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Transplanting wheat (Triticum aestivum L.) ecosystem under organic condition a new paradigm of crop establishment

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Abstract

Transplanting ecosystem of wheat crop under organic conditions has received attention in enhancing productivity and production. A field experiment was conducted during the rabi seasons of 2017-18, 2018-19 and 2019-20 under organic conditions to study the response of wheat cultivars of transplanted organic wheat crop on growth and productivity. The experiment comprised of transplanted ecosystem of wheat and conventional method under two different age old seedlings sown at i,e. 20 & 30 days. The increase in yield from transplanting was due to increase in morphological traits such as the plant heights and number of tillers per square meter. Further, under transplanted ecosystem the cultivars, JAUW 584 recorded the highest grain yield, straw yield and harvest index. Besides, different phenological stages of wheat variety JAUW 584 occurred earlier in transplanted ecosystem under organic condition. Among the different age-old seedling, it was reported that 20 days old seedlings performed better at different phonological stages and recorded significantly higher grain yield (43.80q/ha), straw yield, biological yield and harvest index. In the study it has been envisaged that the transplanted wheat ecosystem not only gave higher yield but also reduced the phenological stages which can be best fit in rice-wheat ecosystem.

KEYWORDS: Organic farming; transplanting wheat; age of seedlings; phenological traits

Introduction

Wheat (Triticum aestivum L.) is one of the leading food crops of the world farming and occupies significant position among the cultivated cereals. Cultivation of wheat has been the symbolic of green revolution that played pivotal role in making the nation a food surplus nation. It is an important cereal crop grown on an area of 29.58 million hectares in India, producing 99.70 million tonnes of grains with an average productivity of 3371 kg/ha (Anonymous, 2018). During the past two decades, wheat direct seeding is the common practice for production, which includes drilling and scattering. The productivity gains from the usual wheat sowing methods with their substantial input dependence have unfortunately been declining. In India, rice –wheat culture is most prevalent one. Late harvest of rice due to delayed maturity and renovation of land in most of the cases require times and thus prevent sowing of wheat at right time. As wheat is mostly a season specific crop, delayed sowing causes abrupt shift of vegetative and reproductive phases resulting in poor expression of crop growth and yield. The wheat growers are thus facing the difficulties to cope with late harvest of rice crop are thereby looking forward for new method of growing wheat. Transplanting ecosystem of wheat is a technology, in which transplanting of wheat seedlings was done to fill the germination gaps, which was found better than seeding, especially late in winter when the soil temperature would not support the seed germination. With adoption of this new transplanting technology in wheat, problems of delayed sowing and terminal heat effect can be solved to some extent as transplanting reduces the crop duration by several days. Raising of wheat seedlings in nursery when rice is in the main field, provide farmers additional time between harvesting of rice and preparing their land for next crop wheat. Hossain and Maniruzzaman (1993) reported that late transplanting of wheat recorded 16% higher grain yield due to production a greater number of grains per spike and grain weight over direct sowing. The purposes of the seedling transplanting wheat culture are in two aspects. One is for obtaining potential yield and the other is for substituting late sowing culture after the later-autumn crops, in addition to filling germination gaps. It was found that in the fertile field, transplanted wheat plants can regenerate higher quantity of active branch roots either from seminal or from adventitious roots, whereby the physiological activities in the whole plant were enhanced with the consequence of increased grain yield. It was concluded that the increased yield by transplanting culture was attributed to the more developed spike, larger leaf area, longer duration of green leaves, and higher resistance to lodging and disease in grain filling period. Seedling transplanting has been adopted in some areas in China. transplanting of wheat had been found to exhibit greater plant height, top stem diameter, total leaf area, number of kernels per spike, kernel weight, spike length, rachis internode length and increment of yield over early and late sowings (Xu et al. 2009). Further, Rai and his coworkers in 2016 used hydroponically raised wheat seedlings of different ages for transplanting and observed that transplanting was superior in terms of crop performance over direct sowing and specifically, transplanting of 7 days old seedlings attained greater plant height, tiller numbers, panicle length, number of grains per panicle, biomass and yield over transplanting of 10 and 12 days old seedlings.

However, it is not clear how advantageous the transplanting culture is over the seeding culture when the former crop is harvested late or how different it is from the seeding culture if the seeding and planting are not late. Unlike rice, although wheat transplanting is not so popular, where at the initial stages of this technology, gap filling was the only reason for its adoption because of its superiority over seed sowing on fertile soil to generate branches of active root and to uplift growth and yield of wheat (Chi et al., 1991). Therefore, in the present study was undertaken wherein seeding and transplanting of organic wheat were done in pair at different time, early and late, to confirm the responses of plant growth and grain yield to the transplanting culture.

Materials and methods

Experimental site, climate and soil

A field experiment was conducted during rabi 2017-18, 2018-19 and 2019-20 at research farm of Organic Farming Research Centre, SKUAST-Jammu. The Experiment site is located at 32° 66' N latitude and 74° 79' E longitude at an elevation of 356 meters above mean sea level. Jammu is located in sub-tropical zone bestowed with hot and dry early summers followed by hot and humid monsoon season and cold winters. The mean annual rainfall is 1200 mm of which 7075 per cent rainfall is received from June to September, whereas remaining 25-30 per cent of rains are received in few showers during winter as a result of Western disturbances from January to March. The daily average maximum temperatures and minimum temperature were 24.6^{o}C and 5.0^{o}C while maximum relative humidity was 89.8 % and minimum relative humidity was 47.8%. The soil of the experimental field was sandy clay loam in texture with pH 7.5, medium in organic carbon, available phosphorus and potassium and low in available nitrogen.

Experimental treatments and management

The experiment treatments comprised of transplanted and conventional method of wheat sowing of 05 different cultivars of wheat viz JAUW 584, RSP 561, WH 1105, RAJ 3765, JAUW 598 and conventional with 02 different age-old seedlings at (20 & 30 days) under organic condition was laid out in a factorial design with three replications. The crop management was done as per the recommended package of practices and only age of seedlings (20 and 30 days old) was altered. The recommended dose of NPK were applied through organic manures; FYM, Vermicompost, Neemcake, etc., where 1/3rd of N (as manure) was applied at the time of sowing and remaining N (as manure and cow urine) was applied in two equal splits at first irrigation or 20-25 days after sowing and at 2nd irrigation or 40-45 days after sowing, respectively. For recording observations on various agronomical traits, five plants in each plot were selected at random and labeled. After the crop reached its physiological maturity, the crop was harvested manually by sickle, close to ground level, and the entire above-ground biomass was removed from the field. While harvesting three rows from either side of the plots (row to row sides) and 50 cm from the proximal and distal ends of the rows of individual plots were harvested separately to eliminate the border effects. After removing border rows and sampling area, a net plot area of 5 m × 3 m was harvested manually for yield estimation. The produce of individual plots was threshed by a Pullman thresher 2 days after harvesting, collected in cloth bags and grain weight was recorded for each treatment. Simultaneously, a grain sample (200 g) was drawn from individual plots to determine the moisture content of grains using an OSAW moisture meter (OSAW, Delhi, India). The grain yield was expressed at14 % moisture.

Soil and plant analysis

Composite soil samples from each plot were collected using a screw auger from 0 to 15 cm. The samples were air-dried in the shade on polythene sheets. After drying, samples were crushed on hard wooden slabs with the help of a wooden roller, passed through a 2 mm sieve and stored for further chemical analysis. The pH of the soil was determined using a digital pH meter with a glass electrode in a 1:2.5 soil-water suspensions (Jackson, 1973). Electrical conductivity (EC) was determined in 1:2.5 soil-water suspension by a conductivity meter (Bower and Wilcox, 1965). Representative sub-samples were used to determine nitrogen and phosphorus by alkaline potassium permanganate method (Subbiah and Asija, 1956), Olsen-P (Olsen et al., 1954) method and potassium content was determined by ammonium acetate-extractable K in a flame photometer (Jackson, 1973).

Statistical analysis

The data was analyzed in R studio utilizing library Agricole in a factorial setup compromising of two factors i.e, method of sowing and six different cultivars. Analysis of variance procedure was used to find out the statistical differences among different sowing methods and cultivars using least significant difference procedure. Further, data was graphically visualized utilizing ggplopt2 library of R studio. A graphical display of all parameters used in the study is given in the form of boxplot in figure 1 and correlation plot is given in figure 2. The factor means and interaction effects of all the parameters are given in Table 1.

Results and discussion

Growth and yield of wheat under the transplanting and conventional (seed sown) methods of organic wheat sowing

The growth attributes i,e plant height, number of effective tillers were significantly influenced under different method of wheat sowing. From the three years study, it was observed that the plant height and no. of effective tillers were increased progressively due to transplanting method. (Table 1) However, there was significant variation in grain yield and harvest index under transplanting method as compared to conventional method (Table 1). Xu et al. (2009) reported that the increased grain yield by transplanting method by the production of the larger quantity of new roots which have higher activity and maintain the activity till late grain filling stages. Further, the seedling transplanted wheat plants are less senescent and have longer time for growth and development, whereby the grain number and grain size increase. This was confirmed by maintenance of green leaf area in both pot and field culture (Evan et al. 1975). Also, transplanted wheat plants tiller more successfully and were resistant to lodging by stronger stems.

Effect of different age seedlings for transplanting on growth and yield in organic wheat crop The effect of different age of seedlings on plant height and number of effective tillers/m^2 were found to be significant and the higher plant height and no. of effective tillers/m^2 were observed in 20 days old seedlings as compared to 30 days old seedlings for transplanting of organic wheat crop (Table 1). From the data on mean grain yield and biological yield, it was revealed that the grain yield and biological yield increased at harvest. Mean grain yield and biological yield were influenced significantly by the 20 days old seedlings as compared to 30 days old seedlings for transplanting of organic wheat crop (Table 1). No matter early or late, transplanting culture resulted in significant increase in grain yield compared to seed sown culture. There was also a positive interaction between culture manner (transplanting or seed-sowing) and timing (early or late) (Evans et al. 1970; Hui et al. 2011).

Effect of different wheat cultivars on growth and yield

The cultivars selected for the present investigation were JAUW 584, RSP 561, WH 1105, RAJ 3765 and JAUW 598. Organic wheat cultivars viz., JAUW 584 and JAUW 598 recorded higher grain, straw yield, biological yield and harvest index compared to other cultivars of organic wheat (Table 1). Transplanting of wheat thus has very good prospect for successful production as transplanting delays senescence, produces high root biomass, more tillers, higher grain yield and possesses high resistances to lodging and diseases (Kimura, 1949; Chi et al. 1991). The maximum grain yield was recorded with JAUW 584 (43.80q/ha) in 20 DAT followed by JAUW 598 (41.60q/ha) in 20 DAT as compared to other cultivars of organic wheat crop (Table 1).

Economics of wheat influenced under the transplanting and conventional (seed sown) methods of organic wheat sowing

The data on gross returns reported that the transplanting method of organic wheat crop at 20 DAT gave highest gross monetary returns (Rs. 96360 ha^{-1}) and the lowest gross returns (Rs. 62920 ha^{1}) by the conventional (seed sown) method of organic wheat at 30 DAT (Table 2). The maximum B C ratio of 2.25 was recorded under transplanted of organic wheat (Cultivar 'JAUW 584') (Table 2).

Effect of age of Seedlings on economics

The data on gross returns revealed that the 20 days old seedlings of organic wheat for transplanting gave highest gross returns as compared to others treatments. Data on net returns reported that the 20 days old seedlings of organic wheat for transplanting recorded higher net returns (Rs. 53502 ha^{-1}) as compared to others treatments.

Effect of cultivars of organic wheat on economics

Among the 5 cultivars of organic wheat viz. JAUW 584, RSP 561, WH 1105, RAJ 3765 and JAUW 598 with 02 age of seedlings (20 and 30 days) for transplanting. The data on gross returns, revealed that the cultivar of organic wheat 'JAUW 584' gave highest gross returns (Rs. 96360 ha^{-1}) at 20 DAT followed by cultivar of organic wheat 'JAUW 598' (Rs. 91520. ha^{-1}) at 20 DAT (Table 2).

Conclusion

From the three years study, it was concluded that the transplanted wheat recorded higher grain yield than that from direct seed sowing. The increase in yield from transplanting was due to increase the plant heights and number of tillers per square meter. Thus, transplanted wheat cultivation technology is better than the conventional cultivation technology because transplanted wheat plant produces tillers more successfully, were resistant to lodging by stronger stems and can tolerate terminal heat stresses in addition to increase in grain yield. The reduction of pedological stages in wheat under transplanted ecosystem fits well for rice-wheat rotation.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

Additional information

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Authors' contributions

Conceptualization, N.P. and V.S.; methodology, N.P., J.S., and A.S; writing—original draft, N.P.; writing— review and editing, R.K.S., and V.S.; resources, V.S.; supervision, V.S. and R.K.S.; formal analysis, M.I.J.B., and N.P. All authors have read and agreed on the final version of the manuscript

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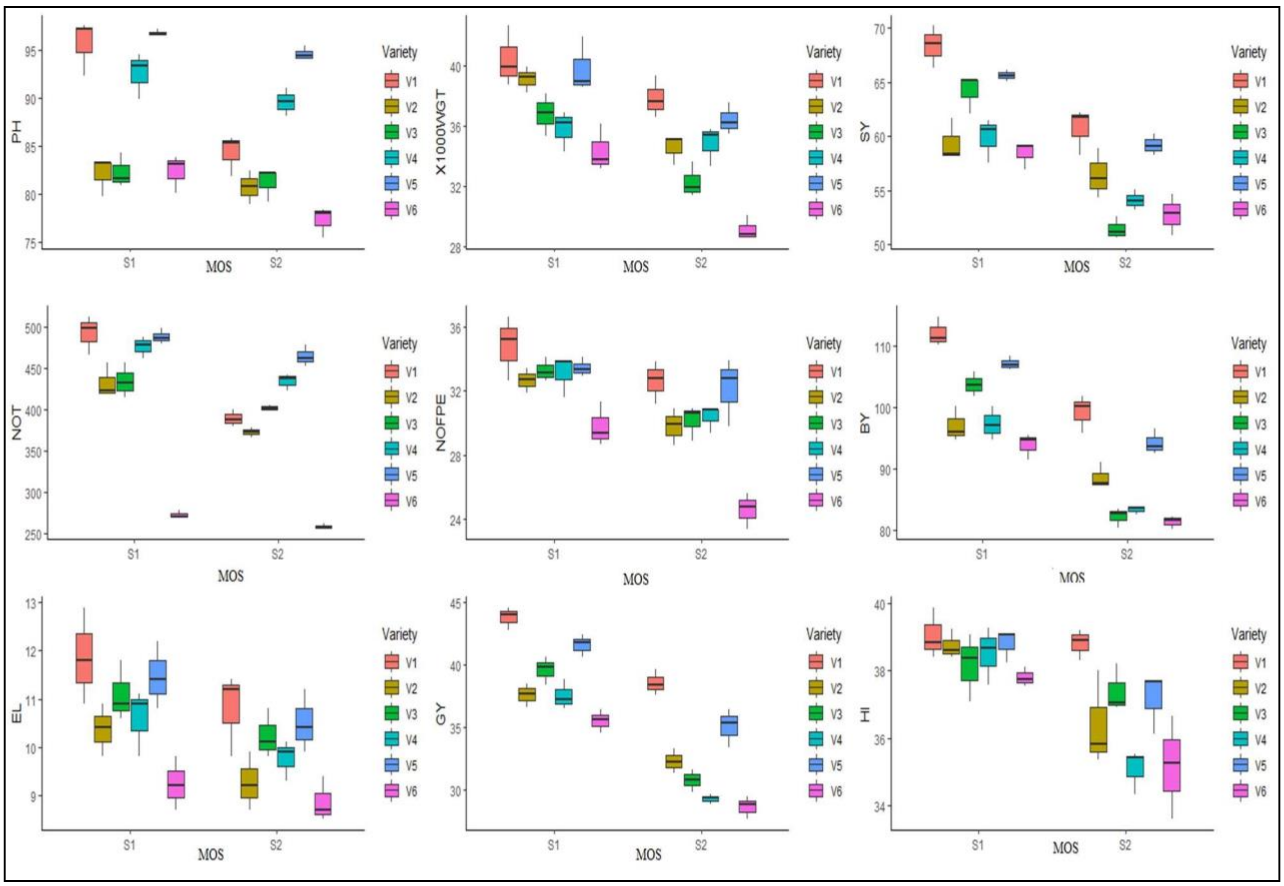

Fig.1 Gboxplots of growth and yield parameters of wheat under the transplanting and conventional (seed sown) methods of organic wheat sowing

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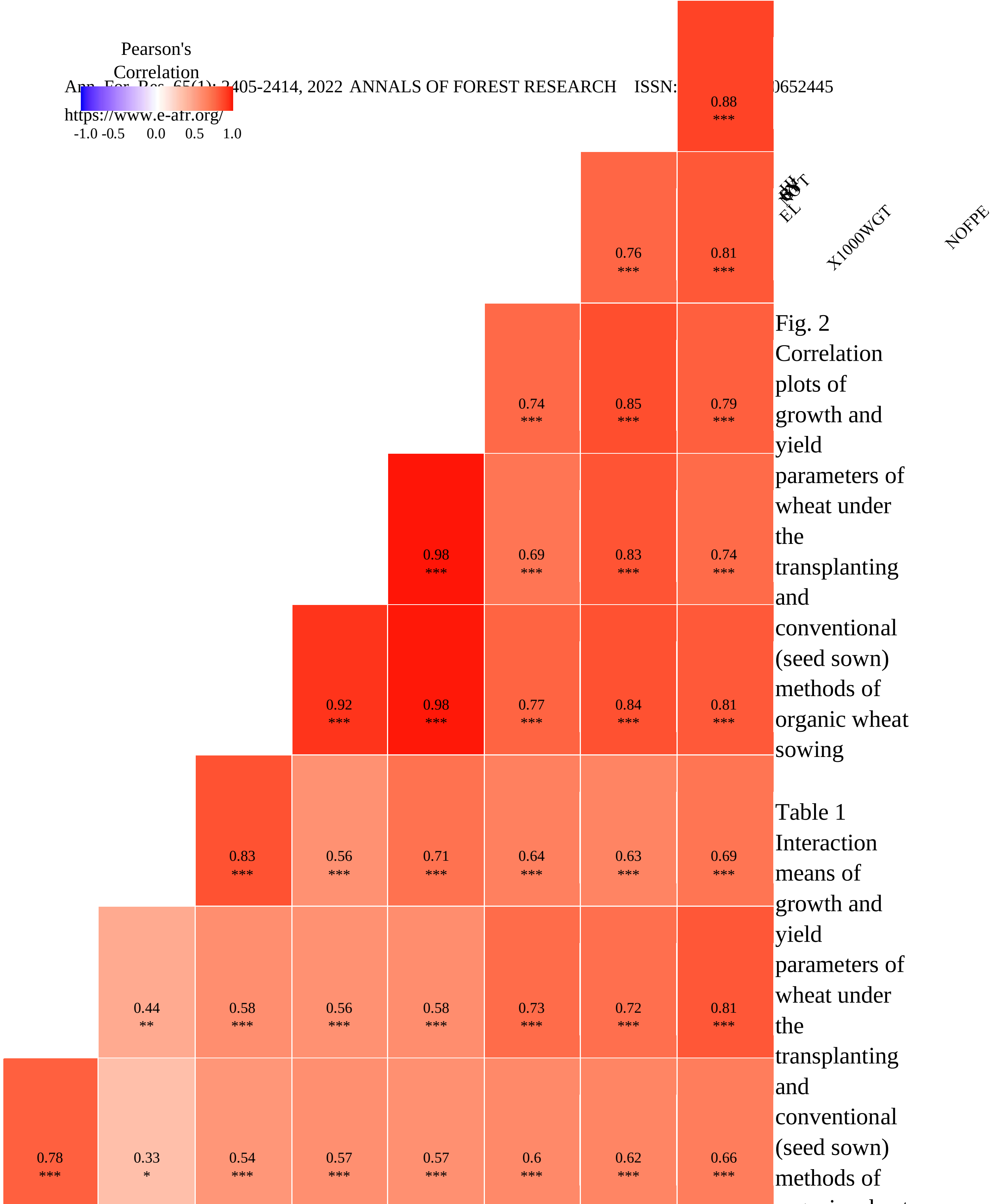

Fig. 2 Correlation plots of growth and yield parameters of wheat under the transplanting and conventional (seed sown) methods of organic wheat sowing

Table 1 Interaction means of growth and yield parameters of wheat under the transplanting and conventional (seed sown) methods of organic wheat cultivation

Plantheight(cm)	Varieties / DAT	V1	V2	V3	V4	V5	V6	Mean	C.D (p≤0.05)
	S1	95.65	82.10	82.30	92.54	96.72	82.40	88.62	S= 2.54 V= 1.23
	S2	84.35	80.75	81.24	89.58	94.58	77.32	84.64	
	Mean	90.00	81.42	81.77	91.06	95.65	79.86		
									SxV= 2.99
Effectivetillers/m2		V1	V2	V3	V4	V5	V6	Mean	S= 54.33 V= 32.10 SxV=67.34
	S1	492.00	432.00	434.00	476.00	488.00	272.00	432.33	
	S2	389.00	372.33	401.67	434.00	464.33	257.67	386.50	
	Mean	440.50	402.17	417.83	455.00	476.17	264.83		
Ear length) cm		V1	V2	V3	V4	V5	V6	Mean	S= 1.33 V= 1.77 SxV= 2.05
	S1	11.87	10.37	11.10	10.60	11.47	9.23	10.77	
	S2	10.80	9.27	10.23	9.77	10.50	8.87	9.91	
	Mean	11.33	9.82	10.67	10.18	10.98	9.05		
No.of grains/ear		V1	V2	V3	V4	V5	V6	Mean	S=0.34 V= 0.21 SxV=2.05
	S1	34.80	32.67	33.27	33.10	33.43	29.80	32.84	
	S2	32.60	29.80	30.13	30.37	32.17	24.60	29.94	
	Mean	33.70	31.23	31.70	31.73	32.80	27.20		
1000 grain weight(g)		V1	V2	V3	V4	V5	V6	Mean	S= 1.53 V= 1.10 SxV=1.93
	S1	40.40	39.10	36.77	35.80	39.80	34.37	37.71	
	S2	37.83	34.57	32.30	34.83	36.40	29.17	34.18	
	Mean	39.12	36.83	34.53	35.32	38.10	31.77		

Yield (q/ha.)		V1	V2	V3	V4	V5	V6	Mean	S= 2.05 V= 1.93 SxV=2.14
	S1	43.80	37.60	39.60	37.50	41.60	35.50	39.27	
	S2	38.53	32.27	30.73	29.23	35.03	28.60	32.40	
	Mean	41.17	34.93	35.17	33.37	38.32	32.05		
Straw yield(q/ha)		V1	V2	V3	V4	V5	V6	Mean	S= 3.55 V= 3.98 SxV=4.05
	S1	68.38	59.43	64.17	59.87	65.60	58.40	62.64	
	S2	60.77	56.43	51.43	54.10	59.20	52.77	55.78	
	Mean	64.58	57.93	57.80	56.98	62.40	55.58		
Biological yields(q/ha)		V1	V2	V3	V4	V5	V6	Mean	S= 7.76 V= 9.33 SxV=10.21
	S1	112.18	97.03	103.77	97.37	107.20	93.90	101.91	
	S2	99.30	88.70	82.17	83.33	94.23	81.37	88.18	
	Mean	105.74	92.87	92.97	90.35	100.72	87.63		
Harvest Index		V1	V2	V3	V4	V5	V6	Mean	S= 2.53 V= 1.90 SxV=2.81
	S1	39.05	38.75	38.17	38.52	38.80	37.80	38.52	
	S2	38.81	36.39	37.40	35.08	37.17	35.16	36.67	
	Mean	38.93	37.57	37.78	36.80	37.99	36.48		

Table 2 Comparative economics of cultivars, transplanting and conventional (seed sown) methods of organic wheat cultivation

Treatments	Variety	Gross monetary return	Cost of production	Net monetary return	B. C Ratio

20 DOT 1st (S1)	V1	JAUW 584	96360	42858	53502	2.25
	V2	RSP 561	82720	42858	39862	1.93
	V3	WH 1105	87120	42858	44262	2.03
	V4	RAJ 3765	82500	42858	39642	1.92
	V5	JAUW 598	91520	42858	48662	2.14
	V6	Conventional through seed drill	78100	36622	41478	2.13
30 DOT 2nd (S2)	V1	JAUW 584	84773	42858	41915	1.98
	V2	RSP 561	70987	42858	28129	1.66
	V3	WH 1105	67613	42858	24755	1.58
	V4	RAJ 3765	64313	42858	21455	1.50
	V5	JAUW 598	77073	42858	34215	1.80
	V6	Conventional through broadcasting	62920	36622	26298	1.72