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Performance of greengram, *Vigna radiata* (L.) Wilczek cultivars under different tillage methods

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ABSTARCT

A field experiment was conducted during 2017-18 at the Agronomy Farm, College of Horticulture, Vellanikara, Thrissur, Kerala with the objectives to study the response of selected greengram cultivars under different tillage methods and to identify the most economical combination of cultivar and tillage. Split plot design was adopted with three replications. The main plot treatments were four methods of tillage (minimum tillage, minimum tillage fb pendimethalin @ 1kg ha^{-1}(PE), minimum tillage fb imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS and conventional tillage fb two hand weedings at 15 and 30 DAS. The sub plot treatments were four cultivars - C0 6, CO 7, CO 8 and VBN(Gg)2. The study revealed that the tillage methods and cultivars had influence on growth, yield and quality of greengram. The weed density and dry weight were lower under minimum tillage fb herbicide treatments and conventional tillage fb hand weedings. The cultivar CO 8 in minimum tillage fb imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS (M_4V_3) recorded higher seed yield (942 kg ha^{-1}) and it was at par with conventional tillage fb hand weedings (911 kg ha^{-1}) (M_4V_3). It can be inferred that cultivar Co 8 grown under minimum tillage fb post emergence application of combination herbicide imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS can be recommended for summer rice fallows considering the yield and profitability.

Keywords: *Greengram, imazethapyr + imazamox,* minimum tillage, pendimethalin and seed yield

Greengram [*Vigna radiata* (L.) Wilczek] is one of the thirteen food legumes grown in India and the third most important pulse crop after chickpea and pigeonpea. Greengram is one of the hardiest among pulse crops (Shersingh *et al*., 2016). The total area under greengram in India was 34.50 lakh ha with a total production of 15.91 lakh tones (DPD, 2017). In an integrated approach, the development of cropping systems with efficient tillage methods will help crops to compete with weeds. Diversifying cropping systems with greengram can serve as an effective alternative to summer fallows. A change to conservation tillage along with improved genotypes will be beneficial to farmers due to reduced costs and improved yield. Presently, minimum tillage and chemical tillage practices are gaining importance in conservation agriculture due to their role in soil and moisture conservation. By the use of conservation agricultural practices like minimum tillage and residue mulching, pulse crops like blackgram or greengram can be better established. With introduction of improved short duration cultivars significant expansion in area and production has been observed in summer mungbean during last one decade (Chadha, 2010). Moreover, being a short duration crop, it has great scope in rice based cropping systems of Kerala. Greengram can be successfully grown with conservation agriculture practices with maximum yield and profit in rice fallows, thus enhancing the system productivity and profitability (Behera *et al*., 2014).

Among various production practices, establishment techniques, weed management practices and new cultivars have vast potential to enhance yield of greengram. Hence, the present investigation was carried out for standardizing the production technologies for enhancing the productivity of greengram with the objectives to study the response of selected greengram cultivars under different tillage methods and to identify the most economical combination of cultivar and tillage.

The experiment was conducted in the summer rice fallows of Agronomy Farm, College of Horticulture, Vellanikkara, Thrissur. The experimental field is located at 10^0 31′ N latitude and$76^0$13′ E longitude and an altitude of 40.3m above mean sea level. The soil of the experiment site is sandy loam under taxonomical order Entisol and acidic in nature. The soil was high in organic carbon with medium P and low in available N and K. The experiment was conducted in summer rice fallows after the harvest of rice during December 2017 to March 2018. Split plot design was adopted with three replications. The main plot treatments were four tillage methods *viz*., M_1 - Minimum tillage (primary tillage only), M_2 - Minimum tillage followed by (*fb*) pre emergence application of pendimethalin @ 1kg ha^{-1}, M_3 - Minimum tillage *fb* post emergence application of (imazethapyr + imazamox) @ 80 g ha^{-1} at 20 DAS and M_4 - Conventional tillage (Primary and secondary tillage) *fb* two hand weedings (HW) at 15 and 30 DAS. Sub plot treatments had four cultivars of green gram *viz*., V_1 - CO 6, V_2 - CO 7, V_3 - CO 8 and V_4 -VBN (Gg) 2.

In minimum tillage the field was ploughed only once and seed bed were taken with minimum soil disturbance

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with the previous rice crop residue. In conventional tillage, the field was ploughed three times thoroughly with tractor, followed by secondary tillage and seed beds were prepared without the crop residues. Pre emergence application of pendimethalin @ 1 kg ha^{-1} was done at 3 days after sowing (DAS) and post emergent application of imazethapyr + imazamox @ 80 g ha^{-1} was done at 20 DAS. In conventional tillage, two hand weedings were done at 15 and 30 DAS. Gap filling was done after two weeks of planting to maintain the plant population. Lime, cowdung and fertilizers were applied as per the package of practice recommendations (Anon., 2016). Line sowing was done on 14th December 2017 at a seed rate of 20 kg ha^{-1} with a spacing of 25 x 15cm. Weeding was done as per the tillage methods. First two harvesting was done by picking the dried pods with hands and the third harvesting was done on 5th March 2018 by pulling out the whole plant.

Biometric observations and physiological parameters were recorded at 30 DAS, at flowering and at maturity. Yield and yield attributes were also recorded. Weed density and weed dry weight were calculated at 30 DAS and at flowering. Weed density was randomly taken using 1 x 1 m quadrant at four places in each plot and were counted and recorded. Weeds were uprooted from sampling area of each plot, dried in shade and then dried in hot air oven at 70°C and dry weight was recorded and expressed in g m^{-2}. Weed control efficiency (WCE) was calculated as per the formula (Kondap and Upadhyay, 1985). Soil analysis was done before and after the experiment for finding out the available nutrient status. Economics was analyzed by gross returns and benefit cost ratio (BCR). Data relating to each character is analyzed by applying the Analysis of Variance technique.

The data in the table 1 indicated that the growth characters *viz*., plant height, numbers of branches and leaf area varied significantly with tillage methods at flowering and at harvest stages but not during vegetative growth phase.The taller plants were observed in minimum tillage *fb* imazethapyr + imazamox @ 80g ha^{-1} at 20 DAS (M_3) and conventional tillage followed by two hand weedings at 15 and 30 DAS (M_4). This was mainly due to weed free situation which is evident from data on weed dry matter production in the table 4. The shortest plants were observed in minimum tillage due to the severe crop weed competition. The number of branches was higher in minimum tillage *fb* herbicide treatments due to the less crop weed competition. The higher leaf area in minimum tillage followed by application of herbicide imazethapyr + imazamox @80g ha^{-1} at 20 DAS and conventional tillage followed by two hand weedings at 15 and 30 DAS were due to more vigorous growth of plants.

The cultivars *viz*., CO 8 (V_3) and and VBN (Gg) 2 (V_4) had higher values for all the growth parameters as compared to CO 6 (V_1) and CO 7 (V_2). Greengram cultivar with narrower leaves and higher light interception was found to have a higher yield potential compared to greengram with broader leaves (Lee *et al*., 2014). In this experiment the cultivar Co 8 had narrower leaves which might have contributed to higher yield compared to other three cultivars.

The physiological parameters in the table 2 *viz*., CGR, LAI and LAD were affected by tillage methods. The leaf area index (LAI) increased with crop growth up to flowering after which it declined. This was attributed to leaf fall and concurred with earlier findings of Kumar *et al.* (2000). Flowering is governed by the phenology of particular cultivar, than physical factors like tillage and cultural practices. The growth analysis indicated that in all cultivars CGR values increased up to 30-44 days after sowing (DAS) and thereafter declined till maturity. LAI values followed an increasing trend up to 45 DAS due to peak vegetative growth at this stage and thereafter started declining. In all the cultivars, LAI of cultivars Co 8 (V3) and VBN (Gg) 2 (V4) were at par and superior to Co 6(V1) and Co 7(V2). The cultivar Co 8 (V3) recorded the higher LAD at all growth stages which is a better reason for high yield potential of this cultivar. The higher values of LAI resulted due to better branching which resulted in higher leaf area in cultivar Co 8.

The yield attributes *viz.*, number of pods plant^{-1} and number of seeds pod^{-1} varied significantly with tillage methods. Minimum tillage *fb* application of herbicide imazethapyr + imazamox @80g ha^{-1} at 20 DAS (M_3) recorded higher number of pods (22.14), and number of seeds pod^{-1} (11.81) and was at par with conventional tillage *fb* two hand weedings at 15 and 30 DAS (M_4). This may be due to favourable soil moisture condition in minimum tillage plots along with lesser weed competition due to post emergent herbicide application resulted in higher productivity. Similarly conventional tillage treatments helped to develop a favorable environment for crop growth which resulted in better yield parameters. Conventional tillage had a positive impact on crop growth rate in comparison to no-tilled plots (Sangakkara, 2007).

The results revealed that the tillage methods significantly influenced the yield. Minimum tillage *fb* post emergence application of imazethapyr + imazamox @ 80g ha^{-1} at 20 DAS (M_3) recorded higher seed yield (748.33 kg ha^{-1}) and it was at par with conventional tillage *fb* two hand weedings at 15 and 30 DAS (M_4) and found superior to the other two methods of tillage. The minimum tillage (M_1) recorded the lowest seed yield (369.85 kg ha^{-1}). Minimum tillage *fb* imazethapyr + imazamox @ 80g ha^{-1} at 20 DAS recorded 102 per cent

Table 1: Effect of tillage methods and cultivars on growth parameters

Treatments	Plant height (cm)			Number of branches			Total leaf area (cm^2)		
	At 30 DAS	At flowering	At maturity	At 30 DAS	At flowering	At maturity	At 30 DAS	At flowering	At maturity
Tillage methods (M)									
M_1-Minimum tillage	15.06	27.67	33.24	3.32	4.78	5.49	181.74	824.57	489.57
M_2-Minimum tillage + pendimethalin	14.86	30.72	35.48	3.32	5.17	5.97	188.14	942.16	598.26
M_3-Minimum tillage + (imazethapyr + imazamox)	14.30	32.42	38.98	3.41	5.10	6.00	201.46	1089.02	720.43
M_4-Conventional tillage + 2 HW	14.13	32.12	39.01	3.17	4.73	5.72	183.81	1078.77	658.68
SEm (±)	**0.60**	**0.47**	**0.63**	**0.10**	**0.09**	**0.06**	**13.42**	**41.36**	**33.99**
LSD (0.05)	**NS**	**1.66**	**2.22**	**NS**	**0.31**	**0.21**	**NS**	**145.91**	**119.92**
Cultivars (V)									
V_1-CO 6	13.99	29.00	33.16	3.40	4.79	5.67	173.24	931.15	551.11
V_2-CO 7	13.85	29.05	36.41	2.98	4.86	5.64	169.94	950.68	549.46
V_3-CO 8	15.23	33.78	44.74	3.49	5.12	5.92	207.97	1030.25	679.55
V_4-VBN (Gg)2	15.29	31.11	41.72	3.33	5.02	5.95	204.01	1022.44	686.83
SEm (±)	**0.43**	**0.79**	**0.812**	**1.09**	**0.19**	**0.16**	**8.43**	**39.70**	**31.95**
LSD (0.05)	**1.25**	**2.31**	**2.38**	**0.32**	**NS**	**NS**	**24.76**	**NS**	**93.82**

Table 2: Effect of tillage methods and cultivars on physiological parameters

Treatments	Crop growth rate (g m^{-2}d^{-1})				Leaf area index			Leaf area duration (days)		
	15-30 DAS	30-45 DAS	45-60 DAS	60-75 DAS	30 DAS	At flowering	At harvest	15-30 DAS	30-45 DAS	45-60 DAS
Tillage methods (M)										
M_1-Minimum tillage	0.99	2.70	11.11	6.89	0.48	2.20	1.30	10.96	20.12	26.28
M_2-Minimum tillage *fb* pendimethalin	1.10	2.92	15.92	7.97	0.50	2.51	1.59	11.85	22.60	30.80
M_3-Minimum tillage *fb* (imazethapyr + imazamox)	1.48	3.07	20.29	9.17	0.53	2.90	1.92	12.77	25.80	36.18
M_4-Conventional tillage	1.55	3.09	17.83	8.78	0.49	2.87	1.75	11.52	25.25	34.75
SEm (±)	**0.09**	**0.14**	**0.95**	**0.63**	**0.03**	**0.11**	**0.09**	**0.98**	**1.01**	**1.19**
LSD (0.05)	**0.32**	**NS**	**3.35**	**NS**	**NS**	**0.39**	**0.31**	**NS**	**3.58**	**4.22**
Cultivars (V)										
V_1-CO 6	1.11	2.86	14.35	7.11	0.46	2.48	1.46	10.38	22.08	29.64
V_2-CO 7	1.19	2.76	15.20	7.81	0.45	2.53	1.46	10.52	22.41	30.00
V_3-CO 8	1.51	3.14	18.40	9.34	0.55	2.74	1.81	13.28	24.76	34.19
V_4-VBN (Gg) 2	1.29	3.00	17.21	8.54	0.54	2.72	1.83	12.92	24.52	34.18
SEm (±)	**0.09**	**0.14**	**0.93**	**1.12**	**0.02**	**0.10**	**0.08**	**0.62**	**0.79**	**1.04**
LSD (0.05)	**0.27**	**NS**	**2.75**	**NS**	**0.06**	**NS**	**0.25**	**1.84**	**2.31**	**3.05**

Table 3: Effect of tillage methods and cultivars on yield and yield attributes and quality

Treatments	No. of nodules at 30 DAS	No. of nodules at flowering	No. of pods plant^{-1}	Length of pod (cm)	No. of seeds pod^{-1}	Days to 50 percent flowering	100 seed weight	Seed yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Protein content (%)
Tillage methods (M)										
M_1-Minimum tillage	9.70	17.12	15.26	7.83	10.60	44.67	3.68	369.85	1792.59	21.84
M_2-Minimum tillage *fb* Pendimethalin	12.11	17.95	15.87	7.81	10.99	45.25	3.67	570.91	2510.37	21.81
M_3-Minimum tillage *fb* (Imazethapyr + imazamox)	11.48	18.27	22.14	8.36	11.81	45.50	3.62	748.33	3127.41	22.32
M_4 -Conventional tillage	12.30	19.69	21.72	8.40	11.57	44.50	3.67	705.00	2827.97	21.91
SEm (±)	**0.43**	**0.44**	**0.68**	**0.36**	**0.21**	**0.51**	**0.05**	**28.03**	**126.75**	**0.16**
LSD (0.05)	**1.55**	**1.57**	**2.40**	**NS**	**0.75**	**NS**	**NS**	**98.90**	**447.15**	**NS**
Cultivars (V)										
V_1 -CO 6	10.66	17.05	15.46	7.31	10.97	45.58	3.54	491.82	2308.15	21.34
V_2 -CO 7	11.39	17.82	17.40	8.34	10.69	44.75	3.70	522.12	2340.74	22.41
V_3 -CO 8	12.05	19.40	22.39	8.68	11.71	44.42	3.75	735.61	2902.04	22.08
V_4 -VBN (Gg) 2	11.49	18.76	19.75	8.06	11.60	45.17	3.66	644.55	2707.41	22.06
SEm (±)	**0.46**	**0.53**	**0.74**	**0.23**	**0.18**	**0.43**	**0.04**	**18.84**	**105.92**	**0.26**
LSD (0.05)	**NS**	**1.56**	**2.18**	**0.69**	**0.53**	**NS**	**0.11**	**55.31**	**311.01**	**NS**

Table 4: Effect of tillage methods and cultivars on weed density, weed dry weight, weed control efficiency and soil fertility

Treatments	density at 30 DAS	density at flowering	weight at 30 DAS (g m^{-2})	weight at flowering (g m^{-2})	control efficiency at flowering (%)	Organic carbon (%)	Nitro-gen (kg ha^{-1})	Phosp-horus (kg ha^{-1})	Potas-sium (kg ha^{-1})
Tillage methods (M)									
M_1 -Minimum tillage	3.18	4.33	11.58	47.50	0	1.13	138.47	16.66	180.29
M_2 -Minimum tillage *fb* Pendimethalin	2.66	3.57	7.25	20.50	55	1.04	128.10	14.24	148.52
M_3 -Minimum tillage *fb* (Imazethapyr + imazamox)	2.47	3.16	4.92	9.92	79	1.10	129.67	13.66	151.16
M_4 -Conventional tillage	2.45	2.48	2.58	3.67	92	1.02	116.02	13.21	132.64
SEm (±)	**0.11**	**0.19**	**0.41**	**1.51**	**1.71**	**0.01**	**3.12**	**0.60**	**4.50**
LSD (0.05)	**0.37**	**0.69**	**1.45**	**5.33**	**6.02**	**0.04**	**11.00**	**2.13**	**15.90**
Cultivars (V)									
V_1 -CO 6	2.74	3.55	6.17	21.33	57	1.05	126.40	14.48	156.94
V_2 -CO 7	2.73	3.27	6.58	20.75	53	1.08	128.62	14.94	153.49
V_3 -CO 8	2.82	3.35	6.67	19.92	58	1.09	127.05	13.72	154.14
V_4 -VBN (Gg)2	2.46	3.37	6.98	19.58	58	1.07	130.20	14.63	148.03
SEm (±)	**0.09**	**0.15**	**0.42**	**1.72**	**2.34**	**0.01**	**3.48**	**0.50**	**8.70**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

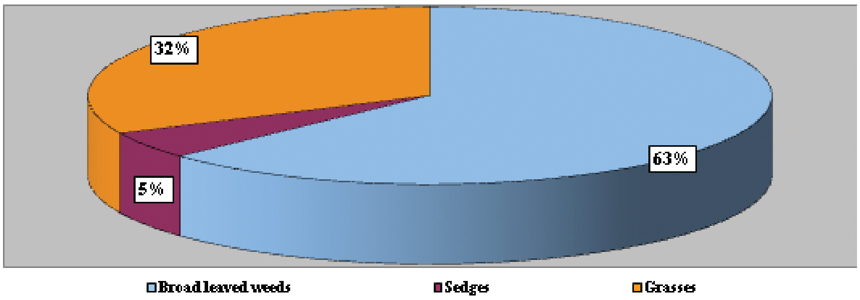

Fig. 1: Species wise distribution of weeds in experimental field

Table 5: Economics of green gram cultivation under tillage methods

Treatments	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	B:Cratio
M_1 - Minimum tillage	38694	31437	0.81
M_2 -Minimum tillage *fb* pendimethalin	41348	48527	1.17
M_3 -Minimum tillage *fb*(imazethapyr + imazamox)	41690	63608	1.53
M_4 -Conventional tillage + two hand weedings	52494	59925	1.14

Table 6: Interaction effect of tillage methods and cultivars on seed yield and economics

Treatments	Seed yield(kg ha^{-1})	Gross returns(Rs ha^{-1})	B:C ratio
M1V1	341	28952	0.75
M1V2	410	31167	0.81
M1V3	631	33330	0.86
M1V4	585	32300	0.83
M2V1	367	34876	0.84
M2V2	526	44715	1.08
M2V3	629	59242	1.43
M2V4	567	55276	1.34
M3V1	392	53627	1.29
M3V2	697	53473	1.28
M3V3	942	80106	1.92
M3V4	911	67227	1.61
M4V1	380	49764	0.95
M4V2	650	48167	0.92
M4V3	791	77427	1.47
M4V4	757	64342	1.23

higher seed yield than minimum tillage. The increase yield under minimum tillage *fb* imazethapyr + imazamox @ 80g ha^{-1} at 20 DAS was mainly due to the increase in growth and yield attributes. This was in conformity with the findings of Kumar *et al*. (2014) in summer greengram. The harvest index was not significantly varied by tillage methods which was also reported by Banjara *et al.* (2017).The biological yield was the highest in minimum tillage *fb* imazethapyr + imazamox @80g ha^{-1} at 20 DAS (M_3) (3127.41 kg ha^{-1}) and was at par with conventional tillage *fb* hand weedings (M_4) (2827.97 kg ha^{-1}). The lowest biological yield (1792.59 kg ha^{-1}) was recorded in the minimum tillage (M_1) which in turn resulted in lower seed yield and dry matter production. The protein content did not vary with methods of tillage.

Higher values of yield components *viz*., number of pods plant^{-1}, number of seeds pod^{-1}, 100 seed weight and harvest index were recorded in Co 8 (V_3) *fb* VBN

(Gg) 2 (V_4). The cultivar CO 8 (V_3) recorded the highest seed yield (735.61 kg ha^{-1}) and superior to other three cultivars. It was followed by VBN (Gg) 2 (V_4) with a seed yield of 644.55 kg ha^{-1} (Table 3). The cultivars CO 6 (V_1) and CO 7 (V_2) were at par with a seed yield of 491.82 kg ha^{-1} and 522.12 kg ha^{-1}. The higher seed yield in Co 8 (V_3) due to higher growth and yield attributes.

The cultivar CO 8 in minimum tillage *fb* Imazethapyr + imazamox @ 80g ha^{-1} at 20 DAS (M_4V_3) recorded higher seed yield (942.42 kg ha^{-1}) and it was at par with conventional tillage followed by hand weeding treatments (M_4V_3). The lower seed yield (340.61 kg ha^{-1}) was recorded in minimum tillage with Co 6 (M_1V_1) and it was at par with minimum tillage with other three cultivars (M_1V_2, M_1V_3 and M_1V_4) and minimum tillage + pendimethalin @ 1kg ai ha^{-1} with Co 6 (M_2V_1). This was due to the differential response of greengram cultivars under different tillage methods. Imran *et al.* (2016) also reported that plant height, yield and yield attributes and protein content of greengram were significantly affected by cultivars and tillage systems.

The percentage distributions of weeds in experimental field are illustrated in the fig. 1. Nineteen weed species were observed and the predominant were broad leaved weeds. The important broad leaved weeds were *Melochia chorchorifolia*, *Heliotropium indicum*, *Grangea maderaspatana*, *Cleome viscosa*. Among grasses, the predominant species were *Oryzasativa*, *Echinochloa colona*, *Eleusine indica* and *Digitaria ciliaris*. C*yperus iria* was the only sedge observed. The weed density and dry weight were lower under minimum tillage treatments followed by herbicide treatments and conventional tillage followed by hand weedings.

These treatments reduced the crop weed competition which had favoured crop growth and provided higher grain and stover yield. At flowering stage, the lowest grass population was recorded in conventional tillage followed by hand weeding. Weed population at 30 DAS and at flowering stage revealed that there was no significant variation in population of sedges. This may be due to their lower population density. Weed density of broad leaved population at 30 DAS and flowering stage revealed that the broad leaved weed population varied significantly with tillage methods. The lowest value of broad leaved weed population was recorded in conventional tillage followed by hand weedings (M4). It was at par with the minimum tillage followed by herbicide treatments. The herbicides pendimethalin or imazethapyr + imazamox were equally effective in reducing the weed density of broad leaved weeds at 30 DAS. The lowest yield in the minimum tillage (M_1) may be due to the highest weed dry weight and weed density. Enhanced growth and yield attributes in post-emergence application of imazethapyr + imazamox led to less crop and weed competition and higher seed yield of greengram. The highest WCE was recorded in conventional tillage followed by hand weedings (92%) and was followed by minimum tillage *fb* imazethapyr + imazamox (M_3) (79%).

Tillage methods affects the nutrient availability in the soil by modifying soil physical properties such as aggregate size, porosity, moisture content and bulk density (Chandra *et al*., 2017). The results in the table 4 clearly indicated that the methods of tillage had significant influence on soil fertility status. In the present study, minimum tillage method had 11 per cent more organic carbon content than conventional tillage system. The increased organic carbon content under minimum tillage may be due more crop residues left on soil surface which led to accumulation of organic carbon in soil. Among the tillage methods, the best treatment with respect to available nitrogen, phosphorus and potassium after the experiment was minimum tillage when compared to conventional tillage. The percentage increase of available nitrogen, phosphorus and potassium in minimum tillage over conventional tillage were 19, 26 and 36 per cent, respectively.

Economics in the table 5 and 6, also showed the same trend as that of seed yield of greengram. The cost of cultivation of greengram varied with the tillage methods. The economics of cultivation revealed that less cost of cultivation from the minimum tillage plots due to less labour cost compared to conventional tillage *fb* hand weedings. Cultivar Co 8 (V_3) recorded higher gross and net returns due to high seed yield. The same variety had also recorded the highest benefit cost ratio due to its higher productivity which was *fb* VBN (Gg)2 (V_4) and Co 7 (V_2). The cultivars Co 6 (V_1) recorded the lowest net returns due to lower seed yield.

It can be concluded that greengram cultivar Co 8 grown under minimum tillage method *fb* post emergence application of combination herbicide imazethapyr + imazamox @ 80 g ha^{-1} at 20 DAS can be recommended for summer rice fallows considering the yield and profitability.

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