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Effect of different Dates of Sowing, Spacing and Nutrient Levels on Growth and Yield of Buckwheat (*Fagopyrum esculentum* L.)

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ABSTRACT

An experiment was carried out to study the effect of different dates of sowing, spacing and nutrient levels on growth and yield of buckwheat (*Fagopyrum esculentum* L.) at Agronomy field unit, Zonal Agricultural Research Station (ZARS), Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore during *kharif* season of 2019-2020 and 2020-2021. The experiment was laid out in split split plot design with eighteen treatment combinations replicated thrice. Main plots includes three different dates of sowing (D_1: July 1st fortnight, D_2: July 2nd fortnight and D_3: August 1st fortnight), two sub plots on spacing (S_1: 30 x 10 cm and S_2: 45 x 15 cm) and three sub-sub plots on nutrient levels (N_1: 50:10:10 N:P_2O_5:K_2O kg ha^{-1}, N_2: 60:20:20 N:P_2O_5:K_2O kg ha^{-1} and N_3: 70:30:30 N:P_2O_5:K_2O kg ha^{-1}). Among different dates of sowing, sowing during July 1st fortnight has recorded significantly higher plant height, number of leaves and SPAD meter reading (82.08 cm, 34.53, 44.55 and 50.73, respectively) over other dates of sowing. The closer spacing of 30 × 10 cm recorded taller plants (82.64 cm) and wider row spacing of 45 × 15 cm has recorded higher number of leaves (34.79) and SPAD meter reading (45.68 and 52.33, respectively). Application of 70:30:30 NPK kg ha^{-1} has recorded significantly taller plants, higher number of leaves and SPAD meter reading (80.03 cm, 34.04, 45 and 50.20, respectively) and found on par with application of 60:20:20 NPK kg ha^{-1}. Narrow spacing of 30 × 10 cm has recorded significantly higher grain yield (948 kg ha^{-1}) and straw yield (2412 kg ha^{-1}) as compared to wider row spacing. Application of 70:30:30 NPK kg ha^{-1} has recorded significantly higher grain yield (891 kg ha^{-1}) and straw yield (2175 kg ha^{-1}) and which was found on par with application of 60 : 20 : 20 NPK kg ha^{-1}.

Keywords: Buckwheat, SPAD, Grain yield, Harvest index

BUCKWHEAT *(Fagopyrum* spp.) is a dicot pseudo-cereal belongs to family polygonaceae and buckwheat is neither a nut nor a cereal but is included in a separate group called 'pseudocereals' as it shows both similarities and differences with cereals. In India, buckwheat is grown in Jammu Kashmir, Himachal Pradesh, Uttarakhand, West Bengal, Sikkim, upper parts of Assam, Arunachal Pradesh, Nagaland, Meghalaya, Manipur, Kerala, Tamil Nadu (Nilgiris and Palani hills) and Chhattisgarh. Out of the 20 species of genus *Fagopyrum*, only two *Fagopyrum esculentum* L. (common buckwheat) and *Fagopyrum tataricum* L. (tartary buckwheat) are cultivated in India. Among two, tartary buckwheat cultivation is more common at higher altitudes (>2500 m) and common buckwheat cultivation confined to lower altitudes extended up to 1000 m. In Himalayan region, tartary buckwheat occupies about 90 per cent of cultivated land as a pure crop and it has the greater potential to produce good yield under rainfed condition of Himalayan ecosystem when soil moisture is not able to support any kind of crop cultivation.

Buckwheat has the potential for fixing atmosphere nitrogen and solubilizing native soil phosphorus and potassium. It thrives well under poor soil fertility conditions and it is a multi use crop cultivated for grain purpose and grains are used for human consumption, livestock, piggery and poultry feeds, as green manures, soil binding crop and as a smother crop. Despite of its many uses, farmers are not showing interest in buckwheat cultivation due its low productivity and profitability as compared to other high yielding crops. In many regions, farmers have less awareness about cultivation practices of buckwheat from sowing to harvesting with its nutritional aspect. The information on suitability of buckwheat to southern part of India in general and Karnataka in particular with regard to suitable genotypes, date of sowing, crop geometry and their nutrient requirement is lacking. With this background, current study was undertaken with the objectives to find out optimum sowing window, spacing and nutrient level for higher yield of buckwheat.

Material and Methods

The experiment was carried during *kharif* season of 2019-20 and 2020-21 at Agronomy Field Unit, Zonal Agricultural Research Station (ZARS), Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore. It is situated at 13º 05' North latitude and 77º 34' East longitudes with an altitude of 924 meters above mean sea level which comes under Eastern Dry Zone (ACZ-V) of Karnataka. The soil of the experimental site was red sandy loam with slight acidic in reaction (6.30) with an electrical conductivity of 0.25 dS m^{-1}. Soil is medium in available nitrogen (285.5 kg ha^{-1}), phosphorus (38 kg ha^{-1}) and potassium (248 kg ha^{-1}). The experiment with eighteen treatment combinations *viz.,* three dates of sowing (D_1: July 1st fortnight, D_2: July 2nd fortnight and D_3: August 1st fortnight), two planting geometry (S_1: 30 x 10 cm and S_2: 45 x 15 cm) and three nutrient levels (N_1:50:10:10 N:P_2O_5:K_2O kg ha^{-1}, N_2:60:20:20 N:P_2O_5:K_2O kg ha^{-1} and N_3:70:30:30 N:P_2O_5:K_2O kg ha^{-1}) were laid out in split-split plot design and replicated thrice.

The data on different growth and yield parameters at harvest stage of crop were recorded in each treatment on randomly selected five plants from each net plot and mean value was worked out. Yield was recorded from each net plot and expressed as kg ha^{-1}. The experimental data collected on growth and yield components of plant were subjected to Fishers's method of Analysis of Variance (ANOVA) as outlined by Panse and Sukhatme (1967). Wherever, F test was significant for comparison among the treatment means, critical difference (CD) was worked out. If F test found non-significant, again CD values NS (Non significant) was indicated.

Results and Discussion

The pooled data on plant height and number of leaves per plant varied significantly due to different treatments (Table 1). Significant difference in plant height was observed among different dates of sowing. Sowing during 1st fortnight of July has recorded significantly higher plant height at harvest (82.08 cm) over July 2nd fortnight (75.27 cm) as well August 1st fortnight (73.86 cm). The significant differences in plant height among different dates of sowing might be due to long growing period enabled efficient utilization of available resources such as nutrients, water and sunlight at given time. Similar results were reported by Sobhani *et al.,* 2014 and Lee *et al.* (2001) who were also stated that early sowing helps to put forth more plant height compared to late sown plants. Plant height was significantly influenced by different plant spacing. The closer spacing of 30 × 10 cm recorded taller plants at harvest (82.64 cm) as compared to wider row spacing of 45 × 15 cm (71.50 cm). Higher plant height at closely spaced plots might be due to increased competition for different resources among the buckwheat plants. Whereas, closer spacing produces less number of branches and leaves along with less solar radiation which in more auxin concentration led to increased plant height. Similar results were reported by Jyothi *et al.* (2021) who found that plant height slightly decreased with widening distances between rows up to 75 cm apart but with non-significant difference for plant grown between 30 and 45 cm. The average plant height was also significantly influenced by different nutrient levels at harvest. Application of 70:30:30 NPK kg ha^{-1} has recorded significantly taller plants (80.03 cm) and found on par with application of 60:20:20 NPK kg ha^{-1} (77.95 cm) but there is significant difference with application of 50:10:10 NPK kg ha^{-1} (73.24 cm). Plant height was improved with the higher level of fertilizer application in buckwheat by improving vegetative growth and better absorption of nutrients. Inamullah *et al.* (2012) reported that generally plant height increased with increase in nitrogen and phosphorous levels. Interaction on dates of sowing, spacing and nutrient levels found non-significant with respect to growth at harvest.

TABLE 1

Plant height (cm) and number of leaves $plant^{-1}$ of buckwheat as influenced by dates of sowing, planting geometry and nutrient levels at harvest (pooled data of 2 years)

Treatments		Plant height (cm)				Number of leaves $plant^{-1}$			
		D_1	D_2	D_3	S×N	D_1	D_2	D_3	S×N
			D×S×N				D×S×N		
S_1	N_1	83.60	78.07	74.70	78.79	27.02	25.70	23.13	25.28
	N_2	89.01	82.20	79.15	83.45	32.15	30.27	25.30	29.24
	N_3	91.49	83.85	81.72	85.69	33.95	31.80	27.15	30.97
S_2	N_1	72.92	64.25	65.88	67.68	34.80	32.88	27.98	31.89
	N_2	77.01	70.44	69.87	72.44	38.83	35.60	31.70	35.38
	N_3	78.47	72.78	71.87	74.37	40.45	37.23	33.65	37.11
			D×S		S		D×S		S
S_1		88.03	81.37	78.52	82.64	31.04	29.26	25.19	28.50
S_2		76.13	69.16	69.21	71.50	38.03	35.24	31.11	34.79
			D×N		N		D×N		N
N_1		78.26	71.16	70.29	73.24	30.91	29.29	25.56	28.59
N_2		83.01	76.32	74.51	77.95	35.49	32.93	28.50	32.31
N_3		84.98	78.32	76.79	80.03	37.20	34.52	30.40	34.04
M		82.08	75.27	73.86		34.53	32.25	28.15	
S.V.			S.Em±	CD at 5 %			S.Em±	CD at 5 %	
D			0.68	2.68			0.27	1.06	
S			0.48	1.66			0.42	1.45	
N			0.81	2.36			0.79	2.30	
D×S			0.83	NS			0.73	NS	
D×N			1.40	NS			1.37	NS	
S×N			1.14	NS			1.12	NS	
D×S×N			1.98	NS			1.93	NS	

Legend:

Dates of sowing (D)	*Recommended spacing (S)*	*Nutrient levels (N)*
D_1: July 1st fortnight	S_1: 30 cm x 10 cm	N_1: 50:10:10 NPK kg ha^{-1}
D_2: July 2nd fortnight	S_2: 45 cm x 15 cm	N_2: 60:20:20 NPK kg ha^{-1}
D_3: August 1st fortnight		N_3: 70:30:30 NPK kg ha^{-1}

The significant differences in number of leaves were observed among different dates of sowing. July 1st fortnight of sowing has recorded significantly higher number of leaves (34.53) over July 2nd fortnight (32.25) as well August 1st fortnight (28.15). The significant differences in number of leaves among different dates of sowing might be due to long growing period enabled efficient utilization of available resources such as nutrients, water and sunlight at given time. The results are in confirmation with findings of Sobhani *et al.* (2014) and Whitehead *et al.* (2002). Numbers of leaves were significantly influenced by different plant spacing. The wider row spacing of 45 × 15 cm recorded higher number of leaves (34.79) as compared to closer spacing of 30 × 10 cm (28.50). Higher number of leaves at wider spaced plots might be due to less competition for different resources *viz.,* solar radiation, nutrient and water among the buckwheat plants. In closer spacing less number of leaves is mainly because of more computation between the plants for the different resources. Similar results was also observed by Law-Ogbomo and Ajayi (2009) they revealed that planting density significantly affected the number of leaves and the crop growth rate and it is positively in favor with the wider row spacing. The average numbers of leaves were also significantly influenced by different nutrient levels at harvest. Application of 70:30:30 NPK kg ha^{-1} has recorded significantly higher number of leaves (34.04) and found on par with application of 60:20:20 NPK kg ha^{-1} (32.31) but significant with application of 50:10:10 NPK kg ha^{-1} (28.59). Number of leaves was improved with the higher level of fertilizer application in buckwheat by improving vegetative growth and better absorption of nutrients. Jeena Mary *et al.* (2018) also revealed that the positive influence of higher nitrogen on number of leaves was due to the fact that nitrogen is required for cell division and cell elongation which triggers the growth of meristematic tissue and the efficient utilization of this by the plants manifested in production of higher number of leaves. The above results were also in line with findings of Inamullah *et al.* (2012). Interaction on dates of sowing, spacing and nutrient levels has found non-significant effect on number of leaves at harvest stage of buckwheat crop growth.

Chlorophyll content (SPAD meter reading) of buckwheat was influenced significantly by dates of sowing, spacing and different fertilizer levels at anthesis and full bloom stage (Table 2). July 1st fortnight of sowing has recorded significantly higher chlorophyll content (SPAD meter reading) at anthesis (44.55) and full bloom stage (50.73) over July 2nd fortnight at full bloom (49.06) as well August 1st fortnight at anthesis (42.91) and full bloom stage (47.13). The higher chlorophyll content (SPAD meter reading) during early date of sowing might be due to favorable climatic condition led to better rate of photosynthesis as well vegetative growth of crop. Good and equal distribution of rainfall during early sowing window led to efficient utilization of nutrients helped synthesis of more chlorophyll content (SPAD meter reading). The results are in line with Whitehead *et al.* (2002). Total chlorophyll content (SPAD meter reading) was significantly influenced by different plant spacing. The wider row spacing of 45 × 15 cm recorded significantly higher chlorophyll content (SPAD meter reading) at anthesis (45.68) and at full bloom stage (52.33) as compared to narrow spacing of 30 × 10 cm (41.91 and 45.61, respectively). This could be mainly attributed to lesser competition between plants for nitrogen and better availability of nitrogen for longer period to the plants leads to higher photosynthetic activities and increased the chlorophyll content (SPAD meter reading). Chlorophyll content (SPAD meter reading) was also significantly influenced by different nutrient levels. Application of 70:30:30 NPK kg ha^{-1} has recorded significantly higher chlorophyll content (SPAD meter reading) at anthesis (45) and at full bloom stage (50.20) and found on par with application of 60:20:20 NPK kg ha^{-1} (44.23 and 49.43, respectively). But there is significant difference with application of 50:10:10 NPK kg ha^{-1} (42.16 and 47.28, respectively). The higher chlorophyll content (SPAD meter reading) obtained under higher rate of fertilizer levels would probably be evident from LAD values and relatively higher plant nitrogen content due to higher leaf photosynthetic area coupled with persistence of the leaf area for relatively longer period. These results are in similar line with those of Pavani *et al*. (2012). Interaction on dates of sowing, spacing and nutrient levels was found non-significant effect on relative chlorophyll meter reading at anthesis and full bloom stages of buckwheat crop growth.

The data on days to 50 per cent flowering and maturity of buckwheat were significantly influenced by date of sowing and spacing. The pooled data on days to 50 per cent flowering and maturity varied significantly due to different treatments of buckwheat crop (Table 3). Different dates of sowing did not differ significantly on days to 50 per cent flowering but was significantly influenced on days to mature. Buckwheat sown during August 1st fortnight has taken more number of days (67.24 days) to reach maturity stage followed by July 2nd fortnight (64.68 days) and then

TABLE 2

Chlorophyll meter reading (SPAD meter reading) of buckwheat as influenced by dates of sowing, planting geometry and nutrient levels at different growth stages (pooled data of 2 years)

Treatments		At anthesis (25 DAS)				At full bloom (40 DAS)			
		D_1	D_2	D_3	S×N	D_1	D_2	D_3	S×N
			D×S×N				D×S×N		
S1	N1	41.20	40.18	39.27	40.22	45.43	44.11	42.34	43.96
	N2	42.80	42.94	41.19	42.31	47.84	45.90	44.35	46.03
	N3	43.97	43.54	42.11	43.20	48.93	46.67	44.95	46.85
S2	N1	45.06	43.73	43.52	44.10	52.36	50.97	48.50	50.61
	N2	46.91	46.30	45.27	46.16	54.51	52.98	51.01	52.83
	N3	47.36	46.90	46.11	46.79	55.32	53.74	51.63	53.56
			D×S		S		D×S		S
S1		42.66	42.22	40.86	41.91	47.40	45.56	43.88	45.61
S2		46.44	45.64	44.97	45.68	54.06	52.56	50.38	52.33
			D×N		N		D×N		N
N1	43.13	41.96	41.40	42.16	48.89	47.54	45.42	47.28	
N2	44.86	44.62	43.23	44.23	51.17	49.44	47.68	49.43	
N3	45.66	45.22	44.11	45.00	52.12	50.20	48.29	50.20	
M	44.55	43.93	42.91		50.73	49.06	47.13		
S.V.			S.Em±	CD (p=0.05)			S.Em±	CD (p=0.05)	
D			0.27	1.05			0.31	1.21	
S			0.33	1.13			0.35	1.20	
N			0.70	2.03			0.79	2.29	
D×S			0.56	NS			0.60	NS	
D×N			1.21	NS			1.36	NS	
S×N			0.98	NS			1.11	NS	
D×S×N			1.70	NS			1.93	NS	

Legend:

Dates of sowing (D)	*Recommended spacing (S)*	*Nutrient levels (N)*
D1: July 1st fortnight	S1: 30 cm x 10 cm	N1: 50:10:10 NPK kg ha-1
D2: July 2nd fortnight	S2: 45 cm x 15 cm	N2: 60:20:20 NPK kg ha-1
D3: August 1st fortnight		N3: 70:30:30 NPK kg ha-1

July 1st fortnight has taken less number of dates (58.31 days) to reach maturity stage. This might be due to late planting reduces growth and yield because the buckwheat plant life cycle is limited with temperature and photoperiod. Buckwheat is also cool season crop and with decrease in temperature from July second fortnight to September first fortnight, number of days taken to 50 per cent flowering and days to maturity has increased. Days to 50 per cent flowering and maturity varied significantly due to different planting geometry. The wider row spacing of 45 × 15 cm has taken more number of days to 50 per cent flowering (34.34 days) as well number of days to maturity period (64.30 days) as compared to narrow spacing of 30 × 10 cm (33.21 and 62.52, respectively). This could be mainly due to lesser

TABLE 3

Days to 50 per cent flowering and maturity of buckwheat as influenced by dates of sowing, planting geometry and nutrient levels (pooled data of 2 years)

Treatments		Days to 50 % flowering				Days to maturity			
		D_1	D_2	D_3	S×N	D_1	D_2	D_3	S×N
		D×S×N				D×S×N			
S1	N1	32.95	33.85	33.70	33.50	57.90	64.37	66.70	62.99
	N2	32.35	33.20	33.05	32.87	57.37	63.83	66.50	62.57
	N3	32.75	33.55	33.45	33.25	56.90	63.23	65.90	62.01
S2	N1	34.55	34.95	35.15	34.88	59.85	65.57	68.50	64.64
	N2	33.35	34.05	34.15	33.85	59.08	65.58	68.13	64.27
	N3	33.65	34.65	34.60	34.30	58.77	65.50	67.72	63.99
			D×S		S		D×S		S
S1		32.68	33.53	33.40	33.21	57.39	63.81	66.37	62.52
S2		33.85	34.55	34.63	34.34	59.23	65.55	68.12	64.30
			D×N		N		D×N		N
N1		33.75	34.40	34.43	34.19	58.88	64.97	67.60	63.81
N2		32.85	33.63	33.60	33.36	58.23	64.71	67.32	63.42
N3		33.20	34.10	34.03	33.78	57.83	64.37	66.81	63.00
M		33.27	34.04	34.02		58.31	64.68	67.24	
S.V.		S.Em±		CD at 5 %		S.Em±		CD at 5 %	
D		0.24		NS		0.26		1.02	
S		0.26		0.88		0.28		0.96	
N		0.56		NS		0.50		NS	
D×S		0.44		NS		0.48		NS	
D×N		0.97		NS		0.87		NS	
S×N		0.79		NS		0.71		NS	
D×S×N		1.37		NS		1.23		NS	

Legend:

Dates of sowing (D)	*Recommended spacing (S)*	*Nutrient levels (N)*
D1: July 1st fortnight	S1: 30 cm x 10 cm	N1: 50:10:10 NPK kg ha-1
D2: July 2nd fortnight	S2: 45 cm x 15 cm	N2: 60:20:20 NPK kg ha-1
D3: August 1st fortnight		N3: 70:30:30 NPK kg ha-1

competition for different resources in wider spacing and more computation in narrow spacing with higher plant population and higher demand for nutrients for their growth and development. Different nutrient levels did not differ significantly on days to 50 per cent flowering as well days to maturity but however application of 60:20:20 NPK kg ha^{-1} and 70:30:30 NPK kg ha^{-1} has taken less number of days to 50 per cent flowering (33.36 and 33.78 days, respectively) and days to maturity (63.42 and 63, days) as compared to application of 50:10:10 NPK kg ha^{-1} (34.19 and 63.81, respectively). The above results were conformity with the findings of Sajjad *et al.* (2014) who stated that quinoa is a short-day plant and exhibited a positive relation with photo periodism and it is a function of sowing dates and time taken to complete phenology

TABLE 4

Grain yield, straw yield and harvest index of buckwheat as influenced by dates of sowing, planting geometry and nutrient levels (pooled data of 2 years)

Treatments		Seed yield (kg ha^{-1})				Straw yield (kg ha^{-1})				Harvest index			
		D_1	D_2	D_3	S×N	D_1	D_2	D_3		D_1	D_2	D_3	S×N
		D×S×N				D×S×N			S×N	D×S×N			
S1	N1	912	891	872	891	2139	2121	2100	2120	0.30	0.30	0.30	0.30
	N2	977	967	942	962	2570	2370	2494	2478	0.28	0.29	0.28	0.28
	N3	998	990	985	991	2649	2602	2662	2637	0.28	0.28	0.27	0.28
S2	N1	776	743	735	751	1453	1428	1447	1443	0.35	0.34	0.34	0.34
	N2	801	764	755	773	1637	1658	1566	1620	0.33	0.32	0.33	0.32
	N3	817	786	769	791	1728	1729	1680	1713	0.32	0.31	0.32	0.32
		D×S			S	D×S			S	D×S			S
S1		963	949	933	948	2453	2364	2419	2412	0.28	0.29	0.28	0.29
S2		798	764	753	772	1606	1605	1564	1592	0.33	0.32	0.33	0.33
		D×N			N	D×N			N	D×N			N
N1		844	817	804	821	1796	1774	1773	1781	0.32	0.32	0.32	0.32
N2		889	865	848	867	2104	2014	2030	2049	0.30	0.30	0.30	0.30
N3		908	888	877	891	2189	2165	2171	2175	0.30	0.30	0.30	0.30
M		880	857	843		2029	1985	1991		0.31	0.31	0.31	
S.V.		S.Em±		CD at 5 %		S.Em±		CD at 5 %		S.Em±		CD at 5 %	
D		19		NS		20		NS		0.005		NS	
S		9		31		15		53		0.002		0.006	
N		10		29		40		115		0.004		0.012	
D×S		16		NS		26		NS		0.003		NS	
D×N		17		NS		68		NS		0.007		NS	
S×N		14		NS		56		NS		0.006		NS	
D×S×N		24		NS		97		NS		0.010		NS	

Legend:

Dates of sowing (D)	*Recommended spacing (S)*	*Nutrient levels (N)*
D1: July 1st fortnight	S1: 30 cm x 10 cm	N1: 50:10:10 NPK kg ha-1
D2: July 2nd fortnight	S2: 45 cm x 15 cm	N2: 60:20:20 NPK kg ha-1
D3: August 1st fortnight		N3: 70:30:30 NPK kg ha-1

and its development phases. Parvin *et al.* (2013) also stated that late planting reduces yield because the plant life cycle is limited with temperature and photo period. Interaction on date of sowing, spacing and nutrient levels was found non-significant effect on days to 50 per cent flowering and maturity of buckwheat.

The data on grain yield of buckwheat was significantly influenced by different treatments at harvest. Among different dates of sowing, there was no significant difference with grain yield (Table 4) but, July 1st fortnight of sowing has recorded numerically higher grain yield of buckwheat (880 kg ha^{-1}) followed by July 2nd fortnight (857 kg ha^{-1}) and August 1st fortnight (843 kg ha^{-1}). The differences in grain yield among different dates of sowing might be due to higher dry matter production and other yield parameters. The superiority of early sowing with respect to yield attributes and grain yield may also be due to efficient utilization of natural resources (water and nutrients) with optimum vegetative growth and higher translocation of photosynthates from source to sink. The above results are in line with the findings of Hakan *et al*. (2014) and Sajjad *et al*. (2014) in quinoa and Chaudhari *et al*. (2009) in amaranth crop. The similar results were obtained by Parvin *et al*. (2013) who stated that late planting reduces yield because the plant life cycle is limited with temperature and photo period. The grain yield of buckwheat was significantly influenced by different planting geometry and narrow spacing of 30 × 10 cm has recorded significantly higher grain yield (948 kg ha^{-1}) as compared to wider row spacing of 45 × 15 cm (772 kg ha^{-1}). Higher grain yield of buckwheat with narrow spaced plots might be due to better utilization of available resources *viz.,* space, water and nutrients with optimum plant population and the lesser yield with wider spacing was mainly because of could not compensate in the grain yield mainly due to their less plant density. Above results were in line with findings of Chaudhari *et al.* (2009) among different crop geometry, narrow row spacing of 30 cm recorded significantly higher seed yield of grain Amaranth (*Amaranthus hypochondriacus* L.) as compared with wider row spacing. Hulihalli and Shanthaveerayya, (2018) reported that planting geometry of 30 cm x 10 cm recorded significantly higher grain yield of buckwheat compared to other planting geometries. Results were also in line with Henderson *et al.* (2000) and Malligawadit and Patil (2015). The grain yield of buckwheat was also significantly influenced by different nutrient levels at harvest. Application of 70:30:30 NPK kg ha^{-1} has recorded significantly higher grain yield of buckwheat (891 kg ha^{-1}) and which was found on par with application of 60:20:20 NPK kg ha^{-1} (867 kg ha^{-1}) but there was significant with application of 50:10:10 NPK kg ha^{-1} (821 kg ha^{-1}). Improvement in grain yield of buckwheat with higher nutrient levels might be due to more vegetative growth and increased plants metabolic activities and higher NPK fertilization contributed to better carbohydrates as similation improved yield attributing characters *viz.,* number of clusters and number of seed per cluster under sufficient supply of fertilizers. Higher nutrients helped the crop to put forth higher growth and growth attributing parameters which contributed for more photosynthesis could made plant to synthesize more photosynthates resulted in significantly higher yield. Above results were in line with findings of Maruti *et al.* (2018) reported that the reduction in yield due to application of lower dose of nutrients might be attributed to reduction in yield contributing characters *viz.,* number of clusters per plant, seeds per cluster and test weight. The higher dose of nutrients application resulted in better growth and yield. These were attributed to more availability of nutrients which in turn resulted in higher yield attributing characters. Similar results were also reported by Saini and Negi (1998); Jeena Mary *et al.* (2018); Hulihalli & Shanthaveerayya (2018) and Anand *et al.* (2021). Interaction of dates of sowing, spacing and nutrient levels was found non-significant effect on grain yield of buckwheat.

Result on straw yield and harvest index of buckwheat was significantly influenced by spacings and different nutrient levels (Table 4). The straw yield of buckwheat was observed non-significant difference among different dates of sowing. But significantly influenced by different planting geometry and spacing of 30 × 10 cm has recorded significantly higher straw yield (2412 kg ha^{-1}) as compared to wider row spacing of 45 × 15 cm (1592 kg ha^{-1}). More vegetative growth per plant under wider row spacing, higher straw yield of buckwheat per ha was more in narrow row spacing due to accommodation of more number of plants per unit area. The above results were in agreement with findings of Bhargava *et al.* (2007) and Olofintoye *et al.* (2015). The straw yield of buckwheat was also significantly influenced by different nutrient levels. Application of 70:30:30 NPK kg ha^{-1} has recorded significantly higher straw yield of buckwheat (2175 q ha^{-1}) and which was found on par with application of 60:20:20 NPK kg ha^{-1} (2049 q ha^{-1}). Improvement in straw yield of buckwheat with higher nutrient levels might be due to improving vegetative growth and better absorption of nutrients. Jeena Mary *et al.* (2018) revealed that the positive influence of higher nitrogen on dry matter production was due to the fact that nitrogen is required for cell division and cell elongation which triggers the growth of meristematic tissue and the efficient utilization of this by the plants manifested in production of higher dry matter. Interaction on dates of sowing, spacing and nutrient levels was found non-significant effect on straw yield of buckwheat.

With respect to harvest index, there was no significant difference among different dates of sowing but, wider row spacing of 45 × 15 cm has recorded significantly higher harvest index (0.33) as compared to narrow spacing of 30 × 10 cm (0.29). Higher harvest index in wider spacing might be due to minimum plants per unit area which received maximum balanced fertilizer, plenty of sunlight and space. Increased plant density has resulted decreased harvest index due to reduced photosynthethic area in turn due to increased competition for natural resources including solar radiation and nutrients. Decreased photosynthates and reduced translocation of assimilates to grain has resulted in lower harvest index. The harvest index of buckwheat was also significantly influenced by different nutrient levels. Application of 50:10:10 NPK kg ha^{-1} has recorded significantly higher harvest index (0.32) over application of 60:20:20 NPK kg ha^{-1} (0.30) and application of 70:30:30 NPK kg ha^{-1} (0.30). Increased harvest index might be due to optimum supply of the NPK for their magnanimous role in vegetative and reproductive phase of the plant. Interaction on dates of sowing, spacing and nutrient levels was found non-significant effect on harvest index of buckwheat.

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