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Development of Backpack Battery Powered Ultra-Low Volume Crop Protection Machine

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Abstract:-The purpose of applying agricultural chemical is to supply nutrients for plant growth and pest control. Thus, acceptance of spray chemical as an effective crop husbandry practices had lead to development of many sprayers, some of which have remained ineffective, expensive and uneconomical and obsolesce. A triplicate test was conducted in laboratory and field was found to be satisfactory and workable. The maximum swath width of developed machine is 1.0 meter and cover 0.4.hecter per hour. It has 1.02 coefficient efficiency. The construction of the back pack tank permits replacement of worn out parts and easy handling during operations.

Keywords:- Agricultural Chemicals, Backpack, Crop protection Machine.

I. INTRODUCTION

Application of science and technology in farming is advancing speedily in developing countries, especially Nigeria. The purpose of applying agro-chemical is to supplement artificial nutrient, control pests and diseases in crop production. Ajit and Roger (1993) defined pesticide as a chemical that kills pest. Pest may include weeds, insects, fungi etc. According to their recent report, agro-chemicals includes; artificial fertilizer, insecticide, herbicide and growth regulating hormones. Liquid chemicals which may be in form of emulsion concentrate, suspension or wet able powder are either contact, systematic or fumigant.

Ciba-Geigy chemical company (1986) defined herbicide as spray mixtures which interfere with plant life and killing the target plant. The mode of actions includes; altering cell balance, interfering with cell formation, causing abnormal growth and inhibit photosynthesis. They may be selective or non selective.

Olufade (1980) reported that farming operations. He further classified types of battery powered sprayer into; Electrodyn sprayer made of electric discharge feed tank with earthen electric static wire and hand-held cultural-low volume sprayer using gravity feed tank with electric motor.

Culpin (1986) reported that hand-held battery powered sprayer utilizes a single disc, fitted with gravity feed tank of 1.0 – 5.0 liters capacity and are mostly employed in small farms and vegetable crops. On the other hand, Micro (1997) reported that, spray droplet depends on the spinning disc and dry cell battery strength. The serrated edges of discs breaks chemical spray mix into fine droplets and deposits by breeze, thus allowing several rows to be treated in single pass.

Knapsack sprayer for instance require the use of large volume of water, thus several refilling of tank is necessary before one acre of land could be sprayed. This is a problem where water is scarce. This design will provide an affordable means of spraying chemicals mix without frequent refilling of tank. It utilizes spray mix economically and effectively and is suited for developing countries technology especially Nigeria. Therefore, the objective of this study was to develop a battery powered ultra-low volume sprayer of efficient utilization of agricultural chemicals.

II METHOD

Stout (2002) senior expert reported that, locally available materials must be considered in fabricating machines to reduce the manufacturing cost.

2.1.1Design Consideration

In design consideration more attention will be needed to design of machine for condition in developing countries and especially the needs of small famers.

Thus, the following parameter was considered in development and fabrication of the crop protection machine.

2.1.2Backpack Tank

The backpack tank is a reservoir of spray mix with maximum capacity of 10 liters; 320mm height, 240mm length and 160mm breadth. Two holes were constructed, one on the top discharge. The tank cover is vented for atmospheric pressure with vent tube of 3mm diameter and effective length of 25mm.

2.1.3 Battery Case

A cylindrical shape for housing five dry cell batteries with effective length of 607mm and 40mm diameter was constructed with poly vinyl chloride (PVC) because of its resistance to chemical attack and corrosion agents.

2.1.4 Extension Tube

A square tube, measuring 10X10mm and effective length of 670mm was constructed for extension of the sprayer head. It is resistant to corrosion, low density and thus easy to handle during field operation.

An electric device that converts electric power to mechanical power enables the spinning disc to distribute and deposit spray mixture on target plants or pests. The electric motor uses a starter with wound rotor, having lops of wire. The rotor consists of commutator and winding (armature) with effective diameter of 20mm. The loops terminate at commutator segment on which stationary brushes are fixed. The in-built maximum speed of the motor is 4000 rpm with fully charged batteries.

2.1.5 Spinning Disc (atomizer)

Spinning disc is a plastic material of S.A.E with tensile strength of 46MPa. It is resistant to acid, alkaline and petroleum solvent. Spray liquid is fed by gravity tank through feed nozzle. As the spray mixture splashes on the disc blade, it breaks into fine droplets by the serrated edges of the disc. The centrifugal force acting on the disc finally breaks into fine particles for distribution and disposition.

2.1.6 Strap Assembly (Belt)

Strap assembly includes hooks, slide and belt for firm and rigid support on the back of the operator during field operation. The belt was made of nylon material while the hooks and slide were made with plastic materials. Slides are adjustable to suit the height of different operators. Hooks are also fastened on the bottom of the backpack tank. The maximum length of the belt is 80mm and 20mm width.

2.1.7 Tank Screen (Filter)

The tank screen was made of plastic material with fine mesh were of stainless steel.
The inlet and discharge diameters are 44mm and 80mm respectively while the height is 20mm.

2.2 Design of Machine Elements

2.2.1 Backpack Tank

The basic hydraulic principles influencing design of gravity-feed sprayer are as follows:

$Q_{max} = Va_o$ ---------- (1)

Where; Q_{max} is the maximum discharge of spray mixture in m^3/hr or litres/hr
V = the velocity of spray mixture through the tank orifice in m/s
$a_{o=}$ the area of tank orifice in m^2

$Q_{max} = a_o c \sqrt{2gH}$ ---------- (2)

Where; c is the overall head coefficient of discharge H= the height of liquid chemical in the backpack tank, g= the acceleration due to gravity in m/s^2

c = ---------- (3)

Backpack tank exert a force when loaded; thus W = mg
Where; W = weight of unloaded tank, m = mass of unloaded tank = 1.5kg based on laboratory measurement, g = acceleration due to gravity = $9081 m/s^2$
Weight of empty tank W = 1.5 × 9.81 = 14.72N
Now, force exerted by loaded tank is W = mg
Note: 1 litre = 1 kg, capacity of the tank = 10 litres = 10 kg + 1.5 kg = 11.5 kg
W' = mg = 11.5 × 9.81 = 112.8N

2.2.2Design of Strap Assembly (Belt)

Belt is subjected to tension when tank is loaded with spray mixture.
Maximum tensional stress $\Phi max = F/A$
Where F = weight of the loaded tank acting on one belt = 56.4N,
A = effective cross-sectional area of the belt = length × breath = $(1000 \times 32)\ mm^2$
$= 32.000 mm^2$
Tension acting on one belt, Φ = $= 0.00176 N/mm^2$

2.2.3 Construction and Fabrication of the Machine

The primary aim of this work was to design and construct a backpack battery powered ultra-low volume sprayer (as a better alternative to the existing obsolete gravity-feed battery powered sprayer) using relatively cheap and locally available materials for its fabrication and its construction to fit the current trend in farming especially in developing countries such as Nigeria.

The joining process was by fusion of the plastic parent material by melting and subsequent solidification to fabricate a hollow bracket for holding hooks and belts at the bottom of the tank.

A discharge at the side of the tank, with an effective diameter of 5mm and extension tube of 30mm for fitting the feed horse was carried out by plastic welding. The rear part was drilled using drilling machine for fitting the sprayer head and locking device. Holes were drilled in a similar way for fitting the switch plug ad other fastening devices.

The battery case has an effective length of 670mm to accommodate five dry cells of 1.5 volt. Tank screen was constructed using plastic materials and fine stainless steel mesh to prevent dirt and other fine particles from entering the back and subsequent blockage of the orifice. The shape of the screen is in form of screen is in form of a truncated cone. The fine mesh was welded using fusion with the plastic parent materials.

III. RESULTS AND DISCUSSION

The tests carried out involved laboratory and field tests on the fabricated machine. Result of the laboratory tests is presented in Table 1. The parameters considered includes flow rate through the orifice and nozzle, their corresponding velocities were also computed based on the data obtained at various level of heads of spray mixture in the tank. Measuring cylinder and stop clock were used in determining the flow rate. The result shown in Table 1 indicates that the machine is effective especially for small scale farms in areas with scarce water supply.

3.1 Field Performance Test

Field performance test was carried out using the modified version under conducive weather on a vegetable crop. The performance parameters of the modified version are satisfactory with efficiency coefficient of 1.02. It can spray 0.4ha/hr and utilizes 4.8 liters of spray mixture per hour at an operator's pace of 1m/s, when the battery is fully charged. It maintains one meter swath width with good uniformity coverage.

IV Conclusion and Recommendation

The triplicate field test conducted on vegetable crops with 'Cypercal 400 EC' insecticide indicates that the sprayer is effective and efficient for small and medium scale farms based on the flow rate, capacity, and distribution uniformity among other parameters.

The following are therefore recommended based on observations from the laboratory and field performance tests:

- The machine is efficient and effective especially in local areas with scarce water supply
- It is recommended for small and medium scale farms and vegetable crops
- It has effective uniformity of coverage with minimal environmental pollution
- The spray mixture is resistant to drift and evaporation
- The design provides easy replacement of worn out spare parts.
- It is trouble free during field operation and easy to handle.
- It reduces frequent refilling of tank during field operation.

Table1: Performance Parameters of Tank Orifice and Nozzle

Backpack	Flow Rate (ml/min)		Computed Velocities (m/s^2)	
Liquid Head (mm)	Tank orifice	Nozzle	Tank orifice	Nozzle
44	1200	160	1.60	6.40
88	1370	165	1.75	7.00
132	1425	170	1.90	7.60

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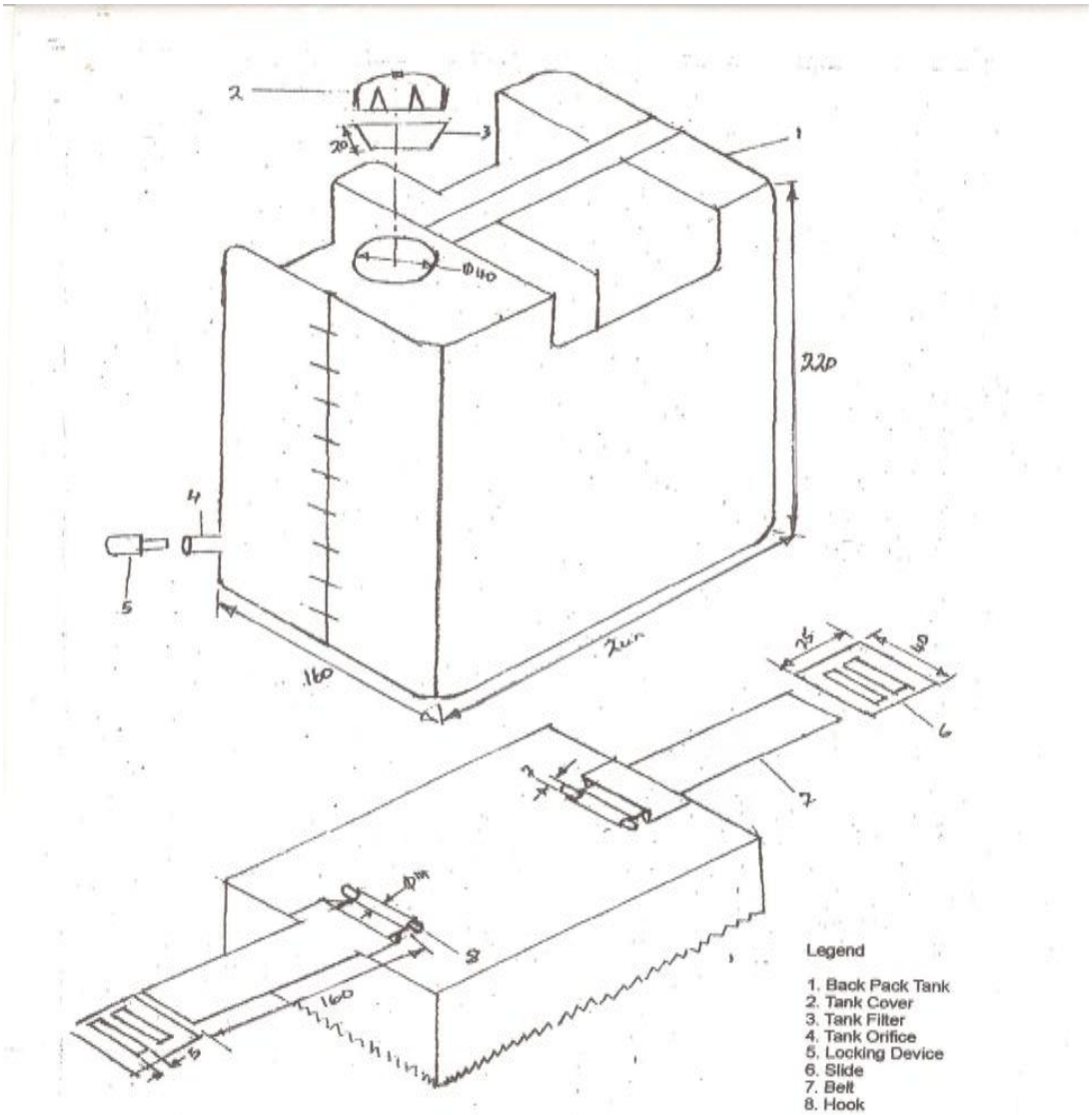
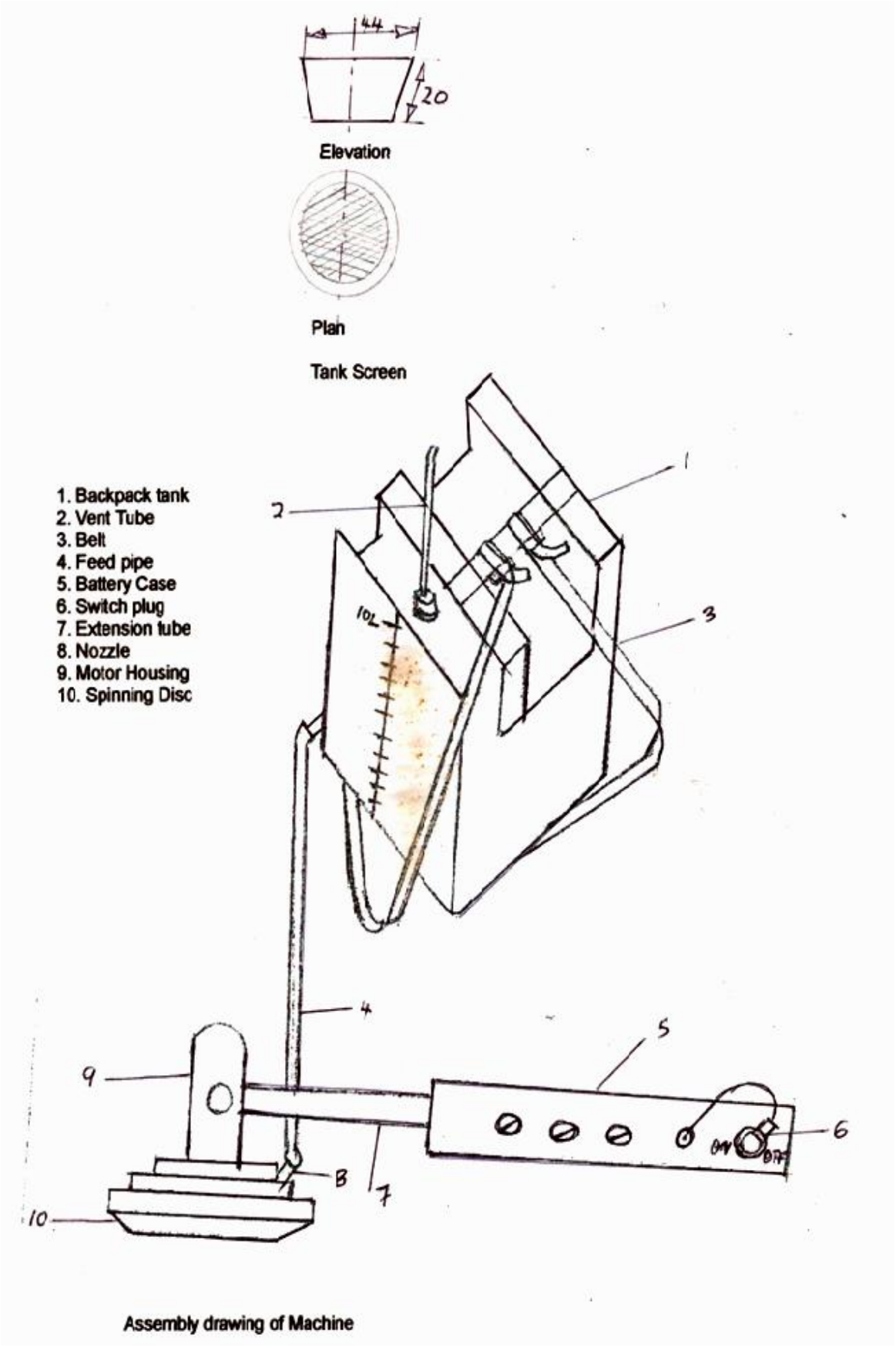
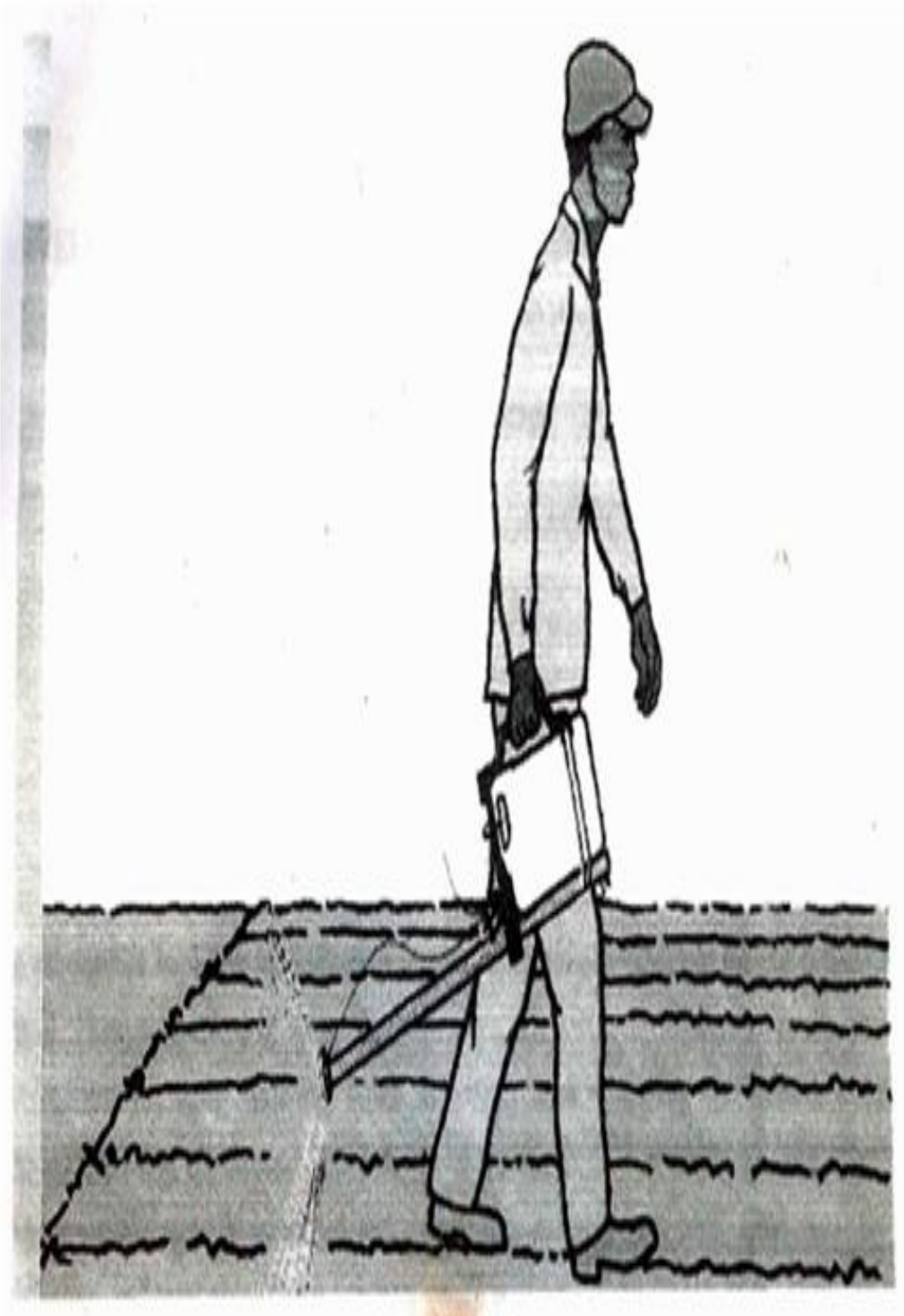


Fig 1: Isometric Design of back pack tank
All dimensions in mm



Assembly drawing of Machine



Field Operation of original version

Plate 1: Field Operation Test