Vol. 14(4), pp. 24-31, 15 March, 2019
DOI: 10.5897/SRE2016.6411
Article Number: BE06F8560496
ISSN 1992-2248

http://www.academicjournals.org/SRE

ACADEMIC JOURNALS
expand your knowledge

Scientific Research and Essays

Full Length Research Paper

Precision attributes based index for the selection of efficient agricultural machinery

Manjeet Singh[1], Karun Sharma[2*], Pramod Mishra[1], Bharat Patel[1] and S K Singh[1]

[1]Department of Farm Machinery and Power Engineering, Punjab Agricultural University, Ludhiana, India.
[2]Krishi Vigyan Kendra, Samrala, Punjab Agricultural University, Ludhiana, India.

Received 5 May, 2016; Accepted 25 January, 2017

Development and introduction of high capacity, precise, reliable and energy efficient machinery/equipment is the need for judicious use of inputs. Manufacturing of agricultural machinery in India is varied in nature and starts from village artisans, tiny units, cottage to small scale industries, organized tractor and agricultural machinery manufacturers including energy and processing machinery industry. Precision in application rates for higher input-use efficiency can be achieved only by improving the designs of the existing machinery/equipment. Precision index (PI) of machine/equipment is based on its capability to perform a given task in an accurate manner. It is a worthwhile attribute to compare the performance of different equipment and operations to enhance the productivity of a given farm. The purpose of study was to propose an index, that is, PI to select efficient and precise machine/equipment for the farmers. PI values were calculated for three types of machinery namely zero seed cum fertilizer drills, planters and spraying machines. It was concluded that drill Make 2, tested in the year 2004, was having the highest PI value, that is, 0.97 or 97% followed by drill Make 1 having PI value 0.95 or 95% tested in the same year. Drill Make 5 tested in the year 2013 was having minimum PI value, that is, 0.80 or 80%. PI value for happy seeder machine was 0.88 or 88%. During the testing of multi-crop planter in year 2014, the variability of doubling attribute was more, that is, 28% followed by missing having 20% value and produced influence on PI which was observed to be 0.83 or 83%. PI of semi-automatic and automatic potato planter was found to be 0.70 and 0.80, respectively. The value was not much satisfactory and could be ranked under average category. PI of electrostatic sprayer mounted with single as well as twin nozzle was observed to be the highest, that is, 0.89 followed by PI of air assisted sprayer with single and double nozzle, that is, 0.83 and 0.84, respectively.

Key words: Precision index, zero till seed cum fertilizer drill, happy seeder, spraying machines, planting machines.

INTRODUCTION

Mechanization imparts capacity to the farmers to carry out farm operations, with ease and lesser drudgery. It helps the farmers to achieve timeliness, precisely meter and apply costly input with better efficacy and efficiency. Efficient machinery helps in increasing productivity by about 30% (Kulkarni, 2012) besides enabling the farmers

*Corresponding author. E-mail: karunluckysharma@gmail.com.

to raise second crop in a year. Raising more crops with high productivity is a path for meeting the future food requirement of population. Development and introduction of high capacity, precise, reliable and energy efficient equipment is the need for judicious use of inputs. For crop production human, animal and mechanical energy is extensively used. There is increase in crop productivity up to 12 to 34% due to mechanization along with enhancement in cropping intensity by 5 to 22%. Seed-cum-fertilizer drill facilitates saving in seeds and fertilizer about 20%. There is an increase in the gross income of the farmers in the range of 29 to 49% due to mechanisation (Anonymous, 2013). Zero till drill was found to be most time saving (88%) and energy efficient (79%) as compared to conventional sowing. The zero drill was more economical, that is, 79% as compared to conventional sowing (Singh et al., 2014).

Manufacturing of agricultural machinery in India is varied in nature and starts from village artisans, tiny units, cottage to small scale industries, organized tractor and agricultural machinery manufacturers including energy and processing machinery industry. Standardization and quality control measures are inadequate except in the organized sector like in tractor manufacturing. Equipment for efficient irrigation, appropriate use of pesticides, micronutrients and minimizing their excess use to protect soil health and environment is a growing concern. Selection of correct sprayer for chemical application is an important issue for effective pest and weed control. Studies indicate that 70% of the success of chemical depends on the effectiveness of its application (Malik et al., 2012). By mechanization in spraying devices, chemicals were distributed equally on the farm and reduced the quantity of waste, resulted in prevention of losses and wastage of input. It reduced the cost of production and gave higher productivity in minimum input (Das et al., 2015).

Precision in application rates for higher input use efficiency can be achieved only by improving the designs of the existing equipment. The critical operations in the crop production cycle where implementation precision has a significant role are (a) seeding/planting, (b) fertilizing, (c) chemical applications, (d) irrigation, and (f) inter-cultural operations. At present, the availability of state-of-art precision equipment for different operations is lacking. Precision is an attribute inbuilt in the functional design of a component or components of equipment. Also, desired precision is achieved through proper adjustments and operational parameters while using a mechanical gadget/device to ensure desired accuracy and efficiency.

Precision Index (PI) is based on the capability of equipment to perform a given task in an accurate manner. It is a worthwhile attribute to compare the performance of different equipment and operations to enhance the productivity of a given farm. An inter-disciplinary approach among agricultural engineers, agronomists, soil scientists, and horticulturists might help in developing the qualitative and quantitative precision indices for different farm equipment. PI ought to be computed on the basis of extensive field testing of a given implement/equipment/component. It is a mathematical and statistical measure of precision for any machinery. Before purchasing equipment, the user ought to know the PI for the equipment recommended to him. One must buy/custom-hire farm equipment with high PI. The PI can be compared for machinery irrespective of their make and type with same purpose or function of operation. Manufacturer/Supplier must apprise him about the same. Therefore, the role of testing centre/testing agency assumes critical importance in the context of adoption and propagation of precision farm equipment and machinery. Qualitative precision indices of farm equipment will be very useful for the selection of equipment.

In the present study, different make and types of seed drills, multi-crop planters, and sprayers were selected to compute their PI. There is no information available regarding computation of a quantitative PI. The purpose of study is to propose an index, that is, PI to select efficient and precise equipment for the farmers.

MATERIALS AND METHODS

Selection of suitable material and methods used for the study are briefly described under this part. Zero till seed-cum-fertilizer drills, multi-crop planters and sprayers manufactured and commercialized with different make and models by different manufacturers were selected for the study. These models are being tested and evaluated by the government testing centers as per the BIS norms and manufactured by different manufacturers.

Selection of machines

PI values were calculated for two types of functionality as sowing and plant protection and the machineries were zero seed cum fertilizer drills, planters and spraying machines (Figure 1). Five numbers of zero seed cum fertilizer drills of different make and models and a recently introduced second generation drill like happy seeder machine for direct sowing of wheat in combine harvested field were selected for the study. Various design and operational specifications of selected drill machines are shown in Table 1. Different planters such as multi crop planter, semi-automatic potato planter and automatic potato planter were selected to find their PI. A tractor operated potato planter was evaluated at Latif experiment farm and found that the field efficiency and field capacity of potato planter was 67.5% and 0.80 ha/h, respectively. Planter covered more area in less time and saved labour (Mari et al., 2002). Technical specifications like metering mechanism, metering device and metering power source were considered and shown in Table 2.

Five types of sprayers namely Gun type, Knapsack type, Electrostatic type, Boom Type and Air assisted type were selected for knowing the PI value. Electrostatic and mist blower sprayers were evaluated for deposition efficiency and biological efficacy. Spray deposition efficiency of electrostatic sprayer was very high with uniform distribution irrespective of leaf taxonomy, anatomy and morphology. The usage of chemicals was about 30 to 35% in case

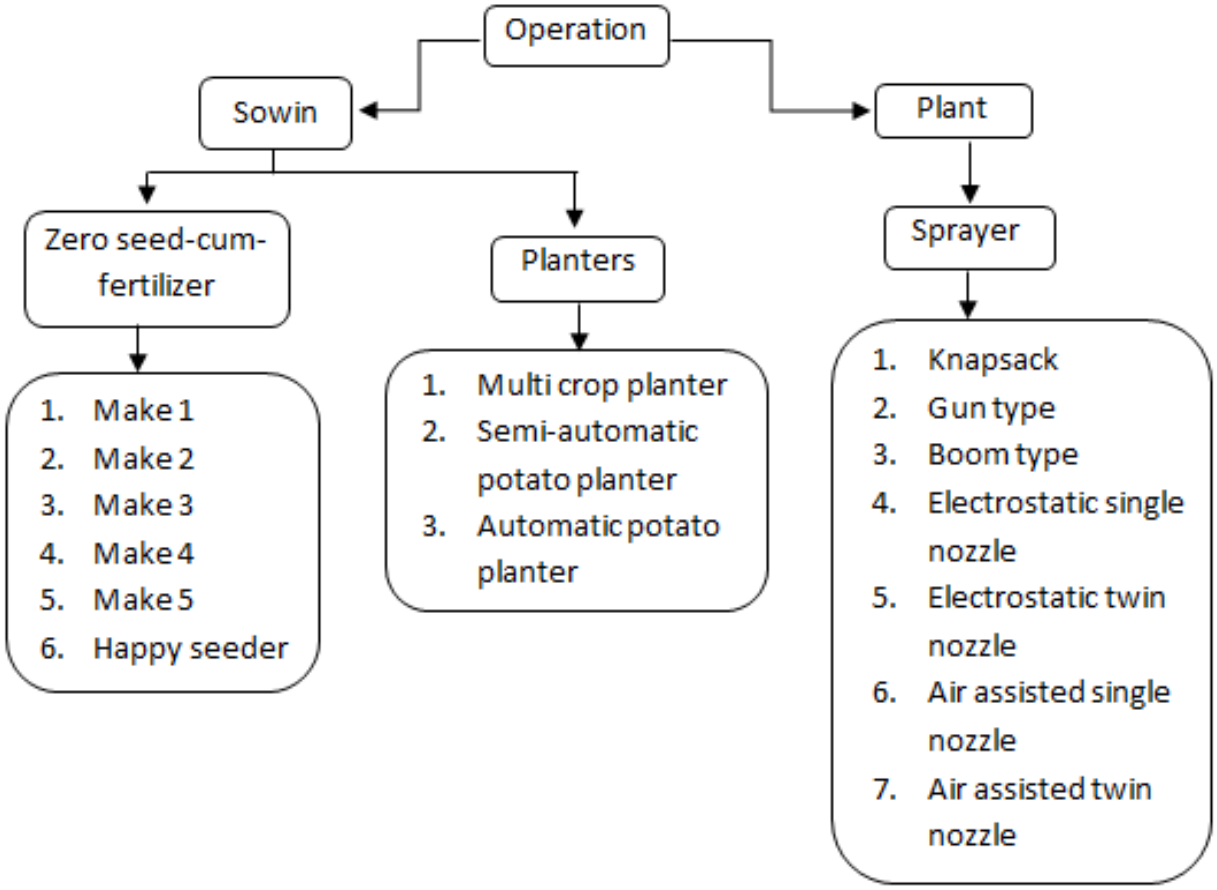

Figure 1. Selected machinery.

Table 1. Technical specifications of selected drill machines.

Specification	Zero Seed cum Fertilizer Drill					Happy Seeder
	Make 1	Make 2	Make 3	Make 4	Make 5	
Furrow openers (Nos.)	11	11	11	11	11	09
Seed metering device (Type)	Fluted roller	Fluted roller	Fluted roller	Fluted roller	Fluted roller	Fluted roller
Dia. size (mm) & fluted rollers (Nos.)	48.6 & 11	46.2 & 11	48.7 & 11	46.6 & 11	48.4 & 11	47.5 & 09
Fertilizer distributer (type)	Vertical disc	Fluted roller	Plate type	Fluted roller	Plate type	Fluted roller
Dia. size (mm) & metering device (Nos.)	129.3 & 11	46.2 & 11	90.0 & 11	46.6 & 11	90.0 & 11	50.0 & 09
Forward speed, km/h	3.0	3.0	3.0-5.0	3.0	3.0-5.0	2.0- 3.0

Table 2. Technical specifications of selected planting machines.

Specification	Multi-crop planter	Automatic potato planter
Power source	Tractor	Tractor
Metering mechanism (type)	Disc with notches	Picker wheel
Seed metering devices (Nos.)	04	02
Notches/Pickers on metering device (Nos.)	24	10
Disc diameter (mm)	172	-
Crop cultivated	Cotton, soybean, maize	Potato

Table 3. Technical specifications of selected spraying machines.

Specification	Gun type	Knapsack	Electrostatic backpack	Boom type	Air assisted
Spray tank capacity (l)	500-1000	15	15	500	15
Power source	Tractor PTO	Lever operated	Petrol engine	Tractor PTO	Petrol engine
Operating pressure (kg/cm^2)	10-25	3.5 -4.5	4.2-4.9	15-25	4.2-4.9
Hose pipe length (m)	60-300	-	33	-	33
Nozzles (Nos.)	Single	Single	Single/Twin	16 – 18	Single/Twin
Nozzle (type)	Solid cone	Hollow cone			

Figure 2. Field operational view of selected machines.

of electrostatic sprayer of air assisted sprayer (Subhagan et al., 2016). Important technical specifications like tank capacity, power source, operating pressure, number and type of nozzles of these sprayers are shown in Table 3.

Figure 2 shows the operational view of machines like zero till seed cum fertilizer drill, multi crop planter, happy seeder and electrostatic sprayer, selected for the calculations of their PI.

Precision attributes of different machines

To obtain the PI of selected equipment/machine, there is need to identify the different precision attributes of that machine. Figure 3 shows the various types of attributes/parameters selected for seed cum fertilizer drill, planters and sprayers. During seed drill operation, it is desired that there should not be variation in seed rate among the different furrow openers. Hence, two precision attributes one inter row variation in seed rate and another intra row variation in fertilizer rate were identified to observe the PI of selected seed cum fertilizer drills. To compute PI for the planter, various types of attributes/parameters like missing, doubling, seed damage, seed to seed distance and depth of placing were selected. These parameters were important as they were having the direct concern with yield or output of the crop. For ensuring better yield, seed to seed distance and depth of placing the seeds should be optimum; otherwise, it puts the adverse influence on crop yield. For obtaining the PI for sprayers, five precision attributes such as volume median diameter (VMD), number median diameter (NMD), uniformity coefficient (UC), droplet density (DD) and volume of spray deposition (VSD) were identified and ranked as the important precision attributes to compute PI for sprayers.

Computation of PI (Quantitative)

While purchasing equipment, the farmer need to know the PI for the

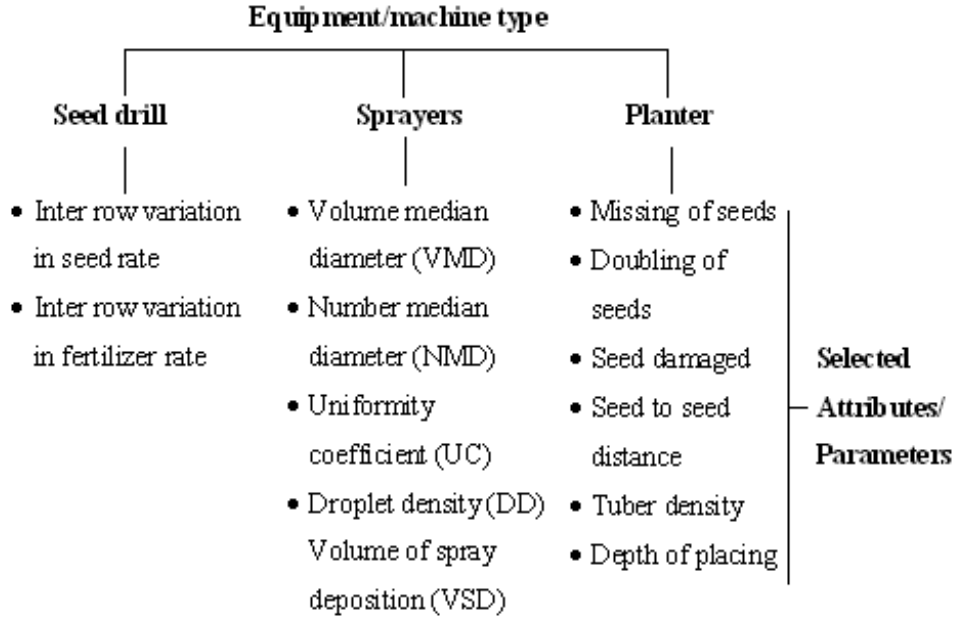

Figure 3. Different types of selected attributes/parameters.

Table 4. Precision index of different types of sowing drill machines.

Sowing drill machines	Year of testing	Coefficient of Variance (CV)		Precision Index (PI)
		Seed Rate	Fertilizer Rate	
Make 1	2004	0.04	0.07	0.95
Make 2	2004	0.03	0.03	0.97
Make 3	2006	0.33	0.03	0.82
Make 4	2007	0.07	0.04	0.94
Make 5	2013	0.06	0.33	0.80
Happy Seeder (HS)	2014	0.09	0.15	0.88

equipment recommended to him. Obviously, the user would like to buy/custom-hire farm equipment with high PI. Manufacturer/ Supplier must apprise him about the same. Hence, the following expression is being suggested. It can be further modified/rectified based on the inputs received from stake holders.

$$\text{Precision Index} = 1 - \left[\frac{\sum_{i=0}^{n} (\text{VPA})_i}{n}\right] \quad (1)$$

$$\sum_{i=0}^{n} \text{VPA} = \text{CV1} + \text{CV2} + \text{CV3} + \cdots \quad \text{CVi}$$

where n is the total number of precision attributes, VPA is the variation in precision attribute or coefficient of variation (in decimal), and CVi is the coefficient of variation of respective attributes.

Agricultural equipment are classified into five categories such as very low, low, moderate, high and very high as per PI (qualitative) values. The classification of equipment is completely based on calculated value of PI. Machine with more calculated value or close to 1 will be more precised.

RESULTS AND DISCUSSION

PI of sowing machines

Inter row variations in seed and fertilizer rate were measured at an average seed and fertilizer rate of 76.87 and 128.10 kg/ha, respectively during their testing. PI (Qualitative) of different drill machines calculated with the help of PI expression (Equation 1), are shown in Table 4. The coefficient of variance (CV) for seed rate was varied from 0.03 for Make 2 drill to 0.33 for Make 3 drill. Seed rate of second generation drill, that is, happy seeder machine was having more CV, that is, 0.09 than all other selected drills except Make 3 drill. Similarly, coefficient of variance for fertilizer rate was varied from 0.03 for drill of Make 2 to 0.33 for drill of Make 5. Fertilizer rate of happy seeder machine was having more CV, that is, 0.15 than

Table 5. Precision index of planting machines.

Type of planter	Testing year	Variability in							PI
		Missing	Doubling	Fertilizer rate	Tuber Damage	Seed spacing	Tuber Density	Depth of placing	
Multi-crop	2014	0.20	0.28	0.04	-	-	-	-	0.83
Automatic potato	2013	0.29	0.45	-	0.16	0.09	0.10	0.08	0.80
Semi-automatic potato	1980	0.31	0.63	-	0.35	0.18	0.10	-	0.70

all other selected drills except Make 5 drill. It could be concluded that drill of Make 2, tested in the year 2004, was having the highest PI value, that is, 0.97 or 97% followed by Make 1 drill having PI value 0.95 or 95% tested in the same year. Make 5 drill tested in the year 2013 was having minimum PI value, that is, 0.80 or 80%. PI value for happy seeder machine was 0.88 or 88%, which seems to be low. This may be due to poorer working conditions of the machine, as it is operated for direct sowing of wheat crop in paddy stubble conditions.

PI of planting machines

Table 5 shows the PI of planting machines based on the variability of different attributes. The PI of multi-crop planter was observed by finding the variability of various attributes like missing, doubling and inter row fertilizer rate. The variability in doubling attribute was more that is 28% followed by missing with 20% value and produced influence on PI which was observed to be 0.83 or 83%. Inter row fertilizer rate attribute was having less effect on PI of planter due to its lesser variability, that is, 4.0%.

Variability of precision attributes, that is, missing, doubling, tuber damage, seed to seed distance tuber density and depth of placing was measured to observe the PI of semi-automatic and automatic potato planter. With the help of PI expression, PI was found to be 0.80 for automatic potato planter, tested in the year 2013. Similarly, the PI of semi-automatic planter, tested in the year 1980, was found to be 0.70. The value of PI was influenced more by attributes like doubling and missing which was having variability of 45 and 29%, respectively as compared to other attributes like tuber damage, seed to seed distance, tuber density and depth of placing which was having CV in the range of 0.08 to 0.16. In case of semi-automatic potato planter, the reason of lower PI was the higher variability in attributes like doubling, missing and tuber damage which were having variability, 0.63, 0.31 and 0.35%, respectively, found more as compared to other attributes.

PI of spraying machines

Figure 4 and Table 6 shows the CV and PI of selected sprayers of different types calculated by using various precision attributes such as number median diameter (NMD), volume median diameter (VMD), uniformity coefficient (UC), droplets density (DD; No. of Droplets cm^{-2}), area covered by droplets (AC; mm^2 cm^{-2}) and volume of spray deposition (VSD; cc cm^{-2}). In case of Knapsack sprayer, the variability of attributes was measured in the range of 0.30 to 1.31, influenced and being the reason of lower PI having index value 0.40. The major impact on PI of Knapsack sprayer was produced by VSD having 1.31 CV followed by NMD and DD having CV 0.55 and 0.51, respectively. PI of gun and boom type sprayer was observed having values 0.54 and 0.73, respectively. The values of CV for gun and boom type sprayer were observed in the range of 0.13-0.73 and 0.04-0.39, respectively. In gun type sprayer, maximum and minimum variability was found in DD and VMD, shared 73 and 13%, respectively. In boom type sprayer, the maximum influence on PI was produced by NMD, UC and VSD attributes, having variability 37, 32 and 39%, respectively. PI of electrostatic sprayer mounted with single as well as twin nozzle was observed to be on highest that is 0.89 followed by PI of air assisted sprayer with single and double nozzle having PI values 0.83 and 0.84, respectively. In electrostatic sprayer, the range of CV of selected attributes varied from 0.06 to 0.17 and the CV for air assisted sprayer was found in the range of 0.06 to 0.43 for UC and DD, respectively.

By comparing the PI of spraying machines, it could be instated that the field performance of electrostatic sprayer whether single or twin nozzle, was found to be efficient as compared to other spraying machines. Lower PI of Knapsack sprayer ranked it as poor sprayer due to its lower efficacy and efficiency comparing to other sprayers.

Conclusions

The following conclusions were drawn from the present study:

(1) It was concluded that seed cum fertilizer drill of Make 2, tested in the year 2004, was having the highest PI value, that is, 0.97 or 97% followed by Make 1 drill having PI value 0.95 or 95% tested in the same year.
(2) Make 4 drill tested in the year 2007 was having PI

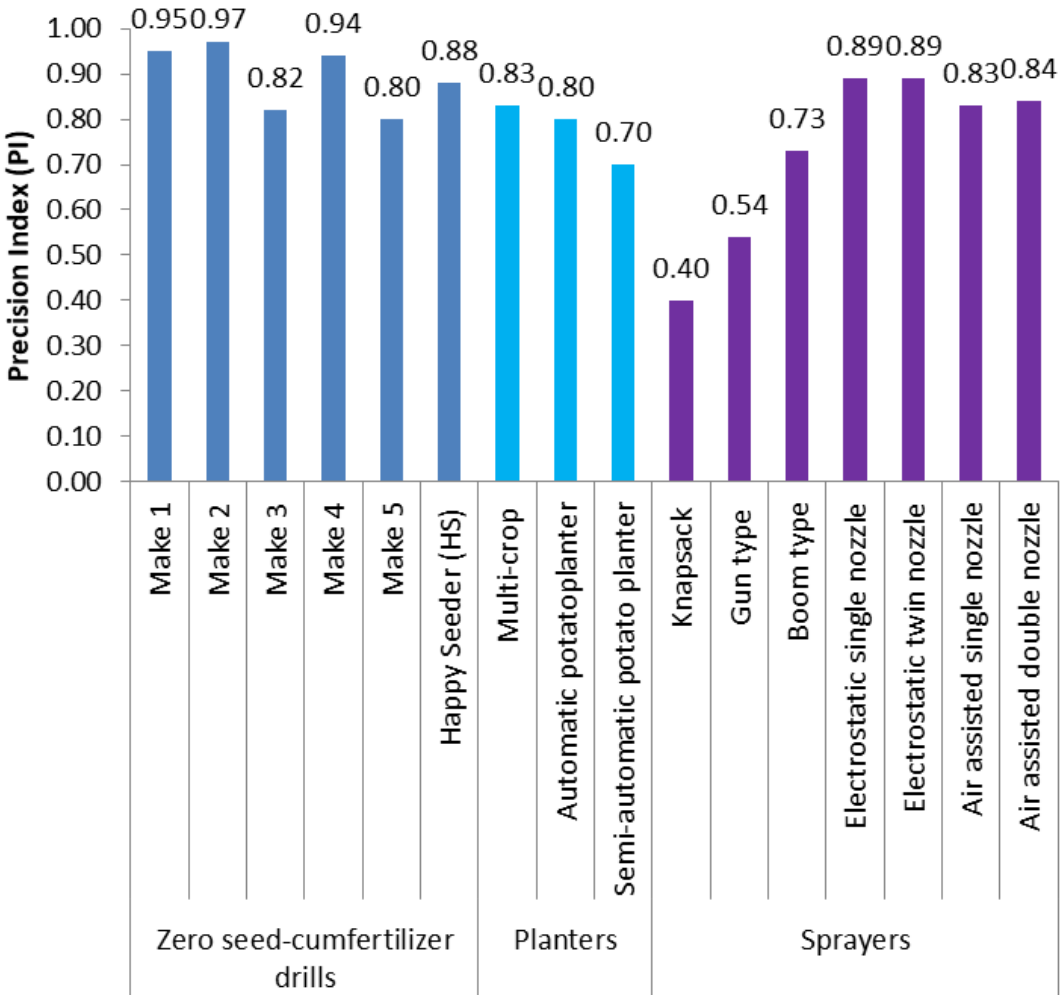

Figure 4. Precision index of selected machines.

Table 6. Precision index of different types of spraying machines.

S/N	Type of Sprayer	Variability in					Precision Index
		VMD	NMD	UC	DD	VSD	
1	Knapsack	0.30	0.55	0.35	0.51	1.31	0.40
2	Gun type	0.13	0.50	0.62	0.73	0.32	0.54
3	Boom type	0.04	0.37	0.32	0.25	0.39	0.73
4	Electrostatic single nozzle	0.14	0.09	0.08	0.14	0.08	0.89
5	Electrostatic twin nozzle	0.12	0.11	0.06	0.17	0.08	0.89
6	Air assisted single nozzle	0.16	0.09	0.08	0.43	0.07	0.83
7	Air assisted double nozzle	0.11	0.11	0.06	0.43	0.07	0.84

value 0.94 followed by Make 3 and Make 4 which were having lower PI values, that is, 0.82 and 0.80, respectively as compared to other drills of different Make.

(3) From the testing of seed cum fertilizer drills, it was found that the manufactured drill machines of different Makes were having different PI values which varied from 0.80 to 0.97. Hence, it was concluded that drill machines manufactured by different Makers were not standardised as all drills of different Make were having different PI values.

(4) PI value for happy seeder machine was 0.88 or 88%, which seems to be low. This may be due to poorer

working conditions of this machine, as it operated for direct sowing of wheat crop in paddy stubble conditions.
(5) During the testing of multi-crop planter in year 2014, the variability of doubling attribute was more, that is, 28% followed by missing having 20% value and produced influence on PI which was observed to be 0.83 or 83%.
(6) PI of semi-automatic and automatic potato planter was found to be 0.70 and 0.80, respectively. The value was not much satisfactory and could be rank under average category.
(7) PI of electrostatic sprayer mounted with single as well as twin nozzle was observed to be highest, that is, 0.89 followed by PI of air assisted sprayer with single and double nozzle, that is, 0.83 and 0.84, respectively.
(8) The range of CV of selected attributes was varied from 0.06 to 0.17 and 0.06 to 0.43 for electrostatic and air assisted sprayer, respectively.
(9) Field performance of electrostatic sprayer whether single or twin nozzle, was found to be efficient as compared to other spraying machines and fairly assessed it an effective and efficient sprayer followed by air assisted sprayer.

Hence, it is concluded from the study that the PI of machine/equipment is a tool to the farmers and researchers used/helped to procure and select an optimum agricultural equipment/machine for farm use and for research intention. With the results of PI, further refinement and modification in the existing component/ machine/equipment can be done from the researcher and manufacturers' sides.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Anonymous (2013). Report of the sub-group on agricultural implements and machinery for formulation of 9th five year plan, Govt. of India.

Das N, Maske N, Khawas V, Chaudhary SK, Dhete RD (2015). Agricultural Fertilizers and Pesticides Sprayers - A Review. International Journal for Innovative Research in Science and Technology 1(11):44-47.

Kulkarni SD (2012). Mechanization of agriculture – Indian scenario, Central Institute of Agricultural Engineering (CIAE), Bhopal, India. P 19.

Malik RK, Pundir A, Dar SR, Singh SK, Gopal R, Shankar PR, Singh N, Jat ML (2012). Sprayers and spraying techniques - A manual, CSISA, IRRI and CIMMYT.CG Block, National Agricultural Science Centre (NASC) Complex, DPS Marg, New Delhi 110 012, India. P 20.

Mari GR, Memon SA, Leghari N, Brohi AD (2002). evaluation of tractor operated potato planter. Pakistan Journal of Applied Sciences 2(9):889-891.

Singh P, Singh S, Singh BR (2014). Performance of Zero-Till Drill for Wheat Cultivation at Farmer's Fields. International Journal of Science and Research 3(7):2078-2084.

Subhagan SR, Dhalin D, Khtatawkar DS (2016). Comparative evaluation of electrostatic sprayer with powered mist blower. International Journal of Engineering Research and Development 12(8):04-11.