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Ergonomic evaluation of self-propelled planter for NEH region

Asif Beg[1] • N.S. Chauhan[2]

[1]Research Scholar, College of Agricultural Engineering and Post-Harvest Technology, Central Agricultural University, Ranipool, Gangtok, Sikkim (India)

[2]Professor, College of Agricultural Engineering and Post-Harvest Technology, Central Agricultural University, Ranipool, Gangtok, Sikkim (India)

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ABSTRACT

In Indian agriculture, seed placement is one of crucial operations as it affects seed germination, growth and the productivity. Further, in narrow terraces of North Eastern Hilly Region use of tractor operated planters and other conventional planter is not feasible. In addition, commercially available planters use mechanical metering which has many limitations including, skidding of the wheel, non-uniform seed rate, wastage of the seed and higher maintenance cost. Therefore, a lightweight self-propelled planter is required for precise seed placement with less drudgery in terraced terrain with a vertical interval more than 1 m. Anthropometric dimensions of Sikkim workers were considered for designing important parts of the self-propelled planter. The developed self-propelled planter was evaluated as per an ergonomic consideration for performance parameters. The optimum values of different dependent variables were observed when planter was operated with subject's age of 25 years and at 2 cm depth of operation. The values of heart rate, oxygen consumption rate, energy expenditure rate, grip fatigue, overall discomfort rating, and body part discomfort rating were 108 bpm, 550 $ml.min^{-1}$, 17.50 $kJ.min^{-1}$, 5.32%, 2 and 30 respectively. When the planter was operated with optimum values of independent parameters, namely subjects age and depth of operation. HR, OCR, EER, GF, ODR and BPDR for broadcasting were 46.58, 22.70, 25.55, 35.52, 20.0 and 17.50% lesser than the values for labors while using the planter. The extra effort had helped the farmers to save the cost of the planting by 49.83%. In addition, precision seed placement could reduce seed rate and get higher yield.

1. Introduction

In the evolving socio-economic environment and technological advancement, it is necessary to apply advanced concepts of engineering to modernize agricultural operations for sustainability. Mechanization of agricultural operations has played a crucial role in effective and timely completion of field operations in plain regions, but it has largely gone unnoticed in hilly region. The majority of fields in the hills and mountains are in shape of small, and varying size terraces, and farmers mostly use manual and bullock power (Singh and Vatsa, 2007).Smaller size plots (terraces) also limit the accessibility of tractor operated implements developed for plain areas. The weight of the prime mover utilized in the hill region must be between 100 and 110 kg, which may be lifted by one or two persons from one terrace to another (Singh and Vatsa, 2007).Thus, a lightweight self-propelled farm equipment's and machines are necessary to complete crucial farm operations (tillage, sowing/planting, weeding and harvesting) with less drudgery in terraced terrain with a considerable vertical interval between terraces.

Human is the most vital component of human - animal - machine system in case of manually operated machines. While designing the agricultural implement, human energy requirement should be considered and care should be taken to eliminate or reduce the operators walking behind the implements. The issues related to the ergonomics such as anthropometric dimensions, strength parameters, and force required to operate the machine, level of comfort, should be understood and applied while designing the farm equipment. Traditional farming is dependent on human and

*Corresponding author: anamika.iit26@gmail.com

animals involving lot of drudgery. Therefore, capabilities and anthropometric dimensions of the operators must be taken while designing the farm equipment and work stations. This would reduce the human energy requirement to operate the tool/equipment without affecting its performance adversely.

Seed sowing is a crucial operation and it must be completed within desired time period. Crop output would be reduced when seeds are planted either too early or too late. The recommended seed rate must be applied in the field while keeping seed to seed and row to row spacings in mind, particularly in blackgram crops.Crops can grow consistently if seed dropping is done with uniform plant to plant spacing (Panning, 2000).

Planters are the advanced version of the seed drills in which single seed or group of seeds are placed at a predetermined depth and the space interval. Thus, in case of planters, row to row and seed to seed distances are maintained, allowing for adequate space for individual plant growth (Aware and Aware, 2014).

Most of the seed metering mechanism in planter/seed drill are of mechanical type which work by attaching a ground wheel, and use drive through gears or chains from the ground wheel. These planters are less efficient due to slippage between the wheel and ground, and chain instability result in poor planting quality (He *et al.* 2017).In mechanical seed metering mechanisms, the seed, coming in direct contact of mechanism, may be damaged and lose their viability and germination percentage. In addition, conventional drills, using mechanical mechanisms, are incapable of operating at high operating speeds (Kumar and Durairaj, 2000). Further, these devices are subjected to wear and tear due to continuous friction between moving parts and therefore need frequent maintenance.

An electronically controlled planter can eliminate many of the inefficiencies associate with planter with mechanical metering mechanism and can significantly increase yield. Seed metering mechanism powered by electric or hydraulic motors can effectively prevent the seed irregularities caused by wheel slippage on the ground and vibrations, thereby increasing the working speed and improving seeding accuracy (Li *et al.* 2015).

Use of electronic for metering mechanism is one of the options to achieve accurate seed spacing with higher efficiency. Important advantages of electronic-based seed metering mechanism includeno skid, uniform seed rate, optimum use of seeds, higher accuracy, low maintenance cost, minimized seed loss and machine design to be compact and viable (Baral *et al.* 2019 and Li *et al.* 2015).

In India, 85% of farmers depend on agriculture for their living and have less than 2 hectares (ha) of farmed land. Consequently, it is crucial to focus on these small farmers and the farm equipment suitable for small plots. Blackgram is mainly cultivated in India, Pakistan, Sri-Lanka, Burma and some countries of South East Asia. The total production of pulses in the India during 2020-21 was 23.01 million metric tons (DAFW, 2023). Production of pulses in NEH Region during 2020-21 was 244002.63 tons. In Sikkim, share of blackgram in total pulse production was 52.95 % in 2018-19 (Sikkim, 2023).

Blackgram [*Vigna mungo (L.) Hepper*)] is a major pulse crop with a distinct role in Indian agriculture. This pulse is main ingredient of Indian diet, as it contains vegetable protein and supplement to cereal-based diet. It provides a major portion of the protein needs of the vegetarian population of the country. In addition, it is an essential source of animal feed.

In Sikkim, it is also known as *Kalodal'* or '*Panhelo dal',* and is widely cultivated in all the dry belts of South and West districts of Sikkim. In Sikkim, cropping area under *Urd* cultivation, production, and productivity were 3550 hectare, 2780 tones and is 783.10 kg ha^{-1} respectively during 2018-19 (Sikkim, 2023). This crop is grown in cropping systems as a mixed crop, cash crop, sequential crop, and in cropping systems as a sequential crop after the harvest of rice. Common local varieties include Pant-U-19, Pant-U-31, T-9, Azad-urd-1, PDU-1, KU-300, Kalindi, SKM-PD-3 (Islam *et al.* 2013).

In the North Eastern region of India, blackgram is grown under rainfed condition during all three crop seasons, namely *Kharif* (August-September), *Rabi* (September-November), and *Zaid* (February-March). During Kharif season, its sowing should not be delayed beyond 25th March during spring and sowing may be completed by 15th July.Sowing in 15th August to 15th September has been found ideal in this region. The crop should be sown at 25-30 cm row to row and 5-10 cm plant to plant spacing to maintain optimum plant population. The recommended values of depth of seeding and seed rate should be 3-4 cm and 20-25 kg ha^{-1} respectively (Babu *et al.* 2015). Therefore, a planter, using ergonomic dimensions and strength parameters of Sikkim farm workers, was evaluated. It consisted of electronic seed metering system for precise seed placement.

2. Methodology

The ergonomic evaluation of self-propelled planter with electronic seed metering system in comparison with broadcasting method of sowing (blackgram crop) was conducted to work out heart rate, oxygen consumption, energy expenditure rate, grip fatigue overall discomfort rating and body part discomfort rating during the operation. The ergonomic study included four male subjects who were chosen at random. The subjects were carefully selected to ensure that they were medically fit to participate in the trials and were representative of the farm workers of Sikkim.

Subjects were chosen from the age range of 25 to 35 years old because this is when maximum strength is reached (Gite and Singh, 1997).On the basis of laboratory experiment the independent parameters, groove size 5.45 mm, hopper fill level ¼ and forward speed 1 km h^{-1} offered the optimum performance indices for blackgram seeds. The values of missing index and multiple index for the operating parameters were 5 and 3.34% respectively.

Design of experiment

To achieve the desired goal of optimizing the operating parameters and experimental design, the following experimental design was used Table 1 contains information on the independent and dependent variables.

Estimation of dependent variables

During planting/broadcasting, *Heart rate* was measured by computerized polar heart rate monitor. It consists of polar coded transmitter, elastic strap, wristwatch type receiver and interface. The sensor of heart rate monitor was fixed on the chest of the operator and its display was fixed on wrist of the operator, i.e., within the signal range of the device after 10 min. duration of continuous work and data were downloaded for the analysis (Fig. 2). *Oxygen consumption rate (OCR)* is a measurement to assess whole body fatigue. However, in present study, it was computed from the heart rate values of the operator by using the equation (1) given by Singh *et al.,* (2008).*Energy expenditure rate (EER),*is the amount of energy that a person needs to do a physical function (breathing, circulating blood, digesting food) or physical movement. Here equation developed by Yadav *et al.* 2007 was used to estimate energy expenditure rate in kJ min $^{-1}$. Grip dynamometer was used to measure grip fatigue [the strength of muscles of the operator (before and after the sowing operation] for right and left hands (Fig. 3). Grip fatigue was calculated by the using equation (3) (Chauhan, 2006).

Table 1. Experimental plan of ergonomic evaluation of self-propelled planter in field condition

S.No	Independent variables	Symbol	Levels	Dependent variables
1	Age	A	(A_1-25, A_2-27, A_3-34 and A_4-35	• Heart rate (HR), beats min^{-1} • Oxygen consumption rate (OCR), ml min^{-1} • Energy expenditure rate (EER), kj min^{-1} • Grip fatigue (GF), % • Overall discomfort rating (ODR) • Body part discomfort rating (BPDR)

Figure 1. Field evaluation of the planter

Figure 2. Measuring heart rate

Figure 3. Measuring grip fatigue

$$OCR = 0.0114\ HR - 0.68 \qquad \ldots (1)$$

Where,

OCR = oxygen consumption rate, ml min^{-1},

HR = Heart rate, beats min^{-1}

$$EER = \frac{HR-66}{2.4} \qquad \ldots (2)$$

Where,

EER = Energy expenditure rate, kj min^{-1}

$$G_f = \frac{S_r - S_w}{S_r} \times 100 \qquad \ldots (3)$$

Where,

G_f = grip fatigue, (%),

Sr = strength of muscles at rest, kg,

S_w = strength of muscles at work, kg.

Overall discomfort rating (ODR), was used to quantify body pain or fatigue arising as a result of working posture and excessive stress on muscles due to various physical activities performed by the subjects. For the assessment of ODR, a category ratio scale (CR-10) given by Borg (1982) was used (Fig. 4). *Body part discomfort rating (BPDR),* is a measure of localized discomfort which may restrict the duration of work depending upon the static load involved. The technique suggested by Corlett and Bishop (1976) was used to determine BPDR (Fig.5). The body was divided into 27 regions and intensity of pain / fatigue experienced by the subject was noted down as per category ratio CR-10 scale (Fig. 4).

Table 2. Grade of physical work based on HR, OCR

Sl. No.	HR, beats min^{-1}	OCR, l min^{-1}	Grade of work
1	<75	<0.5	Very light
2	75-100	0.5-1.0	Light
3	100-125	1.0-1.5	Moderately heavy
4	125-150	1.5-2.0	Heavy
5	150-175	2.0-2.5	Very heavy
6	>175	>2.5	Unduly heavy

Source: Yadav *et al.*, 2007.

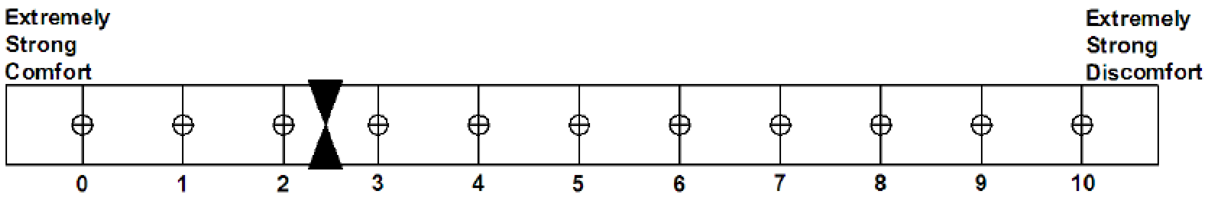
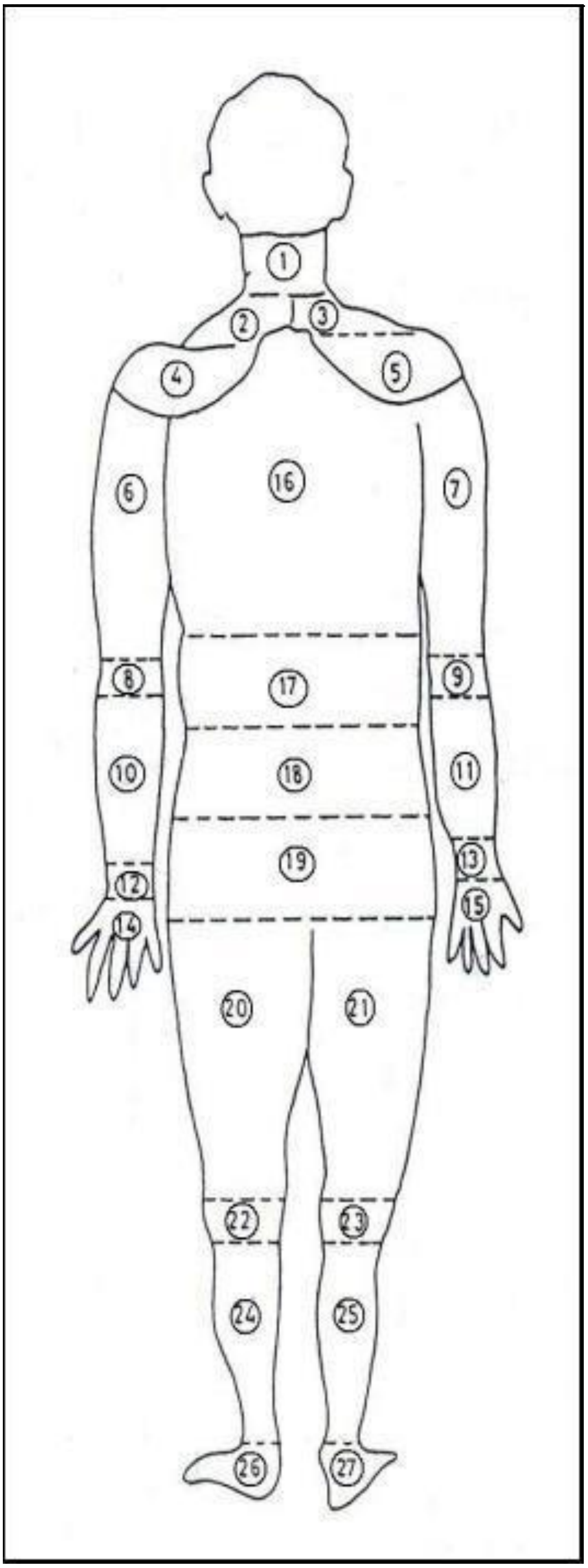


Figure 4. Overall discomfort rating scale



1 Neck
2 Clevicle Left
3 Clevicle Right
4 Left Shoulder
5 Right Shoulder
6 Left Arm
7 Right Arm
8 Left Elbow
9 Right Elbow
10 Left Forearm
11 Right Forearm
12 Left Wrist
13 Right Wrist
14 Left Palm
15 Right Palm
16 Upper Back
17 Mid Back
18 Lower Back
19 Buttocks
20 Left Thigh
21 Right Thigh
22 Left Knee
23 Right Knee
24 Left Leg
25 Right Leg
26 Left Foot
27 Right Foot

Fig.5. Regions for evaluating body Part Discomfort Score (Inthiyaz *et al.* 2021)

Optimization of independent parameter for developed planter

Taguchi method is used widely in designing the experiment and the optimization in engineering analysis. It is a dominant design that reduces the number of tests and minimizes the effects of factors that cannot be controlled (Palanikumar, 2011 and Asilturk and Akkus, 2011). It uses a loss function to calculate the deviation between the desired values and the experimental values. This loss function is converted into a signal-noise (S/N) ratio [(Asilturk and Akkus, 2011 and Koksoy and Muluk, 2004)].

The experimental observations were then transformed into signal to noise ratio. The smaller-the-better was used to obtain minimum heart rate, oxygen consumption, energy expenditure rate, grip fatigue, overall discomfort rating and body part discomfort rating for better operator comfort according to Mezarcioz and Ogulata (2011).

$$\frac{S}{N} = -10 \log \left\{ \frac{1}{n} \sum Y^2 \right\} \qquad \ldots (4)$$

Where,

S = Signal (dB)

N = Noise (dB)

n = number of experiment replications in a trial and

Y = measured output values

In this study, the Taguchi method was used to assess ergonomics performance of the planter and Taguchi L_{16} arrangement was used for experimenting. To determine the optimal conditions and the best operating parameters, the S/N ratio was calculated. The lower is better was used to determine the S/N ratio for heart rate, oxygen consumption, energy expenditure rate, grip fatigue, overall discomfort rate and body part discomfort rate. The experiment results and S/N ratios are shown in Table 3.

3. Results and Discussion

General information of subjects

General information such as age, height, and weight of subjects were measured, and based on information collected from subjects, the age of agricultural labourers ranged between 25-35 years, with an average height and weight of 163.2 cm and 66.5 kg, respectively.

Table 3. Signal-noise (S/N) ratios of various different parameters.

Sl No.	A	B	HR	S/N HR	OCR	S/N OCR	EER	S/N EER	GF	S/N GF	ODR	S/N ODR	BPDR	S/N BPDR
1	25	2	108	-40.66	550	-54.80	17.50	-24.86	5.32	-14.51	2	-6.02	30	-29.54
2	25	3	114	-41.13	610	-55.70	20.00	-26.02	5.32	-14.51	2	-6.02	36	-31.12
3	25	4	119	-41.51	670	-56.52	22.08	-26.88	5.37	-14.59	4	-12.04	41	-32.25
4	25	5	123	-41.79	720	-57.14	23.75	-27.51	5.35	-14.56	4	-12.04	45	-33.06
5	27	2	111	-40.90	580	-55.26	18.75	-25.46	8.21	-18.28	3	-9.54	33	-30.37
6	27	3	117	-41.36	650	-56.25	21.25	-26.54	8.21	-18.28	3	-9.54	38	-31.59
7	27	4	121	-41.65	690	-56.77	22.91	-27.20	8.34	-18.42	4	-12.04	40	-32.46
8	27	5	127	-42.07	760	-57.61	25.41	-28.10	8.33	-18.41	5	-13.97	45	-33.06
9	34	2	110	-40.82	570	-55.11	18.34	-25.26	9.11	-19.19	3	-9.54	32	-30.10
10	34	3	115	-41.21	630	-55.98	20.41	-26.19	9.63	-19.67	4	-12.04	39	-31.82
11	34	4	128	-42.14	770	-57.72	25.84	-28.24	9.70	-19.73	4	-12.04	42	-32.46
12	34	5	131	-42.34	810	-58.16	27.08	-28.65	9.71	-19.74	5	-13.97	47	-33.44
13	35	2	113	-41.06	600	-55.56	19.58	-25.83	10.41	-20.34	3	-9.54	34	-30.62
14	35	3	117	-41.36	650	-56.25	21.25	-26.54	10.65	-20.54	4	-12.04	37	-31.36
15	35	4	131	-42.34	810	-58.16	27.08	-28.65	10.67	-20.56	4	-12.04	43	-32.66
16	35	5	133	-42.47	830	-58.38	27.91	-28.91	10.85	-20.70	5	-13.97	50	-33.97

Analysis of Variance

Analysis of variance (ANOVA) was used to determine the individual interaction of all of the control factor in the test. In this study, ANOVA was used to analyze the effect of independent variables on dependent variables 5% significant level and a 95% confidence level and the results are summarized in Table 4 to Table 9. The last column of the table shows the percentage value of each parameter contribution, which indicates the degree of influence on ergonomics performance.

According to Table 4, the percent contribution of the A and B factors on the heart rate were found to be 11.79 and 83.27%, respectively. The effects of subject and depth of operation on heart rate, 25 year and 2 cm were significant at 5% significant level. Thus, the most important factor affecting the heart rate was depth of operation

Referring to Table 5, the percent contribution of the A and B factors on the oxygen consumption rate were found to be 11.51 and 84.04%, respectively. The effects of subject.and depth of operation on oxygen consumption rate, 25 year and 2 cm were significant at 5% significant level. Thus, the most important factor affecting the oxygen consumption rate was depth of operation.

Regarding to Table 6, the percent contribution of the A and B factors on the energy expenditure rate were found to be 11.34 and 84.35%, respectively. The effects of subject and depth of operation on energy expenditure rate, 25 year and 2 cm were significant at 5% significant level. Thus, the most important factor affecting the energy expenditure rate was depth of operation.

Regarding to Table 7, the percent contribution of the A and B factors on the grip fatigue were found to be 99.64 and 0.22%, respectively. The effects of subject and depth of operation on grip fatigue, 25 year and 2 cm were significant at 5% significant level. Thus, the most important factor affecting the grip fatigue was depth of operation.

Table 4. ANOVA for heart rate

Source	DF	Seq SS	Adj SS	Adj MS	F	P	PC %
Age of the subjects, year (A)	3	0.60	0.6051	0.20	7.15	0.009*	11.79
Depth of operation, cm (B)	**3**	**4.27**	**4.2727**	**1.42**	**50.51**	**0.000***	**83.27**
Residual Error	9	0.25	0.2538	0.02			4.94
Total	15	5.13					100

Significant at 5% level of significance

PC (%): Percentage contribution

P<0.05 Determine significance of factor at 95% of confidence level.

Table 5. ANOVA for oxygen consumption rate

Source	DF	Seq SS	Adj SS	Adj MS	F	P	PC %
Age of the subjects, year (A)	3	2.35	2.35	0.78	7.76	0.007*	11.51
Depth of operation, cm (B)	**3**	**17.15**	**17.15**	**5.71**	**56.66**	**0.000***	**84.04**
Residual Error	9	0.90	0.90	0.10			4.45
Total	15	20.41					100

Significant at 5% level of significance

Table 6. ANOVA for energy expenditure rate

Source	DF	Seq SS	Adj SS	Adj MS	F	P	PC%
Age of the subjects, year (A)	3	2.88	2.88	0.96	7.88	0.007*	11.34
Depth of operation, cm (B)	**3**	**21.46**	**21.46**	**7.15**	**58.65**	**0.000***	**84.35**
Residual Error	9	1.09	1.09	0.12			4.31
Total	15	25.45					100

Significant at 5% level of significance

Table 7. ANOVA for grip fatigue

Source	DF	Seq SS	Adj SS	Adj MS	F	P	PC %
Age of the subjects, year (A)	**3**	**82.92**	**82.92**	**27.64**	**2079.99**	**0.000***	**99.64**
Depth of operation, cm (B)	3	0.17	0.17	0.05	4.50	0.034*	0.22
Residual Error	9	0.11	0.11	0.01			0.14
Total	15	83.22					100

Significant at 5% level of significance

Table 8. ANOVA for overall discomfort rating

Source	DF	Seq SS	Adj SS	Adj MS	F	P	PC %
Age of the subjects (A)	3	22.30	22.30	7.43	4.72	0.030*	24.15
Depth of operation (B)	**3**	**55.83**	**55.83**	**18.60**	**11.82**	**0.002***	**60.50**
Residual Error	9	14.17	14.17	1.57			15.35
Total	15	92.29					100

Significant at 5% level of significance

Table 9. ANOVA for body part discomfort rating

Source	DF	Seq SS	Adj SS	Adj MS	F	P	PC %
Age of the subjects (A)	3	0.92	0.92	0.30	4.33	0.038*	3.78
Depth of operation (B)	**3**	**22.91**	**22.91**	**7.63**	**107.27**	**0.000***	**93.60**
Residual Error	9	0.64	0.64	0.07			2.62
Total	15	24.48					100

Significant at 5% level of significance

Regarding to Table 8, the percent contribution of the A and B factors on the overall discomfort rating were found to be 24.15 and 60.50%, respectively. The effects of subject and depth of operation on overall discomfort rating, 25 year and 2 cm were significant at 5% significant level. Thus, the most important factor affecting the overall discomfort rating was depth of operation.

Regarding to Table 9, the percent contribution of the A and B factors on the body part discomfort rating were found to be 3.78 and 93.60%, respectively. The effects of subject and depth of operation on body part discomfort rating, 25 year and 2 cm were significant at 5% significant level. Thus, the most important factor affecting the body part discomfort rating was depth of operation.

Dependent parameters viz. HR, OCR, EER, GF, ODR and BPDR were measured/estimated using methodologies discussed in material and method section. The optimization of independent variables was performed using Taguchi Method (Krishnaiah and Shahabudeen, 2012) Minitab 18 software was employed for optimization. The lowest value of HR, OCR, EER, GF, ODR and BPDR is important for better operator comfort. Therefore, the "smaller-is-better" option was used for the calculation of the S/N ratio. Relationships between different dependent variable and respective S/N ratio are shown in Figure 6 to 11.

The optimum level for each control factor was identified having the highest S/N ratio in the levels of that control factor. The levels of the factors A and B giving the best HR, OCR, EER, GF, ODR and BPDR was specified as A_1B_1. Therefore, optimum HR, OCR, EER, GF, ODR and BPDR were obtained using the subject25 having years of age (A_1), and 2 cm as depth of operation (B_1).

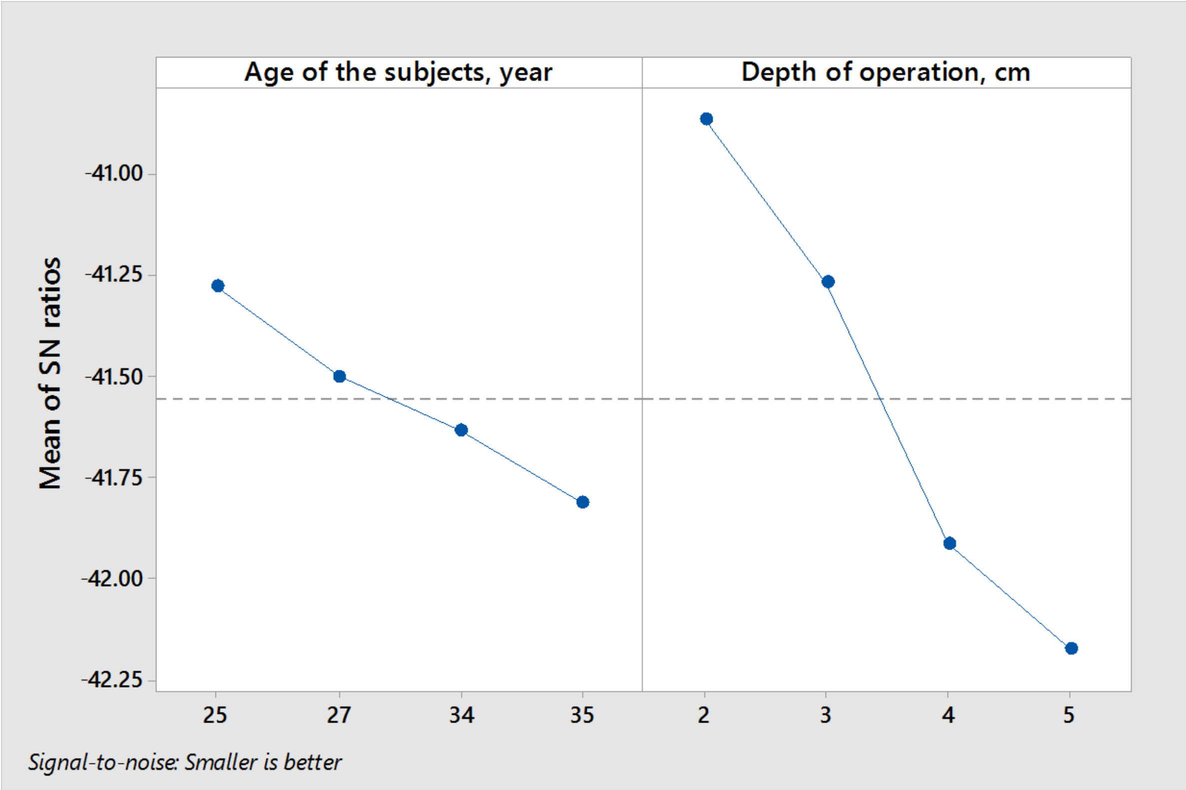


Figure 6. Effect of subjects age and depth of operation on S/N ratios for heart rate

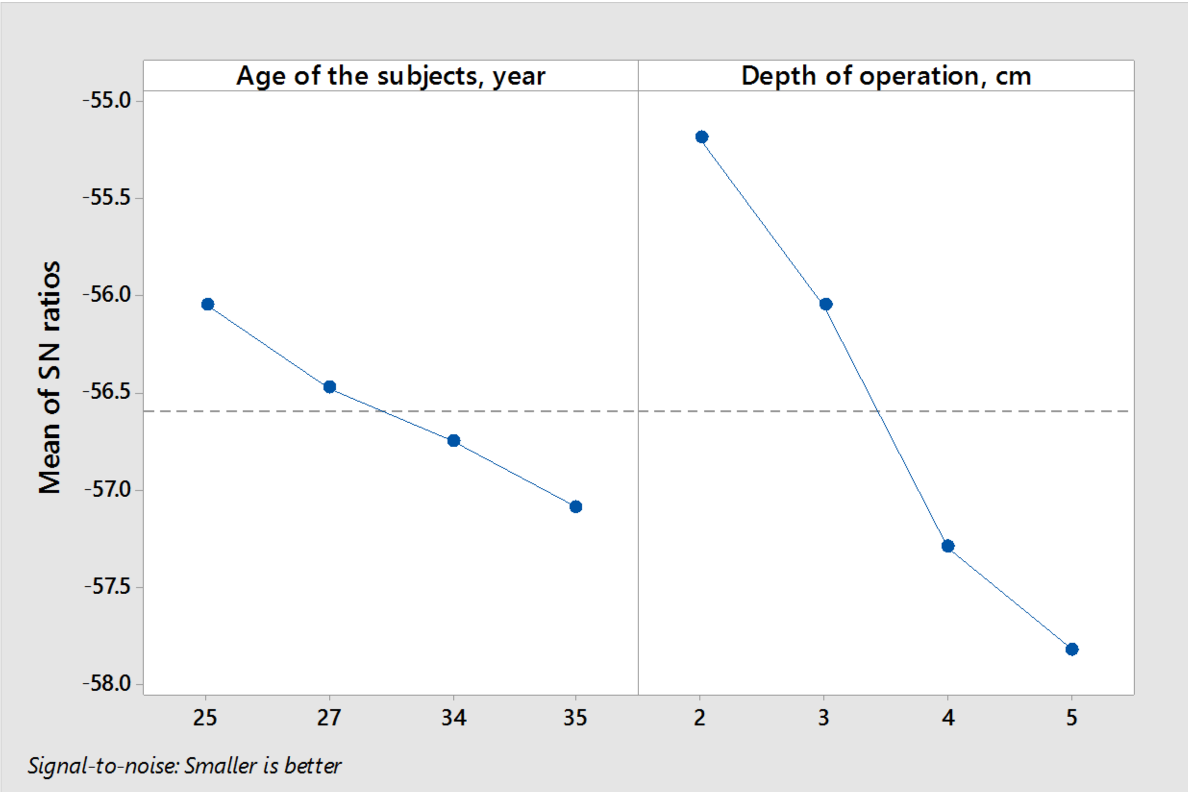


Figure 7. Effect of subjects age and depth of operation on S/N ratios for oxygen consumption rate

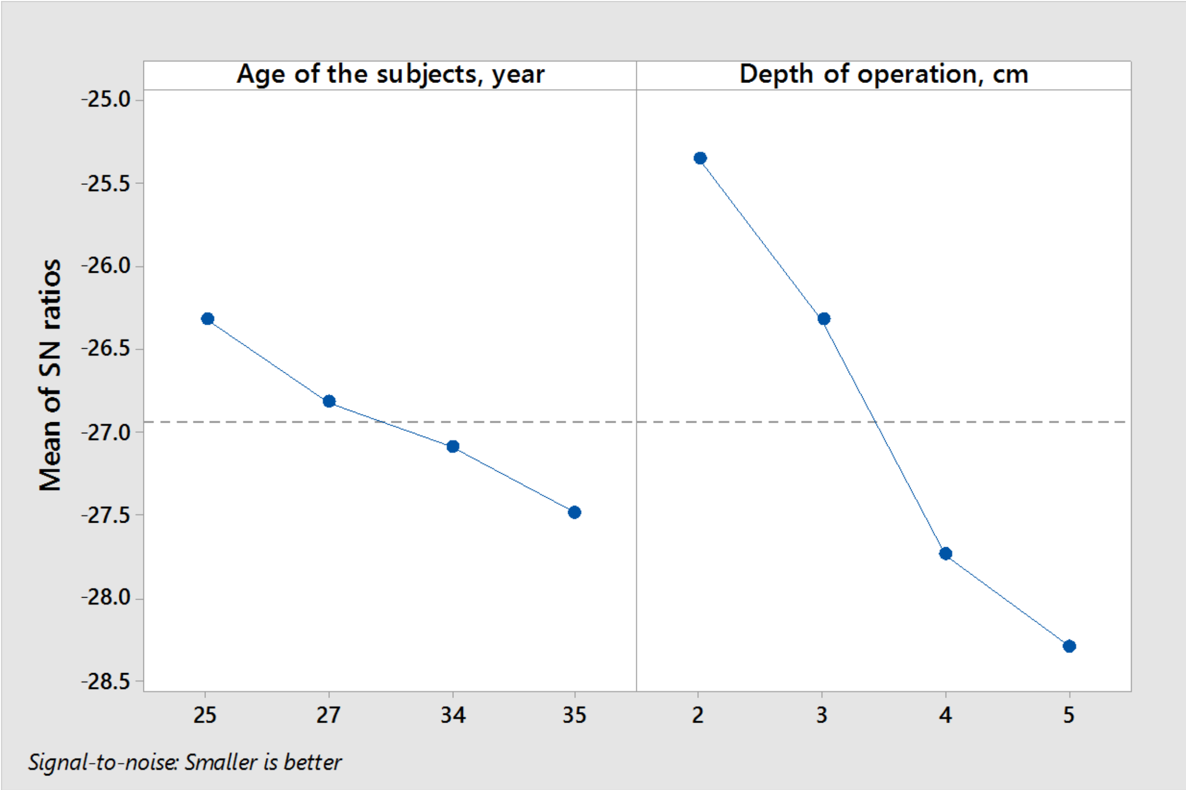


Figure 8. Effect of subjects age and depth of operation on S/N ratios for energy expenditure rate

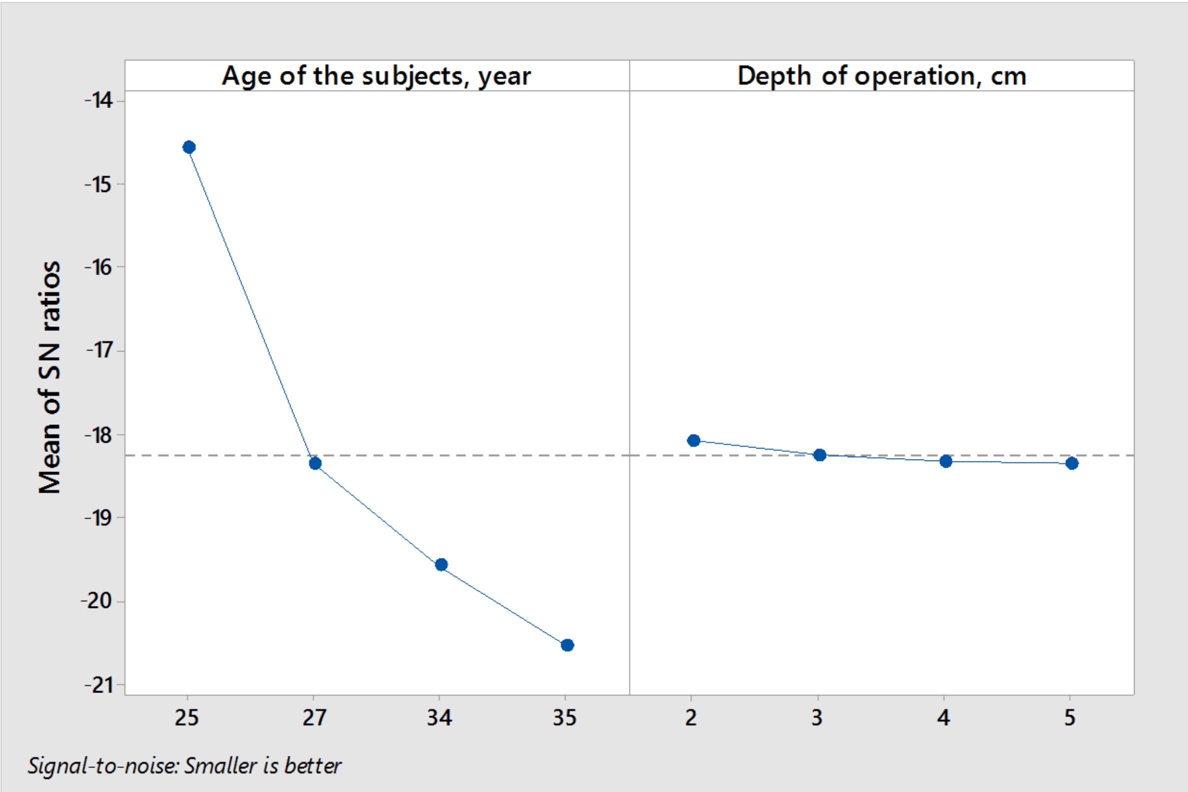


Figure 9 . Effect of subjects age and depth of operation on S/N ratios for grip fatigue

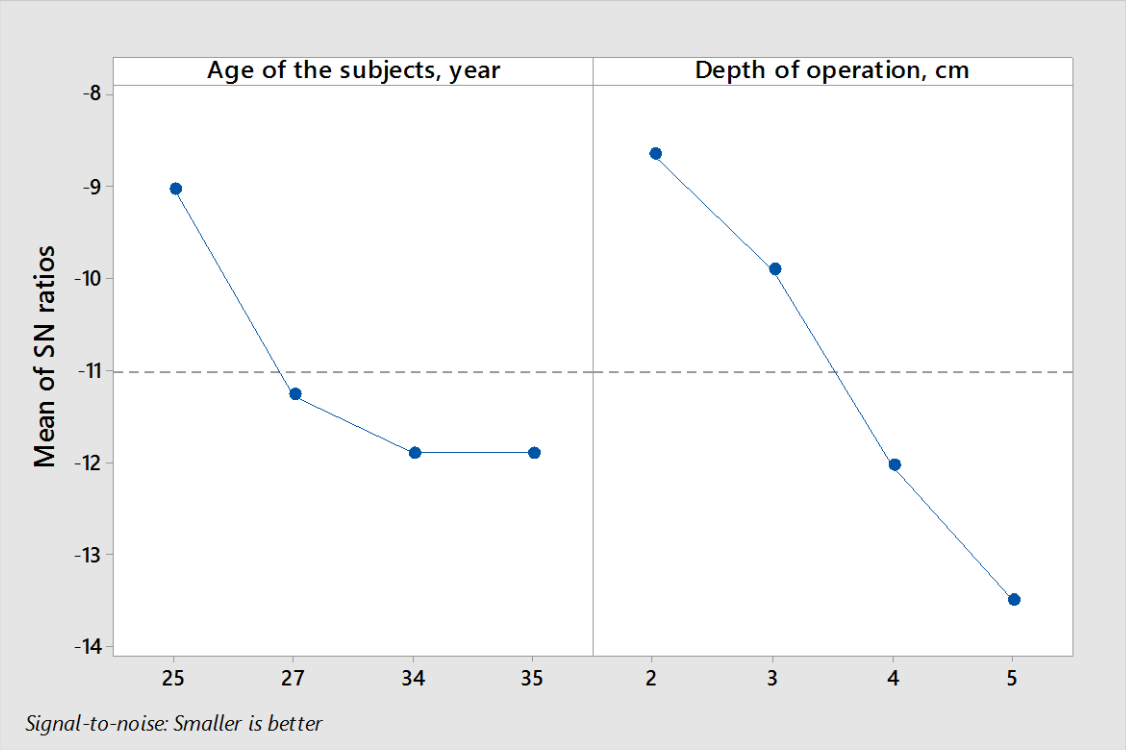


Figure 10 . Effect of subjects age and depth of operation on S/N ratios for overall discomfort rating

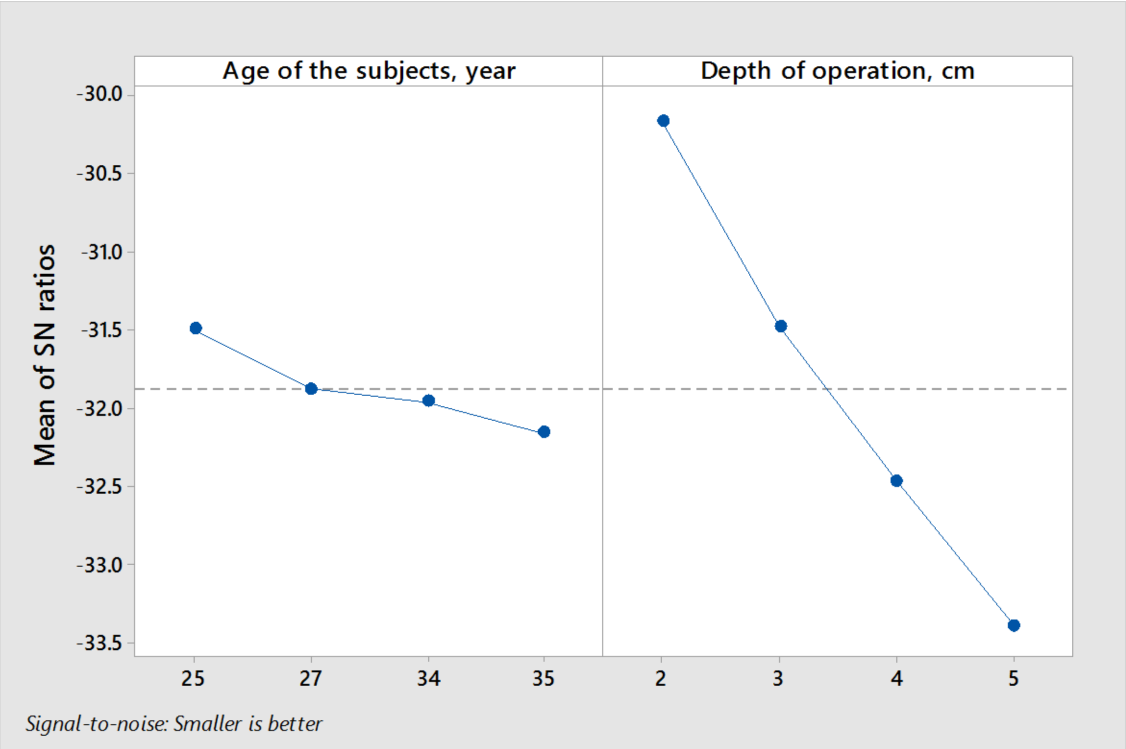


Figure 11. Effect of subjects age and depth of operation on S/N ratios for body part discomfort rating

Comparison of planting of blackgram using developed planter with traditional broadcasting

In order to compare the physiological costs of the operator while using the developed planter and while sowing of the crop by following traditional broadcasting method, various parameters related physiological cost and field capacity were compared and relevant data is summarized in Table 10.

Table 10 Comparison of physiological cost and performance data of blackgram planting using developed planter and by traditional broadcasting method

S No.	Particulars	Planting using developed planter (A)	Traditional broadcasting (B)	% Difference $\frac{A-B}{A} \times 100$
1	Resting, HR	86.47	85.75	0.84
2	Working, HR	108	97.25	9.95
3	ΔHR	21.53	11.5	46.58
4	Resting, OCR	305.75	297.55	2.68
5	Working, OCR	550	425.1	22.70
6	Resting, EER	8.52	8.22	3.52
7	Working, EER	17.50	13.03	25.55
8	ODR	2	2.5	20
9	BPDR	30	24.75	17.50
10	GF	5.32	3.43	35.52

It is evident from Table 10 that values of ΔHR, OCR and EER for broadcasting were 46.58%, 22.70 and 25.55% lower than the values for the labors while working with the developed planter. Further, the values of GF, ODR and BPDR for broadcasting were 35.52, 20.0 and 17.50% lower than those for the labors while operating the developed planter. This is mainly to the fact that for operation of the planter labors had to perform extra physical tasks compared to that during broadcasting. The extra effort had helped the farmers to save the cost of the planting by 49.83%. In addition, precision seed placement could be helped to reduce seed rate and to get higher yield.

4. Conclusions

Based on the study undertaken, following conclusions can be drawn.

- Actual field capacity of the planter was 0.024 ha h^{-1}.
- The S/N ratio based optimized value of working HR beats min^{-1} was 108 beats min^{-1} among all the treatments. Thus, the work done was categorized as light and moderate work. The S/N ratio based optimized values of OCR, EER, and GF were 550ml min^{-1}, 17.50 $kJmin^{-1}$ and 5.32 % respectively.
- According to the Borge (CR-10) scale, the ODR values fell into the area of mild to moderate discomfort. Because the operator must hold the handle and walk behind at the same time, the forearm, wrist, palm, thighs, legs, and foot felt discomfort.
- Physiological and physical responses (HR, OCR, EER, GF, ODR and BPDR) values were higher while sowing using developed self-propelled planter as compared to that by traditional broadcasting method. The extra effort had helped the farmers to save the cost of the planting by 49.83%. In addition, precision seed placement could be helped to reduce seed rate and to get higher yield.
- The results of ANOVA showed that subjects and depth of operation are the significant parameters.

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