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Evaluation Effective Traits on Crop Production of Breed Wheat under Warm and Dry Climate Condition (Khuzestan Province, Southwest of Iran)

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ABSTRACT

BACKGROUND: Knowing about seed yield and its components plays an important role for being successful in evaluative programs. For optimization of crop production, sowing at the appropriate time to fit the cultivar maturity length and growing season is critical.
OBJECTIVES: Current study was done to assess the effect of different planting date and density on seed yield, its components and harvest index of breed Wheat.
METHODS: This research was carried out via split plot experiment based on randomized complete blocks design with three replications. The treatments included four planting dates (November 6^{th} and 21^{st}, December 6^{th} and 21^{st}) and different density (300, 400, 500, 600 and 700 seed per square meter).
RESULT: According result of analysis of variance effect of planting date, density and interaction effect of treatments on all measured traits (instead number of seed per spikelet) was significant. Delay in planting caused the number of spikes per m^2, number of seeds per spike, 1000-seed weight and seed yield from 493.3 spikes, 46.2 seeds, 32.2 grams and 6964 $kg.ha^{-1}$ on the planting date of 30 November to 493.3 spikes, 40 seeds, 28.5 grams, 4831.6 $kg.ha^{-1}$ should be reduced on 30 December. Assessment mean comparison result of interaction effect of treatments indicated maximum seed yield (7298.7 $kg.ha^{-1}$) was noted for 6 Nov. and 500 plant per m^2 and lowest one (4235.2 $kg.ha^{-1}$) belonged to 6 Dec. and 700 plant per m^2 treatment.
CONCLUSION: Generally based on result of current research planting date in domain sixth until twenty-first of November with density of 500 plants per m^2 had the highest crop production and it can advise to farmers under studied region.

KEYWORDS: *Biomass, Phenology, Seed, Spike, Yield.*

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1. BACKGROUND

Wheat (*Triticum aestivum* L.) is a major cereal crop in many parts of the world and it is commonly known as the king of cereals. It belongs to Poaceae family and globally, after maize and rice is the most cultivated cereal. Wheat crops, being grown in a wide range of environments that affect overall performance, particularly grain yield and end-use quality. Wheat yield and end-use quality depend upon the environment, genotype and their interaction. Grain yield and quality of winter wheat are affected by several factors and crop management has a very important role among them. For achieving high yields and grain quality of wheat it is important to apply all the cultural practices completely and on time and adapt them to cultivars (Yadi *et al*., 2016). Wheat production in the south of Khuzestan, Iran is constrained by heat stress for late sowing dates. For optimization of yield, sowing at the appropriate time to fit the cultivar maturity length and growing season is critical (Andarzian *et al*., 2015). Winter wheat is one of the most important staple food crops in Iran, with a cultivation area of nearly 6.33 million ha and a production exceeding 14 million tons in 2015. Wheat is a thermo-sensitive crop, and any change in air temperature may alter the length of its growing period and subsequently grain yield (Chattaraj *et al.*, 2014). Seed yield is considered to be a complicated trait, which can be affected by many factors, and usually as a result of insufficient yield heritability factor, direct -selection yield. Is not much effective for it; as a result, for yield breeding we would better use indirect selection. Knowing about seed yield and its components plays an important role for being successful in evaluative programs. Success in breeding and having fruitful varieties of agricultural products with a higher quality depends on knowledge about genetic grain yield controlling and its relation with grain yield components, also to phenologic traits and forage quality (Atrod, 2018). Optimum plant densities vary greatly between areas, climatic conditions, soil, sowing time and varieties. Since, cultivars genetically differ for yield components, individual cultivars need to be tested at a wide range of seeding rates to determine their optimum seeding rate (Wiersma, 2002). Seeding rates for winter wheat can vary widely due to differences in seed quality, planting conditions, planting dates and planting equipment (Lloveras *et al*., 2004). New wheat varieties are more productive and some of them are of higher quality than the old ones. Therefore, their total technological requirements, planting density being one of them, are diverse, due to which they need to be continuously examined for determining their requirements in specific conditions (Caglar *et al*., 2011). Plant distribution patterns and plant densities can practically affect the utilization of environmental resources to the extent that inter- and intra-plant competitions are influenced to a great degree. As a result, plant density is considered a vital factor when setting the aim to reach higher grain yield (Caterina *et al*., 2013). Plant density is not, however, the only factor that influences competition for water. Water uptake by plant communities is also related to their aboveground biomass (Toillon *et al*., 2013; Caterina *et al*., 2013), which increases over time up to a maximum level dictated by the environmental carrying capacity (Toillon *et al*., 2013). Since biomass increment over time in tree plantations is influenced by initial density, closer spacing results in higher carbon fixation rates (Toillon *et al*., 2013; Hakamada *et al*., 2017). Where water is scarce, however, the greater water uptake promoted by denser stands can lead to early exhaustion of available water, which, in turn, leads to decreased productivity or even death of the most sensitive individuals or species in the stand (Hakamada *et al*., 2017). Quantifying plant competition for soil water, therefore, is important not only for physiological plant ecologists, but also for ecological applications, such as ecological restoration and conservation management. Knowing the relationship between planting density and the community response to soil water competition can be an important tool to aid restoration planning and to support management decisions (Honda *et al*., 2019). Delayed planting causes a decrease in duration from time of planting to flowering or maturity. Therefore the decrease in yield, which occurs because of delayed planting, is basically as a result of decrease of biomass during the maturity period (Robertson and Holland, 2004). Delayed planting, inappropriate weather conditions during the flowering period, fertilization and pod formation can cause a decrease in duration of maturity period, affect the number of pods per plant, affect the number and weight of grains and finally can lead to decrease in grain yield (Mendham and Salisbury, 1995). Lower thousand grain weight in late sowing has also been reported by Mian *et al*. (2007). Decrease in duration of crop life cycle with delay in sowing date and coincidence of terminal heat stress in grain filling period caused lower biological yield. This effect of late sowing has also been reported by Rane *et al*. (2007). In province of Khuzestan late planted wheat is exposed to high temperature at the reproductive stage resulting in average grain yield of 3 to 4 $t.ha^{-1}$ as compared to over 6 $t.ha^{-1}$ in cooler regions, because the temperatures often exceeds 30°C during grain filling period. Terminal or late heat stress during the last phases of wheat development especially from booting, heading, anthesis and grain filling stages of the spring wheat cultivars is considered as one of the major environmental constraints that drastically reduces grain number per spike and grain weight and consequently significant reduction in wheat grain yield throughout most of the bread wheat growing areas in this region and other warm and dry regions of Iran (Modhej *et al*., 2008).

2. OBJECTIVES

Current study was done to assess the effect of different planting date and density on seed yield, its components and harvest index of Wheat.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

This research was carried out via split plot experiment based on randomized complete blocks design with three replications. Place of research was located in Ahvaz city at longitude 48°40'E and latitude 31°20'N in Khuzestan province (Southwest of Iran). The treatments included four planting dates (November 6th and 21st, December 6th and 21st) and density (300, 400, 500, 600 and 700 seed per square meter). This experiment had 60 plots. Each plot consisted of 6 lines with a distance of 20 cm and 8 meters length. Physical and chemical properties of studied soil was mentioned in table 1.

Table 1. Physical and chemical properties of studied field

Soil depth (cm)	EC ($ds.m^{-1}$)	pH	Absorbable elements (ppm)			Soil tissue components (%)			Soil type	O.C (%)
			Total N	P	K	Clay	Silt	Sand		
0-30	5.3	7.5	738	11.7	236	37	44	19	Slity clay	0.68
30-60	8.6	7.7	450	10.9	179	44	43	15	Slity clay	0.38

3.2. Farm Management

After ground preparation, soil feeding process was carried out based on the results of soil sample analysis in the laboratory. Nitrogen fertilizer from urea source was consumed at 252 gram per plot. One-third deduction was applied before planting as basal, next section at end of tillering and final one-third deduction applied at the spike emergence stage. Phosphorus (P_2O_5) fertilizer was obtained from triple super phosphate source and was applied in amount 120 gram per plot at pre-planting stage. Potassium fertilizer was applied from the potassium sulfate source at 120 gr per plot. To combat and try control the broadleaf and narrow leaf weeds, Duplosan Super (2.5 $L.ha^{-1}$) and topic (1 $L.ha^{-1}$) herbicides was used at the end of tillage stage and before application of topdressing fertilizer, respectively.

3.3. Measured Traits

In order to determine the yield two planting lines from each plot harvested and after the removal of marginal effect were carried to the laboratory and were placed in the oven at 75°C for 48 hours and after ensuring that the samples were completely dry, they were weighted and finally the total yield was measured. In order to evaluate remobilization efficiency and contribution and current photosynthesis seven days after flowering from each plot after removing the effects of lateral margin, five plants were harvested and total dry weight was measured. Harvest index (HI) was calculated according to formula of Gardener *et al.* (1985) as follows: **Equ.1.** HI= (Seed yield/Biologic yield) ×100.

3.4. Statistical Analysis

Data analysis was performed with using MSTATC software and mean comparison was done by Duncan test at 5% probability level.

4. RESULT AND DISCUSSION

4.1. Number of spike per m^2

According result of analysis of variance effect of planting date, density and interaction effect of treatments on number of spike per m^2 was significant at 1% and 5% probability level, respectively (Table 2). Mean comparison result of different level of planting date indicated that maximum number of spike per m^2 (492.3) was noted for 21 Nov. and minimum of that (433) belonged to 21 Dec. treatment (Table 3).

Table 2. Result analysis of variance of measured traits

S.O.V	df	Number of spike per m^2	Number of spikelet per spike	Number of seed per spikelet	Number of seed per spike
Replication	2	72.9^{ns}	0.041^{ns}	0.12^{ns}	4.08^{ns}
Planting date (P)	3	9253.3**	14.2**	0.83**	100.5*
Error I	6	14.02	0.89	0.0066	3.32
Density (D)	4	61353.5**	80.5**	0.05^{ns}	205.9*
P × D	12	259.9*	18.47**	0.8^{ns}	102.4*
Error II	64	1.63	0.09	0.0022	2.25
CV (%)	-	10.23	9.65	8.89	7.55

$^{ns, *\ and\ **}$: no significant, significant at 5% and 1% of probability level, respectively.

Continue table 2.

S.O.V	df	1000-seed weight	Seed yield	Biologic yield	Harvest index
Replication	2	0.2^{ns}	101193.4^{ns}	9148963.2^{ns}	53.1^{ns}
Planting date (P)	3	40.2**	1367527.9**	201526602.1*	405.5**
Error I	6	2.22	175.99	2431.09	24.66
Density (D)	4	150.6**	2693909.8**	7519869.1*	249.01**
P × D	12	1.04*	20063005.8**	10142192.4*	139.7**
Error II	64	0.092	133.63	1888.06	4.06
CV (%)	-	6.33	9.74	11.02	5.66

$^{ns, *\ and\ **}$: no significant, significant at 5% and 1% of probability level, respectively.

As for Duncan classification made with respect to different level of density maximum and minimum amount of number of spike per m^2 belonged to 700 plant per m^2 (557.50) and 300 plant per m^2 (365.80) (Table 4). Evaluation mean comparison result of interaction effect of treatments indicated maximum number of spike per m^2 (566.6) was noted for 21 Nov. and 700 plant per m^2 and lowest one (375) belonged to 6 Nov. and 300 plant per m^2 treatment (Table 5). Hamidi and Dabagh Mohammadi-nasab (1995) also argue that the gap between high density and peak bloom corn pollination and therefore increases the rate of inoculation of grain s per plant decreased, but the loss of yield per plant per unit area increases whit increasing number of plants.

4.2. Number of spikelet per spike

Result of analysis of variance revealed effect of planting date, density and interaction effect of treatments on number of spikelet per spike was significant at 1% probability level (Table 2). According result of mean comparison maximum of number of spikelet per spike (16.9) was obtained for 6 Dec. and minimum of that (14.6) was for 21 Nov. treatment (Table 3). Evaluation mean comparison result indicated in different level of density the maximum number of spikelet per spike (18.5) was noted for 400 plants per m^2 and minimum of that (13.5) belonged to 700 plants per m^2 treatment (Table 4). Assessment mean comparison result of interaction effect of treatments indicated maximum number of spikelet per spike (20.5) was noted for 21 Nov. and 400 plant per m^2 and lowest one (11.2) belonged to 21 Nov. and 700 plant per m^2 treatment (Table 5). Previous studies on winter wheat indicated that the plant density was related to the accumulated dry matter, the green fraction and the yield (Ozturk *et al*., 2006; Hiltbrunner *et al*., 2007). Hiltbrunner *et al*. (2007) reported that the number of spikelet per spike of wheat changes under different planting densities. Wheat grain yield was improved with increasing plant density as a result of the increased number of spikelet (HuiJuan *et al*., 2009).

Table 3. Mean comparison effect of different planting date on measured traits

Planting date	Number of spike per m^2	Number of spikelet per spike	Number of seed per spikelet	Number of seed per spike
6 Nov.	472.3b	15.4c	3.0ab	46.2a
21 Nov.	492.3a	14.6d	3.1a	42.8b
6 Dec.	456.3c	16.9a	2.5c	41.9c
21 Dec.	433.6d	15.7b	2.8b	40.0d

*Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level.

Continue table 3.

Planting date	1000-seed weight (gr)	Seed yield ($kg.ha^{-1}$)	Biologic yield ($kg.ha^{-1}$)	Harvest index (%)
6 Nov.	32.2a	6964.0a	19951.1a	35.2c
21 Nov.	31.1b	6494.4b	15223.0b	43.9ab
6 Dec.	29.6c	5549.7c	12148.6c	47.4a
21 Dec.	28.5d	4831.6d	12247.4bc	40.2bc

*Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level.

4.3. Number of seed per spikelet

According result of analysis of variance effect of planting date on number of seed per spikelet was significant at 1% probability level but effect of density and interaction effect of treatments was not significant (Table 2). Assesse mean comparison result indicated in different level of planting date maximum number of seed per spikelet (3.1) was noted for 21 Nov. and minimum of that (2.5) belonged to 6 Dec. treatment (Table 3). Mean comparison result of interaction effect of treatments indicated maximum of number of seed per spikelet (3.4) was noted for 6 Nov. and 400 plant per m^2 and lowest one (2.3) belonged to 6 Dec. and 400 plant per m^2 treatment (Table 5). HuiJuan *et al.* (2009) also found spike number per unit area increases in very high sowing density in wheat cultivation. Spike number per unit area is determined by the number of tillers. The total number of tillers are affected by sowing density as well as the number of tillers produced from a single seed. Li *et al.* (2016) reported as the density increases, tillers produced by a single grain become less. There is considerable compensation by crops grown at low densities, which was in agreement with Whaley *et al.* (2000) findings.

4.4. Number of seed per spike

Result of analysis of variance revealed effect of planting date, density and interaction effect of treatments on number of seed per spike was significant at 5% probability level (Table 2). According mean comparison result of different level of planting date maximum number of seed per spike (46.2) was observed in 6 Nov. and lowest one (40.0) was found in 21 Dec. treatments (Table 3). Between different levels of density highest value of number of seed per spike was belonged to 500 plant per m^2 treatment (48.9) and lowest one was for 700 plant per m^2 treatment as 39.7 (Table 4). Mean comparison result of interaction effect of treatments indicated maximum number of seed per spike (20.5) was for 6 Dec. and 500 plant per m^2 and lowest one (31.3) belonged to 6 Dec. and 700 plant per m^2 (Table 5).

Table 4. Mean comparison effect of different density on measured traits

Density plant per m^2	Number of spike per m^2	Number of spikelet per spike	Number of seed per spikelet	Number of seed per spike
300	365.80d	15.9b	2.8a	44.7b
400	444.50c	18.5a	2.8a	41.5c
500	448.30c	16.5b	3.0a	48.9a
600	502.08b	15.5b	2.8a	38.8e
700	557.50a	13.5d	2.9a	39.7d

*Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level.

Continue table 4.

Density plant per m^2	1000-seed weight (gr)	Seed yield ($kg.ha^{-1}$)	Biologic yield ($kg.ha^{-1}$)	Harvest index (%)
300	34.08a	5567.6c	14125.3b	40.5b
400	32.3b	5986.08b	13987.8c	45.08ab
500	30.5c	6705.08a	15299.9a	46.07a
600	30.3c	6011.6b	15283.6ab	42.2b
700	26.2d	5654.5bc	15776.0ab	34.5c

*Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level.

Many authors have reported a reduced crop stand, shorter life cycle, reduced tillering, less biomass production, reduced fertilization and grain development, reduced head size, reduction in number of spikes in m^2, number of grains per spike and seed weight as a result of heat stress, and all of these changes will be translated in reduction of seed yield under heat stress conditions (Gibson and Paulson, 1999, Ayeneh *et al*., 2002 and Irfaq *et al*., 2005).

4.5. 1000-seed weight

According result of analysis of variance effect of planting date, density and interaction effect of treatments on 1000-seed weight was significant at 1% and 5% probability level, respectively (Table 2). Mean comparison result of different level of planting date indicated that maximum 1000-seed weight (32.2 gr) was noted for 6 Nov. and minimum of that (28.5 gr) belonged to 21 Dec. treatment (Table 3). As for Duncan classification made with respect to different level of density maximum and minimum amount of 1000-seed weight belonged to 300 plant per m^2 (34.08 gr) and 700 plant per m^2 (26.2 gr) (Table 4). Evaluation mean comparison result of interaction effect of treatments indicated maximum 1000-seed weight (36.6 gr) was noted for 6 Nov. and 300 plant per m^2 and lowest one (24 gr) belonged to 6 Dec. and 700 plant per m^2 treatment (Table 5). Adjustments for the optimum density of corn are recommended to make plants produce tiller. Proper spacing between plants reduces competition between plants, thus increasing the absorption of water, light, and nutrients, which increases photosynthesis and ultimately grain performance. Raja (2001) reported that the decrease in grain weight due to the increase in density is related to the reduction of grain dry matter accumulation during the three weeks after flowering to the physiological maturity stage.

4.6. Seed yield

Result of analysis of variance showed effect of planting date, density and interaction effect of treatments on seed yield was significant at 1% probability level (Table 2). Mean comparison result of different level of planting date indicated the maximum and the minimum amount of seed yield belonged to 6 Nov. (6964 $kg.ha^{-1}$) and 21 Dec. treatment (4831.6 $kg.ha^{-1}$) (Table 3). Among different level of density maximum seed yield (6705.08 $kg.ha^{-1}$) was obtained for 500 plant per m^2 and minimum of that (5567.6 $kg.ha^{-1}$) was for 300 plant per m^2 treatment (Table 4). Assessment mean comparison result of interaction effect of treatments indicated maximum seed yield (7298.7 $kg.ha^{-1}$) was noted for 6 Nov. and 500 plant per m^2 and lowest one (4235.2 $kg.ha^{-1}$) belonged to 6 Dec. and 700 plant per m^2 treatment (Table 5). Kalateh Arabi *et al.* (2011) study the effect of sowing date on seed yield and yield components of bread wheat reported the highest biological yield (14415 $Kg.ha^{-1}$) was obtained in sowing date 01 December (with 14 ºC soil temperature and GDD = 2247 ºCd). The highest grain yield (4480 $kg.ha^{-1}$) was also produced in 1st sowing date (01 December).

Table 5. Mean comparison interaction effects of treatments on measured

Planting date	Density plant per m^2	Number of spike per m^2	Number of spikelet per spike	Number of seed per spikelet	Number of seed per spike
6 Nov.	300	375.0jk	14.4g	3.0ab	43.2e
	400	451.6fh	16.8d	3.4a	39.6g
	500	455.0fg	16.2e	3.0ab	48.6bc
	600	415.0c	16.2e	3.0ab	48.6bc
	700	565.0a	17.6c	3.1ab	42.0ef
21 Nov.	300	391.6j	14.1g	3.0ab	42.3ef
	400	476.6de	20.5a	2.5bc	43.0ef
	500	483.3e	15.3f	2.5c	45.6d
	600	543.3b	15.3f	3.0bc	41.0fg
	700	566.6a	17.7c	3.0bc	42.3ef
6 Dec.	300	358.3k	18.0c	2.6bc	46.8cd
	400	433.3hi	19.5b	2.3c	47.3cd
	500	438.3gh	17.7c	2.6bc	51.4a
	600	488.2d	13.0j	2.6bc	32.6ij
	700	563.2ab	11.9j	2.6bc	31.3j
21 Dec.	300	338.3l	16.8d	2.8bc	46.6cd
	400	416.7i	13.0j	3.0ab	36.0h
	500	416.6i	16.8d	2.8bc	50.2ab
	600	461.6ef	16.8d	2.7bc	33.0ij
	700	535.0b	11.2k	2.8bc	43.3hi

*Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level.

Continue table 5.

Planting date	Density plant per m^2	1000-seed weight (gr)	Seed yield (kg.ha^{-1})	Biologic yield (kg.ha^{-1})	Harvest index (%)
6 Nov.	300	36.6a	5939.3ef	18611.1ab	32.1f
	400	33.0cd	5909.6ef	19861.1ab	30.3f
	500	33.0cd	7298.7a	20833.3ab	36.0ef
	600	32.3de	6514.5cd	21284.7a	28.2c-f
	700	26.3j	6340.9de	19205.5ab	39.6c-f
21 Nov.	300	34.6b	5746.2fg	13159.7b	44.0b-f
	400	33.6bc	6906.3b	12951.3bc	54.3ab
	500	31.0fg	6838.0b	13854.1b	50.0a-d
	600	31.0fg	6906.0b	18600.0a	37.0d-f
	700	25.3j	6075.2ef	17550.0a	34.3ef
6 Dec.	300	33.3cd	5593.6g	12923.6bc	43.6b-f
	400	31.3ef	6426.6de	12513.0bc	51.3a-c
	500	30.0gh	6761.6bc	13006.9bc	52.0a-c
	600	29.6h	4731.3h	9027.7c	58.0a
	700	24.0k	4235.2i	13270.8b	32.0f
21 Dec.	300	31.6ef	4991.3h	11806.9bc	42.3b-f
	400	31.3ef	4701.6h	10624.9bc	44.3b-f
	500	28.2i	5922.0ef	13505.5b	46.3a-c
	600	28.3i	4318.3i	12223.3bc	35.6ef
	700	23.0k	4325.0i	13077.7bc	32.3f

*Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level.

In the late sowing date, grain yield decreased, because of heat stress at the end of season and low soil temperature average at planting date. There were also significant differences between wheat cultivars for grain yield and biological yield. Moghan 3 had higher grain yield (average of 4324 kg.ha^{-1}) and significantly differed from Arta. In conclusion, suitable sowing date was 01 December with 14ºC soil temperature and GDD = 2247 ºCd. Optimizing plant density is a key factor influencing many aspects of crop management including susceptibility to pathogens, water and fertilizer requirements as well as yield (Dai *et al*., 2014; Jin *et al*., 2017). Enhancement of growth and grain yield of wheat requires sowing at an appropriate density since it directly affects the spike number per unit area. As a consequence, other yield components such as individual grain weight and the number of grains per spike are also affected (Saeys *et al*., 2009; Jin *et al*., 2017).

4.7. Biologic yield

According result of analysis of variance effect of planting date, density and interaction effect of treatments on biologic yield was significant at 5% probability level (Table 2). Mean comparison result of different level of planting date indicated that maximum biologic yield (19951.1 kg.ha^{-1}) was noted for 6 Nov. and minimum of that (12148.6 kg.ha^{-1}) belonged to 6 Dec. treatment (Table 3). As for Duncan classification made with respect to different level of density maximum and minimum amount of biologic yield belonged to 500 plant per m^2 (15299.9 kg.ha^{-1}) and 400 plant per m^2 (13987.8 kg.ha^{-1}) (Table 4). Evaluation mean comparison result of interaction effect of treatments indicated maximum biologic yield (21284.7 kg.ha^{-1}) was noted for 6 Nov. and 600 plant per m^2 and lowest one (9027.7 kg.ha^{-1}) belonged to 6 Dec. and 600 plant per m^2 treatment (Table 5). Ghazvineh *et al*. (2020) by investigate the response of durum wheat cultivars to different planting dates and densities under rainfed conditions reported biological yield and absorbed radiation percentage were 26.9 and 12.9 percent higher respectively in second year of experiment as compared to the first year. Comparison of interactions means showed that STJ genotype under 250 seeding density and 15 days sowing date after effective rainfall, produced highest 1000 kernel weight, while SAJI cultivar at 550 seeding density and planting date before effective rainfall showed the highest kernel yield. The SAJI cultivar showed highest biological yield under 450 seeding density and planting date before effective rainfall.

4.8. Harvest index

Result of analysis of variance showed effect of planting date, density and interaction effect of treatments on harvest index was significant at 1% probability level (Table 2). Mean comparison result of different level of planting date indicated the maximum and the minimum amount of harvest index belonged to 6 Dec. (47.4%) and 6 Nov. treatment (35.2%) (Table 3). Among different level of density maximum harvest index (46.07%) was obtained for 500 plant per m^2 and minimum of that

(34.5%) was for 700 plant per m^2 treatment (Table 4). Assessment mean comparison result of interaction effect of treatments indicated maximum harvest index (58%) was noted for 6 Dec. and 600 plant per m^2 and lowest one (32%) belonged to 6 Dec. and 700 plant per m^2 treatment (Table 5). Harvest index is also affected by delay in planting date, this might be due to the effect of late planting date and terminal heat stress on vegetative and reproductive phases, grain and biological yields and considered as their indirect effect on harvest index. Reddy *et al*. (1987) reported that increasing plant density in corn, harvest index decreased. Cox and Cherny (2001) were observed with increasing density, harvest index decreased. While some researches have expressed the harvest index were not affected by plant density (Hamidi and Dabagh Mohammadinasab, 1995). Pooruoseph *et al* (2001), reported effect of planting pattern and plant density on yield and its components of two varieties of hybrid corn were concluded that the density does not affect by harvest index.

5. CONCLUSION

In this study spike number per m^2, seed number per spike, thousand seed weight, seed and biological yield and harvest index were decreased with delay in sowing date, due mainly to rising temperatures. Generally according result of current research planting date in domain sixth until twenty-first of November with density of 500 plants per m^2 had the highest crop production and it can advise to farmers under studied region.

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FOOTNOTES

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