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PREDICTION OF ONION-BULB YIELD UNDER WEED PRESSURE IN ONION/RICE CROPPING PATTERN OF THE LOWER SWAT VALLEY, N-W PAKISTAN

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ABSTRACT

Average onion yield based on survey of 114 farmers' fields was 21417 kg/ha in lower Swat valley of N-W Pakistan where major cropping pattern is onion/rice. When stepwise regression was done for yield against different variables, like field size, number of plowings, interval between plowings, crop density and weeds' density at different growth stages of crop, it was found that yield is a function of Field size (-1.34) + number of plowings (1750) + interval between first and last plowing (160.62) + mid-season crop density (103.23) + mid-season monocot weeds (-35.92) + mid-season dicot weeds (-24.74) + 17775.49. Figures in parenthesis denote the parameter estimate/ regression coefficient.

Key words: Modeling yield, onion yield as influenced by weeds.

INTRODUCTION

Traditionally, irrigated wheat used to be the winter crop, followed by rice or maize as the summer crop in the lower Swat valley of N-W Pakistan. But during the past two decades, onion has emerged as a major cash crop in Swat valley in the winter (Rabi) season. During the last five years, the area under onion cultivation in Swat has been increased by more than two fold (Defoer & Nieuwkoop, 1991). In Southern part of Swat valley, below Mingora, onion has nearly replaced irrigated wheat during winter. As a result, the two major cropping patterns are, onion-rice and onion-maize. However, onion-rice predominates over the onion-maize cropping pattern.

Both tenants and owners cultivate onion. The economics of onion cultivation are quite interesting. The gross return per acre amounts to more than Rs 35,000, while a net return of more than Rs 22,000 can be generated. The input and labor costs amount to about Rs 13,000, of which the input cost take 50%. Apart from seed, which represents more than two third of the inputs cost, farmers use considerable amounts of agro-chemicals (Nieuwkoop, 1990).

Since weeds pose a major problem in the cultivation of onion, hand weeding is a common practice normally done during the months of April and May. As a result of the small row-to-row distance (high plant density), hand weeding is time consuming, as weeding is done by uprooting the weeds one by one. However, in addition a herbicide, Tribunil (methabenzthiazuron) is used by about 70% of the farmers. The total amount of Tribunil sold by chemical dealers of Mingora only, during the 'Rabi' 1990-91 season, amounts to about 11,000 kg (Nieuwkoop, 1990). Although Tribunal is a broad-spectrum herbicide, it does not effectively control *Cyperus rotundus* and *Echinochloa crus-galli* (being two major weeds in onion as well as rice), but the use of Tribunil has been doubled since 1990 (Marwat, 1996). It is also used in other parts of Pakistan for weed control in onion and its results regarding weed control are promising (Ahmad et al., 1994).

There is an impression that, while effectively controlling dicotyledons and some monocotyledons, Tribunil induces a species shift towards the dominance of sedges (*Cyperus* spp.) and some grassy

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weeds. like *Echinochloa* spp. The resistance of *Echinochloa crus-galli* against methabenzthiazuron is already established in many parts of the world (Heap, 2000). As a result, farmers most probably have to spend more time on controlling such weeds by hand weeding. Moreover, certain weeds such as *Cyperus* spp. are high nutrient consumers, which make them substantial competitors with onion for the nutrient availability (Nieuwkoop, 1990). However, it is not known how important this problem is, to which extent farmers perceive this problem and how they cope with it.

In addition, the high degree of sedges and grassy weeds infestation in onion has, most probably, a negative effect on the rice crop following the onion crop. Since, after the harvest of onion, there is a far little time available for land preparation for the rice, thus weeds are not properly controlled, specially the perennials. Consequently, grassy weeds have become a serious problem in cultivation of rice. However, chemical control in rice is not very common.

The effect of the weed control on onion, its effect on the weed types, distribution and dynamics and its influence on the farmers' management practices are not known. To which extent the (chemical) weed control in onion contributes to the weed problem in rice is also not known either. Therefore, it was proposed to study the factors in addition to weeds problem in the onion-rice cropping pattern which contribute towards onion yield.

MATERIALS AND METHODS

A questionnaire was developed, pretested twice and then finalized. The questionnaire consisted questions ranging from educational status of the farmers to the different agronomic practices used by the farmers in the project area. In such questions, effort was made to know about the indigenous knowledge of the farmers regarding weeds control in addition to the use of chemicals and hand weeding etc. Such questionnaires were tested on a sample of 114 farmers from 14 different locations, represented by 6-10 farmers selected from each location at random. Besides questionnaires, data on weeds density, crop density, crop yield and farmers' view of the most troublesome weeds was collected at early, mid and later stages of crop development. The fields of respective farmers were totally managed by the farmers themselves, whereas a team of researchers collected the data.

Selection of sample farmers and fields

During field visits, farmers were selected at random from those working in the field. Selected farmers were separated by at least three fields from each other. If a farmer had more than one onion field, only such fields were selected, which were supposed to have rice during summer (Kharif). If at all, farmers had more than one onion field and all such fields were having Rice in Kharif, then one field was selected at random.

Weed and crop density and yield data

A quadrate of 0.33 m by 0.33 m size was thrown nine times at random in each of the 114 fields and then the density of different weed species and onion was calculated on per meter square basis. Such data was taken twice, mid-season and then late season. The yield data was also collected in the same manner, and then converted into per hectare basis. Farmers were also interviewed for the three most troublesome weeds of onion.

Herbicide rate

A single herbicide, Tribunil (methabenzthiazuron) 70WP is used in onion in the project area and such herbicide is purchased from the dealers in small packets, although it comes in packets of 800 grams for use in one acre. It was ascertained that the dealers recommend 10 spray pumps of this chemical from a packet of 800 grams. The farmers depend on the recommendation of the dealer after they tell about the area of the field to the dealer. The rate of the herbicide was thus calculated on basis of the number of pumps per measured plot of onion. Such figures were converted in to kg/ha.

RESULTS AND DISCUSSIONS

Data regarding number of plowings, interval between first to last plowing and herbicide rate was collected from the farmers through questionnaires, whereas field size, weed density, crop density and yield data was collected from the concerned field directly. Yield data was correlated with all other variables, viz., size of field, number of plowings, interval between plowings, herbicide rate, density of monocot & dicot weeds in mid and late season, crop density during early, mid and late season. Significant correlation ($P < 0.05$) existed between onion yield and all other variables except crop density. Number of plowings, interval between plowings and herbicide rate were positively correlated; while the rest of the variables had a negative correlation with the yield (Table 1).

Table 1. Correlation coefficient, T-value and probability of different independent variables correlated with onion yield.

Independent variables correlated with yield	Correlation coefficient	T value	Probability
Field size	-0.32	3.60	0.000
Plowing No	0.18	1.98	0.050
Interval between first & last plowing	0.32	3.62	0.000
Herbicide rate	0.25	2.68	0.008
Mid-season Monocot weeds	-0.50	6.07	0.000
Mid season Dicot weeds	-0.33	3.68	0.000
Late-season Monocot weeds	-0.58	7.59	0.000
Late-season Dicot weeds	-0.43	5.06	0.000
Early crop density	-0.02	0.25	0.800
Mid-season crop density	0.12	1.31	0.200
Late-season crop density	0.05	0.55	0.580

Keeping in view the correlation of different variables with yield, Stepwise regression was done using the three main criteria for model fitting, viz., square of multiple correlation coefficient (R^2) achieved by least square fit, residual mean square (s^2), and Mallows' C_p statistics (Table 2.3) (Draper & Smith, 1981). After confirmation of the results based on these criteria, yield model was developed.

Yield = Field size (-1.34) + number of plowing (1750) + interval between first and last plowing (160.62) + mid-season crop density (103.23) + mid-season monocot weeds (-35.92) + mid season dicot weeds (-24.74) + 17775.49.

As shown in Tables 2&3, the model-R^2 value for mid-season monocot weeds is lower (on the contrary partial R^2 is largest). C_p value and residual mean square are largest. R2 is a measure of the proportion of total variation about the mean explained by regression. The larger it is, the better the fitted equation explains the variation in data due to selected variables. Addition of new variables increase R2, but it may not necessarily enhance the precision of the estimate of response; as such precision is again determined by the residual mean square, which usually increase with each decrease in degree of freedom (DF). But in this case the residual mean square decreases (Table 3). In this case, however, all the three criteria for fitting the best model, i.e. increase in R^2, and decrease in residual mean square and Cp value confirms the validity of this model.

Table 2. Summary of stepwise regression for yield against different variables, showing partial R^2, model R^2, Cp statistics, F-value and probability.

Variable	Partial R^2	Model R^2	C_p	F	Prob >F
Mid-season monocot	0 247	0 247	29 632	36 79	0 0001
Field size	0 066	0 313	19 370	10 69	0 0014
Plowings interval	0 051	0 364	12 001	8 73	0 0038
Mid-season dicot weeds	0 017	0 381	10 866	2 97	0 0874
Mid-season crop density	0 019	0 400	9 284	3 48	0 0649
Number of plowing	0 024	0 424	6 829	4.46	0 0370

Mid-season monocot weeds play important role here, determining the major portion of variability in the yield model. In the study area, 102 farmers used Tribunil, a selective herbicide for weed control in onion. However, this herbicide was not effective against *Cyperus* sp. and some other monocot weeds, which is evident from the model and Table 3. Marwat et al. (2002) and Marwat & Hassan (2003) have also confirmed that Tribunil was weaker in controlling grasses and some monocot weeds in the project area and have come up with similar findings

Therefore, majority of the monocot weeds were either not controlled with Tribunil or either late emergence was not checked by the herbicide. On the other hand, dicot weeds had a very little contribution in terms of their impact on yield as compared to monocot weeds, as dicot weeds were easily controlled with the Tribunil However, a suspicion exist about the weeds resistance against the herbicides as Tribunil is being used in the project area for many years; moreover, its dosage might have led weeds resistance against this herbicide, specially in *Echinochloa crus-galli*, which is reported (Heap, 2000). Weed resistance against Tribunil (methabenzthiazuron) is well established and reported in the literature (Prado et al., 1989; Seefeldt et al., 2001, Retzinger & Mallory-Smith 1997).

Table 3. **Parameter estimate, and comparison of R^2, Cp value and residual mean square for independent variables fitted in the model for yield.**

Variable	Parameter estimate	Model R^2	C_p	DF	Residual mean square
Mid-season monocot weeds	-35 92	0 2473	29 631	112	146382836 8
Field size	-1 34	0.3134	19.370	111	134731691 8
Plowing interval	160 62	0 3639	12 000	110	125955336 2
Mid-season dicot weeds	-24 74	0 3808	10 866	109	123734471 7
Mid-season crop density	103 22	0 4001	9 2835	108	120985026 3
Number of plowing	1750 0	0 4241	6 8293	107	117228008 8

Late season weeds were regressed against size of field, early crop density, number of plowings, interval between first and last plowing, farmers' time of transplantation, mid-season crop density herbicide rate, and late-crop density field size and rate of herbicide had significant effect on late-season weeds (data not reported here) With increase in field size, total weeds density increased, while with increase in herbicide rate, the weed density decreased. Number of plowings and early crop density had also negative effect on weed density, however these effects were not significant

From the foregoing discussion it is evident that mid-season monocot weeds had the major role in reducing the onion yield followed by the size of the field. In smaller fields (small holdings), farmers can easily manage the crop and weeds but in larger fields, the problem become severe and is not easily manageable. Similarly interval between successive plowings and number of plowings also results in better control of weeds, which in return consequences in better yield.

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