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EXPERIMENTAL OPTIMIZATION OF PRESSURE DISTRIBUTION MECHANISM IN A PNEUMATIC MAIZE PLANTER FOR LOCAL WORKING CONDITION IN PAKISTAN

Abstract. This study was conducted to evaluate the feasibility of optimizing a series-type air distribution system in pneumatic planter transforming uniform seed placement through efficient vacuum pressure with the blower rotation for the planting of maize crop. A laboratory-based experimental facility was designed to test the performance of the pneumatic planter under four blower speeds (600, 900, 1 200, and 1 500 rpm) and three seed metering (SM) disc rotational speeds (17, 22, and 28 rpm). The most critical performance parameters were the vacuum pressure, the velocity losses of air, and the uniformity of seed-drop. To determine the effect of the blower rotation the on vacuum pressure, the vacuum pressure was observed at different locations in the air distribution system. The experimental results were confirmed with ANSYS simulation modeling the dynamics of airflow and pressure distribution in the series air channel-type. The physical tests and the simulation tests done to determine the behaviour of the seeds in the airflow (vacuum pressure) and accurate delivery of the seeds. The findings revealed that revolution of blowers and rotation of the disc created a statistically significant difference ($p < 0.05$) in a vacuum pressure and seed distribution uniformity. The minimum optimal range of vacuum was –4.2 to –3.9 kPa that was created at 1 500 rotations of blower per minute (BR_4) and 22 rpm disc equivalence and the vacuum range was efficient on seed pick up and vortex seed loss. On the other hand, when the speeds of the blower were low (600–1 200 rpm) the vacuum pressure was weak (–0.24 to –2.28 kPa), with which the placement of the seeds was erratic. Even though BR_4 showed better performance, it also had the negative impact of increasing power requirement and fuel usage due to the heavy demand of the PTO on the tractor. The series type pressure distribution geometry optimized the performance of the pneumatic seed planter in terms of seed placement at BR_4 and disc speed of 22 rpm. Despite the enhanced reliability of operations when there is increased speed of blowers, careful thought should be put on energy efficiency.

Keywords: pneumatic planter, optimization, ANSYS, vacuum pressure, sowing uniformity

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ЭКСПЕРИМЕНТАЛЬНАЯ ОПТИМИЗАЦИЯ МЕХАНИЗМА РАСПРЕДЕЛЕНИЯ ДАВЛЕНИЯ В ПНЕВМАТИЧЕСКОЙ СЕЯЛКЕ ДЛЯ КУКУРУЗЫ С УЧЕТОМ ЛОКАЛЬНЫХ УСЛОВИЙ РАБОТЫ В ПАКИСТАНЕ

Аннотация. Исследование было проведено с целью оценки возможности оптимизации последовательной системы воздушного распределения в пневматической сеялке для обеспечения равномерного размещения семян посредством эффективного вакуумного давления при вращении воздуходувки для посева кукурузы. Лабораторный экспериментальный стенд был разработан для испытаний пневматической сеялки при четырех скоростях вращения воздуходувки (600, 900, 1 200 и 1 500 об/мин) и трех скоростях вращения высевающего диска (17, 22 и 28 об/мин). Ключевыми параметрами оценки являлись вакуумное давление, потери скорости воздуха и равномерность высева семян. Для определения влияния вращения воздуходувки на вакуумное давление последнее фиксировалось в различных точках воздушной распределительной системы. Экспериментальные результаты были подтверждены моделированием при помощи CFD-технологии ANSYS (рассчитывались динамика воздушного потока и распределение давления в системе с последовательным воздушным каналом). Физические испытания и численное моделирование использовались для определения поведения семян в воздушном потоке (вакуумном давлении) и их точной подачи. Результаты показали, что скорость вращения воздуходувки и диска создавали статистически значимую разницу (p < 0,05) в вакуумном давлении и равномерность распределения семян. Минимальный оптимальный диапазон вакуума составлял от –4,2 до –3,9 кПа, что достигалось при 1 500 об/мин воздуходувки (BR_4) и скорости вращения диска 22 об/мин, и этот диапазон был эффективен для захвата семян и снижения потерь из-за вихревого эффекта. С другой стороны, при низких скоростях вращения воздуходувки (600–1 200 об/мин) вакуумное давление было слабым (от –0,24 до –2,28 кПа), вследствие чего размещение семян было неустойчивым. Несмотря на то что режим BR_4 показал лучшие результаты, он имел недостатки – рост потребления мощности и топлива из-за высокой нагрузки на ВОМ трактора. Геометрия конструкции последовательной системы подачи воздуха позволила оптимизировать работу пневматической сеялки по равномерности размещения семян при BR_4 и скорости диска 22 об/мин. При увеличении скорости вращения воздуходувки обеспечивается высокая надежность работы, однако следует учитывать вопросы энергоэффективности.

Ключевые слова: пневматическая сеялка, оптимизация, ANSYS, вакуумное давление, равномерность высева

Для цитирования: Экспериментальная оптимизация механизма распределения давления в пневматической сеялке для кукурузы с учетом локальных условий работы в Пакистане / Афтаб Халик, Фиаз Ахмад, Ибрар Ахмад [и др.] // Весці Нацыянальнай акадэміі навук Беларусі. Серыя аграрных навук. – 2026. – Т. 64, № 1. – С. 76–88. https://doi.org/10.29235/1817-7204-2026-64-1-76-88

Introduction. Maize (Zea mays L.) is widely grown to make several types of by products, which are used in the food and industrial sectors where demand is on a rapid increase in Pakistan, the maize production has improved through its production growing from 6.134 million tonnes to 8.465 million tonnes over the recent five years. Although this is a satisfactory production, reports show that there is a considerable gap between expected and actual yields of maize (8–12 t/ha and 4 t/ha respectively) in Pakistan [1]. Precision sowing machinery can help to establish seedling significantly, thus maximizing the crop yield and profit generation in a unit acre of maize production [2, 3]. The precision seed planters are considered as a better choice, in comparison with traditional and labor-intensive seeding systems [4].

The pneumatic precision planter has been designed with mechanically operated seed metering system that operates under vacuum pressure. The stability of the vacuum pressure has a large impact on the operational efficiency of a pneumatic seeder [5]. Pneumatic planters work with the both positive and negative pressures [6]. The working performance of the pneumatic planter is directly affected by the uniformity and stability of the air distribution system. The length of pipe and distance between the inlet to outlet have insignificant effects on the pressure and velocity loss [7, 8]. However, airflow distributors allocation is one of the most important factors to maintain the desired air pressure for efficient sowing [5, 9, 10]. It can enhance the engine power requirement to attain the desired pressure [11]. Therefore, the importance of the allotter in the air supply system cannot be ignored [5]. Reports show that the airflow distribution geometry highly affects the pressure loss during field operation of pneumatic planter [12–15].

Various studies evaluated design and operating conditions for pneumatic planter air distributors [9, 16–18]. Dai et al. [19] determined the effect of inlet pipe diameters on the pneumatic pressure of the precision planters and found that the increase in internal diameter of the pipe negatively affects the pressure of the pneumatic planter during the sowing operation. Yin et al. [5] examined four types of air distribution allotters for pressure stabilization in the corn planter using computational fluid dynamics (CFD) simulation and found that paralleled axis of the inlet and the outlet was the best way to kept the pressure consistency in seed metering system. Ghafori and Sharifi [20] evaluated the effect of the elbow angles (45°, 60°, and 90°) in the flow pipe with auxiliary air to the initial air intake for the pneumatic planter on seed delivery using CFD simulation and concluded that the 45° elbow performed well and reduced the conveying energy requirement and mitigated the seed damage [20]. The coupling of CFD with Discrete Element Method (DEM) is also an excellent option to simulate the air distribution geometries [21]. Hui Li et al. [22] conducted a research study to optimize the seed motion characteristics and working parameters of an air-assisted centralized pneumatic metering system using CFD-DEM simulation and the simulated results exhibited that air flow velocity 20–24 m/s at different feeding rates improved the sowing uniformity and economized power consumption of the seedling system. The literature reports that an irrational mechanism for the air distribution system of the precision metering device causes uneven air distribution in each seeding unit, high pressure loss, seed loss, and also affects the field performance [23, 24].

The most of pneumatic planter used for maize sowing in Pakistan has a series type air distribution system. The available precision planters consume high power and show less uniformity in drilling the seed. Optimization of air flow system in the pneumatic planters is one of the main hurdles in the adoption of pneumatic planters. Very little is known about the pneumatic air flow geometry, hence it is direly needed to optimize the air flow system in the pneumatic planter.

Thus, the present study was conducted to investigate the effect of air distribution system on pressure profile and by compared with CFD analysis using ANSYS for its validation. The study was also aimed to optimize the series type air distribution system of pneumatic planter at various blower rotations and to determine its effect on the vacuum pressure, air velocity loss and their impact on the seed drop.

Material and Methods. ***Study Site.*** The laboratory experiment tests were performed at the Farm Machinery workshop of the Department of Agriculture Engineering, Bahauddin Zakariya University (Multan, Pakistan). The precision planter was operated with 85 Hp tractor (Millat 385 model) and the seed metering mechanism with 1 kW electric power motor which was integral part of the planter. The graded maize seed (Pioneer-P1429) with 90 % germination rate was used in all treatments to measure the performance of seed metering system.

Pneumatic Planter. In this study, pneumatic precision planter (AgriTech model 2018, AgriTech Industries, Multan, Pakistan) was used for the lab testing and validation of simulated results. The main part of this planter is a perforated seed disc and a circular rotation air suction blower which suck the air from the inlets at the right of each metering unit through 274 cm long pipe and create vacuum. The outlet reaching pipe that conveys the air to outlet was connected with four pipes having 5.10 cm diameter. The blower fan having 52.98 cm diameter was operated with the tractor PTO shaft to create the vacuum pressure. Four rubber pipes connect with the inlet to the air delivery pipe in the series combination. On the rear side of the planter two pneumatic wheels were attached, right side wheel rotates the fertilizer unit and left side operate the seed metering unit. The planter has two furrow openers which makes 68.5 cm wide furrow bed to place the seed (Figure 1).

Working of Laboratory Experimental Setup. The air distribution system plays significant role in the pneumatic planter which stabilize the vacuum pressure for its field. The planter was tested in the laboratory by using a test bench at the farm machinery laboratory of the Department of Agriculture

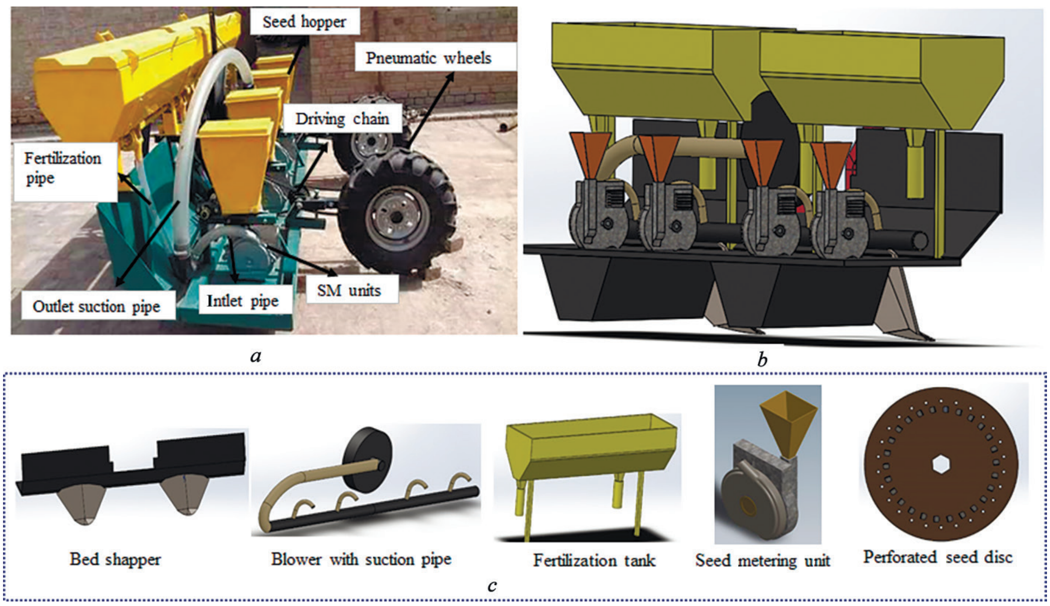

Figure 1. Pictorial representation of AgriTech pneumatic planter (*a*); developed model of planter (*b*); CAD model of planter: functional parts of planter (*c*)

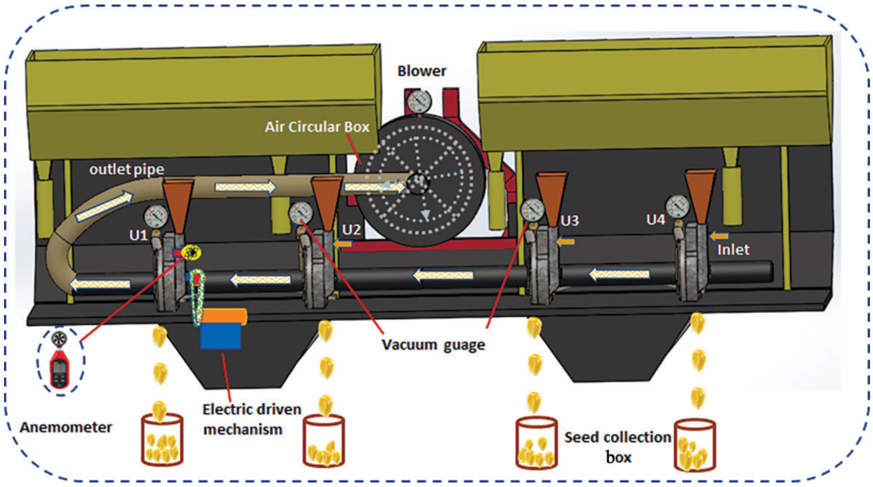

Figure 2. Schematic view of the lab scale motorized test bench

Engineering, Bahauddin Zakariya University. Pressure gauges were installed on each seed metering unit (U_1, U_2, U_3, and U_4) to observe the vacuum pressure. Figure 2, shows the schematic view of the lab test bench which fully equipped with pressure gauge to determine the pressure distribution and seed collectors for seed dropping profile. The test bench was also equipped with an electric motor to run the metering unit at the smooth rotation of seed disc [25, 26] and seed collection boxes. Three sprockets of different diameters were also attached with electric motor to variate the angular speed of seed disc. The main focus of this experiment was to investigate the effect of airflow distributor geometry on the pressure distribution and air velocity profile in four air inlets of seed metering units at the different blower rpm. The pressure loss also effects the seed dropping profile [10, 27, 28].

The effect of pressure loss on the seed drop efficiency also evaluated at different blower rpm and disk rotation as shown in (Table 1). Airflow velocities were measured using a mini anemometer (UT363), with a range from 0.30 m/s and 5 % rdg + 0.5 accuracy. The rotation of the metering disc and blower pully count using Digital Photo Tachometer (RM-1500/1501/1502) PROVA instruments INC. Digital Photo Tachometer had the capacity to count the rpm (10–29999) range with 0.04 % ± 2 accuracy. The planter was tested in the laboratory using selected parameters as shown in Figure 3.

Table 1. **Operational parameters for lab scale testing of machine**

Sr. No.	Parameters	Values
1	Blower revolution (rpm)	600 (BR_1), 900 (BR_2), 1 200 (BR_3), 1 500 (BR_4)
2	Disk rotation (rpm)	17, 22, 28

CFD Simulation of Air Distribution System. The CFD simulation was conducted to determine the effect of air flow geometry on the air pressure and to validate the laboratory findings for the optimization of the planter design. During maize sowing, air pressure was ensured (–3.5 to –4 kPa) in the distributors of the pneumatic precision planter. The CFD method was applied to different mechanical design structures [12]. For the computational method commercial ANSYS (Workbench) Fluent Release 16.2 ©SPS IP, lnc., software was used to analyze the vacuum pressure at each intel.

Building of Geometry. The findings of the flow field analysis depend primarily on the extraction of the computational region and grid features [29]. Therefore, three dimensional solid model of air distribution pipe was design using SolidWorks premium (2022) software (Figure 4, *a*). To simulate pressure distribution in ANSYS Fluent through air delivery mechanism, there is no need to design all part of the precision planter. The material which was used for the development of air distribution pipe was mild steel with density 7 850 kg/m^3, elastic modulus 210 GPa and poison ratio 0.303.

Generation of Mesh. The meshing had done in the ANSYS Fluent 16.2, to build the finite element model as shown in Figure 4, *b*. To get the maximum accuracy of quantitative analysis, tetrahedral cell meshed by fine size of meshing. The grid structure during meshing was cell-vertex to decompose

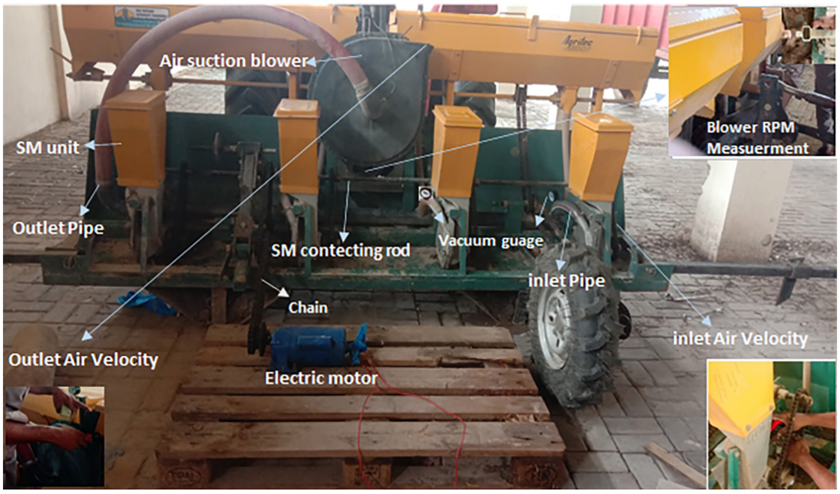

Figure 3. Depiction of laboratory experimental setup to evaluate the series type air distribution system and seed metering (SM) unit

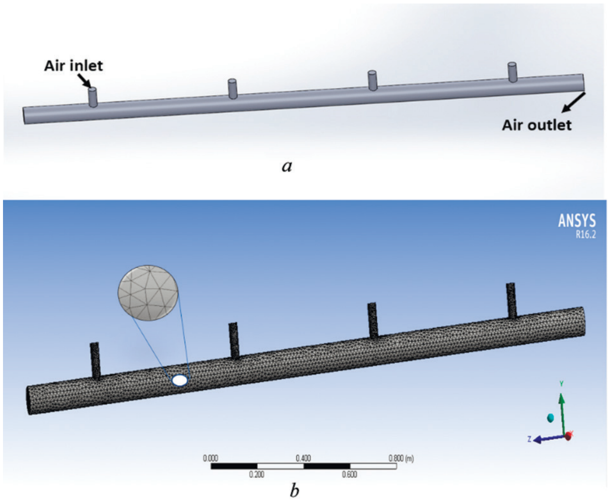

Figure 4. Physical 3D model (*a*); ANSYS meshing of model (*b*)

the flow domain into control volume. The model was meshed with mesh size 1.2 × 10^{-3}, transition ratio 0.72, 137 208 elements and 29 662 nodes.

Boundary Baseline and Parameters. The correctness of calculation is strongly relaying on the boundary conditions of the conducted study. In this study, the mechanics of boundary conditions involved were the blower revolution, airflow velocity and vacuum pressure. To establish these conditions, the reference pressure utilized was the normal room pressure, also known as static pressure (p_0), which is equivalent to 101 325 Pa (760 mmHg). This pressure applied at each inlet, along with the airflow velocity which obtained from laboratory experiments at 600, 900, 1200, and 1500 rpm of the blower. The inlet pressure 10 135 Pa was selected for simulation whereas outlet pressure was adjusted –4000 Pa which is the optimum pressure for maize seed sowing with precision maize. Four different inlet air velocity (18, 30, 45, 55 m/s) was selected for simulation. The laboratory findings were used as input in the simulation model to obtain a pressure profile in the series base air distribution pipe, especially with the variation of airflow velocities.

Model Validation. After the mesh validation the next step was the selection of numerical model for the smooth simulation process. The airflow in the precision pneumatic device was determined to be a continuous compressible phase due to the fact that the flow velocity exceeded with the PTO and blower rotation. This study examined the pressure distribution in the pneumatic pipe. Therefore, with the relativity of the Reynolds number in the air suction units the $k - \varepsilon$ turbulence model was selected. The base of CFD simulation for the airflow turbulence analysis worked on the following equations (1) and (2) describe as mass and momentum conversation equation or Navier Stokes transport equation [30]:

$$\frac{\partial \rho}{\partial t}+\frac{\partial}{\partial x_j}(\rho u_j)=0, \tag{1}$$

$$\frac{\partial \rho u_t}{\partial t}+\frac{\partial \rho u_i u_j}{\partial x_j}=-\frac{\partial p}{\partial x_i}+\frac{\partial \sigma_{ij}}{\partial x_j}\text{standart } k+F_i, \tag{2}$$

where ρ – fluid density (kg/m³); t – time (s); x_j – spatial coordinate (j = 1, 2, 3 for 3D space); u_i, u_j, – velocity component in the j-th direction (m/s); u_t – velocity component (typically time or total velocity); p – pressure (Pa); σ_{ij} – viscous stress tensor components (N/m²); F_i – body force per unit volume (e.g., gravity, buoyancy) in direction i (N/m³); standard k – turbulent kinetic energy.

The equation (3) describes determination of the k – ε turbulence model kinetic energy k and dissipation rate ε:

$$\frac{\partial}{\partial t}(\rho k)+\frac{\partial y}{\partial x_i}(\rho k u_i)=\frac{\partial}{\partial x_j}\left[\left(\mu+\frac{\mu_t}{\sigma_k}\right)\frac{\partial k}{\partial x_j}\right]+P_k+P_b-\rho\varepsilon-Y_M+S_k, \quad (3)$$

where k – turbulent kinetic energy (TKE) (m²/s²); μ – molecular dynamic viscosity (Pa·s or kg/m·s); μ_t – turbulent (eddy) viscosity; σ_k – turbulent Prandtl number for k; P_k – production of k due to mean velocity gradients; P_b – buoyancy production (or destruction) of turbulent kinetic energy; ρε – dissipation rate of TKE (energy lost due to turbulence); Y_M – contribution of fluctuating dilatation in production of k compressible turbulence to the overall dissipation rate; S_k – user-defined source term (additional sources of k).

Data Analysis. For the data analysis used statistical Software (Statistix 8.1, Tallahessee, FL, USA) for analysis of variance (ANOVA) and (LSD) pairwise evaluation of the collected data for laboratory experiments. The least significant difference (LSD) test was used to segregate treatment outcomes. However, the F-test indicated statistical significance at the 0.05 probability level.

Results and Discussions. ***Laboratory Experiment Outcomes.*** Pneumatic maize planter needs to work under suitable and stable air pressure for the precision sowing of seeds. Therefore, the experimental workbench was tested at four blower revolutions to adjust the minimum pressure loss and efficient air velocity profile.

This Figure 5 shows, the loss of pressure at the PU during laboratory experiments. The mean values of the pressure and air velocity loss at four metering units were collected after three repetitions. The statistical analysis of the data shows a significant factor ($p < 0.05$).

The vacuum pressure (–2.11, –1.78, –0.75, and –0.24) kPa was observed on U_1, U_2, U_3 at U_4 at BR_1 was 600 rpm. Figure 6 also shows that as the with the increase of the blower speed the vacuum pressure

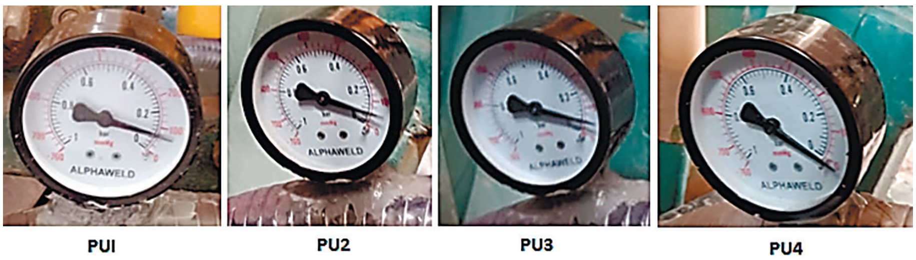

Figure 5. Pictorial presentation of unit-wise pressure loss in pneumatic units (PU) at selected blower revolutions

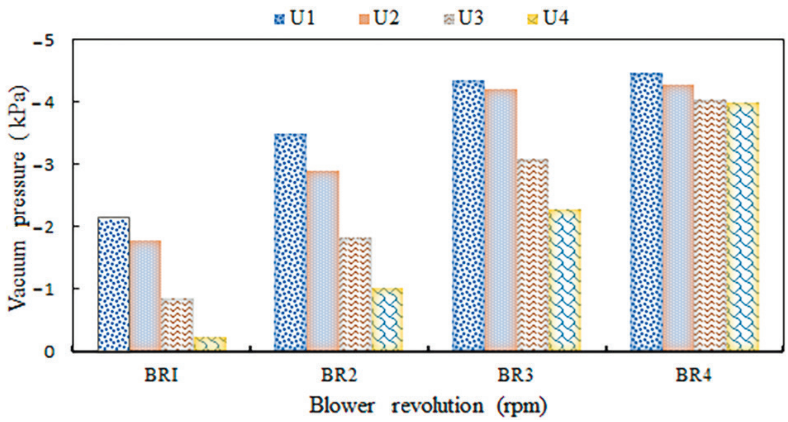

Figure 6. Graphical presentation of unit-wise pressure profile at selected blower rotations

availability also increased such as vacuum pressure was increased on U_4 from –1.02 kPa to –2.28 as the blower revolution increased from 900 (BR_2) to 1200 (BR_3) and similar trend was also observed on other units. However, graph shows that there was minimum pressure variation (–4.45, –4.27, –4.03, and –3.98) kPa on all seed distribution units found at the 1 500 rpm (BR_4) of blower revolution as compared to that of other blower speeds. Likewise, during the laboratory experiment found the average pressure variation at whole metering system was –2.8 kPa at BR_1, and –1.7, –0.5, –0.2 for BR_2 to BR_4. The findings also revealed that in series type air distribution system reduced the pressure loss with increasing the blower revolution but utilized more the engine power.

It represents the pressure loss in each PU at different blower revolutions. In a series-type air supply system, the pressure drops from unit to unit but was minimum at the unit which was close to the outlet.

Effect on Air Velocity. Figure 7 displays that pressure drops directly relate to the air velocity profile at pneumatic units. In a series type supply system, the air velocity drop at the inlets as far from the suction outlet [5]. Additionally, the air velocity profile describes with the set of multi-color histograms on the graph. The set of extreme left histograms (BR_1) shows that the air velocity dropped from 1.78 m/s at U_1 to 0.68 m/s at U_4. The air velocity profile at BR_2 was (2.06, 1.62, 1.40, and 1.10) m/s while at BR_3 ranges from (2.49, 2.36, 1.96, and 1.60) m/s from U_I to U_4. Furthermore, the depiction of histogram height on the graph shows that at BR_4 found a minimum air velocity drop was (3.2, 3.16, 3.10, and 3.08) m/s which helps to attain the maximum pressure. The height of histogram at the first three blower revaluations, clarify that at BR_2 and BR_3 the air velocity drop was less as compared to BR_1 that increases the utilization of PTO power. The collective air velocity from each inlet helps out to maintain the –4 kPa pressure which is recommended for maize seed sowing. The collective air outlet velocities at tested blower revolutions were 18 m/s at BR_1, 30 m/s at BR_2, 45 m/s at BR_3 and 55 m/s at BR_4 which used in the CFD analysis.

The graph variations were cleared that the planter attain optimum pressure and air velocity at BR_4 for proper seed picking from the perforated seed disc. The air velocity and vacuum pressure play important role in the precise placing of seed at the adjusted distance and depth [31–33]. However, the histograms of the laboratory experimental data reveled that as like pressure, the air velocity profile was stabilize at BR_4, and gradually decrease from U_2 to U_4. There should be need to improve the air distribution system to stabilize the air velocity and pressure with minimum utilization of tractor power.

CDF Simulation Analysis. Computational fluid dynamics (CFD) study was conducted to characterize the effect of air distribution geometry on the pressure profile by the feasible model selection and numerical simulation under the different inlet air velocities. Therefore, the measured values of study provide the idealized condition to optimizing of the air distribution geometry.

Figure 8, *a* & *b* represents the CFD simulation of pressure distribution geometry at the 600 and 900 blower rpm. The air velocity at the inlets of simulation model was 18 m/s for BR_1 and 30 m/s for BR_2, with 10.1325 and –4.000 kPa inlet pressure and outlet pressure. The selected air flow velocity was constant in each unit during CFD simulation. The contours of the simulation result show multi-color profile which describe the pressure pattern. These contours pattern of simulation shows that there

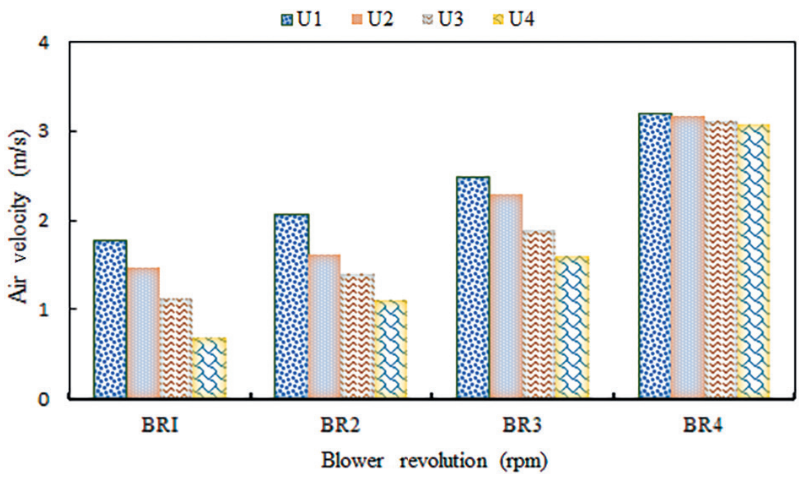

Figure 7. Depiction of unit-wise air velocity profile at selected blower revolutions

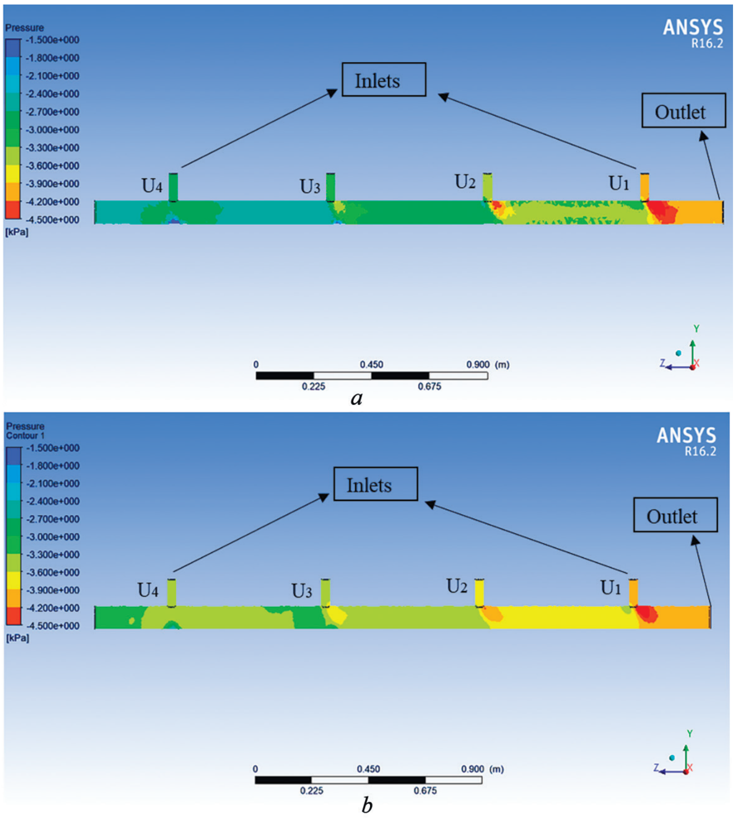

Figure 8. Depiction of pressure distribution profile at 600 blower rpm (*a*); at 900 blower rpm (*b*)

is highest pressure loss at 600 rpm of blower revolution. The color gradient of pressure contours in air delivery pipe shows that unit wise drop of pressure had similar trend as the laboratory experiment. The color gradient (legends) in the Figure shows the range of pressure –4.2 to –3.9 (red), –3.9 to –3.3 (yellow), –3.3 to –2.7 (green) and –2.7 to –2.1 (indigo). In the Figure extreme right-side contours with red color represents the inlet which close to the outlet. Likewise, the change of contours color from red to indigo depicted the variation of pressure in the U_2 to U_4. The pressure contours with multi-color gradient showed that the pressure at the 18 m/s inlet velocity was (–3.6, –2.95, –2.46, and –1.72) kPa whereas, at the 30 m/s inlet velocity the pressure was (–3.84, –3.45, –3.19, and –2.81) kPa from U_1 to U_4. From the pressure contours of BR_1 and BR_2 cleared that the pressure drops gradually increase as the inlet away from the outlet. The reason behind that the elongation of air delivery pipe pressure drop was more at unit U_4 due to less air friction [5].

Figure 9, *a* & *b* illustrate the pressure profile at 1 200 and 1 500 blower rpm. The simulations were performed at air inlet velocities of 45 m/s for BR_3 and 55 m/s for BR_4. In Figure 9, *a* contour had the color range from red to green which shows the –4.2 to –3 kPa pressure range. The color combination of the simulation results depicted that at the 45 m/s air velocity the pressure profile was in between –4.2 to –3.6 kPa in the first three units and –3.6 to –3 kPa between U_3 and U_4. In Figure 9, *b* represents the distribution of vacuum pressure at 55 m/s air velocity in each unit was between –4.2 to –3.9 kPa with minimum drop. The contour gradients show that the pressure distribution was –4.2 kPa at the U_1, while (–3.99, –3.92, and –3.91) kPa at the U_2, U_3, and U_4. The simulation results conclude that at the 1 500 blower rpm or 55 m/s velocity had a minimum unit wise pressure drop as compare to other three air velocities. The gradients of contours show only red and yellow colors at BR_4 which identify the range –4.2 kPa to –3.91 of pressure. The laboratory outcomes and simulation findings cleared that the minimum pressure drop at 1 500 blower rpm and the planter performs well.

The research studies revealed that at low pressure the 15 to 25 % more missing index was produced due to the detachment of the seed with disc hole [34–36]. Therefore, the air suction blower rpm should avoid to operate in this range of 18 to 30 m/s air velocity or 600–900 rpm blower revolutions to overcome the seed loss.

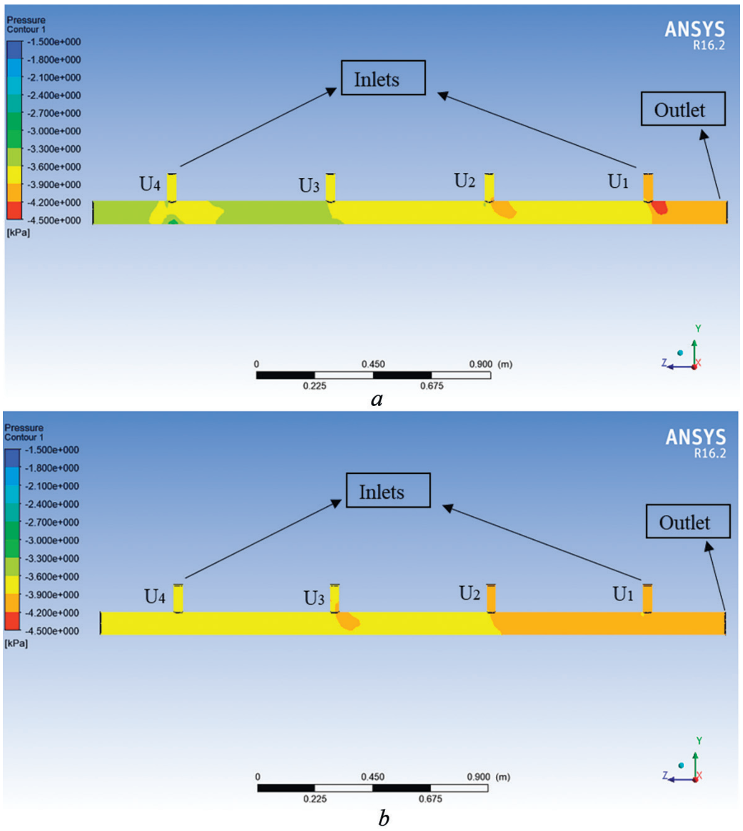

Figure 9. Pressure distribution profile at 1 200 blower rpm (*a*); at 1 500 blower rpm (*b*)

Comparative Analysis of CFD and Laboratory Outcomes. Comparative relation between the laboratory and simulation findings is presented in Figure 10. The amber lines with square markers represent simulation results of air delivery mechanism while blue lines with circular markers stands for laboratory results. In the graph, for BR 600, the amber line shows sharp dip and reflects pressure from –4 to –1 kPa while blue line has gentle slope from U_1 to U_2 and compares slope pattern with the amber line. Variation in the gradient of the lines was noticeable for the case of BR 1 200. These variations can be linked with each other at three units (U_1, U_2, and U_3) and deviate at U_4. Furthermore, at the 1 500 BR the both simulation and laboratory experiment outcomes lines were closed. The graphical representation of comparative results suggested that a clear gap between effect of pressure drop at the 600, 900 and 1 200 blower rotation (BR) or 18, 30 and 45 m/s air velocities. The outcomes of both studies revealed that at the 1 500 blower rpm or 55 m/s air velocity, the pressure distribution was stabilized in between –4.2 to –3.9 kPa in each unit. However, this is the efficient condition for maize seed picking and precise placement in the soil.

Comparison of the study pointed that air friction in pipe effected the pressure and air velocity. When the pipe is long, pressure and velocity drop is usually insignificant due to pipe friction. But if the length of the pipe or channel is very short, these so-called minor losses may become major [5, 37]. The experiment and simulation results indicated that the length of the air delivery pipe and inlet connection were two significant parameters that directly affect the pressure and velocity drop.

Effect Studied Parameters on Seed Dropping. The seed dropping profile also evaluates at three disk rotations R_1, R_2, and R_3 (17, 22, and 28) rpm which was tested at four blower revolutions 600, 900, 1 200 and 1 500 rpm as previous calculations. Figure 11, shows the graphical representation of the seed dropping profile with respect to weight drop from each unit at selected blower rpm and disc rotations. In the graph, lower black line with blue markers shows the seed dropping at BR_1, amber dotted line with green square markers stands for the BR_2, middle green line with red triangular markers represents the BR_3 seed frequency. Further, the top dark blue line with cross square markers depicted the seed dropping at BR_4 which shows the maximum frequency. The seed corporations in Pakistan provide 8–10 kg seed weight per acre for maize crop. According to this the perforated seed disc with 26 holes should

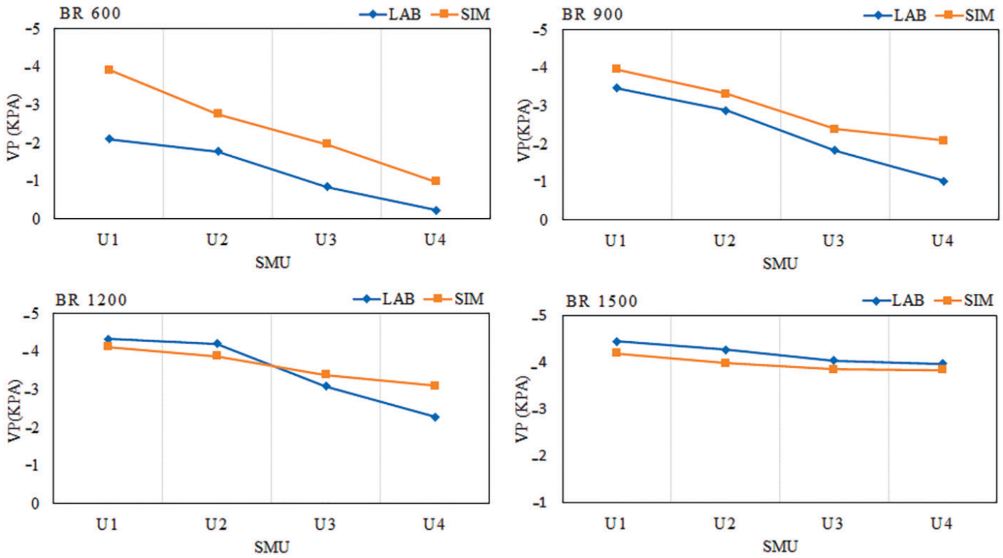

Figure 10. Comparison of laboratory and simulation finding for the validation of study

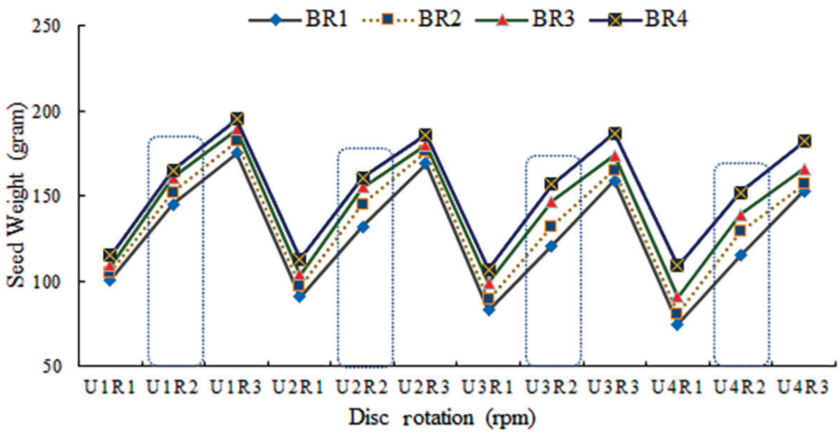

Figure 11. Effect of seed drop with the variation of blower rotation

drop 113 g seed at 17-disc rpm, 168.8 g at 22 and 187.62 at 28 rpm of disc. The colored graphical lines depicted the data which cleared that at 22-disc rpm and 1 500 blower revolution (BR_4) the seed drop equally from each unit (U_1R_2, U_2R_2, U_3R_2, U_4R_2). The graph lines show that at the first unit (U_1) seed dropping rate was near to calculated amount but decrease up to this like with effect of pressure drop. The frequency of seed dropping equalize at BR_4, because of the low pressure drop that was cleared during laboratory and simulation study.

The seed dropping from the unit at the 17 and 28 disc rpm shows more variation as the pressure profile. The blue doted boxes on the graph lines identify the minimum seed loss at R_2 and selected blower revolutions (BR) in seed metering units. This study concluded that in the series types air distribution system the at the 22-disc rpm and 1 500 blower rpm could be an efficient condition to reduce the seed loss in the pneumatic planter.

The reasonable allocation of the airflow system is important to equalize vacuum pressure in precision planters [6, 10, 38]. The importance of the air supply system cannot be ignored during the planter design [39]. The laboratory experiment and simulation results concluded that it is necessary to change the air distribution geometry in parallel, cylindrical end distribution air allotters, and cylindrical circumferential distribution air allotters for the equal distribution of pressure and air velocities [40–43]. The high suction force increases the use of engine power and fuel consumption. The pressure on each unit affects the seed dropping. For the efficient sowing of maize crop the optimum pressure should be round to 4 kPa [17, 44]. The motorized seed metering mechanism control the disc rotation during sowing.

This study concluded that for the series types air distribution system required highest blower revolution (1 500 rpm) which will ultimately require higher power to stabilize the pressure for pneumatic planter and speed placement.

Conclusion. Precision planters are the best option to mechanized the maize sowing, as the air distribution geometry plays vital role on the performance of the pneumatic planter. In this study the optimization of the air distribution system of local pneumatic planter had been performed to investigate the pressure configuration. The laboratory experiments and ANSYS simulation were performed to investigate the planter performance at 600, 900, 1 200, and 1 500 blower rpm. The outcomes of the laboratory and simulation study concluded that at the blower revolution of 600, 900 and 1 200 rpm had a 18, 30 and 45 m/s air velocity create more pressure drop from –3.5 to –1.8 kPa, which badly effect the planter performance. Furthermore, at the 1 500 rpm or 55 m/s air velocity the operating pressure was in between from –4.2 to –3.9 kPa which is recommended for the maize seed sowing. To maintains this pressure, the series air distribution system, utilize more engine power and fuel consumption as high blower revolution. The wheel driven seed mechanism of planter converts into motorized system to control the seed disk rotation at 17, 22, and 28 rpm. The laboratory experimental outcomes found the efficient seed dropping with minimum seed loss at 1 500 rpm of blower and 22 rpm of disc rotation. The experimental data and results of this study provides the research guidelines and design consideration to modify the new pneumatic planting machinery.

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