Research Article

Impact of Weed Control Techniques on Intercropping of Mungbean with Maize under Agro Climate Condition of Peshawar

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Abstract | The efficiency of maize + mungbean intercropping method for yield and yield attributes were studied under different crop combination at the Research Farm of The University of Agriculture Peshawar, Pakistan during the year 2012. The study was carried out in a split-plot design with three replications. Herbicide treatments (herbicide used and herbicide not used) were assigned to main plots, while intercropping treatments (sole maize, sole mungbean, 5 rows of mungbean + 6 rows of maize, 10 row of mungbean + 6 rows of maize) were allotted to subplots. Results of the study revealed that weed density m^{-2}, fresh weed biomass in maize and mungbean crops were significantly affected by both the main-plot and sub-plot treatments. Similarly, number of seeds pod^{-1}, thousand grains weight, grain and biological yield of mungbean were also found significant. In main plots, weed density m^{-2} (16.47) and fresh weed biomass (529.8) were lower in herbicide treated plots in mungbean crop. Number of seeds pod^{-1} (10.85), thousand grains weight (30.15g), grain yield (366.56 kg ha^{-1}) and biological yield of mungbean (1306.7 kg ha^{-1}) were higher in herbicide treated plots. Subplots sown with sole mungbean resulted in heavier 1000 grains weight (32.95g), higher number of seeds pod^{-1} (11), grain yield (427 kg ha^{-1}) and biological yield (1522 kg ha^{-1}). The intercropping treatments of 10 rows mungbean + 6 rows maize resulted in lighter 1000 grains weight (30.1g) and seeds pod^{-1} (10). Grain yield (269 kg ha^{-1}) and biological yield (1023 kg ha^{-1}) of mungbean were significantly lower in 5 rows mungbean + 6 row maize intercropping treatments. It is concluded from our results that sowing of mungbean as sole was the most effective in terms of mungbean grain and biological yields. Mungbean can also serve as a compatible component in intercropping system involving maize crop, based on our results.

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Introduction

Mungbean (*Vigna radiata* L.) is an important 'kharif' legume crop of Pakistan, essentially grown for its edible seeds production. In Pakistan major mungbean growing provinces are Sindh and Punjab. Punjab alone contributes up to 85% of the total production and 88% of the total area (NARC, 2016). Mungbean is a dual purpose crop used both as food and feed, providing up to 22-24% of plant proteins (Rosaiah et al., 1993).

Intercropping is method of cultivating more than one crop species simultaneously in the same piece of field, for the purpose of diverse production and increased net income through proficient consumption

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of all available resources (Nazir et al., 1997; Zhang et al., 2007). Intercropping system offers harmonization of different crops to reduce the failure risk in case of attack by weeds, insect and disease. Intercropping legume crops with cereals plays an important part in the proficient utilization of natural resources (Marer et al., 2007). Planting legumes (e.g. mungbean) with cereal crops (e.g. maize) is a perfect match for intercropping as they have different roots zones and different nutrient requirements for their growth as compared to mono cropping (Li et al., 2003). Moreover, scientific utilization of land and water resources can efficiently help in weeds suppression, enhanced agro-biodiversity and improvement in soil moisture and fertility. Growing cereals with legumes help prevent the soil moisture loss that keeps the soil surface moist for longer durations as compared to the sole maize cropping (Kumar et al., 2008). Tsubo et al. (2003) reported that legume-maize intercropping reduces the amount of nutrients drawn from soil as compared to maize monoculture. In addition, Kamanga et al. (2010) reported that intercropping legumes with maize decreases the risk of crop failure, and Ghosh et al. (2007) called it an efficient cropping system in terms of resource-use-efficiency.

System of intercropping is receiving popularity in Pakistan among the framing communities due to its manifold profits (Nazir et al., 1997). Scientific literature to our knowledge is not available on the effect of maize-mungbean intercropping on the yields and yield-components in Peshawar. Therefore, the objectives of this study were to study the effect of maize-mungbean intercropping on maize and mungbean yields and yield-components in the agro-ecological circumstances of Peshawar region.

Materials and Methods

Experimental site and treatments used

The experiment was conducted at the Research Farm of the University of Agriculture Peshawar, Pakistan in 2012. The experiment was consisted of herbicide use and different intercropping of maize and mungbean. The experiment was laid out in randomized complete block design with split-plot arrangement replicated three times. The herbicide treatments were assigned to main plots and the intercropping treatments were assigned to sub plots. The herbicide treatment was a pre-emergence application of pendimethalin at a rate of 1.5 kg a.i. ha^{-1} (Stomp 330 EC, Syngenta). Non-treated control treatment with no herbicide application was included for comparison. The intercropping consisted of sole mungbean, sole maize, 5 rows of mungbean + 6 rows of maize and 10 rows of mungbean + 6 rows of maize.

Seedbed preparation

Prior to seed sowing, the seedbed was prepared by ploughing the field twice with mould board plough followed by harrowing. The land was prepared according to the standard practices in order to improve moisture conservation of the soil required for soil-seed interaction, for better seed germination, emergence, growth and development.

Agronomic practices

A composite soil sample was collected from the field before sowing the crop and samples were taken from each experimental unit after the crop is harvested for determination of soil fertility. Recommended dose of nitrogen and phosphorus (150 kg in the form of Urea and 100 kg ha^{-1} in the form of single super phosphate (SSP), respectively) were applied to all the experiment constantly. Full P and half N were applied at sowing and the remaining N was applied at the time of second irrigation. The sole mungbean crop received only 30 kg N ha^{-1} as a starter dose due to the fact that legume fix atmospheric nitrogen. The size of each experimental unit (sub-plot) was 5 x 4.8, with 6 rows of maize crop in each unit, each row 5 m long and spaced 0.8 m apart. Mungbean seeds were sown by hand hoe with inter rows cultivation of maize as per treatments descriptions. Data were collected on weed density, fresh weed biomass, number of seeds pod^{-1}, thousand grains weight, grain and biological yield of mungbean.

Data collection procedures

Weed density m^{-2} were recorded from three randomly selected sites in each sub plot weeds were counted which falls with the boundaries of a quadrate of known size and were averaged. The weeds counted were then uprooted and were weighed with digital balance in order to record fresh weeds biomass. The seeds were counted in ten randomly selected pods in each plot and were averaged to calculate seeds pod^{-1}. Thousand grains were selected from the seed lot of each plot and were weighed with digital balance. Three central rows were harvested from each plot, was sundried, weighed and converted to kg ha^{-1} for recording biological yield. For grain yield, the pods of three central rows were threshed and grains were weighed and converted to kg ha^{-1}.

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The grain yield and biological yield per hectare were calculated by using the following formulae:

$$GY = \frac{GW \times 10000}{RL \times R - R \times NR}$$

$$BY = \frac{GW \times 10000}{RL \times R - R \times NR}$$

Whereas:

GY is grain yield, GW is grain weight in the harvested area of each plot, RL is row length, R-R is row to row distance, NR is number of rows, and BY is biological yield in kg ha^{-1}.

Statistical analysis

The data were statistically analysed using the statistical software Statistix 8.1 for split-plot design. Means were compared using least significant difference (LSD) test at 5% level of probability when F values were significant (Steel and Torrie, 1983).

Table 1: *Weed density m^{-2} and fresh weed biomass (kg ha^{-1}) as affected by herbicide use and intercropping treatments*

Treatments	Weed density m^{-2} 30 DAS	Fresh weed biomass (kg ha^{-1})
HERBICIDES (A)		
Stomp 330EC (pendimethalin)	16.47 b	529.8 b
Control	42.90 a	2751.5 a
$LSD_{0.05}$	*	*
INTERCROPPING (B)		
Sole maize (6 rows)	36.88 a	2389.5 a
Sole mungbean (15 rows)	31.57 c	1836.7 c
5 Row Mungbean + 6 row maize	28.033 d	1456.0de
10 Row Mungbean + 6 row maize	24.450 f	1100.6 g
$LSD_{0.05}$	1.9873	113.89
$LSD_{0.05}$ INTERACTION of AxB	2.8105	161.06

*Means with different letters are significantly different at 5% probability level; * Significant at P≤0.05*

Results and Discussion

Weed Density m^{-2}

The herbicide use, intercropping treatments and the interaction of herbicide with intercropping had a significant effect on weed density. The average weed density was 16.47 m^{-2} in treatment of herbicide use as compared to the plots in which herbicide was not use (42.90 m^{-2}). Intercropping treatments showed fewer weed densities in the sole treatments. For the intercropping effect, the lowest weed density of 24.45 m^{-2} was recorded in the intercropping of 10 rows cowpea + 6 rows maize and highest (36.88 m^{-2}) in sole maize treatments. The data indicated that intercropping of 5 rows of legumes with 6 rows of maize had comparatively higher weed density than the intercropping of 10 rows of legumes with 6 rows of maize (Table 1). Thus intercropping feature can play a role in declining the weed density. The highest weed density in sole maize could be due to free existing spaces for the germination of weeds (Bilalis et al., 2010; Poggio, 2005). Buchler et al. (2001) and Ghosheh et al. (2005) studied that maize-legume intercropping suppressed the weed density and improved crop growth and development by providing more nutrients available for crop growth and development.

Interaction effect of herbicide and intercropping was also significant on weed density m^{-2}. The study indicates that when maize intercropped with legumes in 1:1 and 1:2 reduced the weed growth significantly when compared with sole maize (Tripathi and Singh, 1983). The interaction effect has been displayed in **Figure** 1.

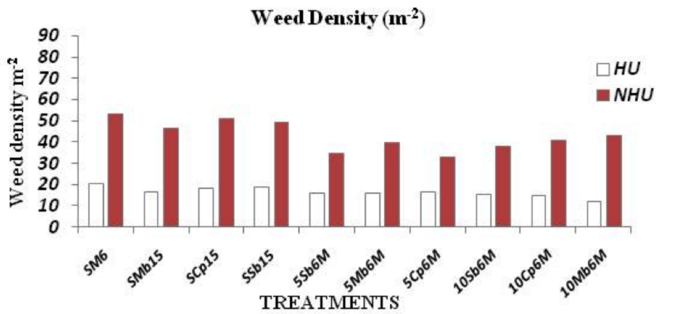

Figure 1: *Interaction between herbicides and intercropping for weed densities*
HU=*Herbicide used;* **NHU**=*No herbicide used*

Fresh Weed Biomass (kg ha^{-1})

For interpretation of the actual field situation, fresh weed biomass was selected for analysis and explaining results because the moisture loss from the plants canopy is mostly uniform. The parameter of fresh weed biomass was significantly affected by the year factor (Table 1). Weed fresh biomass was significantly affected by the herbicide treatments. The average weed fresh biomass was 529.8 kg ha^{-1} in the treatments of herbicide was not use and 2751.5kg ha^{-1} was recorded in the plots of herbicide use. Intercropping treatments and their interactions were also significant. Among the intercropping treatments, the lowest weed fresh biomass of 1100 kg ha^{-1} was recorded in 10 rows

Table 2: *Number of seeds pod^{-1}, thousand grain weight (g), grain yield (kg ha^{-1}) and biological yield (kg ha^{-1}) of mungbean as affected by herbicide use and intercropping treatments*

Treatment	Number of seeds pod^{-1}	1000-grain weight (g)	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})
HERBICIDES (H)				
Stomp330EC (pendimethalin)	10.853 a	30.156 a	366.56 a	1306.7 a
Control	8.613 b	26.489 b	315.89 b	1201.8 b
LSD$_{(0.05)}$	2.1496	3.3153	3.6094	66.710
INTERCROPPING (IC)				
Sole mungbean (15 rows)	11.240 a	32.950 a	427.33 a	1522.3 a
5 Row Mungbean + 6 row maize	10280 b	30.150 b	269.50 c	1023.3 c
10 Row Mungbean + 6 row maize	7.680 c	21.867 c	326.83 b	1217.0 b
LSD$_{(0.05)}$	0.9100	3.31533	10.025	31.211
H x IC	*	*	*	*

Means of the same category followed by different letters are significantly different at P≤0.05 level using LSD test

mungbean + 6 rows maize and highest (2389 kg ha^{-1}) in sole maize treatments. Intercropping of 10 rows of legumes with 6 rows of maize had comparatively lower weed density than the intercropping of 5 rows of legumes with 6 rows of maize (Table 1). The highest weed fresh biomass in sole maize treatments could be as a result of free available niches for the weed seeds for emergence.

There was a significant effect of interaction, effect of herbicide uses and intercropping on weed fresh biomass. In a study, Tripathi and Singh (1983) opined about intercropping of maize and soybean and stated that growing one or two soybean rows in between maize rows reduced the weed growth significantly as compared to sole maize. Ghosheh et al. (2005) and Buchler et al. (2001) studied the beneficial effects of maize+legume intercropping on crop growth and also on weed suppression. The interaction effect has been displayed in Figure 2. Results are in conformation with the finding of Ford and Pleasant (1994) as well.

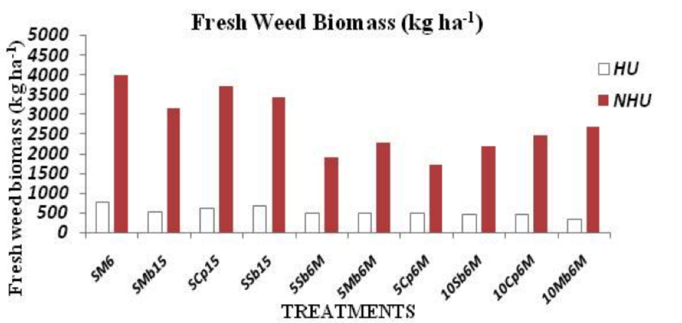

Figure 2: *Interaction between herbicides and intercropping for weed fresh biomass*
HU=*Herbicide used;* **NHU**=*No herbicide used*

Number of Seeds pod^{-1}

Number of seeds pod^{-1} is an important parameter for the total yield of mungbean. The number of mungbean seeds pod^{-1} was significantly affected by the different parameters. The herbicide use, intercropping treatments and their interaction all had a significant effect on the number of mungbean seeds pod^{-1}. Higher number of mungbean seeds (10.85 pod^{-1}) was recorded in the plots treated with herbicide and lower (8.613 pod^{-1}) in the treatments where herbicide was not applied (Table 2). Akhtar et al. (2000) reported similar results.

The intercropping treatments had a significant effect on the number of mungbean seeds pod^{-1}. The highest number of seeds of mungbean (11.24 pod^{-1}) was noted in plots of sole mungbean crop sown at a row-to-row distance of 30 cm. A decrease in number of seeds pod^{-1} was also noted with increase in intercropping density, the sole mungbean treatment had the highest number of seeds (11.24 seeds pod^{-1}) as compared to the intercropping of 5-rows mungbean with 6-rows maize (10.28 seeds pod^{-1}) and intercropping of 10-rows mungbean with 6-rows maize (7.68 seeds pod^{-1}). It became clear that with increase in number of plants per unit area, the number of seeds pod^{-1} also decreased due to intra or inter-specific competition. Therefore, on one side weed competition resulted in reduction of number of mungbean seeds pod^{-1} but through intercropping the weed competition is though hampered, however the intercropping also resulted in competition among the crop plants and the intercrop plants.

The interaction effect of the herbicide use and the intercropping treatments on number of mungbean seeds pod^{-1} was statistically significant as well (Figure 3). The range of number of seeds pod^{-1} was 7.28 - 12.8. The value of mungbean number of seeds pod^{-1}

was highest in sole mungbean treatments under herbicidal use, while the intercropping of mungbean 10-rows + 6-rows maize under no herbicide use had lowest number of seed pod^{-1}. The reason for higher seeds pod^{-1} in sole mungbean plots may be due to availability of nutrients and less competition between the maize and mungbean plants (Oljaca et al., 2000).

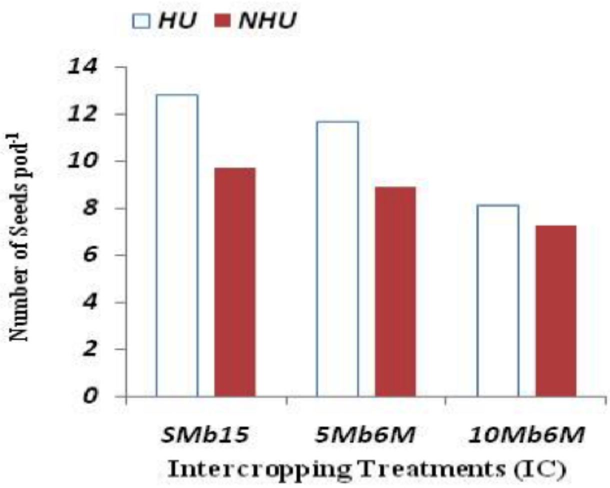

Figure 3: *Interaction of herbicides and intercropping for number of mungbean seeds pod^{-1}*

Thousand Grain Weight (g)

Mungbean thousand grains weight is an important parameter which positively affects the final yield of mungbean. Data showed that thousand grain weights were significantly affected by intercropping of mungbean with maize crop. There was a significant effect of the herbicide use, the intercropping treatments and their interaction on thousand grain weight of mungbean. Higher thousand grain weights of 30.15 g were recorded in the plots treated with herbicide as compared to the no herbicides used (26.48 g) (Table 2).

The highest thousand grain weight was noted in plots of sole mungbean as compared to intercropping mungbean + maize. It could be due to higher resources availability and less competition among the maize and mungbean plants. Mungbean grain weight and yield was convincingly higher when it was sown alone as compared to intercropped. Our results agree with the findings of Thavaprakaash et al. (2005) and Nishat (1989) who reported that when wheat was intercropped with lentil, the 1000-grain weight decreased due to wheat lentil intercropping.

The interaction effect on thousand-grain weight of mungbean was statistically significant (Figure 4). Thousand grain weights ranged between 7.28 and 12.8. Sole mungbean plots under treatments applied with herbicides showed the highest thousand grain weight under the intercropping of mungbean 10-rows + 6-rows maize, while under no herbicide use it showed the lowest thousand grain weight of mungbean.

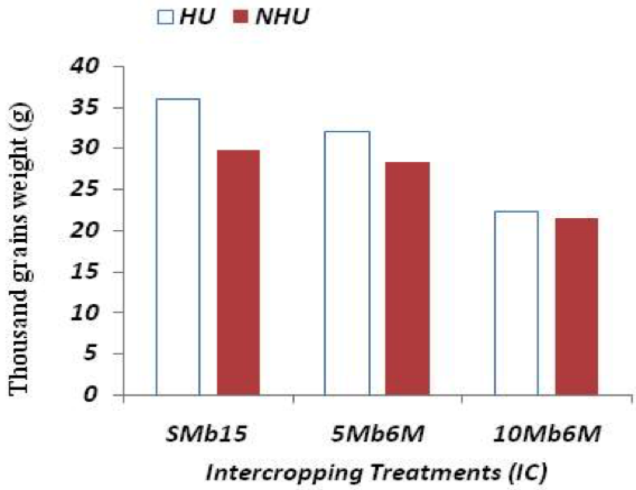

Figure 4: *Interaction of herbicides and intercropping for thousand grains weight (g) of mung bean*
HU=*Herbicide used;* **NHU**=*No herbicide used*

Grain Yield (kg ha^{-1})

Grain yield of mungbean data indicated that grain yield of mungbean was significantly affect by different intercropped treatments. The herbicide use, the intercropping treatments and their interaction all had a significant effect on grain yield. Higher grain yield of mungbean (366.56 kg ha^{-1}) was recorded in the plots treated with herbicide and lower grain yield was (315.89 kg ha^{-1}) recorded in the treatments where herbicide was not used (Table 2).

The intercropping treatments showed a significant effect on mungbean grain yield. The highest grain yield of mungbean was noted in plots of sole mungbean (427.33 kg ha^{-1})as compared to the intercropping of 5-rows mungbean with 6-rows maize (326.83 kg ha^{-1}) and intercropping of 10-rows mungbean with 6-rows maize 10.025 kg ha^{-1}. Tsubo and Walker (2000) who reported yield reduction in mungbean when intercropped with maize crop. Our results are supported by Sunilkumar et al. (2005), who reported decreased grain yield of mungbean as compared to single cropping system, due to poor competition of mungbean crop with maize for nutrients.

Among the interaction effects the highest values of mungbean grain yield were noted in sole mungbean plots under herbicidal treatments and lowest in the intercropping of mungbean 10-rows + 6-rows maize under no herbicide use (Figure 5).

Biological Yield (kg ha^{-1})

The data on mungbean biological yield showed that the herbicide use, the intercropping treatments and their interaction all had a significant effect on biological yield of mungbean (Table 2). Greater biological yield of mungbean (1306.7 kg ha^{-1}) was recorded in the plots treated with herbicide our results are supported by those of Evan et al. (2001).

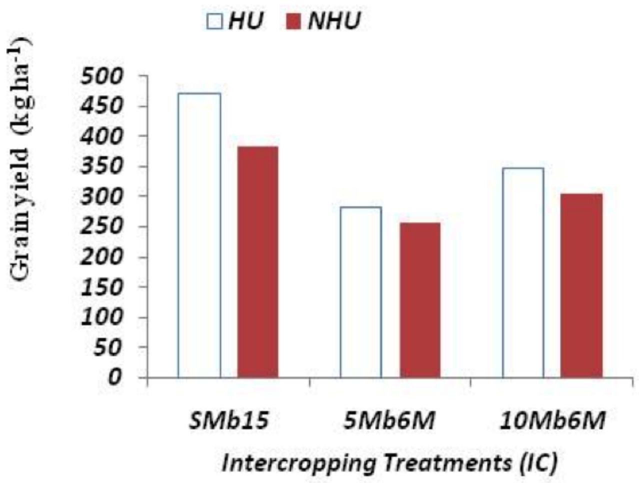

Figure 5: *Interaction between herbicides and intercropping for grain yield (kg ha^{-1}) of mung bean*

The highest biological yield of mungbean (1522.3 kg ha^{-1}) was noted in plots of mungbean sown as sole crop as compared to the intercropping of 5-rows mungbean with 6-rows maize (1023.3 kg ha^{-1}) and intercropping of 10-rows mungbean with 6-rows maize (1217.0 kg ha^{-1}) (Khan et al. (2012). The biological yield of mungbean decreases because of the intra or inter specific competition when sown mungbean as intercropped with maize. Singh (2000) and Polthanee and Trelo-ges (2003) had reported reduced yields of soybean in comparison with the mono-cropping.

The interaction effect of the herbicide use and the intercropping treatments on biological yield was statistically significant as well (Figure 6). The range of biological yield was 1023.3 - 1522.3. The highest value of mungbean biological yield was recorded in sole mungbean plots under herbicidal treatments and lowest in the intercropping of mungbean 10-rows + 6-rows maize under no herbicide use.

Resistance of weeds against herbicides is one of the important issues in many countries these days. The use of single modes of action herbicide for weed control has resulted in the evolution of herbicides resistant weeds. Therefore, the use of residual herbicides and herbicides with different modes of action along with other cultural weed control program is an important component of weed management (Chahal et al., 2014, 2015; Aulakh et al., 2013).

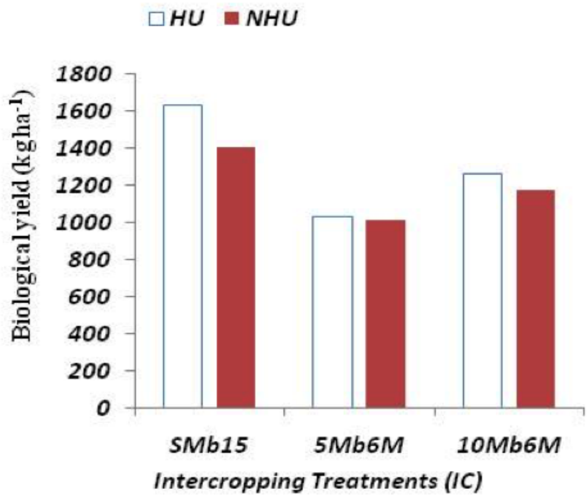

Figure 6: *Interaction of herbicides and intercropping for biological yield (kg ha^{-1}) of mung bean*
HU=*Herbicide used;* **NHU**=*No herbicide used*

Conclusion

In light of the results, the integrated use of pendimethalin as pre-emergence herbicide with intercropping of mungbean (a legume crop) in alternate rows with maize crop is a best way of achieving desirable weed control and crop yield.

Authors' Contribution

Dr. Ijaz Ahmad Khan has supervised Ms. Shahida Bibi in her PhD program and this article is a portion of the research.

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