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DEVELOPMENT AND EVALUATION OF TWO-ROW HAND HELD MANUAL PLANTER FOR BLACK PEPPER SEEDS

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Abstract. The study focused on the development of a portable low-cost planter for black pepper (*Piper nigrum L.*). The physical attributes of Tellicherry black and Malabar black variety of black pepper seed in terms of tri-axial dimensions, angle of repose, roundness and test weight were used to select the design values of individual components of planter. The mean tri-axial dimensions and angle of repose of Tellicherry black pepper and Malabar black ranged as 4.33 – 4.35 mm, 27° and 4.42 – 4.45 mm, 25°, respectively. The roundness was recorded as 1.06 mm – 1.07 mm and 1.04 – 1.14 mm under similar conditions. The test weight of 1000 seeds, used to design the hopper was recorded as 38.6 g and 42.1 grams, respectively.

The black pepper planter (H x h x W x w = 1000 x 920 x 300 x 150 mm) comprised of seed hopper, fulcrum-based seed metering device, handle, adjustable row to row distance and seed tubes. The developed planter was evaluated in terms of seed spacing (15, 20 and 25 cm) and two black pepper varieties (Tellicherry black and Malabar black). The performance parameters of missing percentage, multiple percentage and field capacity (ha h^{-1}) and economic parameters of operating cost, breakeven point, benefit-cost ratio and payback period were recorded.

The optimization of the results through Design-Expert 13.0 revealed 31% missing percentage and 24.6% multiple percentage at 15 cm seed spacing with field capacity of 0.03 ha per hour. The operational cost (Rs h^{-1}), benefit cost ratio, breakeven point (ha) and payback period (hours) was calculated as 84.97, 1.30, 16.36 and 58.85, respectively. The cost of operation of the hand held two row planter was found be Rs. 2832 per hectare.

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Abbreviations:
H = Maximum height, mm
h = Minimum height, mm
W = Maximum width, mm
w = Minimum width, mm

***Keywords**: Planter, pepper, design, portable, performance, spacing, variety, efficiency, breakeven point, payback.*

INTRODUCTION

Piper nigrum (*Black pepper L.*) from family *Piperaceae* is cultivated in the tropical regions of Brazil, Vietnam, Indonesia and India, contributing about 72% of the global production [1]. It possesses rich nutrient composition in terms of 37.4 % carbohydrate, 25.5%, 23.6% fibers and 5.3% fat content [2]. It also contains potassium, calcium, phosphorus and magnesium to the tune of 0.66%, 0.20%, 0.16% and 0.16 percent [3].

The origin of the crop can be traced from the Western Ghats region of India, particularly in the states of Kerala, Tamil Nadu, Karnataka, Konkan, Pondicherry, Andaman and Nicobar Islands. India has the privilege to occupy the top slot in terms of production, consumption and export of black pepper with an annual production of 61000 tons from 1,37,378 hectares from the total global production of 546 million tones [4]. Black pepper has helped India to stay afloat in international trade in terms of export earnings from foreign exchange, thereby, earning the title of 'black gold'. Geographically, it is known as Kali Mirch in Urdu and Hindi; Pippali in Sanskrit; Milagu in Tamil and Peppercorn, White pepper, Green pepper, Black pepper, Madagascar pepper in English. It is widely believed that *Karimunda* is most popular in the series comprising of *Kottanadan*, *Narayakodi*, *Aimperian*, *Neelamundi*, *Kuthiravally*, *Balankotta* and *Kalluvally* from a total of 75 cultivars grown in Indian subcontinent.

Black pepper is perceived as 'king of spices' with broad spectrum of applications in pharmaceuticals, preservative, food industry, perfume enterprises and households [5]. Black pepper contains major pungent alkaloid Piperine (1-peperoyl piperidine) essential in pharmacology and traditional Ayurvedic and Unani System of medicines. Piperine possesses multiple properties like antihypertensive and antiplatelets, antioxidant [6], neurodegeneration [2], anti-bacterial [7], antidiarrheal [8], analgesic [9], anti-depressant [10], insecticidal and larvicidal characteristics [11], anti-fungal [12], anti-protozoal [13] properties.

Piperine enhances the therapeutic efficacy of drugs, vaccines and nutrients by increasing oral bioavailability and inhibiting metabolizing enzymes [14]. It also enhances the cognitive action and fertility among mammals.

The piperine has a stimulating effect on pancreatic and intestinal enzymes responsible for digestion process. Besides that, black pepper is used in flour enhancer [15], herbal medicines, preservative and biocontrol agent [7].

The propagation of black pepper is carried out through pepper cuttings and seeds. The pepper cutting is ready for transplantation in the main field in about 3-4 months. This time creates obstruction in terms of time and land.

On the other hand, the plantation of black pepper seeds is still carried through broadcasting method, which is manifested with high time consumption, uneven seed spacing, exorbitant seed rate and drudgery [16]. The efficiency of the broadcasting method rests exclusively on the skill of the operator. The non-availability of appropriate planter for black pepper has rendered the system unsustainable. This has prompted the farmers to rely extensively on broadcasting method for planting purpose. Moreover, the cultivation of black pepper in polyhouses demand small portable planter.

The designers and researchers have already utilized engineering parameters to design and develop agricultural machinery related to sowing vegetables [17], pea [18], seed metering [19]; extraction chilly [20], maize [21], mixing [22], peeling [23], grading [24], cracking [25] and harvesting [26]. The involvement of the engineering parameters in design has the propensity to develop an efficient machine with drilling mechanism, resulting in uniform seed spacing, proper root growth, better crop management, thereby, reduction in cost of production and increase in crop yield. The uniformity of seed establishment and plant distribution are dependent on the type of planting tools and techniques employed, that have the direct bearing with the crop yield. The importance of hand-held planters has started gaining traction due to the consciousness of conservation agriculture dubbed minimum tillage. This study focused on the design and development of low-cost portable planter for black pepper on the basis of engineering properties of black pepper seeds. It also encompasses the evaluation at field level to ascertain the variation in seed deposition efficiency.

MATERIALS AND METHODS

The development of the individual components of the hand held two row planters demanded the measurement of the physical and engineering properties of the black pepper seeds to arrive at logical conclusion for selecting the design parameters.

Procurement of materials

The black pepper seed varieties (*Tellicherry Black, Malabar Black*) were purchased from the local market and moisture content was determined by gravimetric method. The moisture content was found to be 12 % for both the varieties. The physical and engineering parameters of the two varieties of black pepper (Tellicherry Black, and Malabar Black) essential to select the design values includes:

I. **Size**: The size was represented by tri-axial dimensions, measured using digital Vernier Caliper possessing 0.01 mm accuracy, Fig. 1. It was desired to decide the diameter of the hole in the metering mechanism to accommodate the seeds of different varieties of black pepper.
II. **Angle of repose (**θ): The smooth flow of the seeds from the seed hopper towards the metering mechanism was decided on the basis of angle of repose. The angle of repose was measured by placing the seeds (heap) on the tilting box and raising the platform till the seeds start rolling down.

$$\theta = \tan^{-1}\left[\frac{2\,h}{D}\right]$$

Where,
h = Height of the heap, mm
D = Diameter of plate, mm

III. **Roundness**: The smoothness of the metering hole defines the efficiency of the metering mechanism. The roundness of the seeds was determined by the ratio of the polar diameter to equatorial diameter. The design value for the roughness of the metering hole was decided based on roundness value.

$$\text{Roundness} = \frac{Dp}{De}$$

Where,
D_p = Polar diameter, mm
D_e = Equatorial diameter, mm

IV. **Test weight**: The volume of the seed hopper was determined by measuring the test weight of 1000 seeds on electronic weighting balance with a least count of 0.01 g, Fig. 2. The procedure involves the random selection of 1000 black pepper seeds from Tellicherry Black and Malabar Black variety and placing them on weighing balance at a time. It was imperative to decide the volume of seeds that should be placed in the seed hopper at one time. It helped to decide the live load on the planter during operation.

Conceptualization and development of planter

The planter for black pepper was conceptualized and sketch using Creo 2.0 design software, Fig 3(a). The design values were selected from the measured values. The whole intention was to keep the design simple and provide adjustments to reduce the overall cost of fabrication and allow the farmer to adjust the planter for different varieties with different sowing practices, Fig 3(b). The metering mechanism of the planter was designed separately to allow uniform metering of individual black pepper seeds. The planter comprised of main frame, seed hopper, handle, seed tube, clutch, adjustable handle and width accessories, Fig. 3(c).

The seed metering mechanism consists of a clutch, clutch wire, fulcrum lever, spring and an inward depressed washer. A seed hopper was mounted on top of each vertical pipe along with fulcrum to open or close the metering hole. The opening size of the vertical tube was reduced to accommodate the black pepper seed with the help of washer. The washer allowed only a specific size of the seed to pass through the hole. The movement of the fulcrum up and down was controlled by a wire connected with clutch.

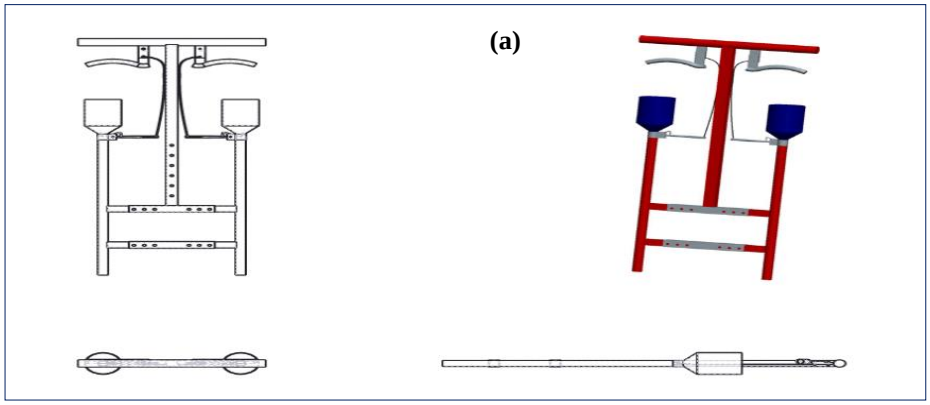
The compression of the clutch generates a pull to lift the fulcrum from the metering hole, allowing the seed to pass from the seed hopper to the metering hole. The loosing of the clutch pulls the fulcrum to the original position with the help of springs and blocks the metering hole. This prevents the movement of the seed from the seed hopper to the seed tube.

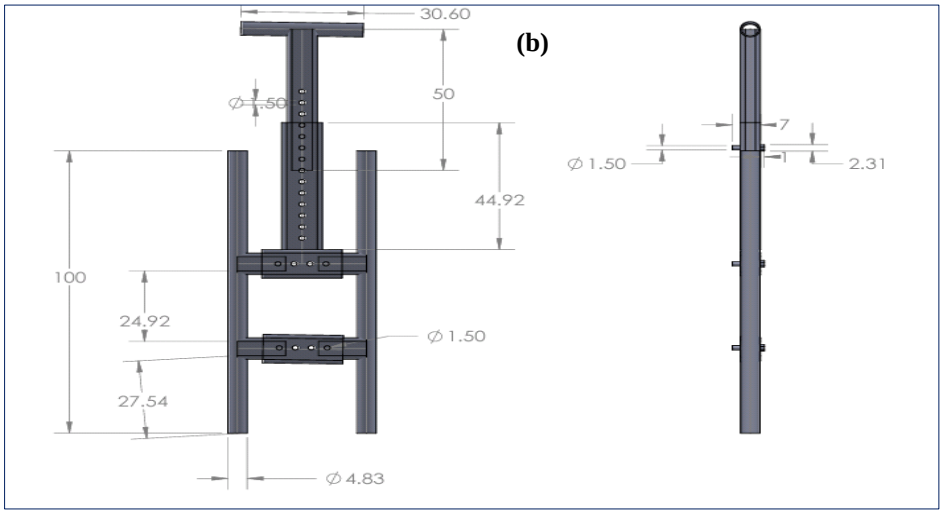
Evaluation of the developed prototype

The evaluation of the developed prototype of hand-held tow row planter was carried out to check the efficacy of the seed metering mechanism, uniformity of seed distribution, seed damage and multiplicity/missing of the seeds in the row. The procedure involved estimation of its performance under two levels of black pepper varieties (Tellicherry black, Malabar black) and seed spacing (15, 20 and 25 cm). The response parameters were measured in terms of missing percentage, multiple seed index and field capacity, Table 1.

Fig.1. Measurement of size of black pepper seeds by digital Vernier Caliper

Fig.2. Determination of test weight by electronic weighing balance





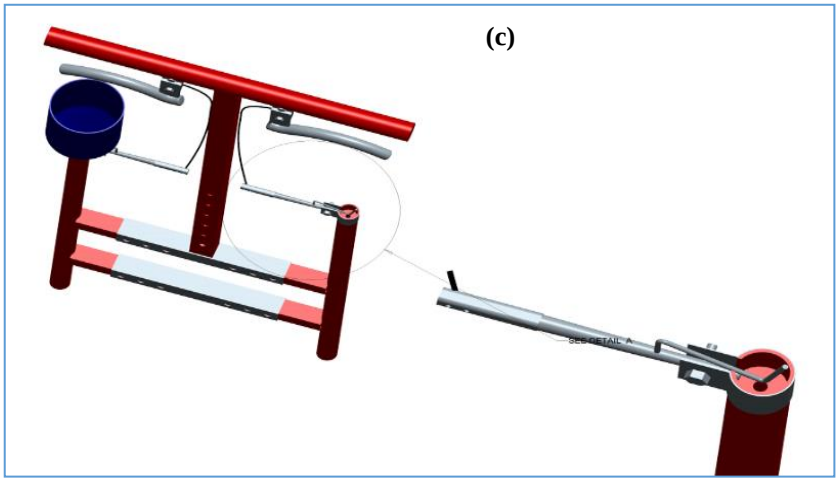


Fig. 3(a)-Conceptual view, (b)-Working components, (c)-Metering Mechanism

Table 1. Plan of experiment for evaluation of hand held two row planter

Type	Parameters	Levels`	Response
Performance evaluation	Varieties	2 (Tellicherry Black, Malabar Black)	• Missing index (%) • Multiple index (%) • Field capacity, ha h^{-1}
	Seed spacing	(15 cm, 20 cm and 25 cm)	
Economic evaluation	• Cost of the planter, Rs. • Operating cost, Rs. ha^{-1} • Benefit-cost ratio • Breakeven point, ha • Payback period, hours		

Measurement of response parameters: The parameters that ultimately defines the efficiency of the planter were considered to arrive at a logical conclusion. The parameters of missing index and multiple index indicates the uniformity of the seed distribution at the field level.

A.Missing index: The missing of the seeds in a particular row was calculated by counting the number of seeds dropped to the total number of seeds that should have been dropped in that particular length of the strip, [27].

$$\text{Missing Index, \%} = \frac{N}{M} \times 100 \quad \text{.....(1)}$$

Where,
N = number of seeds missing during operation into seed tube
M = number of seed dropped if no missing occurred

B.Multiples index: It is the representative of multiple droppings at one single point. It refers to the percentage of spacing that is less than or equal to half of the set plant distance [27].

$$\text{Multiple Index, \%} = \frac{n}{M} \times 100 \quad \text{.....(2)}$$

Where,
n = number of multiple seeds during operation into seed tube
M = number of seed dropped if no multiple seed drop occurred

C.Field efficiency: The field efficiency defines the percentage of useful work. It is calculated by the ratio of actual field capacity to theoretical field capacity [28].

$$\text{Field efficiency, \%} = \frac{AFC}{TFC} \times 100 \quad \text{.....(3)}$$

Where,
AFC = Actual field capacity, ha h^{-1}
TFC = Theoretical field capacity, ha h^{-1}

Development of plater for black pepper seed

The planter comprised of mainframe, seed hopper, handle, seed tube and clutch**.** The main frame served as the foundation for supporting the individual components of the planter. It held the components in place and provided base for mounting handle, seed metering mechanism and seed tube. The main frame consists of two vertical pipes attached with the help of two horizontal adjustable square pipes. The main frame was provided with square having holes on the entire surface to allow the width adjustment. A funnel shaped seed hopper was fabricated with the involvement of angle of repose to allow the smooth flow of the seed towards the metering mechanism. It served as repository of seeds.

The handle of manually operated hand held planter was designed to allow maximum number of people to operate it. The middle finger palm diameter of Indian workers was considered for deciding the diameter of the handle of the planter. The vertical adjustment of the handle was intended to reduce the drudgery associated with bad posture and inability to operate the planter efficiently. The handle was made from galvanized iron flat bars each of 600 mm long and circular bars of 19 mm diameter fastened to the frame. The inner circular bar slides inside the outer bar to extend the height of the planter with the help of nuts and bolts. The seed tubes were meant to carry the metered seeds from the seed hopper to the hole made in the seed bed.

The conical shaped pointers at the bottom of the vertical tubes were designed to penetrate in the soil and allow the metered seed to flow into it. The clutch was attached with the handle for ease of operation. The wire of the clutch was fastened to the fulcrum of the metering mechanism to open or close the metering hole. The compression and relaxation of the clutch was transmitted to the fulcrum by means of a wire to open or close the metering hole. Two clutches were provided on extreme end of the handle for seed sowing in two rows.

The fabrication of the hand held two row planter was carried out at workshop, College of Agricultural Engineering and Technology (COAET), SKUAST – K, Kashmir, J&K. The planter consists of main frame, seed hopper, handle, seed tube and clutch. The design values were selected based on the physical parameters and review of literature. The main frame of the machine (Table 2.) was 1000 x 300 mm.

Table 2. Specifications and design values of hand held two row planter

S. No.	Components	Material	Functions	Design parameter	Design value
1.	Main frame	Galvanized Iron	To provide the support to the planter	-	100 × 30 cm
2.	Seed hopper	LDPE	To store the seeds	Angle of repose, Test weight, Roundness	500 g capacity
3.	Handle	Galvanized Iron	For operating the machine	Anthropometric data (Middle finger palm diameter)	41 cm length, ¾ inch diameter
4.	Seed Tube	Mild Steel	To pass the seeds to the hole made in the seed bed	Size, Roundness,	62 cm length, ¾ inch diameter
5.	Clutch	Mild Steel	For operating the metering mechanism	-	8 mm diameter
6.	Fulcrum	Mild Steel	To block and pass the seeds into seed tube	-	2 mm diameter

RESULT AND DISCUSSION

Physical characteristics of black-pepper seed varieties relevant to design of planter

The physical properties of the seeds viz. size, roundness, angle of repose and test weight were determined to select the design values of individual components of the machine.

I.Size: The dissimilarity in the size of the seeds provided an opportunity to select an average value that will be the representative of the size for black pepper seed varieties. This helped to accommodate maximum size variation.

The mean and standard deviation of Tellicherry black pepper was found to vary from 4.33 mm – 4.35 mm and 0.33 – 0.45, respectively. In case of Malabar seeds (Table 3.) the mean and standard deviation ranged from 4.42 mm to 4.45 mm and from to 0.20 – 0.35.

Table 3. Variation in the size of black pepper varieties

Variety	R_1, mm	R_2, mm	R_3, mm
Tellicherry black	4.74	4.7	4.61
	3.64	4.62	3.85
	4.85	4.62	4.28
	4.59	4.66	4.37
	4.16	3.8	3.85
	4.09	4.51	4.45
	3.68	4.43	5.07
	4.17	4.14	4.17
	4.43	4.07	4.44
	4.9	3.94	4.26
Mean ± SD	4.33 ± 0.45	4.35 ± 0.33	4.34 ± 0.36
Malabar black	4.21	4.1	4.28
	4.59	4.52	4.56
	4.71	4.49	4.32
	4.97	4.39	4.45
	4.42	4.31	4.13
	4.58	4.28	4.38
	3.68	4.33	4.27
	4.28	4.84	4.98
	4.66	4.41	4.49
	4.36	4.55	4.61
Mean ± SD	4.45 ± 0.35	4.42 ± 0.20	4.45 ± 0.24

II.Angle of Repose: The angle of repose measurement was required to ensure the fabrication of seed hopper of the hand-held planter prompting smooth flow of the seeds towards the metering mechanism. The angle of repose of Tellicherry black and Malabar black was found to be approx. 27° and 25° with standard deviation (Table 4.) of 1.18 ad 1.72, respectively.

Table 4. Measurement of angle of repose for Tellicherry and Malabar black variety

Angle of repose	Tellicherry Black	Malabar Black
R_1	27.6	24.28
R_2	25.5	22.69
R_3	27.5	26.13
Mean ± SD	~27 ± 1.18	~25 ± 1.72

*Each replication is an average of 50 random samples

III.Roundness: The measurement of roundness of the seed was essential to decide the diameter of the size in the metering mechanism for smooth flow.

The roundness of the seed of Tellicherry black and Malabar black variety ranged (Table 5.) from 1.06 mm to 1.07 mm and 1.04 – 1.14 mm

Table 5. Roundness of Tellicherry black and Malabar black variety

	R_1	R_2	R_3
Tellicherry black	1.04	1.05	1.06
	1.11	1.05	1.06
	1.04	1.04	1.03
	1.12	1.15	1.11
	1.04	1.05	1.02
Mean ± SD	1.07 ± 0.04	1.07 ± 0.05	1.06 ± 0.03
Malabar Black	1.04	1.07	1.12
	1.03	1.07	1.08
	1.05	1.07	1.11
	1.06	1.17	1.30
	1.02	1.02	1.07
Mean ± SD	1.04 ± 0.01	1.08 ± 0.06	1.14 ± 0.09

Test Weight: The test weight determines the size and the type of material to be used for the fabrication of the seed hopper. The test weight of 1000 seeds of Tellicherry black and Malabar black variety of black pepper (Table 6.) were found to be 38.6 g and 42.1 g

Table 6. Test weight of 1000 seeds of Tellicherry and Malabar black

Variety	Test weight (g)		
Tellicherry black	38.64		
	38.64		
	38.64		
Mean	38.64		
Malabar black	42.19		
	42.19		
	42.19		
Mean	42.19		
	1.05	1.07	1.11
	1.06	1.17	1.30
	1.02	1.02	1.07
Mean ± SD	1.04 ± 0.01	1.08 ± 0.06	1.14 ± 0.09

Evaluation procedure for uniformity of seed distribution

The evaluation was carried out in 5 m length strip constituting an area of 0.0025 ha. The prototype of the hand held two row planter for black pepper was operated by pressing the clutch to operate the metering mechanism and deliver the seeds through the seed tube at variable seed spacing. The seed spacing in between the rows was controlled by shifting the inner rectangular bar out and fixing the distance by nut and bolt. The number of seeds dropped was observed for missing and multiple percentage to check the distribution of the seeds.

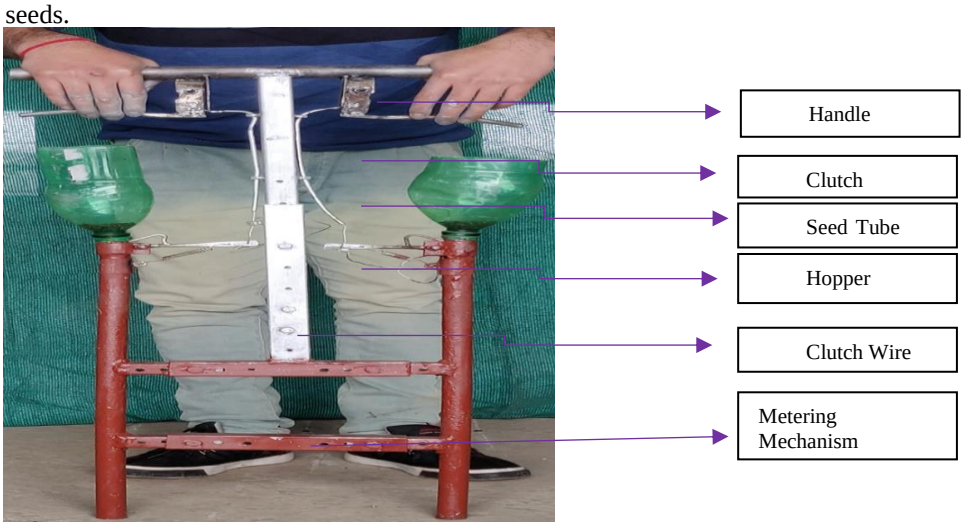
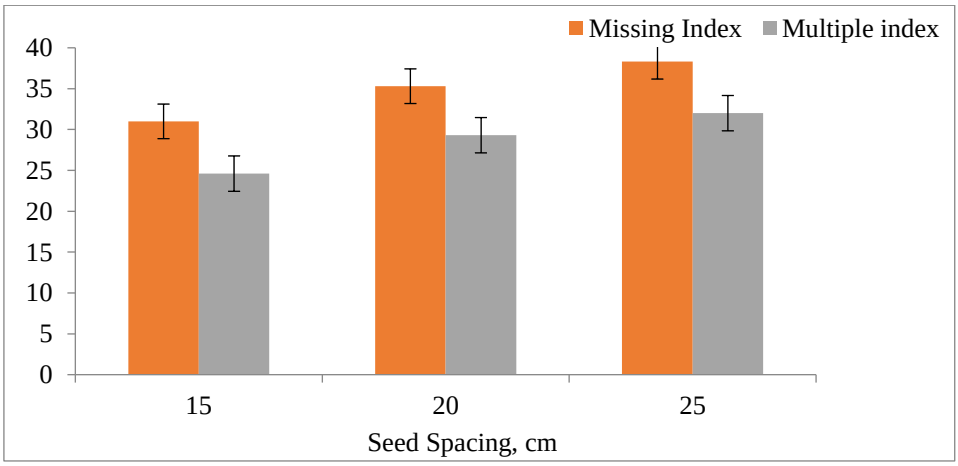


Fig.4. Prototype of hand held two row planter for black pepper

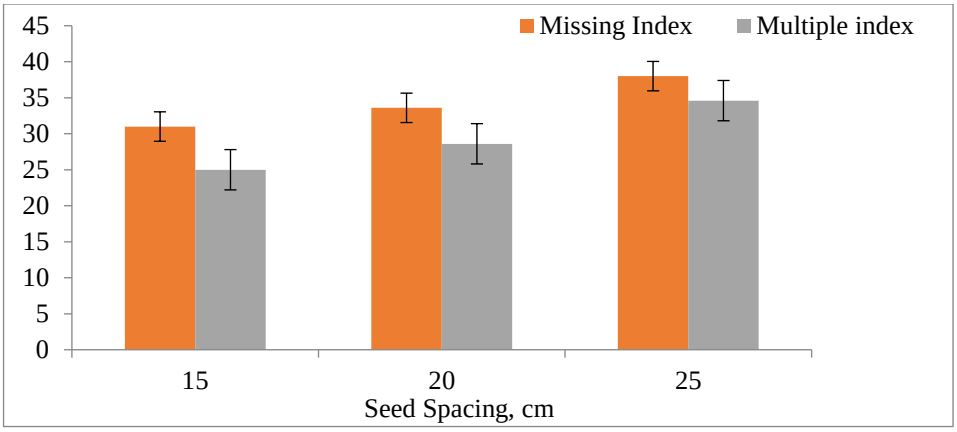
Fig. 5. Measurement of missing and multiple percentage

A. Effect of seed spacing on missing percentage and field capacity

The variation in missing percentage was observed for seed spacing, Fig. 6. At 15 cm, the missing percentage was observed to be 31 % for both Tellicherry and Malabar black pepper. The higher percentage was due to higher moisture content of the black pepper seeds resulting in blockage of metering hole. At higher seed spacing of 20 cm, the missing percentage increased to 35.3 % and 33.6 % and further to 38.3 % and 38 % at 25 cm for Tellicherry and Malabar black pepper, Fig. 6 (a). The field capacity ranged from 0.02 – 0.03 ha h^{-1} in all the experiments. The increase in missing percentage at 20 cm and 25 cm was mainly due to the increase in distance between clutch and metering hole. This tends to increase the force required to operate the clutch.



(a)



(b)

Fig. 6. Missing and multiple percentage (a) Tellicherry, (b) Malabar black pepper variety

Variation in multiple percentage and field capacity

At certain occasions, it was observed that more than one seed was dropped. This was mainly due to the fault in metering mechanism, high moisture content of black pepper seeds, prolonged clenching of clutch lever and inappropriate spring tension. At speed spacing of 15 cm, the multiple percentage was 24.6 % and 25 % for Tellicherry and Malabar black pepper variety with field capacity of 0.03 ha h^{-1}, Fig. 6 (b). When main frame was extended to increase the spacing between seeds to 20 cm, the multiple percentage was found to be 29.3 % and 28.6 %, respectively. The highest multiple seed percentage of 32 % and 34.6 % was found to be associated with the seed spacing of 25 cm. The distance between the clutch and metering mechanism defined the intensity of seed metering and multiple seed percentage index.

Cost economics of developed two row hand held planter

The economic feasibility is one among the prime factors that defines the acceptance of the machine among the farming community. The total cost incurred in the development of prototype of two row hand held planter was about Rs. 1500. The economic analysis revealed the operating cost as Rs. 84.97 per hour, benefit cost ratio of 1.30, breakeven point 16.36 ha and payback period of 58.85 hours, Table 7. The cost of operation obtained by the ratio of operating cost and field capacity as Rs. 2832 per hectare.

Table 7. Economic analysis of two row black pepper planter

S. No.	Item	Value
1.	Total operating cost, Rs h^{-1}	84.97
2.	Benefit-cost ratio	1.30
3.	Break-even point, ha	16.36
4.	Payback period, hours	58.85

CONCLUSIONS

A low-cost portable planter for black pepper was designed, developed and evaluated at field conditions. The planter comprised of handle, clutch, seed hopper, metering mechanism and seed tubes. The evaluation of the planter at field conditions revealed a missing percentage of 31% and multiple percentage of 24.6% at 0.03 ha h^{-1} field capacity. The cost of the two-row black pepper planter was calculated as Rs. 1500.

The operating cost, benefit-cost ratio, breakeven point and payback period was calculated as Rs. 84.97 per hour, 1.30, 16.36 ha and 58.85 hours, respectively. The cost of operation of the hand held two row planter was found be Rs. 2832 per hectare. The planter can be useful for small land holdings and small farmers.

Conflict of Interest: The authors declare that no conflict of interest exists in any manner.

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REFERENCES

[1] Sawe, B. E. 2019. The world's top black pepper producing countries, Vol. 2020. WoldAtlas.com.

[2] Lee, JG., Chae, Y., Shin, Y. and Kim, Y. 2020. Chemical composition and antioxidant capacity of black pepper pericarp.*Appl Biol Chem* **63**, 35.https://doi.org/10.1186/s13765-020-00521-1

[3] Al-Jasass, F.M. and Al-Jasser, M. S. 2012. Chemical composition and fatty acid content of some spices and herbs under Saudi Arabia conditions. Sci World J. https://doi.org/10.1100/2012/859892

[4] Subha, S. P. and Balamurugan, S. 2020. Economic analysis of pepper cultivation in India. International Journal of Economics and Management Studies, pp. 1-5.

[5] Spence, C. (2024). The king of spices: on pepper's pungent pleasure. International Journal of Gastronomy and Food Science. 35, 100900. https://doi.org/10.1016/j.ijgfs.2024.100900

[6] Gorgani, L., Mohammadi, M., Najafpour, G.D. and Nikzad, M. (2017). Piperinethe bioactive compound of black pepper: from isolation to medicinal formulations. Compr Rev Food Sci F. 16(1): pp.124–140

[7] Ahmad, N., Fazal, H., Abbasi, B.H., Farooq, S., Ali, M. and Khan, M. A. 2012. Biological role of *Piper nigrum* L. (Black pepper): a review. Asian Pac J Trop Biomed. 2: S1945–S1953

[8] Bajad, S., Bedi, K.L., Singla, A.K. and Johri R.K. 2001. Antidiarrheal activity of piperine in mice.*Planta Med.* **67**: pp.284–287.

[9] Costa, R., Machado, J. and Abreu, C.2016. Evaluation of analgesic properties of *Piper nigrum* essential oil: a randomized, double-blind, placebo-controlled study. World Journal of Traditional Chinese Medicine 2(2): pp.60–64. https://doi.org/10.15806/j.issn.2311- 8571.2015.0032.

[10] Khan, M., 2015. Comparative physicochemical evaluation of fruits and antidepressant potential of volatile oils of fruits of local *Piper* species. Orient. J. Chem. 31, pp. 541–545. https://doi.org/10.13005/ojc/310167.
[11] Okumura, Y., Narukawa, M., Iwasaki, Y., Ishikawa, A., Matsuda, H., Yoshikawa, M., Watanabe, T., 2010. Activation of TRPV1 and TRPA1 by black pepper components. Biosci. Biotechnol. Biochem. 74, pp. 68–72.
[12] Gasparetto, A., Cruz, A.B., Wagner, T.M., Bonomoni, T.J., Correa, R. and Malheiros, A. 2017. Seasonal variation in the chemical composition, antimicrobial and mutagenic potential of essential oils from *Piper cernum*. Ind Crops Prod 95: pp.256–263.
[13] Sauter, I. P., Rossa, G. E., Lucas, A. M., Cibulski, S. P., Roehe, P. M., da-Silva, L. A. A., Rott, M. B., Vargas, R. M. F., Cassel, E. and von-Poser, G.L.2012. Chemical composition and amoebicidal acitivity of *Piper hispidinervum* (Piperaceae) essential oil. Ind Crops Prod 40: pp.292–295.
[14] Chonpathompikunlert, P., Wattanathorn, J. and Muchimapura, S.2010. Piperine, the main alkaloid of Thai black pepper, protects against neurodegeneration and cognitive impairment in animal model of cognitive deficit like condition of Alzheimer's disease. Food Chem Toxicol 48: pp.798–802.
[15] McNamara, F. N., Randall, A. And Gunthorpe, M. J. 2005. Effects of piperine, the pungent component of black pepper at the human vanilloid receptor. Br J Pharmacol. 144(6): pp.781-790.
[16] Alan, O. and Ilbi, H. 2023. Effect of cutting treatment on seed yield and seed quality of dill. *Journal of Tekirdag Agricultural Faculty*, 20(1): pp.94-103. https://doi.org/10.33462/jotaf.1073356
[17] Malla, U. M., Khan, A. R., Muzamil, M., Mohiuddin, M., Rashid, S., Banday, R. and Kumar, R. 2022. Development and evaluation of four-row seeder for vegetable crops in the temperate region of Jammu and Kashmir. SKUAST Journal of Research, 24(1): 71-79. http://dx.doi.org/10.5958/2349-297X.2022.00016.2.
[18] Wani, M. H., Muzamil, M., Dixit, J., Faisal, S. and Khan, A. A. 2024. Development of a low-cost portable two row pea planter for Hilly terrain of Kashmir Valley. Journal of Tekirdag Agricultural Faculty 21(3): pp.561-577.
[19] Jadhav, M. L., Din, M., Nandede, B. M. and Kumar, M. 2020. Engineering properties of paddy and wheat seeds in context to design of pneumatic metering devices. *Journal of the Institution of Engineers (India): Series A*,101: pp. 281-292. https://doi.org/10.1007/s40030-019-00430-7.
[20] Mohiuddin, M., Muzamil, M., Dixit, J., Faisal, S. and Khan, I. 2022. Engineering properties of Chilli fruit relevant to the design and evaluation of Chilli seed extractor for hilly region of Kashmir valley. Journal of Institution of Engineering (India): Series A 103: pp. 433-443. https://doi.org/10.1007/s40030-022-00617-5.
[21] Magray, M. A., Fayaz, A., Muzamil, M., Rasool, S., Nath, S., Banday, R. and Faisal, S. 2023. Development and performance evaluation of low-cost cylinder type maize sheller for small farmers of Jammu and Kashmir. SKUAST Journal of Research 25(1): pp. 22-33. http://dx.doi.org/10.5958/2349-297X.2023.00003.X
[22] Muzamil, M., Mani, I., De, D. and Lande, S. 2013. Influence of operational parameters of windrow turner for mass production of compost. International journal of agricultural and statistical science, 9(1): pp. 19 – 28.
[23] Malik, M.A., Faisal, S., Muzamil, M., Langoo, B. A., Shukla, R. M., Reshi, M., Dhekale, B. and Hussain, S. Z. 2023. A Low-Cost Portable Willow Wicker Peeling Machine: An Innovative Mechanical Intervention in the Wickercraft Industry of Kashmir. *J. Inst. Eng. India Ser. A* 104, pp. 271–280. https://doi.org/10.1007/s40030-023-00726-9.

[24] Muzamil, M., Wani, J., Mustafa, A., Mohiuddin, M., Mir, A., Faisal, S. and Nirbhavane, S. 2018. A Low-Cost Divergent Type Apple Grader for Kashmiri Apples. International Journal of Current Microbiology and Applied Sciences 7(4): p.p.3561-3569. https://doi.org/10.20546/ijcmas.2018.704.401.
[25] Rashid, Z., Faisal, S., Muzamil, M., Dixit, J., Shukla, R. M. and Khan, I. 2023. Development of an innovative universal walnut cracking and separating machine for farmers and walnut industry of Kashmir Valley. Journal of Institution of Engineering (India): Series A 104: pp. 355-365. https://doi.org/10.1007/s40030-023-00718-9.
[26] Kumar, A., Muzamil, M. and Dixit, J. 2022. Smart vermicomposting bin for rapid transformation of Dal Lake aquatic weed into fortified vermicompost. Internal Journal of Recycling of Organic waste in Agriculture 12(2). https://doi.org/10.30486/ijrowa.2022.1955835.1445.
[27] Yasir, S. H., Liao, Q., Yu, J. and He, D. 2012. Design and test of a pneumatic precision metering device for wheat. *Agricultural Engineering International: CIGR Journal*, 14(1): pp.16–25.
[28] Bamgboye, I. A. and Mofolasayo, S. A. 2006. Performance evaluation of two row okra planter. *Agricultural Engineering International: CIGR e-Journal*, 8(7). Manuscript PM 06002.

RAZVOJ I EVALUACIJA DVOREDNE RUČNE SEJALICE ZA SEME CRNOG BIBERA

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Apstrakt. Studija se fokusirala na razvoj prenosive jeftine dvoredne sejalice za crni biber (*Piper nigrum L.*). Fizički atributi za seme crnog bibera Tellicherri i i Malabar u smislu tri-aksijalnih dimenzija, ugla trenja, zaobljenosti (sferičnosti) semena i težine 1000 semena, korišćeni su za određivanje projektovanih vrednosti pojedinih komponenti sejalice. Srednje vrednosti tri-aksijalnih dimenzija i ugao trenja Tellicherri crnog i Malabar crnog bibera, kretale su se u rasponu od 4.33 – 4.35 mm, 27° i 4.42 – 4.45 mm, 25°, respektivno. Sferičnost (zaobljenost) semena je 1,06 mm – 1,07 mm i 1,04 – 1,14 mm u sličnim uslovima. Težina 1000 semena, korišćenih za projektovanje rezervoara za seme je 38,6 g i 42,1 grama, respektivno.

Ručna sejalica crnog bibera (H x h x W x w = 1000 x 920 x 300 x 150 mm) ima: rezervoar za seme, uređaj za doziranje semena, ručku, podesiv (promenljiv) razmak između redova, sprovodne cevi za seme. Razvijena sejalica ima razmak redova 15, 20 i 25 cm, za dve sorte crnog bibera (*Piper nigrum L.*). (Tellicherri crni i Malabar crni).

Zabeleženi su parametri performansi procenta greški, višestruki procenat greški i učinka na polju (ha h^{-1}) i ekonomskih parametara troškova eksploatacije, tačke rentabilnosti, odnosa koristi i troškova i perioda otplate.

Optimizacija rezultata kroz program Design-Expert 13.0 je prikazala 31% nedostatka i 24,6% višestrukih greški kod razmaka semena od 15 cm sa poljskim učinkom od 0,03 ha na čas.

Operativni trošak (Rs h^{-1}), odnos troškova i dobiti, tačka rentabilnosti (ha) i period otplate (časova), izračunati su kao 84.97, 1.30, 16.36 and 58.85, respektivno. Utvrđeno je da je cena rada ručne dvoredne sejalice Rs. 2832 po hektaru.

Skraćenice:
H = Maksimalna visina, mm
h = Minimalna visina, mm
W= Maksimalna širina, mm
w = Minimalna širina, mm

Ključne reči: *Sejalica, biber, dizajn, prenosivi, performanse, razmak, raznolikost, efikasnost, tačka rentabilnosti, isplativost.*

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