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Effect of sowing dates and varieties on growth, yield attributes and yields of Horsegram [*Macrotyloma uniflorum* (Lam.) Verdc.] under protective irrigation

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Abstract
An field experiment was conducted during post *kharif* season 2018 at Instructional Farm, BTC College of Agriculture and Research Station, Bilaspur, IGKV, Raipur (C.G.). The experiment was laid in split plot design with two factors namely three sowing dates in the main plot *i.e.* D_1 (14th September), D_2 (20th September) and D_3 (26th September) with five varieties in sub plot *viz*., V_1 (Bilasa Kulthi), V_2 (Indira Kulthi-1), V_3 (Chhattisgarh Kulthi-2), V_4 (Chhattisgarh Kulthi-3) and V_5 (BSP 17-2). The result revealed that maximum plant height, no. of primary branches plant^{-1}, no. of secondary branches plant^{-1}, number of pods plant^{-1} (29.17), weight of pods plant^{-1} (6.13 g), pods length (4.84 cm) and test weight (30.09 g) recorded under D_1 (14th September) in sowing dates and in case of varieties V_2 (Indira kulthi-1) recorded maximum number of secondary branches plant^{-1}, number of pods plant^{-1} (33.29), weight of pods plant^{-1} (6.96 g), pods length (5.10 cm) and test weight (30.17 g). The sowing date D_1 (14th September) was recorded highest seed yield (720.70 kg ha^{-1}), Biological yield (1823.78 kg ha^{-1}) and harvest index (39.51%) as compared to D_2 (20th September) and D_3 (26th September) and in case of varieties V_2 (Indira Kulthi-1) is recorded maximum seed yield (697.04 kg ha^{-1}) and Biological yield (1943.15 kg ha^{-1}).

Keywords: Sowing date, variety, phenology, yield attributes and yield

Introduction
Among the pulses, horsegram is an important post season kharif crop of the country commonly known as "Kulthi" belongs to the family fabaceae. It has diploid chromosome numbers of 2n = 20, 22, 24 (Cook *et al*., 2005) [9]. Crop is an underutilized (Aiyer, 1990) [2] and unexplored (Reddy *et al*., 2008) [19] arid tropical food legume. Horsegram as a legume, it maintains soil fertility through biological nitrogen fixation in soil through root nodules and act as organic manure as well. It is suitable as a cover crop, soil and water conservation and an excellent drought tolerant (Bhardwaj and Yadav, 2012) [5], salinity tolerant (Reddy *et al*., 1998) [18] and heavy metal stress tolerant (Reddy *et al*., 2005) [17] contingent crop.
Crop is popular at maximum extent is Southern Indian states while to some extent in North Indian states. Its centre of origin is South West India (Arora and Chandel, 1972) [3]. Although as a pulse, whole seed of horsegram is utilized as a cattle feed which contains about 12 per cent of protein in fodder. Horsegram seed comprises 57.0 per cent carbohydrate, 22.0 per cent protein and 2.5 per cent fat (Sudha *et al*., 1995) [20]. It is also an excellent source of iron, calcium and molybdenum.
In India, horsegram occupies an area of 326 (000 ha) with a production of 117 (000 tonnes) with an average national productivity of 358 kg ha^{-1} (Anonymous, 2016-17) [1]. Horsegram is important pulse crop mostly grown in Karnataka, Odisha, Chhattisgarh, Andhra Pradesh, Tamil Nadu and Maharashtra which together contributes about 89.23 per cent area and 86.10 per cent production. Higher productivity of horsegram is obtained in Bihar (980 kg ha^{-1}).
In Chhattisgarh, horsegram occupies an area of 44.80 (000 ha) with a production of 16.80 (000 tonnes) and average productivity of 375 kg ha^{-1} (Anonymous, 2016-17) [1]. Horsegram is an important pulse crop of the state and mostly grown in Sarguja, Jagdalpur, Kanker, Korba and Jashpur which together contributes about 69.74 per cent area and 76.61 per cent production. However, the productivity of horsegram is highest in Janjgir (375 kg ha^{-1}).

Materials and Methods
A field experiment was conducted at the Instructional Farm, BTC College of Agriculture and

Research Station, Bilaspur, Chhattisgarh during post *kharif* season of year 2018. The field experiment was laid out in split plot design with three replications. The treatment consisted of three sowing dates in main plot *i.e.* D_1 (14th September), D_2 (20th September) and D_3 (26th September) with five varieties in sub plot *viz.*, V_1 (Bilasa Kulthi), V_2 (Indira Kulthi-1), V_3 (Chhattisgarh Kulthi-2), V_4 (Chhattisgarh Kulthi-3) and V_5 (BSP 17-2). Horsegram was sown with a spacing of 30 cm × 07 cm distance. Gross and net plot size was 6 m × 3 m and 5.72 m × 2.40 m respectively. The soil of the experimental field was sandy clay soil, medium organic carbon (0.64% and 0.61%) and low in nitrogen (150 and 137 kg ha^{-1}), medium in available phosphorus (13.88 and 12.20 kg ha^{-1}) and potassium (204.96 and 189.16 kg ha^{-1}) initial and at harvest soil sample respectively. The mean weekly maximum temperature ranges from 22.4^{0}C (20-26th December) to 34.46^{0}C in (03-09th October). Total rainfall received during cropping period *i.e.* 54.04 mm. A just after sowing irrigation was given one day of the seed to insure good germination and establishment of the seedlings and subsequently need based irrigation (protected irrigation) was given to crop. The crop was raised using seed rate of 20 kg ha^{-1} with row spacing of 30 cm. The seed was treated with carbendazim (12% WP) + Mancozeb (63% WP) @ 2.0 g followed by inoculation with Trichoderma @ 10.0 g kg^{-1} of seed and Rhizobium culture @ 10.0 g kg^{-1} of seed to control soil and seed born diseases. The nutrient dose 20 kg N, 40 kg P_2O_5 and 20 kg K_2O ha^{-1}. Pendimethalin 30 EC @ 1.25 kg *a.i.* ha^{-1} was sprayed as a pre emergence application on the third day after sowing to control weeds. Hand weeding was done twice at 25 DAS and 45 DAS of each sowing date to keep the plots free from weeds. Plant protection of infestation of yellow mosaic virus was control by one spraying of Imidachloprid 20 EC @ 1.25 liter ha^{-1}. To evaluate the treatment effect, the various morphological observations, growth analysis were recorded in the experiment at 25, 50, 75 Days after sowing and at harvest stage. while the phenological observations were recorded on days to flowering, days to 50 per cent flowering and days to maturity at respective stages. The observations on yield and yield attributing characters were recorded at harvest of the test crop. Data were analyzed statistically to determine the significance of the characters studied. Statistical data were analysed by standard procedure by Gomez and Gomez (1984) at the 5% level of significance.

The harvest index of horsegram was obtain by dividing the economic yield (grain yield) by the biological yield (grain yield and straw yield) and represented in percentage (Donald, 1962) [10]

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \times 100$$

Results and Discussion

Effect of sowing dates

The plant height recorded under D_1 (14th September) at 25 (14.13 cm), 50 (33.93 cm), and 75 days after sowing (35.71 cm) as well as at harvest (32.45 cm) were significantly higher as compared to D_3 (26th September) under study. However, values obtained in D_2 (20th September) were at par with D_1 except at 50 days after sowing and which are also better than D_3 values. The possible reason of higher values of plant height under D_1 may be due to early sowing as compared to D_2 and D_3 which favour the growth and development of horsegram. Such types of result were also found by Nagaraju *et al*. (1995) Biswas *et al*. (2002) [13, 7] in blackgram. The number of primary branches $plant^{-1}$ recorded at 25 (4.83), 50 (10.39) and 75 days after sowing (10.92) as well as at harvest (10.09) were significantly higher under D_1 (14th September) as compare to D_3 (20th September) under study. However, values obtained in D_2 (26th September) were at par with D_1 except at harvest and which are also better than D_3 values. The possible reason of higher values of plant height under D_1 may be due to early sowing as compared to D_2 and D_3 which favour the growth and development of horsegram. The number of secondary branches $plant^{-1}$ recorded under D_1 (14th September) at 25 (2.81), 50 (7.25) and 75 days after sowing (8.09) as well as at harvest (8.13) were significantly higher under D_1 than D_3 under study. However, values obtained in D_2 were at par with D_1 and which better than D_3 values. The possible reason of higher values of plant height under D_1 may be due to early sowing as compared to D_2 and D_3 which favour the growth and development of horsegram.

The number of days for the initiation of flowering decreased gradually from D_2 (20th September) and D_3 (26th September) sowing dates due to decreasing day length with delay in sowing. Days to 50 per cent flowering was maximum days recorded under D_1 (47.47 days) followed by D_2 (44.13 days) and D_3 (42.07 days). Days to maturity was maximum days recorded under D_1 (99.53 days) followed by D_2 (97.60 days) and D_3 (94.67 days).

The no. of pods $plant^{-1}$ was significantly higher in D_1 (29.17 pods $plant^{-1}$) than the D_2 (26.80 pods $plant^{-1}$) and D_3 (23.19 pods $plant^{-1}$). Further, D_2 (20th September) was significantly higher than D_3 (26th September). The results are in conformation with the finding of Hussain, (1989) [12]. The weight of pods $plant^{-1}$ observed in D_1 (6.13 g) significantly higher than D_2 (5.16 g) and D_3 (4.64 g). However, D_2 is better than D_3. Sowing date D_1 (14th September) recorded highest pod length (4.84 cm) followed by D_2 (4.76 cm), and D_3 (4.57 cm) but sowing date D_2 was at par with D_1. The test weight of D_1 (30.09 g) was significantly higher as compare to D_3 (29.57 g) under study. However, values obtained in D_2 (29.87 g) were at par with D_1. These are in agreement with the results described by Naidu *et al*. (2017) [14].

The biological yield of horsegram was significant affect by date of sowing. D_1 (14th September) produced significantly highest biological yield (1823.78 kg ha^{-1}) as compared to D_2 (1506.87 kg ha^{-1}) and D_3 (1404.54 kg ha^{-1}). Similarly, D_2 also registered notable higher yield (1506.87 kg ha^{-1}) compared to D_3. The result confirms the investigation of Rafey *et al*. (1988) [16], Bajpai *et al.* (1990) [4] Bobde *et al*. (2018) [8] and Nagaraju *et al*. (1995) [13]. The seed yield of horsegram obtain indicated that date of sowing has significant effect on seed yield. Sowing date D_1 (14th September) produced significantly highest seed yield (720.70 kg ha^{-1}) as compared to D_2 (567.54 kg ha^{-1}) and D_3 (525.61 kg ha^{-1}). Similarly D_2 also recorded significant higher yield as compared to D_3. Sowing date D_3 produced 525.61 kg ha^{-1} and is stood 3rd in position. Production of lower value of yield and yield attributing characters of seed by the crop may be there possible reason of reduction in yield under delayed in sowing, The results confirm the findings of Rafey *et al*. (1988) [16], Bajpai *et al.* (1990) [4] and Nagaraju *et al*. (1995) [13]. The sowing date D_1 (14th September) observed higher harvest index (39.51%) followed by D_2 (37.66%) and D_3 (37.42%). This result confirms the finding of Bobde *et al*. (2018) [8] in kharif green gram.

Effect of varieties

Plant height recorded with V_1 (Bilasa Kulthi) at 25 (13.60 cm), 50 (48.44 cm) and 75 days after sowing (51.96 cm) as well as at harvest (45.84 cm) were significantly highest as compared to other varieties. Variety V_5 (Indira Kulthi-1) was significantly better than V_3 (Chhattisgarh Kulthi-2) and V_4 (Chhattisgarh Kulthi-3) which are statistically at par with V_2 except 50 and 75 days after sowing. The possible explanation of higher values under V_1 may be due to its genetical superior characters. The finding of Prakash *et al.,* (2008) [15] is in similar pattern of the present study. Number of primary branches plant^{-1} recorded at 50 (10.87) and 75 days after sowing (11.33) as well at harvest (10.98) were significantly higher in V_1 (Bilasa Kulthi) as compare to other varieties. Variety V_2 (Indira Kulthi-1) was significantly better than V_3 (Chhattisgarh Kulthi-2) and V_4 (Chhattisgarh Kulthi-3). The main reason of higher branches under variety V_1 (Bilasa Kulthi) is may be to its genetical characters as well growing condition. The finding of Bhattacharya and Bandyopadhyay (1983) [6] is in similar pattern of the present study. The number of secondary branches plant^{-1} recorded at 25 days after sowing (2.89) were maximum in V_2 (Indira Kulthi-1) which was significantly higher than V_1 (2.56) and V_4 (2.44), and statistically at par with V_5 (2.84) and V_3 (2.73) The number of secondary branches recorded in 50 days after sowing and at harvest was maximum in V_2 and was significantly higher than V_3 (Chhattisgarh Kulthi-2), V_4 (Chhattisgarh Kulthi-3) and V_5 (BSP 17-2) but statistically at par with V_1 but in case of 75 days after sowing the highest number of branches (8.40) was recorded in V_2. The result confirms the finding of Prakash *et al.,* (2008) [15] is in similar pattern of the present study.

The in days to flowering was maximum and significantly higher in V_2 (40.78 days) than the V_4 (40 days), V_3 (39.22 days), and V_1 (36.78 days) but statistically at par with V_5 (40.67 days). Such types of varietal differences were also found by Nagaraju *et al*. (1995) Suthar *et al*. (2017) [13, 21] in horsegram. 50 per cent flowering was maximum and significantly higher in V_2 (45.89 days) than the V_1 (41.67 days), V_3 (44.44 days) and V_4 (45.11 days) but statistically at par with V_5 (45.67 days). Variety V_2 (Indira Kulthi-1) taken maximum days to maturity (100.22 days) followed by V_3 (97.44 days), V_4 (97.33 days), V_1 (95.78 days) and V_5 (95.56 days).

The number of pods plant^{-1} were significantly higher in V_2 (33.29 pods plant^{-1}) than V_1 (26.24 pods plant^{-1}), V_3 (21.20 pods plant^{-1}) and V_4 (19.53 pods plant^{-1}). Variety V_5 (BSP 17-2) *i.e*. 31.67 number of pods plant^{-1} was statistically at par withV_2 (Indira Kulthi-1). The weight of pods plant^{-1} considerably highest in V_2 (6.96 g) followed by V_5 (5.32 g), V_1 (5.27 g), V_3 (5.03 g) and V_4 (3.97 g). Among the varieties, maximum pod length (5.10 cm) was found with variety V_2 (Indira Kulthi-1) which was significantly better over all other varieties *i.e.* followed by V_1 (4.82 cm), V_5 (4.65 cm), V_4 (4.56 cm) and V_3 (4.48 cm). The significantly higher test weight of studied crop was recorded in V_2 (30.17 g) followed by V_1 (30.15 g), V_5 (29.79 g), V_4 (29.55 g) and V_3 (29.54 g).

Variety V_2 (Indira Kulthi-1) produced significantly highest biological yield (1943.15 kg ha^{-1}) of horsegram as compared to all other varieties. Variety V_1 (1515.78 kg ha^{-1}) was at par with V_5 (1585.35 kg ha^{-1}). V_3 (Chhattisgarh Kulthi-2) and V_4 (Chhattisgarh Kulthi-3) observed statistically similar and stood 3rd in position. The variety V_2 (Indira Kulthi-1) produced significantly highest seed yield (697.04 kg ha^{-1}) among the all other varieties. Variety V_5 (638.32 kg ha^{-1}) and V_1 (602.85 kg ha^{-1}) yielded statistically at par yield and significantly higher than V_4 (560.74 kg ha^{-1}) and V_3 (524.13 kg ha^{-1}). Variety V_4 and V_3 observed statistically similar and stood 3rd in position. The possible reason of higher yield of variety V_2 is that this variety recorded higher growth and yielding attributing parameters as compared to other varieties. Such types of varietal differences were also reported by Nagaraju *et al*. (1995) [13] and Suthar *et al*. (2017) [21] in horsegram. The V_5 variety recorded peak harvest index (40.26%) and least harvest index was recorded by V_2 (35.87%).

Table 1: Effect of dates of sowing and varieties on growth characters of horsegram

Treatment	Plant height (cm)			
	25 DAS	50 DAS	75 DAS	At harvest
A. Dates of sowing (D)				
D_1: (14th September)	14.13	33.93	35.71	32.45
D_2: (20th September)	13.79	26.99	34.61	31.51
D_3: (26th September)	10.15	26.72	29.27	25.65
S. Em ±	0.17	1.33	1.08	0.64
CD at 5%	0.68	5.22	4.25	2.53
B. Varieties (V)				
V_1: (Bilasa Kulthi)	13.60	48.44	51.96	45.84
V_2: (Indira Kulthi-1)	13.11	25.62	34.51	31.69
V_3: (Chhattisgarh Kulthi-2)	12.33	22.80	25.49	22.27
V_4: (Chhattisgarh Kulthi-3)	12.11	23.20	26.13	23.16
V_5: (BSP 17-2)	12.29	26.00	27.89	26.39
S. Em ±	0.24	1.60	1.84	1.86
CD at 5%	0.71	4.68	5.36	5.42
Interaction (D×V)				
S. Em ±	0.42	2.78	3.18	3.21
CD at 5%	NS	NS	NS	NS

Treatment	Number of primary branches plant^{-1}			
	25 DAS	50 DAS	75 DAS	At harvest
Dates of sowing				
D_1: (14th September)	4.83	10.39	10.92	10.09
D_2: (20th September)	4.72	10.36	10.64	9.41
D_3: (26th September)	4.01	9.51	10.16	9.24

S. Em ±	0.16	0.17	0.12	0.07
CD at 5%	0.65	0.67	0.49	0.28
Varieties				
V_1: (Bilasa Kulthi)	4.51	10.87	11.33	10.98
V_2: (Indira Kulthi-1)	4.44	10.53	11.31	10.64
V_3: (Chhattisgarh Kulthi-2)	4.67	9.36	9.67	8.51
V_4: (Chhattisgarh Kulthi-3)	4.22	9.53	9.73	8.58
V_5: (BSP 17-2)	4.76	10.13	10.82	9.20
S. Em ±	0.12	0.18	0.30	0.36
CD at 5%	0.36	0.54	0.86	1.04
Interaction (D×V)				
S. Em ±	0.21	0.32	0.51	0.62
CD at 5%	NS	NS	NS	NS

Treatment	Number of secondary branches plant^{-1}			
	25 DAS	50 DAS	75 DAS	At harvest
Dates of sowing				
D_1: (14th September)	2.81	7.25	8.09	8.13
D_2: (20th September)	2.72	7.10	8.04	8.08
D_3: (26th September)	2.55	6.61	7.31	7.56
S. Em ±	0.04	0.10	0.16	0.07
C.D at 5%	0.17	0.41	0.65	0.28
Varieties				
V_1: (Bilasa Kulthi)	2.56	7.27	7.87	8.02
V_2: (Indira Kulthi-1)	2.89	7.72	8.40	8.64
V_3: (Chhattisgarh Kulthi-2)	2.73	6.33	7.44	7.42
V_4: (Chhattisgarh Kulthi-3)	2.44	6.47	7.51	7.54
V_5: (BSP 17-2)	2.84	7.16	7.84	7.98
S. Em ±	0.11	0.24	0.17	0.28
CD at 5%	0.32	0.70	0.51	0.83
Interaction (D×V)				
S. Em ±	0.19	0.42	0.30	0.49
CD at 5%	NS	NS	NS	NS

Table 2: Effect of sowing dates and varieties of horsegram on days to flowering, 50 per cent flowering and maturity

Treatment	Days to		
	Flowering	50 per cent flowering	Maturity
A. Dates of sowing (D)			
D_1: (14th September)	41.53	47.47	99.53
D_2: (20th September)	39.27	44.13	97.60
D_3: (26th September)	37.67	42.07	94.67
S. Em ±	0.09	0.12	0.05
CD at 5%	0.35	0.48	0.19
B. Varieties (V)			
V_1: (Bilasa Kulthi)	36.78	41.67	95.78
V_2: (Indira Kulthi-1)	40.78	45.89	100.22
V_3: (Chhattisgarh Kulthi-2)	39.22	44.44	97.44
V_4: (Chhattisgarh Kulthi-3)	40.00	45.11	97.33
V_5: (BSP 17-2)	40.67	45.67	95.56
S. Em ±	0.24	0.28	0.37
CD at 5%	0.70	0.82	1.07
Interaction(D×V)			
S. Em ±	0.42	0.49	0.63
CD at 5%	NS	NS	NS

Table 3: Effect of dates of sowing and varieties on yield attributing characters of horsegram

	Yield attributing characters			
	Number of pods plant^{-1}	Weight of pods plant^{1} (g)	Pods length (cm)	Test weight (g)
A. Dates of sowing (D)				
D_1: (14th September)	29.17	6.13	4.84	30.09
D_2: (20th September)	26.80	5.16	4.76	29.87
D_3: (26th September)	23.19	4.64	4.57	29.57
S. Em ±	0.55	0.20	0.05	0.06
CD at 5%	2.15	0.80	0.18	0.24
B. Varieties (V)				
V_1: (Bilasa Kulthi)	26.24	5.27	4.82	30.15
V_2: (Indira Kulthi-1)	33.29	6.96	5.10	30.17

V_3: (Chhattisgarh Kulthi-2)	21.20	5.03	4.48	29.54
V_4: (Chhattisgarh Kulthi-3)	19.53	3.97	4.56	29.55
V_5: (BSP 17-2)	31.67	5.32	4.65	29.79
S. Em ±	1.56	0.44	0.07	0.10
CD at 5%	4.57	1.28	0.22	0.30
Interaction(D×V)				
S. Em ±	2.71	0.76	0.13	0.18
CD at 5%	NS	NS	NS	NS

Table 4: Effect of dates of sowing and varieties on yield of horsegram

Treatment	Seed yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest Index (%)
A. Dates of sowing (D)			
D_1: (14th September)	720.70	1823.78	39.51
D_2: (20th September)	567.54	1506.87	37.66
D_3: (26th September)	525.61	1404.54	37.42
S. Em ±	25.76	35.69	-
CD at 5%	101.13	140.12	-
B. Varieties (V)			
V_1: (Bilasa Kulthi)	602.85	1515.78	39.77
V_2: (Indira Kulthi-1)	697.04	1943.15	35.87
V_3: (Chhattisgarh Kulthi-2)	524.13	1347.99	38.88
V_4: (Chhattisgarh Kulthi-3)	560.74	1499.70	37.39
V_5: (BSP 17-2)	638.32	1585.35	40.26
S. Em ±	39.75	118.39	-
CD at 5%	116.01	345.55	-
Interaction (D×V)			
S. Em ±	68.84	205.05	-
CD at 5%	NS	NS	-

Conclusion

Sowing date D_1 (14th September) produced significantly highest seed yield (720.70 kg ha^{-1}) as compared to D_2 (567.54 kg ha^{-1}) and D_3 (525.61 kg ha^{-1}).Variety V_2 (Indira Kulthi-1) significantly produced higher grain yield (697.04 kg ha^{-1}) followed by V_5 (638.32 kg ha^{-1}) V_1 (602.85 kg ha^{-1}), V_4 (560.74 kg ha^{-1}) and V_3 (524.13 kg ha^{-1}).

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