Agric. Sci. Digest., 37(4) 2017 : 263-269
Print ISSN:0253-150X / Online ISSN:0976-0547

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
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Development of protective clothing for agricultural workers

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Received: 11-07-2017 Accepted: 13-11-2017 DOI: 10.18805/ag.D-4458

ABSTRACT

Farm workers are exposed to pesticide vapours and organic dust during various farm activities which may leads to many health problems. To minimize health hazards protective clothes were designed with reference to fabric and functional features. Designed protective clothing was given to twenty five farm workers involved in pesticide application and forty farm workers (25 males and 15 females) engaged in threshing activity, for a period of one month to access their suitability and acceptability. On the basis of suitability and acceptability recommended protective clothing for pesticide applicators were jacket with hood and *pyjama* of water proof fabric (having lining of cotton hosiery fabric), Chemical Resistant mask, Glasses/goggles, Nitrile gloves and Sports shoes. For threshing activity recommended protective clothing were : apron with hood and full sleeves with elasticized cuffs (elastic in two rows),Pleated mask / beak mask, Glasses/goggles ,Sports shoes, Mittens/gloves (for male) and for female : *Kameez* with full sleeves preferably elasticized cuffs or apron, hood mask/scarf mask ,glasses/goggles, sports shoes, mittens/gloves.

Key words: Acceptability, Design development, Functional features, Health hazards, Protective clothing, Suitability.

INTRODUCTION

India which has world's largest number of agriculture workers is one of the biggest producers in the world and new varieties being produced every day. The crop area under these high yield varieties need more water, more fertilizers, more pesticides and other chemicals. The agricultural workers are exposed to many risks *viz.*, biological, physical, chemical and trauma (Nadiger and Samuel, 2004). In developing countries, the use of pesticides is one of the most relevant occupational hazards for agricultural workers.

According to Mock and Jennings (1999) during pesticide application, the farm workers are exposed to pesticide vapours which enter body via dermal absorption, inhalation and ingestion. Pesticides are absorbed through skin at the time of mixing, loading, application, and equipment maintenance. Hence dermal exposure accounts for 87-90% of the total exposure of pesticides because the skin of a human adult has a superficial surface area of approx. 1.73 m^2, a major focus of accidental exposure (Weigel, 2012). Due to inadequate protective clothing and drift of spray droplets, farm workers suffer from short-term health risks i.e. allergy, eye irritation, nausea, vomiting, diarrhea, headache and rashes and in long run may affect the brain, lungs, heart, liver, blood and other organs (Suri and Chakrabarty, 2002).

Major problems faced by the workers during thrashing are largely related to skin like itching, dry skin, cracks, pimples and acne. Other physical health problems are: pain in shoulder & elbow, stiffness and tremors in hands. Wearing the proper clothes at work can help to prevent some injuries to the body. Various farm jobs require different types of clothing (Dwivedi and Kiran. 2013).

Considering the occupational health problems of faced by farm workers during pesticide application and wheat threshing, it was felt necessary to design appropriate protective clothing for them. Protective clothing/accessories were designed and constructed in accordance with farm workers' needs to reduce their health problems also improve their job efficiency. Thus keeping in view the needs and problems faced by the farmers; present study was undertaken with the following objectives:

1.To design and construct Protective clothing.
2.To assess the suitability and acceptability of Protective clothing.

MATERIALS AND METHODS

Development of protective clothing

➢**Protective clothing/accessories for pesticide applicator:** Jacket with polo collar, jacket with hood, *Pyjama* and cap of water resistant fabric having lining of cotton hosiery fabric (existing dress), pleated mask and beak mask.

➢**Protective clothing/accessories for farm workers for wheat threshing**

- **Males:** Apron with cap, apron with hood, pleated and beak mask.
- **Females:**Apron,scarf mask, hood mask and capron.

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Goggles/plain glasses and gloves were not developed but these were procured from market and tried on respondents for both the activities.

Development of protective clothing was done with reference to:

(i) Fabric (ii) Functional features

Fabric: Five samples for each selected dress were collected from Delhi market. For comparative analysis, two samples for each dress were selected on the basis of test results of various parameters i.e. burning test, microscopic test, chemical tests, fabric count, fabric weight, fabric thickness, water permeability and air permeability.

Field testing of designed protective clothing/accessories:

Selection of respondent's: Twenty five farm workers involved in pesticide application and Forty farm workers (25 males and 15 females) involved in wheat threshing were selected from different villages of Hisar district.

Protective clothing/accessories were constructed by incorporating design features using selected fabrics. These were given to the respondents for a period of one month for assessment of suitability and acceptability.

Assessment of suitability and acceptability of developed protective clothing/accessories: For suitability and acceptability assessment of designed protective clothing and accessories, the opinion of the respondents was sought on performa after the trials. Extent of suitability was assessed

(ii) Comparative analysis of functional features and fabric

1. Protective clothing/accessories for farm workers involved in pesticide application		
Dress-I	**Dress-II**	**Comparative Analysis**
Jacket with polo collar & cap	Jacket with hood (hood of double layer fabric)	Cap did not provide proper protection to forehead, ears and neck from pesticide vapours
	Elastic along with string in hood	Kept hood in position and covered coverage of head, forehead and face properly
Pyjama: Elastic at waist level and bottom level	*Pyjama*: Elastic at waist level and bottom level	Nil
Fabric		
Slightly stiff texture	Very soft texture	Feel comfortable
Existing Accessories		
Existing Masks		
Beak mask(Small length)	Beak mask (Mask length increased)	cover the face properly
Pleated mask (with cap)	Pleated mask (without cap)·	Elastic was used to hold mask at ear·
Mask length decreased	Cap replaced with hood	
Fabric of mask		
Voile	Water resistant fabric· Poplin· Chemical resistant mask	Voile Fabric did not provide proper protection from pesticide vapours
Gloves		
Surgical gloves	Nitrile gloves	Nitrile gloves Worn-out frequently
2. Protective clothing/accessories for farm workers involved in Threshing activity (For males)		
Apron		
Apron & cap	Apron with hood	Cap did not provide protection to forehead, face, ears and neck from organic dust
	Elastic at forehead	Kept hood in position and covered coverage of head, forehead and face properly
Single row of elastic at cuffs	Two rows of elastic at cuffs	Sleeves with single row of elastic raised and needs to be set frequently, causing discomfort
Pocket without flap	Pocket with flap	prevent accumulation of husk/dust inside the pocket
Fabric of apron		
Terry voile	Terry voile fabric used for apron-I did not provide proper protection	Terry-cot and Poplin
Accessories		
Masks		
Beak mask(Small length)	Beak mask (Mask length increased)	cover the face properly
Pleated mask (with cap)	Pleated mask (without cap)·	Elastic was used to hold mask at ear·
Mask length decreased	Cap replaced with hood	
Fabric		
Voile	Cambric and Poplin	Voile fabric did not provide proper protection from organic husk/dust

with reference to ease of wearing, ease of removing, protection from pesticide vapours,/protection from organic dust and comfortable during wear on three point rating scale For assessment of acceptability level, formulated statements were measured with reference to appeal, designing components, work efficiency, maintenance and adoption feasibility on three point rating scale.

RESULTS AND DISCUSSION

Assessment of physical properties of fabric used for protective clothing

Water resistance fabric: Dress made of (sample-1) used in dress-I was tested during pilot study. Nylon (sample-1) used in dress-I was not liked by the respondents due to its appearance and slightly stiff texture, hence other four soft texture fabric samples were collected and tested on various parameters and the data has been presented in Table-1.

Sample-III was very soft in texture, had lowest air permeability, highest percentage of evaporative resistance of fabric and lowest absolute water permeability. Sample also had highest yarn count, lowest thickness and lowest weight. Hence dress-II was developed using fabric of sample-III and compared with the dreess of sample- I for further research work.

100% cotton fabric: Voile used in mask was not very protective against organic dust hence four more fabric samples collected were tested for their physical properties and data are presented in Table 1. Besides voile, two fabrics i.e. cambric: 1 and poplin: 1 having moderate air permeability was selected for masks and compared with readymade chemical resistant mask.

Fabrics used for apron: Terry-voile (sample-1) used in apron-1 (Pilot study) did not provide proper protection from organic dust; hence other four thicker fabric samples were tested on various parameters and the data has been presented in Table 1. Two fabrics having lesser air permeability as well as thicker than terry voile were selected for development of apron. To make comparison, one blend i.e. terry cot (45:55) and poplin were selected for further research work.

Suitability assessment of protective clothing/accessories for pesticide applicators: The results high lighted that Jacket with hood (dress-II) was more suitable ($\bar{x}_w$=2.75) as compared to jacket and cap (dress-I) scoring ($\bar{x}_w$=2.20) only because of hood (Table 2). It was also preferred due to soft textured fabric. *Pyjama* of water proof fabric having elastic at waist and bottom level was found to be comfortable, easy to wear and remove. Lining of cotton hosiery fabric absorbed perspiration and provided comfort to the wearer. Shape of all the masks was highly appropriate.

Chemical resistant mask ($\bar{x}_w$=2.85) provided maximum protection against vapours and was comfortable than masks of cambric ($\bar{x}_w$=2.30), voile ($\bar{x}_w$=2.10) and poplin ($\bar{x}_w$=1.68). Nitrile gloves were found to be better

Table 1: Assessment of physical properties of fabric used for protective clothing

Sample No.	Fabric used	Texture of fabric	`Yarn count	Weight (g/m^2)	Thickness (mm)	Water Permeability		Air permeability (20% level) m^3/m^2/min
						Evaporative resistance of fabric (%)	Absolute Water vapour permeability (Pa m^{2}w-1)	
1. Water resistant fabric								
i.	Nylon	Slightly Stiff	77x64	70	12	87	1.7	1.249
ii.	Nylon	Soft	79x68	83	12	97	0.3	0.835
iii.	Nylon	V. Soft	84x72	70	9	99	0.2	0.833
iv.	Nylon	Soft	77x68	79	10	78	2.4	1.208
v.	Nylon	Soft	81x71	71	10	98	0.3	0.835
2.100% cotton fabric used for mask								
i.	Voile	Stiff	68×65	69	18	45	9.5	191.70
ii.	Cambric:1	V. Soft	78×69	79	23	62	4.5	133.36
iii.	Cambric: 2	Soft	72×61	85	20	61	5.7	149.21
iv.	Poplin :1	Soft	84×73	129	27	69	7.8	58.34
v.	Poplin :2	Soft	85×74	135	29	71	6.8	45.01
3.Fabrics used for apron								
i.	Terry voile(52% polyester & 48% cotton)	Soft	77×68	71	19	45	9.5	133.36
ii.	Terry cot (45% polyester & 55% cotton)	V. Soft	85×72	95	25	52	6.5	70.16
iii.	Terry cot (55% polyester & 45% cotton)	Soft	81×70	82	24	58	6.2	75.01
iv.	Cambric (100% Cotton)	V. Soft	78×69	79	22	61	5.7	91.68
v.	Poplin (100% Cotton)	Soft	84×73	129	27	72	4.8	58.34

Table 2: Suitability assessment of protective clothing/accessories for pesticide applicators

n= 25

Functional features of garments/accessories	Characteristics of functional features	WMS ($\overline{X}_w$)	Overall WMS
Jacket of water proof fabric			
Dress-I- Jacket with polo collar and cap	• Protects neck from pesticide vapours	2.10	
Fabric and its texture	• Comfortable	2.30	2.20
Dress-II- Jacket with hood	• Protects neck from pesticide vapours	2.90	
Fabric and its texture	• Comfortable	2.60	2.75
General functional features of both dresses			
Front opening with zip	• Easy to wear and remove	2.60	2.65
	• Easy to operate	2.70	
Full sleeves with elastic at wrist level	• Protects arms from pesticide vapours	2.34	2.34
Pockets on both sides of opening	• To keep hanky or medicine etc	2.90	2.90
Size of pockets	• Appropriate	2.90	2.90
Comfortable during wear	• Less than one hour	2.80	
	• One hour	2.80	2.56
	• Two hour	2.55	
	• Three hour	2.10	
***Pyjama* of both dresses**			
Elastic at waist level	• Easy to wear	2.75	2.78
	• Easy to remove	2.60	
	• Comfortable	2.90	
Elastic at bottom	• Comfortable	2.90	
Comfortability during wear	• Less than one hour	2.90	
	• One hour	2.90	2.68
	• Two hour	2.70	
	• Three hour	2.25	
Accessories			
Modified masks			
Beak mask	• Easy to wear	2.85	
	• Easy to remove	3.00	2.85
	• Coverage of face	2.79	
	• Elastic at sides of mask comfortable during wear	2.83	
Pleated mask	• Easy to wear	2.85	
	• Easy to remove	3.00	2.87
	• Coverage of face	2.83	
	• Elastic at sides of mask comfortable during wear	2.83	
Chemical resistant mask (readymade)	• Easy to wear	2.15	
	• Easy to remove	3.00	2.65
	• Coverage of face	2.60	
	• Elastic at sides of mask comfortable during wear	2.60	

continue Table 2.....

continue Table 2

Fabric				
Poplin	•	Protects from pesticide vapours	2.45	1.68
	•	Comfortable for breathing	1.90	
Voile	•	Protects from pesticide vapours	2.15	2.10
	•	Comfortable for breathing	2.05	
Cambric	•	Protects from pesticide vapours	2.30	2.35
	•	Comfortable for breathing	2.40	
Chemical resistant mask (readymade)	•	Protects from pesticide vapours	2.90	2.85
	•	Comfortable for breathing	2.80	
Gloves				
Surgical gloves (Existing)	•	Prevented irritation and itching on hand	2.70	
	•	Easy to wear	1.90	
	•	Easy to remove	2.10	2.30
	•	Comfortable	2.55	
	•	Easy to work	2.60	
	•	Durability	1.95	
Nitrile gloves(Suggested)	•	Prevented irritation and itching on hand	2.75	
	•	Easy to wear	2.50	
	•	Easy to remove	2.75	2.50
	•	Comfortable	2.15	
	•	Easy to work	2.10	
	•	Durability	2.80	
Goggles/Plain glasses	•	Prevented redness, irritation and itching of eyes	2.70	2.75
	•	Comfortable	2.80	
Synthetic fabric Shoes	•	Prevents irritation and itching on foot	2.85	**2.77**
	•	Protects foot from cuts and sore	2.70	

($\bar{x}_w$ =2.50) than surgical gloves ($\bar{x}_w$ =2.30) with reference to ease of wearing, removing and durability. Goggles/plain glasses and gloves were found to be very protective. Shoes were also found to be highly suitable.

Suitability assessment of protective clothing/accessories for wheat threshing

Males: Apron-II was assessed to be more suitable ($\bar{x}_w$ =2.90) than Apron-I (=2.63) as it was more protective as well as comfortable(Table 3). Regarding fabric of apron, terry cot (45:55) and poplin were assessed to be more protective against organic dust. Shape of both the masks i.e. beak ($\bar{x}_w$ =2.86) and pleated ($\bar{x}_w$ =2.80) was found to be highly suitable. Mask made from cambric was most suitable ($\bar{x}_w$ =2.88). Goggles/plain glasses, shoes and gloves were found to be highly suitable.

Females : Apron with polo collar and full sleeves along with belt at waist level was found to be highly suitable ($\bar{x}_w$ =2.78) but they preferred to wear *kameez* with full sleeves. Hood mask as well as scarf mask were found to be highly suitable scoring ($\bar{x}_w$ =2.92) and ($\bar{x}_w$ =2.84) respectively. Goggles/ plain glasses, shoes and gloves were also assessed to be highly suitable(Table 4).

Acceptability assessment of protective clothing/ accessories: Protective clothing/accessories were found to be acceptable by maximum number of respondents because they were of the view that one should definitely use protective

Pesticides applicators		**Threshing activity**			
		Males		**Females**	
i	Jacket with hood and *pyjama* of water proof fabric (having lining of cotton hosiery fabric)	i	Apron with hood and full sleeves with elasticized cuffs (elastic in two rows)	i	*Kameez* with full sleeves preferably elasticized cuffs or Apron
ii	Chemical Resistant mask	ii	Pleated mask / beak mask	ii	Hood mask/Scarf mask
iii	Glasses/goggles	iii	Glasses/goggles	iii	Glasses/goggles
iv	Nitrile gloves	iv	Sports shoes	iv	Sports shoes
v	Sports shoes	v	Mittens/gloves	v	Mittens/gloves

Table 3: Suitability assessment of protective clothing/accessories of male farm workers involved in wheat threshing

n=25

Functional features of garments/accessories	Characteristics of functional features	WMS ($\bar{X}_w$)	Overall WMS
Apron-I (existing apron)			
Apron with polo collar and cap	• Protects head and neck from husk/dust	2.52	
Elasticized cuffs (elastic in one row)	• Protects arms from husk/ dust	2.80	**2.63**
	• Comfortable	2.58	
Fabric			
Terry Voile	• Protects from dust	1.48	**1.86**
	• Comfortable during wear	2.24	
Apron-II (modified apron)			
Apron with hood	• Protects head and neck from husk/ dust	3.00	**2.90**
Elasticized cuff (elastic in two row)	• Protects arms from husk/ dust	3.00	
	• Comfortable	2.70	
Fabric			
Terry cot	• Protects from dust	2.76	**2.72**
	• Comfortable during wear	2.68	
Poplin	• Protects from dust	2.76	**2.68**
	• Comfortable during wear	2.60	
Patch pocket with flap	• Position of pocket	2.93	
	• Shape and size of pocket	2.93	**2.91**
	• Flap prevents accumulation of husk/dust in side pocket	2.90	
Mask			
Beak mask	• Easy to put on	2.86	
	• Easy to remove	3.00	
	• Coverage of face	2.79	
	• Easy to breathe	2.90	**2.86**
	• Shape of mask	2.80	
	• Elastic at sides of mask comfortable during wear	2.83	
Pleated mask	• Easy to wear	2.86	
	• Easy to remove	3.00	
	• Coverage of face	2.86	
	• Easy to breathe	2.76	**2.80**
	• Shape of mask	2.83	
	• Elastic at sides of mask comfortable during wear	2.83	
Fabrics of Mask			
Voile	• Protects from dust inhalation	2.20	**2.26**
	• Comfortable for breathing	2.32	
Cambric	• Protects from dust inhalation	2.80	**2.88**
	• Comfortable for breathing	2.96	
Poplin	• Protects from dust inhalation	2.86	**2.12**
	• Comfortable for breathing	1.56	
Goggles/plain glasses	• Protects eyes from husk/ dust	3.00	**3.00**
Gloves/ Mittens	• Prevents irritation and itching on hand	2.80	**2.77**
	• Protects hands from cuts and sore	2.75	
Shoes	• Prevents irritation and itching on foot	2.75	**2.77**
	• Protects foot from cuts and sore	2.80	

Suitability level: Highly suitable: 2.34-3.00, suitable: 1.67-2.33, somewhat suitable 1.00-1.6

clothing as these protects the wearer and also not have adverse effect on work efficiency, functional features/ fasteners used in the garment did not cause pinching and protective clothing can be washed and maintained easily. Based on suitability and acceptability, recommended protective clothing/accessories were:

CONCLUSION

Exposures to pesticides and organic dust are the most important occupational risks among small and marginal farmers. To overcome their occupational health hazard, protective clothing /accessories were designed and tested for their suitability and acceptability. Suitability assessment of designed protective clothing highlighted that all the

Table 4: Suitability assessments of protective clothing/accessories for female farm workers involved in wheat threshing

n=25

Functional features of garments	Characteristics of functional features	WMS	Overall WMS
Apron-I			
Chinese collar	Protects neck from husk/dust	2.53	
Elasticized cuffs	Protects arms from husk/dust	2.67	
Size of elasticized cuff	Comfortable	2.80	**2.78**
Pocket	Position of pocket	2.90	
	Shape and size of pocket	2.90	
Belt at waist	Prevents hindrance of clothing while working	2.80	
Fabrics			
Voile	Protects from dust	2.20	**2.26**
	Comfortable for breathing	2.32	
Cambric	Protects from dust	2.80	**2.88**
	Comfortable for breathing	2.96	
Hood mask			
Head cover of hosiery fabric	Protects head from husk/dust	3.00	
	Protects neck from husk/dust	3.00	
Mask of cambric fabric	Protects from inhalation of husk/dust	3.00	
	Length of mask	3.00	
	Width of mask	3.00	**2.92**
	Comfortable	3.00	
Overall hood mask	Easy to wear	2.60	
	Easy to remove	2.60	
	Comfortable	2.90	
Scarf mask			
Head cover of cambric fabric	Protects head & neck from husk/dust	3.00	
	Protects from husk/ dust inhalation	3.00	
Elastic at nose and forehead in the mask	Keep mask in position	2.90	
	Comfortable	2.90	
Shape of mask	Length of mask	3.00	
	Width of mask	3.00	
Size of head cover	Appropriate	3.00	**2.84**
Strap for knotting	Easy to tie knot	2.50	
	Easy to open knot	2.60	
Overall scarf mask	Easy to wear	2.60	
	Easy to remove	2.90	
Goggles/plain glasses	Protects eyes from husk/dust	3.00	**3.00**
Gloves/ Mittens	Prevents irritation and itching on hand	2.80	
	Protects hands from cuts and sore	2.75	**2.77**

Suitability level: Highly suitable: 2.34-3.00, Suitable: 1.67-2.33, somewhat suitable 1.00-1.66

functional features incorporated in the garments/accessories were assessed to be highly suitable as they provided protection to the wearer without causing any health problem or the hindrance while working. Protective clothing/ accessories were found to be highly acceptable to maximum number of the farm workers. The designed protective clothing reduced their occupational health hazards and increased their work efficiency.

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