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Studies on effect of cut and whole seed tubers, plant spacing and different varieties on quality of potato (*Solanum tuberosum* L.) under Chhattisgarh plains condition

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Abstract
The present study entitled "Studies on effect of cut and whole seed tubers, plant spacing and different varieties on quality of potato (*Solanum tuberosum* L.) under Chhattisgarh plains condition" was conducted during *rabi* season 2019-20 and 2020-21 under All India Coordinated Research Project on Potato, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) This experiment was designed in Factorial Randomized block design had three replications, sixteen treatment combinations, keeping four varieties *i.e.* V_1: K. Jyoti, V_2: K. Pukhraj, V_3: K. Sindhuri and V_4: K. Neelkanth and four plant spacing *i.e.* S_1: 10 cm cut seed tuber, S_2: 15 cm cut seed tuber, S_3: 20 cm cut seed tuber and S_4: 20 cm whole seed tuber. To identifying the most suitable high yielder potato varieties under cut and whole seed tuber, also to find out the best combination of plant spacing and potato varieties suitable for the grower of these region. Among the varieties the quality parameters were differ significantly during first and second year and it was higher specific gravity (1.06 and 1.07), starch content (16.17 and 18.51), total soluble solid (4.51 and 4.59) also significantly in higher V_3 (K. Sindhuri). And among the spacing the quality parameters were differ significantly during first and second year and it was higher starch content (14.83 and 16.55) and total soluble solid (4.99 and 5.25) were also significantly in higher S_4 (20 cm whole seed tuber) during both the year of study. The interaction effect varieties and plant spacing of quality parameters specific gravity (1.08 and 1.09) significantly higher in V_3S_4 (K. Sindhuri and 20 cm whole seed tuber).

Keywords: Cut and whole seed tubers, potato, quality, specific gravity, starch content, total soluble solid

1. Introduction
Potato (*Solanum tuberosum* L.) having probable a centre of origin in South America, where it occupies the largest area. It is an annual herbaceous plant grown in every country in the world. It is called as "King of vegetables". It has fourth position among the food crops after wheat, rice and maize. Potato has been disseminated throughout the world. India is the third-largest producer of potato in the world after China and Russia. In the world, 368.24 million tonnes of potato is being produced in area of 17.57 million hectares with 16.64 tonnes per hectare productivity (Anonymous, 2019) [1-3]. In India, it is cultivated in about the 21.42 lakh hectares area with a production of 513.27 lakh MT and average productivity of 23.68 tonnes per hectare (Anonymous, 2019) [1-3]. In Chhattisgarh, it is mainly cultivated in Sarguja, Raigarh, Jashpur, Balrampur, Bilaspur and Baster as rabi crop and in Mainpat and Samripat hills of Sarguja district as kharif crop. However, it can be grown in all the agro-climatic zones of Chhattisgarh under irrigated conditions. It is presently being grown in an area of 43541 hectares with annual production of 598315 tonnes and productivity 15.02 tonnes per hectare (Anonymous, 2019) [1-3].

Potato is a highly nutritious, easily digestible, wholesome food containing carbohydrates, proteins, minerals, vitamins, high quality dietary fiber with high yielding capability to produce more food per unit area and time than any important vegetable crops which not only helps in food self-sufficiency but provides a good alternative means to earn foreign exchange. A potato tuber contains 70-80 per cent water and 20-25 per cent dry matter consisting edible protein (2.8 g), total sugar (0.6 g), starch (16.3 g), crude fiber (0.5 g), fat (0.14 g), carbohydrate (22.6 g), vitamin C (25 mg), mineral (0.9 g), calcium (7.7 mg), iron 2 (0.75 mg), ash (1-1.5%), amylose (22-25%) and glycoalkaloids (< 1 mg) per 100 g fresh weight as an antinutritional factor (Bist and Sharma,1997) [4].

Cutting whole potato tubers and use the pieces for seed (seed-pieces) is a common practice. This is a key reason for cutting to produce seed-pieces to recommended planting size. However, another key reason is to overcome apical dominance exerted by the apical eye or sprout. In brief, the apical eye or sprout (at the "bud end") suppresses the sprouting of eyes more basal (toward the "stem end"). For more on apical dominance in seed tubers, see panel "Tuber Aging" A major problem with cutting, however, is that it opens a severe and large wound through the skin allowing some key pathogens to get into the seed-piece. Because of this concern, seed-pieces must be allowed to heal (suberize) and seed treatments containing fungicides are applied. The situation is further aggravated in the cultivars, which have a tendency to produce large size tubers. One way of reducing cost of seed input in such cultivars is to use cut seed pieces and maintain higher planting density per unit area than of whole seed tubers.

2. Methodology

The experiment was carried out in Factorial RBD with three replication having sixteen treatment combinations with four varieties assigned to four potato spacing. Each treatment combination was randomly replicated thrice. The treatment details are given below. Experimental site was located at Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.) having with adequate facilities for irrigation and drainage are available.

Seed tubers were cut vertically in such a way that each piece had at least 2-3 eyes (40–50 g by weight). The cut pieces were immediately dip treated with 0.2% dithane M-45 @ 2.5 g ltr^{-1} for 10-20 minutes and shade dried. The cut seed pieces were directly planted after drying. Seeds tubers were planted in furrows made at four different spacing as per the experimental design. The spacing was S_1 (60×10cm planting of cut seed tuber), S_2 60× 15cm planting of cut seed tuber), S_3 (60×20cm planting of cut seed tuber) and S_4 (60 ×20cm planting of whole tuber (recommended spacing)). The treated seed tubers with 2-3 eyes were placed in the furrows as per the spacing. Thereafter, the seed tubers were covered with soil and light irrigation was given.

Nitrogen was applied in form of urea as per the treatments and phosphorous was applied @100 kg/ha in form of Single Super Phosphate (SSP) respectively, whereas, potassium is applied @ 120 kg/ha in the form of Murate of Potash (MOP). The recommended dose of fertilizer *i.e.*,150: 100:100 kg NPK ha^{-1} was applied.

3. Result

3.1 Influence of Variety

The data pertaining Influence of Variety on specific gravity (g cm^2), Starch content, total soluble solid and Uniformity of tubers data were recorded and presented in Table 1, 2, 3 and 4 and depicted in Fig 1, 2 and 3

The results observed that significantly difference among different varieties in first year, second year and pooled mean. It showed that maximum specific gravity (g cm^2) was recorded under V_3 (K. Sindhuri) in first year, second year and pooled mean (1.06, 1.07 and 1.07 g cm^2, respectively). Followed by V_2 (K. Pukhraj) of (1.06, 1.06 and 1.06, g cm^2, respectively). Where, it was minimum under V_4 (K. Neelkanth) during first year, second year and pooled mean (1.06, 1.06 and 1.06 g cm^2, respectively). And Variety V_3 (K. Sindhuri) was recorded for maximum starch content (%) of tuber in first year, second year and in pooled mean (16.17%, 18.51% and 17.34%, respectively), followed by V_2 (K. Pukhraj) was recorded (14.33%, 14.23% and 14.28%, respectively). Where, it was minimum during the first year, second year and pooled mean (12.83%, 13.04%, and 12.94%, respectively), under V_4 (K. Neelkanth). And variety V_3 (K. Sindhuri) was recorded for maximum total soluble solid of tuber in first year, second year and pooled mean (4.51%, 4.59% and 4.55%, respectively), followed by V_2 (K. Pukhraj) was recorded (4.23%, 4.50% and 4.37%, respectively), Where, it was minimum during the first year, second year and pooled mean (4.08%, 4.02% and 4.05%, respectively), under V_4 (K. Neelkanth).

3.2 Influence of spacing

The data pertaining Influence of spacing on specific gravity (g cm^2), Starch content, total soluble solid and Uniformity of tubers data were recorded and presented in Table 31, 2, 3 and 4 and depicted in Fig 1, 2 and 3

The results indicated that the data were differ significantly among different plant spacing during the first year, second year and pooled mean. The maximum specific gravity (g cm^2) in first year, second year and pooled mean, were recorded under S_4 (20 cm whole seed tuber) of (1.07, 1.08 and 1.08 g cm^2, respectively), which were found *at par* with S_3 (20 cm cut seed tuber) of (1.07, 1.07 and 1.07 g cm^2) and S_2 (15 cm cut seed tuber) at (1.06, 1.06 and 1.06 g cm^2, respectively). The minimum (1.04, 1.05 and 1.04 g cm^2, respectively), was recorded under S_1 (10 cm cut seed tuber). And the spacing S_4 (20 cm whole seed tuber) were recorded for maximum starch content (%) of tuber in first year, second year and pooled mean (14.83%, 16.55% and 15.69%, respectively. which were found *at par* with S_3 (20 cm cut seed tuber) of (14.67%, 14.59% and 14.63% respectively) and S_2 (15 cm cut seed tuber) at (13.83%, 14.15% and 13.99%, respectively). Where, it was minimum (13.50%, 13.99% and 13.74%, respectively), under S_1 (10 cm cut seed tuber). And maximum total soluble solid during the first year, second year and pooled mean, were recorded under S_4 (20 cm whole seed tuber) of (4.99, 5.25 and 5.12, respectively), which were found *at par* with S_3 (20 cm cut seed tuber) of (4.31, 4.25 and 4.28) and S_2 (15 cm cut seed tuber) at (4.02, 4.09 and 4.05, respectively). Where, it was minimum under S_1 (10 cm cut seed tuber) of (3.65, 3.82 and 3.73, respectively).

3.3 Interaction effect with variety x spacing

The data pertaining Interaction (Variety x Spacing) on specific gravity (g cm^2), Starch content, total soluble solid and Uniformity of tubers data were recorded and presented in Table 1, 2, 3 and 4 and depicted in Fig 1, 2 and 3

The data indicated that significant differences for interaction of different varieties and plant spacing. The interaction V_3S_4 (K. Sindhuri and 20 cm whole seed tuber) was recorded maximum specific gravity (g cm^2) during the first year, second year and pooled mean (1.08, 1.09 and 1.08 g cm^2, respectively). Followed by V_1S_4 (K. Jyoti and 20 cm whole seed tuber) of (1.07, 1.08 and 1.08 g cm^2, respectively). However, it was minimum (1.03, 1.04 and 1.04 g cm^2, respectively), under V_4S_1 (K. Neelkanth and 10 cm cut seed tuber). The specific gravity of the tubers of potato is a maturity index which is observed taking into account weight of the individual tuber weight of the water displaced by it.

The maximum specific gravity (g cm^2) in first year, second year and pooled mean, were recorded under V_3S_4 (K. Sindhuri and 20 cm whole seed tuber). This might be due to the fact that most quality traits of potato including tuber specific gravity are controlled by genetic factors along with optimum plant spacing facilitate the genotypes to produce best quality tuber with higher spacing Getachew *et al.* (2012). Zebarth *et al.* (2006) also confirmed that specific gravity increased at the wider plant spacing. The wider plant spacing due to the presence of minimum competition the vegetative growth period of plants extended and consumed the highest nutrients resulted found in the higher specific gravity.

The data indicated that there were non-significant differences for interaction of varieties and plant spacing. However, numerically higher starch content (%) of tuber during the first year, second year and pooled mean (17.67%, 24.70% and 21.18%, respectively), were recorded under V_3S_4 (K. Sindhuri and 20 cm whole seed tuber). However, it was less (12.67%, 13.60% and 13.13%, respectively), under V_1S_1 (K. Jyoti and 10 cm cut seed tuber). The maximum starch content per cent of tuber was recorded under treatment V_3 (K. Sindhuri) However, it was higher starch content per cent was recorded under variety S_4 (20 cm whole seed tuber) as compared to other varieties. Among interactions it was showed non-significant differences for interactions of different plant spacing and varieties. The above results are in conformity with the findings of Chadchan *et al.* (1990) [5] reported that potato cv. Kufri Badshah and Kufri Chandramukhi at grown spacing 50x20 cm, 60x20 cm they found that starch percentage were higher in Kufri Badshah than in Kufri Chandramukhi.

The data indicated that the interaction of varieties and plant spacing were differ non-significant. The interaction V_3S_4 (K. Sindhuri and 20 cm whole seed tuber) were recorded for numerically highest total soluble solid during first year (5.67), second year (6.00) and pooled mean (5.83). Where, it was minimum in first year (3.33), second year (3.60) and in pooled mean (3.47), V_4S_1 (K. Neelkanth and 10 cm cut seed tuber). The highest total soluble solid were recorded under V_3S_4 (K. Sindhuri and 20 cm whole seed tuber) Similarly result was found by Thirupal *et al.* (2020) [9] the maximum total soluble solid was recorded from a spacing of 75 x 20 cm followed by spacing 60 x 20 cm was recorded.

Uniformity of potato tubers is presented in Table 4. Potato tuber size and shape is a desirable trait for the physical quality of the potato tubers. Tuber size and shape decides its clientele and region of demands for ware, seed and processing potato depending upon the product-specific requirements. Most of the Indian potato varieties attain their ultimate tuber shape at maturity. The harvested tubers are graded according to their weight *viz*., 0-25 g, 25-50 g, 50-75 g, >75 g. these were examined by visual identification for either uniform (1), or non-uniform (0). The results revealed that the first year (2019-20) more uniform tubers are observed in treatment V1S2, V1S3, V1S4, V3S2, V3S3, V3S4, and similarly second year (2020-21) more uniform tubers are observed in treatment V1S2, V1S3, V1S4, and V3S2, V3S3, V3S4.

Table 1: Specific gravity of potato as influenced by varieties and plant spacing

Treatments	Specific gravity		
	2019-20	2020-21	Mean
A. Variety			
V_1= K. Jyoti	1.06	1.06	1.06
V_2= K. Pukhraj	1.06	1.06	1.06
V_3= K. Sindhuri	1.06	1.07	1.07
V_4= K. Neelkanth	1.06	1.06	1.06
S.Em±	0.14	0.14	0.14
CD (P=0.05)	0.42	0.41	0.42
B. Spacing			
S_1= 10 cm cut seed tuber	1.04	1.05	1.04
S_2= 15 cm cut seed tuber	1.06	1.06	1.06
S_3= 20 cm cut seed tuber	1.07	1.07	1.07
S_4= 20 cm whole seed tuber	1.07	1.08	1.08
S.Em±	0.14	0.14	0.14
CD (P=0.05)	0.42	0.41	0.42
Interaction (A x B)			
V_1S_1	1.04	1.04	1.04
V_1S_2	1.06	1.06	1.06
V_1S_3	1.06	1.07	1.07
V_1S_4	1.07	1.08	1.08
V_2S_1	1.04	1.05	1.05
V_2S_2	1.06	1.06	1.06
V_2S_3	1.07	1.07	1.07
V_2S_4	1.07	1.08	1.08
V_3S_1	1.04	1.06	1.05
V_3S_2	1.06	1.06	1.06
V_3S_3	1.07	1.07	1.07
V_3S_4	1.08	1.09	1.08
V_4S_1	1.03	1.04	1.04
V_4S_2	1.06	1.06	1.06
V_4S_3	1.06	1.07	1.07
V_4S_4	1.07	1.07	1.07
S.Em±	0.29	0.29	0.29
CD (P=0.05)	0.84	0.83	0.84

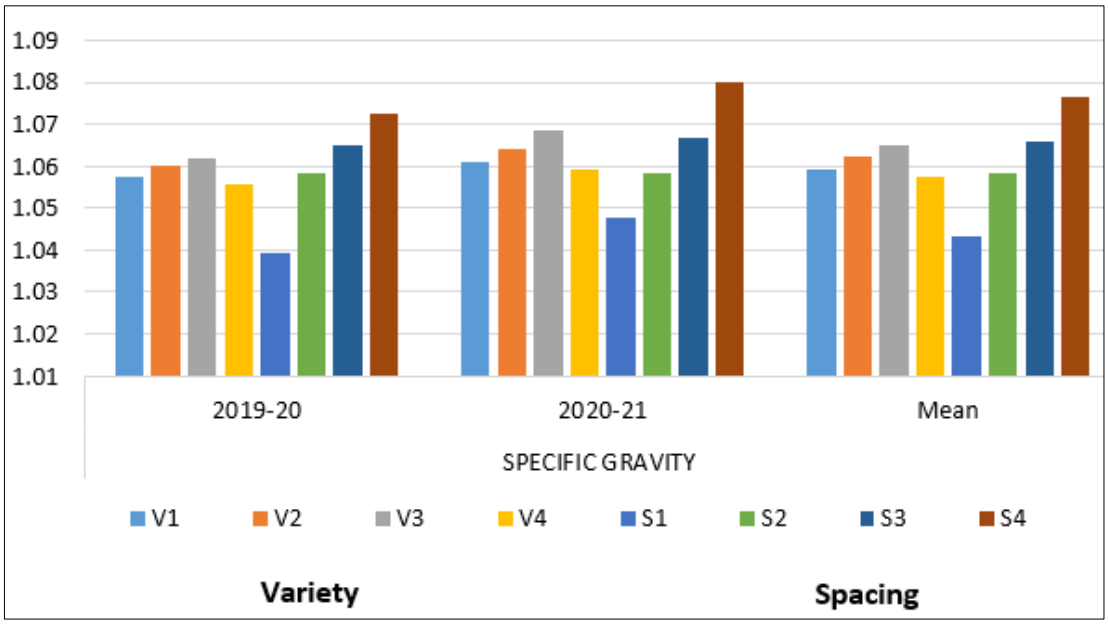

Fig 1: Specific gravity of potato as influenced by varieties and plant spacing

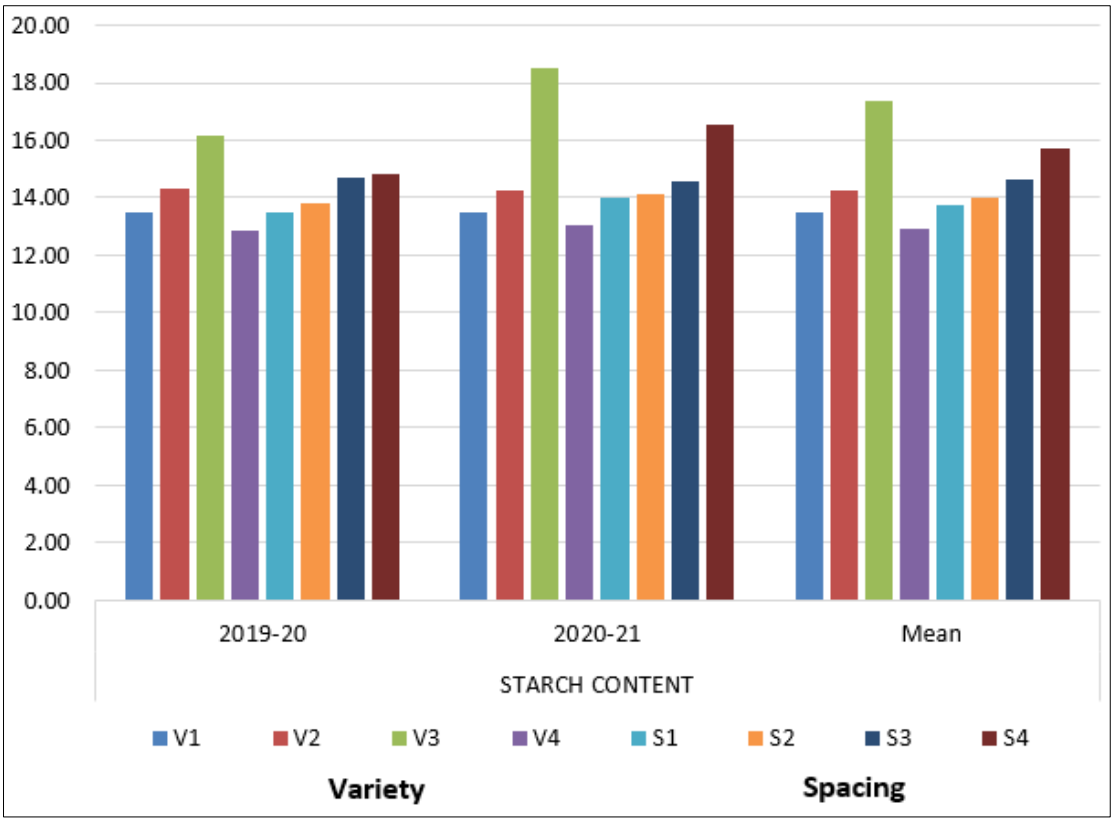

Fig 2: Starch content of potato as influenced by Variety with plant spacing

Table 2: Starch content of potato as influenced by Variety with plant spacing

Treatments	Starch content		
	2019-20	2020-21	Mean
A. Variety			
V_1= K. Jyoti	13.50	13.50	13.50
V_2= K. Pukhraj	14.33	14.23	14.28
V_3= K. Sindhuri	16.17	18.51	17.34
V_4= K. Neelkanth	12.83	13.04	12.94
S.Em±	1.43	1.21	1.32
CD (P=0.05)	4.14	3.50	3.82
B. Spacing			
S_1= 10 cm cut seed tuber	13.50	13.99	13.74

S_2= 15 cm cut seed tuber	13.83	14.15	13.99
S_3= 20 cm cut seed tuber	14.67	14.59	14.63
S_4= 20 cm whole seed tuber	14.83	16.55	15.69
S.Em±	1.43	1.21	1.32
CD (P=0.05)	4.14	3.50	3.82
Interaction (A x B)			
V_1S_1	12.67	13.60	13.13
V_1S_2	13.67	13.65	13.66
V_1S_3	13.67	13.07	13.37
V_1S_4	14.00	13.67	13.83
V_2S_1	14.33	14.00	14.17
V_2S_2	14.33	14.30	14.32
V_2S_3	14.33	14.31	14.32
V_2S_4	14.33	14.32	14.33
V_3S_1	14.67	15.67	15.17
V_3S_2	14.67	16.00	15.33
V_3S_3	17.67	17.67	17.67
V_3S_4	17.67	24.70	21.18
V_4S_1	12.33	12.67	12.50
V_4S_2	12.67	12.67	12.67
V_4S_3	13.00	13.33	13.17
V_4S_4	13.33	13.50	13.42
S.Em±	2.86	2.43	**2.65**
CD (P=0.05)	NS	NS	**NS**

Table 3: Total soluble solid of potato as influenced by varieties and plant spacing

Treatments	**Total soluble solid**		
	2019-20	**2020-21**	**Mean**
A. Variety			
V_1= K. Jyoti	4.15	4.29	4.22
V_2= K. Pukhraj	4.23	4.50	4.37
V_3= K. Sindhuri	4.51	4.59	4.55
V_4= K. Neelkanth	4.08	4.02	4.05
S.Em±	0.13	0.52	0.33
CD (P=0.05)	0.38	1.52	0.95
B. Spacing			
S_1= 10 cm cut seed tuber	3.65	3.82	3.73
S_2= 15 cm cut seed tuber	4.02	4.09	4.05
S_3= 20 cm cut seed tuber	4.31	4.25	4.28
S_4= 20 cm whole seed tuber	4.99	5.25	5.12
S.Em±	0.13	0.52	0.33
CD (P=0.05)	0.38	1.52	0.95
Interaction (A x B)			
V_1S_1	3.67	3.67	3.67
V_1S_2	4.00	4.20	4.10
V_1S_3	4.30	4.30	4.30
V_1S_4	4.64	5.00	4.82
V_2S_1	3.60	4.00	3.80
V_2S_2	4.03	4.02	4.03
V_2S_3	4.30	4.33	4.32
V_2S_4	5.00	5.67	5.33
V_3S_1	4.00	4.01	4.00
V_3S_2	4.04	4.03	4.04
V_3S_3	4.33	4.33	4.33
V_3S_4	5.67	6.00	5.83
V_4S_1	3.33	3.60	3.47
V_4S_2	4.00	4.11	4.05
V_4S_3	4.32	4.03	4.18
V_4S_4	4.67	4.34	4.50
S.Em±	0.26	1.05	0.66
CD (P=0.05)	NS	NS	NS

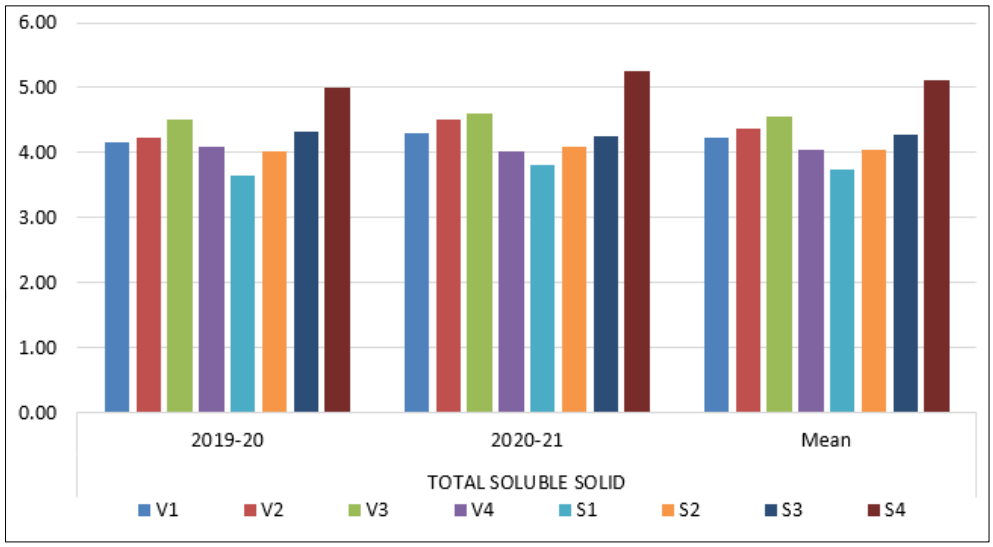

Fig 3: Total soluble solid of potato as influenced by varieties and plant spacing

Table 4: Uniformity and non-uniformity of tubers

Treatments	Uniform (1) 2019-20	Non-uniform (0) 2019-20	Uniform (1) 2020-21	Non-uniform (0) 2020-21
V_1S_1	-	0	-	0
V_1S_2	1	-	1	-
V_1S_3	1	-	1	-
V_1S_4	1	-	1	-
V_2S_1	-	0	-	0
V_2S_2	-	0	-	0
V_2S_3	-	0	-	0
V_2S_4	-	0	-	0
V_3S_1	-	0	-	0
V_3S_2	1	-	1	-
V_3S_3	1	-	1	-
V_3S_4	1	-	1	-
V_4S_1	-	0	-	0
V_4S_2	-	0	-	0
V_4S_3	-	0	-	0
V_4S_4	-	0	-	0

4. Conclusion

The quality parameters *i.e.* specific gravity (g cm^2) was recorded maximum V_3S_4 (K. Sindhuri and 20 cm whole seed tuber) (1.08, 1.09 and 1.08 g cm^2, respectively). And the higher starch content (%) of tuber were recorded under V_3S_4 (K. Sindhuri and 20 cm whole seed tuber) (17.67%, 24.70% and 21.18%, respectively), numerically highest total soluble solid were recorded V_3S_4 (K. Sindhuri and 20 cm whole seed tuber) (5.67, 6.00 and 5.83 respectively).

There for it may be concluded that treatment V_3S_4 (K. Sindhuri and 20 cm whole seed tuber) may be prefer for higher quality of potato.

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