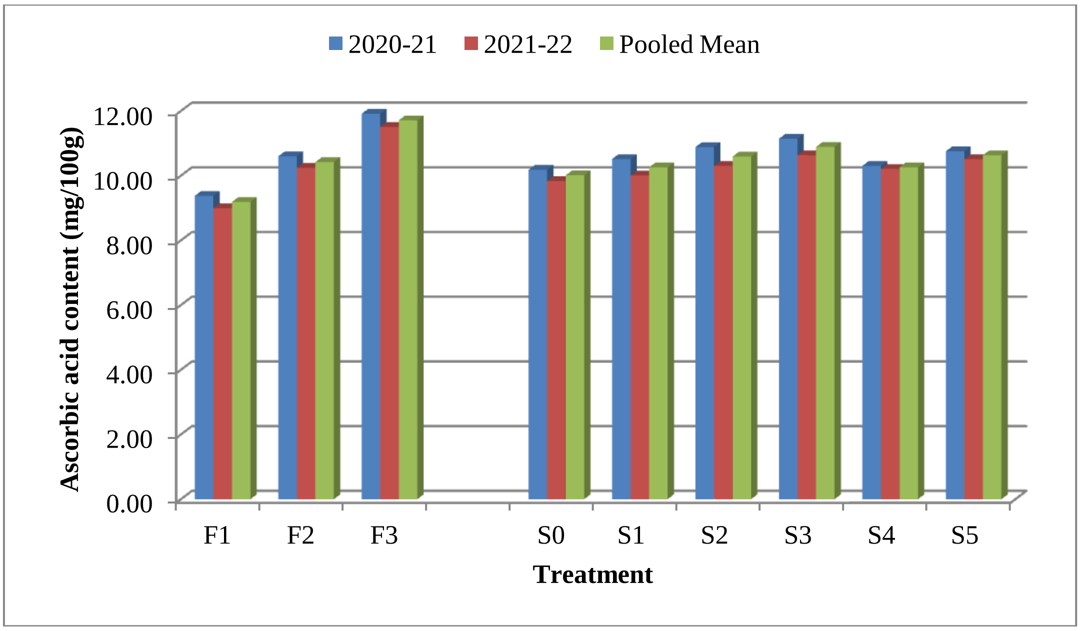

Fig. 2. Effect of different levels of RDF with organic sources on ascorbic acid content (mg/100g) of onion

3.1.3 Total soluble solids (%)

3.1.3.1 Effect of different levels of recommended dose of fertilizers kg/ha

Data pertaining to the effect of fertilizers total soluble solids of bulb are presented in Table 4 and graphically depicted in Fig. 3. Application of different levels of fertility had significant influence on total soluble solids Per cent in both year of experiment as well as in the pooled analysis. The maximum [(12.44%), (12.02%) and (12.23%), respectively] total soluble solids was recorded in 120% RDF treatment, followed by F_2 *i.e.* 100% RDF [(11.68%), (11.19%) and (11.43%), respectively]. Whereas, minimum [(10.80%), (10.35%) and (10.58%), respectively] total soluble solids was recorded in 80% RDF.

Table 4. Effect of different levels of RDF with organic sources on total soluble solids (%) of onion

Treatment	Total soluble solids (%)		
	2020-21	2021-22	Pooled mean
Main treatment: Different levels of RDF/ha (F)			
F_1: RDF 80% (80:40:40 NPK kg/ha)	10.80	10.35	10.58
F_2: RDF 100% (100:50:50 NPK kg/ha)	11.68	11.19	11.43
F_3: RDF120% (120:60:60 NPK kg/ha)	12.44	12.02	12.23
SE (m) ±	0.12	0.11	0.12
CD @ 5%	0.34	0.32	0.35
Sub treatment: Organic sources/ha (S)			
S_0 : Control	11.14	10.79	10.97
S_1 : Biomix 10 kg/ha	11.39	10.95	11.18
S_2 : Biomix 12.5 kg/ha	11.61	11.11	11.36
S_3 : Biomix 15 kg/ha	11.81	11.31	11.56
S_4 : Humic acid 05 kg/ha	11.73	11.26	11.50
S_5 : Humic acid 10 kg/ha	12.14	11.67	11.91
SE (m) ±	0.17	0.16	0.17
CD @ 5%	0.49	0.45	0.50
Interaction effect: Different levels of RDF/ha (F) with Organic sources/ha (S)			
SE (m) ±	0.29	0.27	0.29
CD @ 5%	NS	NS	NS

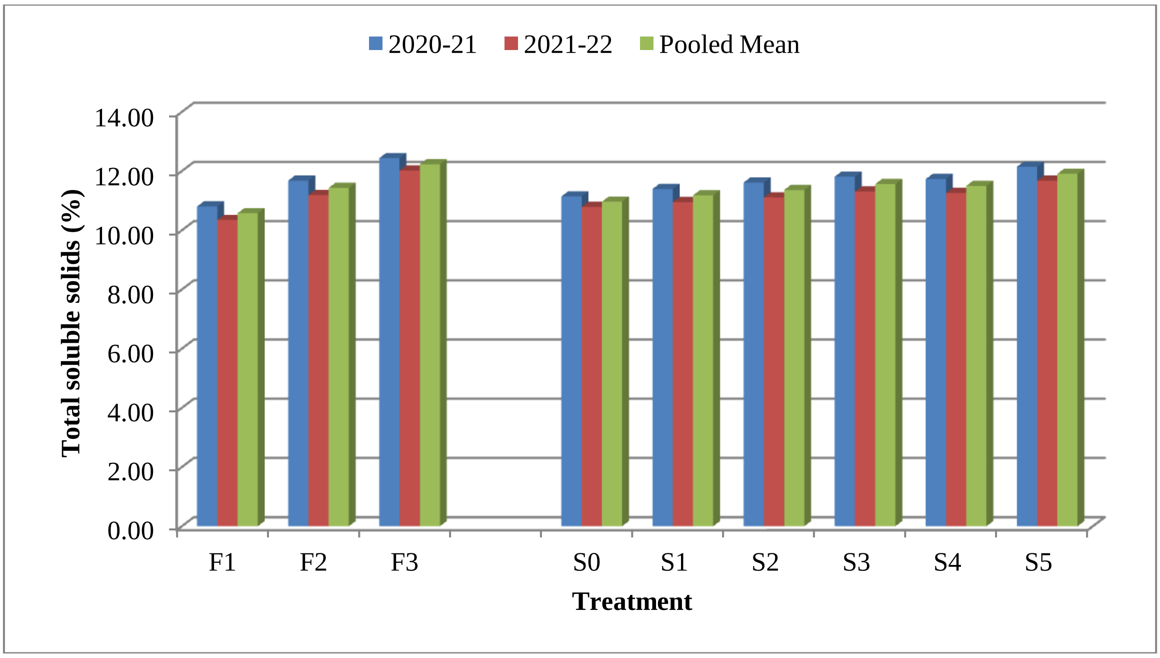

Fig. 3. Effect of different levels of RDF with organic sources on total soluble solids (%) of onion

This might be due to the fact that nitrogen has helped in vigorous vegetative growth and imparted deep green colour to the foliage which favored photosynthetic activity of the plants so there was greater accumulation of food material *i.e*. carbohydrates in the bulb which ultimately resulted in more synthesis of total soluble solids (TSS) content.

Higher total soluble solids was recorded due to higher application of nitrogen that resulted in enhanced vegetative growth that in turn improved the photosynthetic activity and greater accumulation of carbohydrates in onion bulbs. The similar results have been reported by [23]. The results are also in accordance with the findings of [24,25,17] in onion.

3.1.3.2 Effect of organic sources kg/ha

Data from Table 4 indicate that soil application of organic sources had significant effect on total soluble solids percentage of bulb in both the years as well as in pooled analysis. The maximum [(12.14%), (11.67%) and (11.91%), respectively] total soluble solids was recorded in S_5 during 2020-21, 2021-22 and in pooled mean analysis. However, it was statistically at par with S_3 [(11.81%), (11.31%) and (11.56%), respectively] and S_4 [(11.73%), (11.26%) and (11.50%), respectively] during 2020-21, 2021-22 and in pooled mean analysis. Whereas, minimum [(11.14%), (10.79%) and (10.97%), respectively] total soluble solids was recorded in S_0 *i.e.* Control.

In the present study the maximum total soluble solids was reported in the treatment receiving 10 kg humic acid/ha. This might be due to that the application of humic acid increased the nutrient uptake by plant, which resulted in higher photosynthetic rate, better source sink relationship, translocation and accumulation of photo assimilates. Similar results were reported by [11] in onion.

3.1.3.3 Interaction effect

Data from Table 4 indicate that the interaction effect of different levels of fertilizers per hectare with organic sources (Biomix and Humic acid) per hectare on total soluble solids percentage of onion bulb at harvesting during both years of experiments (2020-21 and 2021-22) as well as pooled were found to be non-significant.

3.1.4 Reducing sugar (%)

3.1.4.1 Effect of different levels of recommended dose of fertilizers kg/ha

The data on reducing sugar (Table 5 and Fig. 4) indicated significant differences due to different levels of fertility of onion at harvesting. During the year 2020-21, 2021-22 and pooled mean analysis data, significantly highest [(2.37%), (2.28%) and (2.33%), respectively] reducing sugar of onion was recorded with the treatment F_3 *i.e.* 120:60:60 NPK kg/ha, followed by F_2 [(2.12%), (2.09%) and (2.11%), respectively]. Whereas lowest [(1.98%), (1.92%) and (1.95%), respectively] reducing sugar of onion was observed with the treatment F_1 *i.e.* 80:40:40 NPK kg/ha.

Table 5. Effect of different levels of RDF with organic sources on reducing sugar (%) of onion

Treatment	Reducing sugar (%)		
	2020-21	2021-22	Pooled mean
Main treatment: Different levels of RDF/ha (F)			
F_1: RDF 80% (80:40:40 NPK kg/ha)	1.98	1.92	1.95
F_2: RDF 100% (100:50:50 NPK kg/ha)	2.12	2.09	2.11
F_3: RDF120% (120:60:60 NPK kg/ha)	2.37	2.28	2.33
SE (m) $\pm$	0.03	0.02	0.03
CD @ 5%	0.09	0.07	0.09
Sub treatment: Organic sources/ha (S)			
S_0 : Control	2.05	1.96	2.01
S_1 : Biomix 10 kg/ha	2.08	2.03	2.06
S_2 : Biomix 12.5 kg/ha	2.12	2.08	2.10
S_3 : Biomix 15 kg/ha	2.21	2.15	2.18
S_4 : Humic acid 05 kg/ha	2.15	2.10	2.13
S_5 : Humic acid 10 kg/ha	2.33	2.25	2.29
SE (m) $\pm$	0.04	0.03	0.04
CD @ 5%	0.13	0.11	0.12
Interaction effect: Different levels of RDF/ha (F) with Organic sources/ha (S)			
SE (m) $\pm$	0.08	0.07	0.08
CD @ 5%	NS	NS	NS

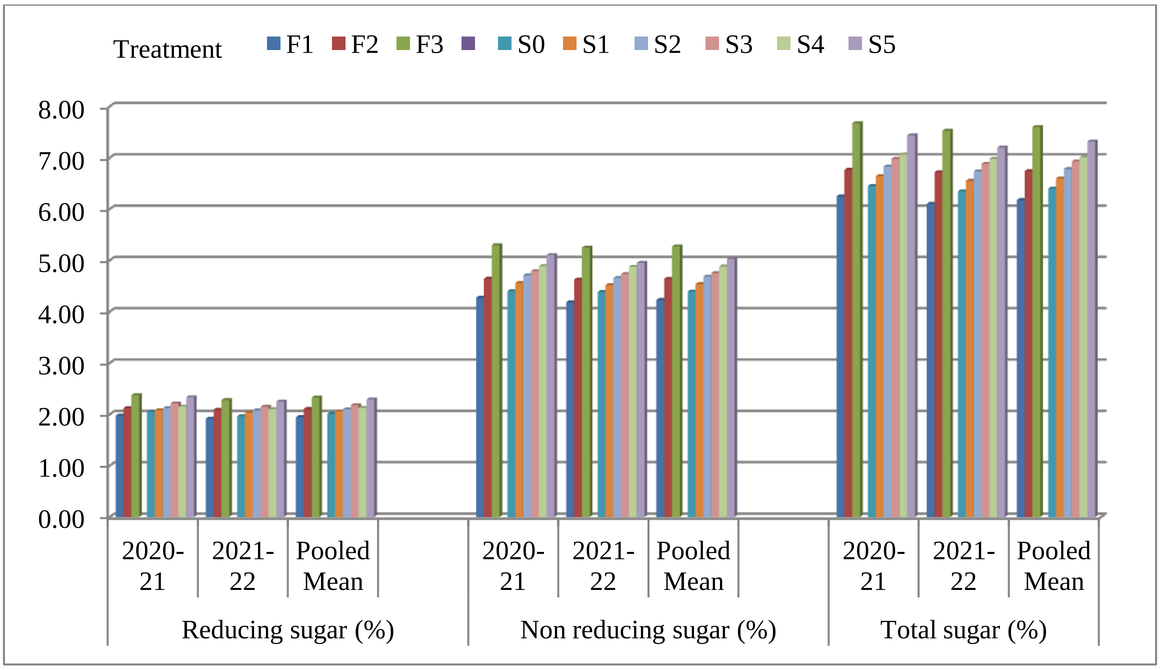

Fig. 4. Effect of different levels of RDF with organic sources on reducing sugar, Non-reducing sugar and total sugar percentage of onion

There were significant effects of different RDF levels on reducing sugar of onion. These may be due to the effect of each incremental dose of RDF caused significant increase in reducing sugar of onion. Highest reducing sugar per cent were observed with RDF level F_3. It showed that application of NPK fertilizers exerted the positive effect on reducing sugar which may be due to the optimum availability of NPK. The nitrogen plays an important role in chlorophyll structure which is responsible for photosynthesis and manufacture of food material in the plants. Phosphorus stimulates early root development and improves the quality of produce. Potash helps to translocation of carbohydrates. These results are in conformity with [23] in onion.

3.1.4.2 Effect of organic sources kg/ha

The data (Table 5 and Fig. 4) indicated that the different organic sources (biomix and humic acid levels) significantly influence reducing sugar in onion bulbs. During 2020-21, 2021-22 and in pooled analysis data influenced by different levels of organic sources (biomix and humic acid levels) showed significantly maximum [(2.33%), (2.25%) and (2.29%), respectively] reducing sugar of onion bulb was recorded with S_5 *i.e.* humic acid 10 kg/ha. However, it was statistically at par with S_3 [(2.21%), (2.15%) and (2.18%), respectively] during 2020-21, 2021-22 and in pooled mean analysis. Whereas, minimum [(2.05%), (1.96%) and (2.01%), respectively] reducing sugar content of onion bulb was recorded with the treatment S_0 *i.e.* Control.

Maximum reducing sugar of onion bulb recorded with humic acid 10 kg/ha. This might be due to humic substances alter the carbohydrate metabolism of plants and promote the accumulation of reducing sugars. Similar results were reported by [11] in onion.

3.1.4.3 Interaction effect

During the year 2020-21, 2021-22 and pooled mean analysis data, there were non-significant differences were observed with interaction effects of different levels of fertility with organic sources on reducing sugar in onion.

3.1.5 Non-reducing sugar (%)

3.1.5.1 Effect of different levels of recommended dose of fertilizers kg/ha

The data on reducing sugar (Table 4. 25 and Fig. 4.19) indicated significant differences due to different levels of fertilizers of onion at harvesting. During the year 2020-21, 2021-22 and pooled mean analysis data, significantly maximum [(5.30%), (5.25%) and (5.27%), respectively] non-reducing sugar of onion was recorded with the treatment F_3 *i.e.* 120% RDF kg/ha, followed by F_2 *i.e.* 100% RDF [(4.64%), (4.63%) and (4.64%), respectively]. Whereas minimum [(4.27%), (4.19%) and (4.23%), respectively] non-reducing sugar of onion was observed with the treatment F_1 *i.e.* 80% RDF kg/ha.

Highest non reducing sugar per cent were observed with RDF level F_3. It showed that application of RDF fertilizers exerted the positive effect on reducing sugar which may be due to the optimum availability of NPK. Nitrogen plays an important role in chlorophyll structure which is responsible for photosynthesis and manufacture of food material in the plants. Phosphorus stimulates early root development and improves the quality of produce. Potash helps to translocation of carbohydrates. These are in conformity with [23].

3.1.5.2 Effect of organic sources kg/ha

The data (Table 6 and Fig. 5) indicated that the different organic sources significantly influence non-reducing sugar in onion bulbs.

During 2020-21, 2021-22 and in pooled analysis data influenced by different levels of organic sources showed significantly maximum [(5.10%), (4.95%) and (5.03%), respectively] non-reducing sugar of onion bulb was recorded with S_5 *i.e.* humic acid 10 kg/ha. However, it was statistically at par with S_3 [(4.79%), (4.73%) and (4.75%), respectively] and S_4 maximum [(4.89%), (4.87%) and (4.88%), respectively]. Whereas, minimum [(4.40%), (4.38%) and (4.39%), respectively] non-reducing sugar of onion bulb was recorded with the treatment S_0 *i.e.* Control.

A maximum non reducing sugar of onion bulb recorded with humic acid 10 kg/ha due to humic substances alters the carbohydrate metabolism of plants and promotes the accumulation of non reducing sugars. Similar results were reported by [11] in onion.

3.1.5.3 Interaction effect

From Table 6 and Fig. 5 data, non-significant differences were observed with interaction effects of different levels of fertility with organic sources on non-reducing sugar in onion bulbs.

3.1.6 Total sugar (%)

3.1.6.1 Effect of different levels of recommended dose of fertilizers kg/ha

The data presented in Table 7 and illustrated in Fig. 6 indicated that, different levels of fertilizers significantly affected on total sugar Per cent of onion. During 2020-21, 2021-22 and pooled data showed significantly maximum [(7.67%), (7.53%) and (7.60%), respectively] total sugar Per cent in F_3 *i.e.* 120% RDF, followed by F_2 *i.e.* 100% RDF [(6.77%), (6.72%) and (6.74%), respectively]. While, minimum [(6.25%), (6.10%) and (6.17%), respectively] total sugar Per cent in F_1 *i.e.* 80% RDF kg/ha.

Table 6. Effect of different levels of RDF with organic sources on non reducing sugar (%) of onion

Treatment	Non reducing sugar (%)		
	2020-21	2021-22	Pooled mean
Main treatment: Different levels of RDF/ha (F)			
F_1: RDF 80% (80:40:40 NPK kg/ha)	4.27	4.19	4.23
F_2: RDF 100% (100:50:50 NPK kg/ha)	4.64	4.63	4.64
F_3: RDF120% (120:60:60 NPK kg/ha)	5.30	5.25	5.27
SE (m) ±	0.06	0.05	0.06
CD @ 5%	0.18	0.15	0.18
Sub treatment: Organic sources/ha (S)			
S_0 : Control	4.40	4.38	4.39
S_1 : Biomix 10 kg/ha	4.56	4.52	4.54
S_2 : Biomix 12.5 kg/ha	4.71	4.66	4.68
S_3 : Biomix 15 kg/ha	4.79	4.73	4.75
S_4 : Humic acid 05 kg/ha	4.89	4.87	4.88
S_5 : Humic acid 10 kg/ha	5.10	4.95	5.03
SE (m) ±	0.10	0.09	0.10
CD @ 5%	0.31	0.27	0.31
Interaction effect: Different levels of RDF/ha (F) x Organic sources/ha (S)			
SE (m) ±	0.20	0.19	0.20
CD @ 5%	NS	NS	NS

There were significant effects of different RDF levels on total sugar of onion. These may be due to the effect of each incremental dose of RDF caused significant increase in total sugar of onion. Highest total sugars per cent were observed with F_3. These may be due to the higher reducing sugar and non-reducing sugar in higher amount of NPK levels.

3.1.6.2 Effect of organic sources kg/ha

The data (Table 7 and Fig. 6) indicated that the values of total sugar Per cent of onion exhibited gradual increase with increase in dose of within the levels of different organic sources over control. Almost similar trend was recorded in respect of total sugar Per cent of onion during 2020-21, 2021-22 and in pooled analysis. During 2020-21, 2021-22 and in pooled analysis data influenced by different levels of organic sources showed significantly maximum [(7.44%), (7.20%) and (7.32%), respectively] total sugar of onion bulb was recorded with S_5 *i.e.* humic acid 10 kg/ha. However, it was statistically at par with S_3 (6.88%) and (6.93%) during 2021-22 and pooled mean and S_4 [(7.06%), (6.98%) and (7.01%), respectively] during both the years as well as pooled mean analysis. Whereas, minimum [(6.45%), (6.35%) and (6.40%), respectively] total sugar of onion bulb was recorded with the treatment S_0 *i.e.* Control.

Soil application of humic acid at 10 kg/ha recorded higher total sugar content in onion. Humic substances possess auxin activity [26] which might have created a larger sink to mobilize the sugars synthesized in leaves to growing bulbs. Humic substances alter the carbohydrate metabolism of plants and promote the accumulation of reducing sugars and non reducing sugar in onion [27]. These results are in accordance with the findings of [11] in onion.

3.1.6.3 Interaction effect

Data from Table 7 and illustrated in Fig. 6 indicate that the interaction effect of different levels of RDF kg/ha with organic sources (biomix and humic acid levels) kg/ha on total sugar Per cent of onion bulbs at harvesting during both years of experiments (2020-21 and 2021-22) as well as pooled mean analysis were found to be non-significant.

3.2 Effect of Different Levels of Fertilizers with Organic Sources on Storage Study

During both years (2020-21 and 2021-22) and in their pooled mean data on storage quality influenced by different levels of fertility and organic sources were recorded on physical weight loss and total soluble solids of onion during the experiment and are presented in Table 8a, 8b and 9; and illustrated in Fig. 5 and 6.

Table 7. Effect of different levels of RDF with organic sources on total sugar (%) of onion

Treatment	Total sugar (%)		
	2020-21	**2021-22**	**Pooled mean**
Main treatment: Different levels of RDF/ha (F)			
F_1: RDF 80% (80:40:40 NPK kg/ha)	6.25	6.10	6.17
F_2: RDF 100% (100:50:50 NPK kg/ha)	6.77	6.72	6.74
F_3: RDF120% (120:60:60 NPK kg/ha)	7.67	7.53	7.60
SE (m) $\pm$	0.08	0.07	0.08
CD @ 5%	0.24	0.21	0.24
Sub treatment: Organic sources/ha (S)			
S_0 : Control	6.45	6.35	6.40
S_1 : Biomix 10 kg/ha	6.64	6.55	6.60
S_2 : Biomix 12.5 kg/ha	6.83	6.73	6.78
S_3 : Biomix 15 kg/ha	6.98	6.88	6.93
S_4 : Humic acid 05 kg/ha	7.06	6.98	7.01
S_5 : Humic acid 10 kg/ha	7.44	7.20	7.32
SE (m) $\pm$	0.13	0.12	0.13
CD @ 5%	0.38	0.35	0.39
Interaction effect: Different levels of RDF/ha (F) x Organic sources/ha (S)			
SE (m) $\pm$	0.23	0.21	0.22
CD @ 5%	NS	NS	NS

3.2.1 Physiological loss in weight (%)

3.2.1.1 Effect of different levels of recommended dose of fertilizers kg/ha

Data from Table 8 (8a and 8b) and illustrated in Fig. 5 indicate that, they obtained results of both the years of experiments as well as pooled data significantly influenced the physiological loss in weight. The drenching with different levels of NPK fertilizers significantly decreases the physiological loss in weight during five months of storage study period.

During 2020-21, 2021-2022 and in their pooled mean analysis at first month after storage data, it was noticed that significantly minimum [(5.57%), (3.29%) and (4.43%), respectively] physiological loss in weight of onion was registered with the F_1 *i.e.* RDF 80% (120:60:60 NPK kg/ha), followed by F_3. Whereas, maximum [(7.84%), (5.83%) and (6.84%), respectively] physiological loss in weight of onion was recorded with the F_2 *i.e.* RDF 100% (100:50:50 NPK kg/ha).

At second month after storage data, it was noticed that significantly minimum [(10.15%), (6.32%) and (8.24%), respectively] physiological loss in weight of onion was registered with the F_1 *i.e.* 120:60:60 NPK kg/ha, followed by F_3. Whereas, maximum [(16.74%), (13.93%) and (15.34%), respectively] physiological loss in weight of onion was recorded with the F_2 *i.e.* 100:50:50 NPK kg/ha.

Third month after storage during both the year (2020-21 and 2021-22) of the experiment and in their pooled mean analysis significantly minimum [(14.45%), (10.42%) and (12.43%), respectively] physiological loss in weight of onion was registered with the F_1 *i.e.* 800% RDF per ha, followed by F_3. Whereas, maximum PLW of onion bulbs was recorded with the F_2 *i.e.* 100% RDF per hectare.

During fourth month after storage both the year (2020-21 and 2021-22) of the experiment and in their pooled mean analysis significantly minimum [(16.00%), (12.20%) and (14.10%), respectively] physiological loss in weight of onion was registered with the F_1, followed by F_3. Whereas, maximum [(22.24%), (20.24%) and (21.24%), respectively] physiological loss in weight of onion was recorded with the F_2.

At final stage of observation *i.e.* fifth month after storage during both the year (2020-21 and 2021 - 22) of the experiment and in their pooled mean analysis significantly minimum [(19.83%), (17.11%) and (18.47%), respectively] physiological loss in weight of onion was registered with the F_1, followed by F_3. Whereas, maximum [(23.88%), (22.95%) and (23.41%), respectively] physiological loss in weight of onion was recorded with the F_2 *i.e.* RDF 100% per hectare.

Lowest physiological loss in weight was occurred in application of lower levels of NPK. These might due to be lowest neck thickness, neck length and lower moisture loss of onion bulb during five months of storage period.

3.2.1.2 Effect of organic sources kg/ha

The data (Table 8a; 8b and Fig. 5) indicated that the values of physiological loss in weight of onion exhibited gradual decreases with increase in dose of within the levels of different organic sources over control. Almost similar trend was recorded in respect of physiological loss in weight of onion during storage period.

During 2020-21, 2021-2022 and in their pooled mean analysis at I month after storage data, it was noticed that significantly minimum [(5.86%), (3.32%) and (4.59%), respectively] physiological loss in weight of onion was registered with the S_3 *i.e.* Biomix 15 kg/ha, followed by S_2, S_1 and S_5. Whereas, maximum [(7.59%), (5.41%) and (6.50%), respectively] physiological loss in weight of onion was recorded with the S_0 *i.e.* Control.

At second month after storage data, it was noticed that significantly minimum [(11.84%), (7.52%) and (9.68%), respectively] physiological loss in weight of onion was registered with the biomix 15 kg/ha, followed by S_2 S_1 and S_5. Whereas, maximum [(15.82%), (13.10%) and (14.46%), respectively] physiological loss in weight of onion was recorded with the S_0.

Third month after storage during both the year (2020-21 and 2021-22) of the experiment and in their pooled mean analysis significantly minimum [(16.53%), (12.14%) and (14.33%), respectively] physiological loss in weight of onion was registered with the S_3 *i.e.* Biomix 15 kg/ha, followed by S_2, S_1 and S_5. Whereas, maximum [(19.73%), (18.26%) and (19.00%), respectively] physiological loss in weight of onion was recorded with the S_0 *i.e.* Control.

During fourth month after storage both the year (2020-21 and 2021-22) of the experiment and in their pooled mean analysis significantly minimum [(17.51%), (14.70%) and (16.10%), respectively] physiological loss in weight of onion was registered with the S_3 *i.e.* Biomix 15 kg/ha, followed by S_2, S_1 and S_5. Whereas, maximum [(21.33%), (19.00%) and (20.17%), respectively] physiological loss in weight of onion was recorded with the S_0.

At final stage of observation *i.e.* fifth month after storage during both the year (2020-21 and 2021-22) of the experiment and in their pooled mean analysis significantly minimum [(19.33%), (17.77%) and (18.55%), respectively] physiological loss in weight of onion was registered with the S_3, followed by S_2, S_1 and S_5. Whereas, maximum [(23.32%), (22.01%) and (22.67%), respectively] physiological loss in weight of onion was recorded with the S_0 *i.e.* Control.

Significantly minimum physiological loss in weight of onion was recorded with the biomix 15 kg/ha during storage period. This might be to less neck thickness and higher nutrient uptake like potassium. Potassium improves many parameters like shining, colour, keeping quality and dry matter accumulation of many crops including onion. Similar results were reported by [21] in onion.

3.2.1.3 Interaction effect

From Table 8a and 8b data, all storage period non-significant differences were observed with interaction effects of different levels of fertilizers with organic sources on physiological loss in weight in onion bulbs.

3.2.2 Total soluble solids (%)

3.2.2.1 Effect of different levels of recommended dose of fertilizers kg/ha

Data from Table 9 and illustrated in Fig. 6 indicate that, they obtained results of both the years of experiments as well as pooled data significantly influenced the total soluble solids. The drenching with different levels of RDF kg/ha significantly increases the total soluble solids during first three months of storage study period and later gradually decreases during both the years (2020-21 and 2021-22) as well as in pooled analysis.

During 2020-21, 2021-2022 and in their pooled mean analysis at first month after storage data, it was noticed that significantly maximum [(13.68%), (13.42%) and (13.55%), respectively] total soluble solids of onion was observed with the F_3 *i.e.* RDF 120% (120:60:60 NPK kg/ha). However, it was statistically at par with F_2. Whereas, minimum [(11.97%), (11.95%) and (11.96%), respectively] total soluble solids of onion was recorded with the F_1 *i.e.* RDF 80% (80:40:40 NPK kg/ha).

At second month after storage data, it was found that significantly maximum [(14.39%), (13.79%) and (14.09%), respectively] total soluble solids was registered with the F_3. However, it was statistically at par with F_2 *i.e.* 100:50:50 NPK kg/ha [(13.44%), (13.30%) and (13.37%), respectively]. Whereas, minimum [(12.42%), (12.39%) and (12.41%), respectively] total soluble solids of onion were recorded with the F_1.

Third month after storage significantly maximum [(14.52%), (14.32%) and (14.42%), respectively] total soluble solids of onion was registered with the F_3 *i.e.* 120% RDF per ha during 2020-21, 2021-22 and pooled mean analysis. While, it was statistically at par with NPK 100:50:50 kg/ha [(14.11%), (13.93%) and (14.02%), respectively]. However minimum [(12.73%), (12.46%) and (12.60%), respectively] total soluble solids was recorded with RDF 80%.

From Table 9 and Fig. 6 data indicated that, non-significant differences was found during fourth month after storage both the year (2020-21 and 2021-22) of the experiment and in their pooled mean analysis.

At final stage of observation *i.e.* fifth month after storage during both the year (2020-21 and 2021-22) of the experiment and in their pooled mean analysis significantly maximum [(11.86%), (11.42%) and (11.64%), respectively] total soluble solids of onion was observed with the RDF 120%. However, it was statistically at par with F_2 [(11.40%), (10.86%) and (11.13%), respectively]. Whereas, minimum [(10.48%), (10.16%) and (10.32%), respectively] total soluble solids of onion was recorded with the F_1 *i.e.* RDF 80% per hectare.

During five month of storage period the maximum total soluble solids were recorded in F_3. These might be due to the supply of the NPK at optimum levels. NPK improves the quality of onion bulbs, especially, phosphorus and potash improves keeping quality and dry matter accumulation of onion.

Table 8a. Effect of different levels of RDF with organic sources on physiological loss in weight (%) of onion during first month to third month of storage period

Treatment	Physiological loss in weight (%)								
	Month I			Month II			Month III		
	2020-21	2021-22	Pooled mean	2020-21	2021-22	Pooled mean	2020-21	2021-22	Pooled mean
Main treatment: Different levels of RDF/ha (F)									
F_1	5.57 (13.65)	3.29 (10.45)	4.43(12.15)	10.15 (18.58)	6.32(14.56)	8.24(16.68)	14.45 (22.34)	10.42 (18.83)	12.43 (20.64)
F_2	7.84 (16.25)	5.83 (13.97)	6.84(15.16)	16.74 (24.15)	13.93 (21.91)	15.34 (23.08)	21.77 (27.81)	19.13 (25.94)	20.45 (26.89)
F_3	6.76 (15.07)	4.26 (11.91)	5.51(13.58)	14.3(22.22)	11.13 (19.49)	12.71 (20.89)	17.93 (25.05)	16.31 (23.82)	17.12 (24.44)
SE (m) $\pm$	0.19	0.11	0.15	0.40	0.34	0.27	0.52	0.41	0.36
CD @ 5%	0.53	0.32	0.43	1.16	0.98	0.79	1.50	1.18	1.03
Sub treatment: Organic sources/ha (S)									
S_0	7.59 (15.99)	5.41 (13.45)	6.50(14.77)	15.82 (23.44)	13.1(21.22)	14.46 (22.35)	19.73 (26.37)	18.26 (25.30)	19.00 (25.84)
S_1	6.39 (14.64)	4.61 (12.40)	5.50(13.56)	13.04 (21.17)	9.89(18.33)	11.47 (19.80)	17.41 (24.66)	14.39 (22.29)	15.90 (23.50)
S_2	5.99 (14.17)	4.03 (11.58)	5.01(12.93)	12.51 (20.71)	9.52(17.97)	11.02 (19.39)	17.08 (24.41)	13.94 (21.92)	15.51 (23.19)
S_3	5.86 (14.01)	3.32 (10.50)	4.59(12.37)	11.84 (20.13)	7.52(15.92)	9.68(18.13)	16.53 (23.99)	12.14 (20.39)	14.33 (22.24)
S_4	7.36 (15.74)	4.98 (12.89)	6.17(14.38)	15.00 (22.79)	11.40 (19.73)	13.20 (21.30)	19.16 (25.96)	16.71 (24.13)	17.94 (25.06)
S_5	7.14 (15.50)	4.39 (12.09)	5.77(13.90)	14.17 (22.11)	11.34 (19.68)	12.76 (20.93)	18.38 (25.39)	16.26 (23.78)	17.32 (24.59)
SE (m) $\pm$	0.26	0.16	0.21	0.57	0.48	0.39	0.73	0.58	0.51
CD @ 5%	0.75	0.47	0.61	1.71	1.40	1.12	2.19	1.74	1.58
Interaction effect: Different levels of RDF/ha (F) x Organic sources/ha (S)									
SE (m) $\pm$	0.45	0.27	0.36	0.99	0.83	0.67	1.26	1.00	0.88
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 8b. Effect of different levels of RDF with organic sources on physiological loss in weight (%) of onion during fourth month to fifth month of storage period

Treatment	Physiological loss in weight (%)					
	Month IV			Month V		
	2020-21	2021-22	Pooled mean	2020-21	2021-22	Pooled mean
Main treatment: Different levels of RDF/ha (F)						
F_1	16.00 (23.58)	12.20 (20.44)	14.10 (22.06)	19.83 (26.44)	17.11 (24.43)	18.47 (25.45)
F_2	22.24 (28.14)	20.24 (26.74)	21.24 (27.44)	23.88 (29.25)	22.95 (28.62)	23.41 (28.94)
F_3	20.23 (26.73)	16.80 (24.20)	18.52 (25.49)	22.02 (27.99)	20.39 (26.84)	21.20 (27.42)
SE (m) $\pm$	0.61	0.47	0.35	0.56	0.52	0.54
CD @ 5%	1.83	1.35	1.01	1.62	1.56	1.56
Sub treatment: Organic sources/ha (S)						
S_0	21.33 (27.51)	19.00 (25.84)	20.17 (26.69)	23.32 (28.88)	22.01 (27.98)	22.67 (28.43)
S_1	19.24 (26.02)	15.91 (23.51)	17.58 (24.79)	21.97 (27.95)	19.63 (26.30)	20.80 (27.13)
S_2	18.63 (25.57)	15.28 (23.01)	16.96 (24.32)	20.73 (27.08)	18.84 (25.72)	19.79 (26.41)
S_3	17.51 (24.74)	14.70 (22.54)	16.10 (23.66)	19.33 (26.08)	17.77 (24.93)	18.55 (25.51)
S_4	20.34 (26.81)	16.91 (24.28)	18.63 (25.57)	23.22 (28.81)	21.62 (27.71)	22.42 (28.26)
S_5	19.89 (26.49)	16.68 (24.11)	18.29 (25.32)	22.89 (28.58)	21.01 (27.28)	21.95 (27.94)
SE (m) $\pm$	0.86	0.67	0.50	0.80	0.73	0.77
CD @ 5%	2.58	2.01	1.44	2.43	2.19	2.31
Interaction effect: Different levels of RDF/ha (F) with organic sources/ha (S)						
SE (m) $\pm$	SE (m) $\pm$	SE (m) $\pm$	SE (m) $\pm$	SE (m) $\pm$	SE (m) $\pm$	SE (m) $\pm$
CD @ 5%	CD @ 5%	CD @ 5%	CD @ 5%	CD @ 5%	CD @ 5%	CD @ 5%

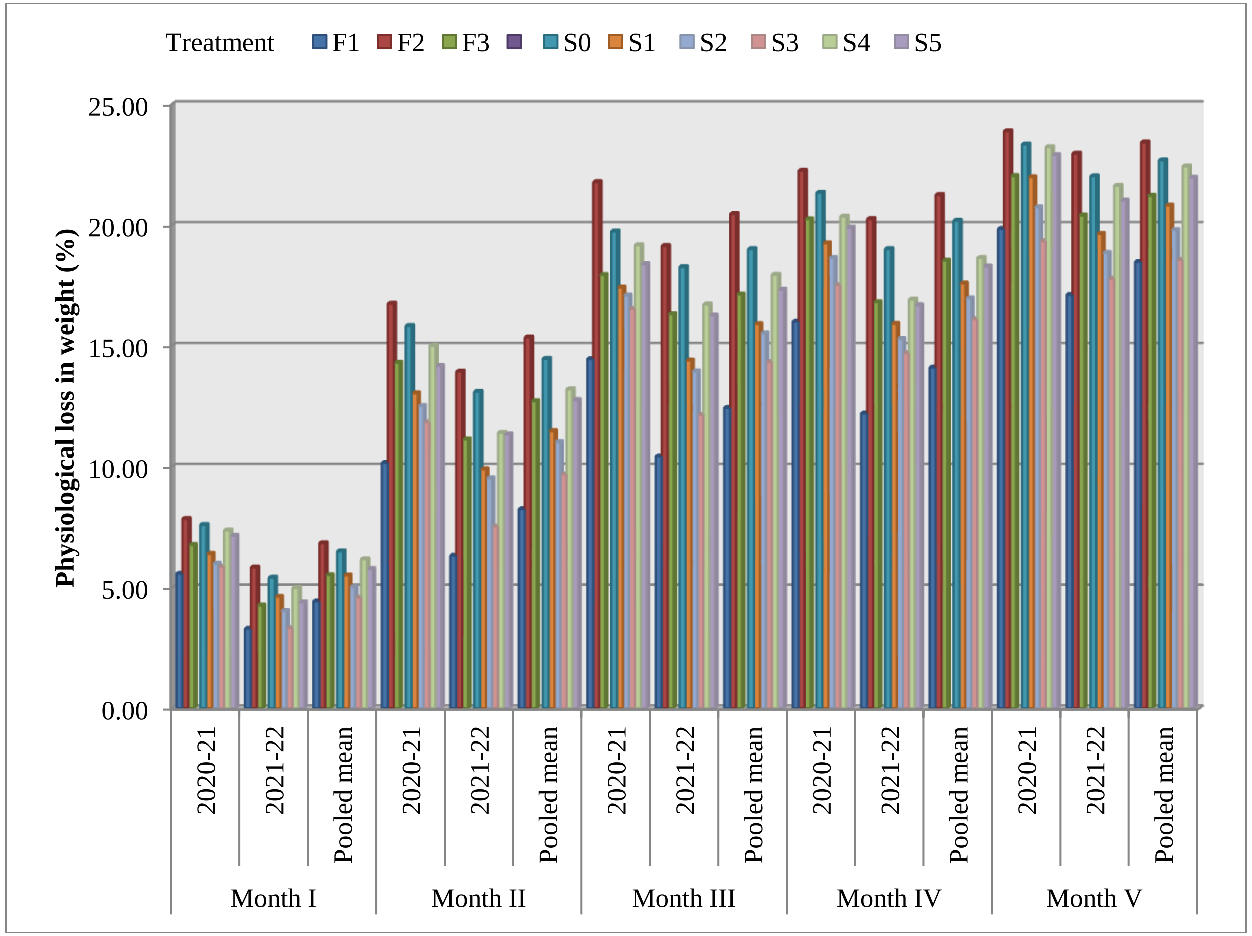

Fig. 5. Effect of different levels of RDF and organic sources per hectare on physiological loss in weight (%) of onion during five months of storage period

Table 9. Effect of different levels of RDF with organic sources on total soluble solids (%) of onion during five months of storage period

Treatment	Total soluble solids (%)														
	Month I			Month II			Month III			Month IV			Month V		
	2020-21	2021-22	Pooled mean	2020-21	2021-22	Pooled mean	2020-21	2021-22	Pooled mean	2020-21	2021-22	Pooled mean	2020-21	2021-22	Pooled mean
Main treatment: Different levels of RDF/ha (F)															
F_1	11.97	11.95	11.96	12.42	12.39	12.41	12.73	12.46	12.60	12.58	12.49	12.54	10.48	10.16	10.32
F_2	13.15	12.98	13.07	13.44	13.30	13.37	14.11	13.93	14.02	13.37	12.83	13.10	11.40	10.86	11.13
F_3	13.68	13.42	13.55	14.39	13.79	14.09	14.52	14.32	14.42	13.65	13.45	13.55	11.86	11.42	11.64
SE (m) $\pm$	0.34	0.33	0.34	0.35	0.34	0.35	0.36	0.35	0.36	0.34	0.34	0.34	0.29	0.28	0.29
CD @ 5%	0.97	0.95	0.97	1.01	0.99	1.00	1.03	1.01	1.02	NS	NS	NS	0.84	0.81	0.82
Sub treatment: Organic sources/ha (S)															
S_0	11.96	11.87	11.91	12.29	12.14	12.22	12.75	12.40	12.57	12.22	12.21	12.22	9.80	9.74	9.77
S_1	13.10	12.92	13.01	13.56	13.17	13.36	13.71	13.50	13.61	13.26	12.81	13.04	11.06	10.75	10.91
S_2	13.32	12.98	13.15	13.71	13.33	13.52	14.04	13.87	13.95	13.45	12.98	13.22	11.41	10.96	11.18
S_3	13.09	13.23	13.16	13.68	13.50	13.59	14.13	13.93	14.03	13.49	13.23	13.31	11.82	11.27	11.55
S_4	12.69	12.40	12.55	13.42	13.26	13.34	13.85	13.65	13.75	13.24	12.96	13.10	11.38	10.79	11.09
S_5	13.42	13.30	13.36	13.84	13.55	13.70	14.27	14.07	14.17	13.53	13.35	13.44	12.00	11.36	11.68
SE (m) $\pm$	0.48	0.47	0.48	0.50	0.49	0.49	0.51	0.50	0.51	0.49	0.48	0.48	0.41	0.40	0.41
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.19	1.15	1.17
Interaction effect: Different levels of RDF/ha (F) with organic sources/ha (S)															
SE (m) $\pm$	0.83	0.82	0.83	0.86	0.84	0.85	0.88	1.43	1.16	0.84	0.83	0.84	0.72	0.69	0.70
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

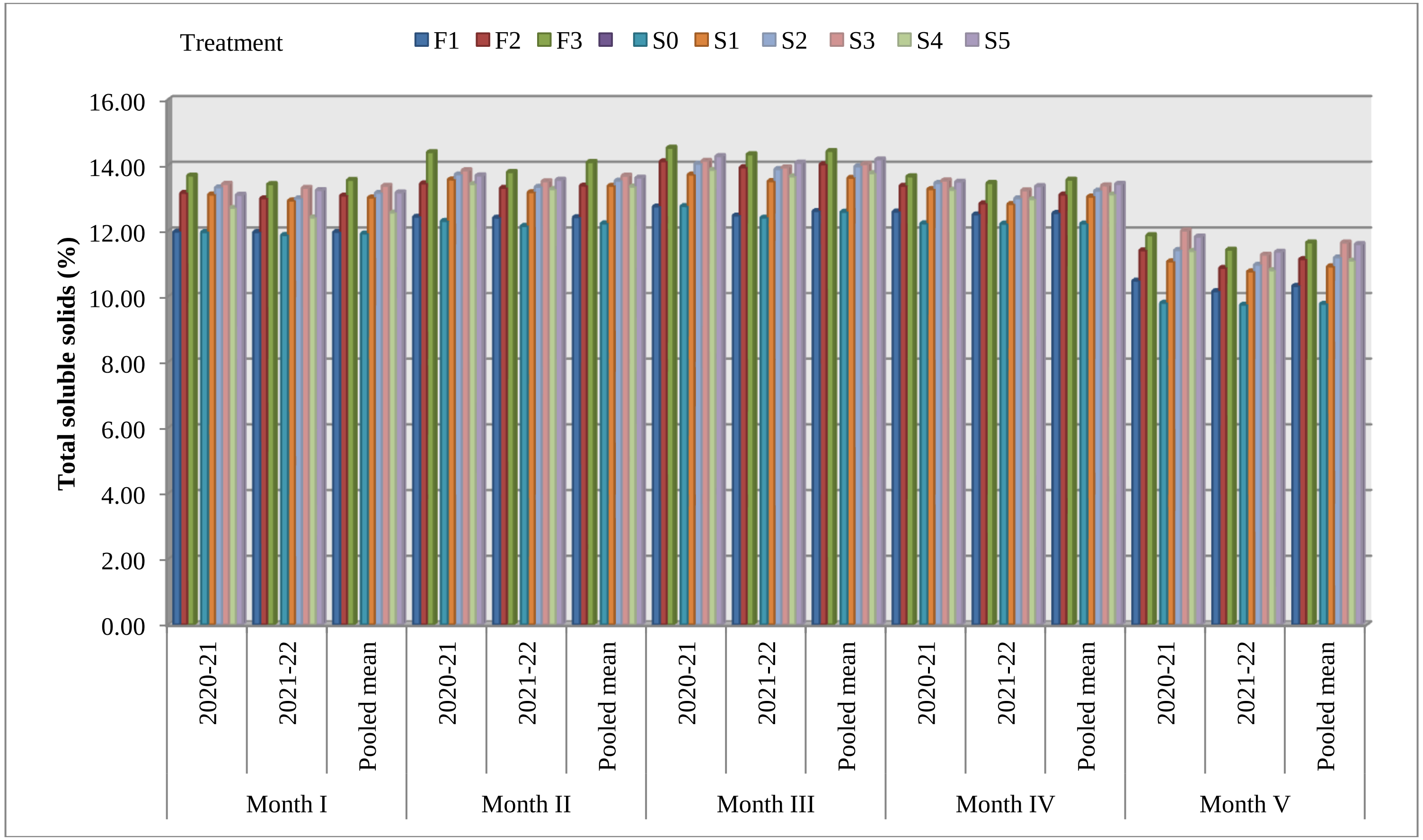

Fig. 6. Effect of different levels of RDF with organic sources on total soluble solids (%) of onion during five months of storage period

3.2.2.2 Effect of organic sources kg/ha

From Table 9 and Fig. 6 data, during first four month storage period non-significant differences were observed in different levels of organic sources on total soluble solids in onion bulbs.

At final stage of observation *i.e.* fifth month after storage during both the year (2020-21 and 2021 - 22) of the experiment and in their pooled mean analysis significantly maximum [(12.00%), (11.36%) and (11.68%), respectively] total soluble solids of onion was registered with the S_5 *i.e.* humic acid 10 kg/ha. However, it was statistically at par with S_1 *i.e.* biomix 10 kg/ha [(11.06%), (10.75%) and (10.91%), respectively], S_2 *i.e.* biomix 12.5 kg/ha [(11.41%), (10.96%) and (11.18%), respectively], S_3 [(11.82%), (11.27%) and (11.55%), respectively] and S_4 [(11.38%), (10.79%) and (11.09%), respectively]. Whereas, minimum [(9.80%), (9.74%) and (9.77%), respectively] total soluble solids of onion was recorded with the S_0 *i.e.* Control.

During storage of onion bulbs the values of total soluble solids were progressively increased from the first storage period, until its reach the highest values at the third month of storage period and later it linearly decreased at the end of fifth month of storage period. This can be attributed to low moisture content in the bulb as the storage period increases, this led to increase the concentration of total soluble solids and dry matter in the bulb and accordingly bulb firmness is increased. Similar results were reported by [28] in onion.

Maximum total soluble solids were recorded with S_5 during storage period this also might be due to higher nutrient uptake like potassium. Potassium also improves many parameters like shining, colour, keeping quality and dry matter accumulation of many crops including onion. Similar results were reported by [21] in onion.

3.2.2.3 Interaction effect

From Table 9 data, all storage period non-significant differences were registered with interaction effects of different levels of NPK with organic sources on total soluble solids in onion bulbs.

4. CONCLUSION

The overall assessment of the results of the present investigation on the "Effect of different levels of fertilizers with organic sources on growth, yield and quality of onion (*Allium cepa* L.)" concluded that, with increasing rates of fertilizers the entire bulb's biochemical quality and storage quality attributes increased. It was noticed that significantly higher biochemical quality and storage quality attributing characters were observed with the application of 120% RDF kg/ha as compared to other treatments. Among, the organic sources, humic acid at 10 kg/ha recorded the highest bulb biochemical quality parameters, except for ascorbic acid content, which was recorded at its maximum under a biomix at 15 kg/ha. During five months of storage in various levels of organic sources, biomix (15 kg/ha) had the lowest physiological loss in weight, except for total soluble solids, which was highest under humic acid (10 kg/ha). Non-significant differences in bulb quality and storage quality were observed with the interaction effects of different levels of NPK with organic sources in onion bulbs.

As these results are based on two research trials, it is suggested to conduct a few more trials to arrive at a concrete conclusion.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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