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Allelopathic effects of sawdust, rice straw, bur-clover weed and cogongrass on weed control and development of onion

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Abstract: Onion (*Allium cepa* L.**)** does not compete well with weeds, especially at the early stage of growth; relatively weed-free conditions are required for successful production. Allelopathy may have a beneficial role in weed control and crop production. Shortage of hand labor and avoidance of synthetic herbicides makes weed control in onion difficult. Response of weeds to allelopathy may vary according to plant species, plant parts and thickness of mulch used. The study was conducted using organic mulches: sawdust (SD), rice straw (RS), bur-clover weed (CW) or cogongrass (CG) in comparison with hand hoeing (HH) and the herbicide butralin+1 hoeing (BUH) on growth, bulb nutrient concentration, yield, and quality of onion plants and control of associated weeds. Weed density responded differently to mulches. *Lolium multiflorum* Lam. was affected less compared to broadleaved weeds. Application of SD, RS, CW, CG, HH and BUH, decreased total weed dry weight at 75 days after onion transplanting by 42, 51, 62, 63, 92 and 98%, respectively. All mulch treatments require an additional hand weeding after 60 days from transplanting. Weed competition caused decreased onion plant dry weight (43-56%), bulb diameter (44%) and marketable yields (65.5%). The CV mulch allowed onion to produce the highest marketable yield. The CW efficacy control was less (up to 62%) compared to HH (98%). Organic mulch are effective for weed control and could be a potential alternative to synthetic herbicides, hoeing or hand removal of weeds in onion organic farming. Further studies are needed to evaluate if combinations of mulches can provide better control than each individually, their side effects on beneficial organisms diseases, and insects and the effectiveness of these mulches under organic production system.
***Keywords**: Allium cepa, mulch, Common Lambsquarters, Italian Ryegrass, Prickly dock, Scarlet Pimpernel.*

Introduction

Onion (*Allium cepa* L.) is not competitive against weeds [1,2,3], due to slow growth rate, short stature, non-branching plant structure, low leaf area, shallow root system, thin canopy and the cylindrical upright leaves do not shade the soil to suppress weed growth [4,5]. Uncontrolled weeds in onion decrease bulb yield by 61.4% [4]; 92.3% [6] with up to 100% unmarketable bulbs from un-weeded plots [6]. Ghosheh and Al-Shannag [7] reported that weed interference was more devastating to onion dry bulb yield than insect infestation. The conventional method of weed control, hand-weeding, is costly and difficult due to close planting. Mechanical weed control is useful for controlling weeds between rows but ineffective for controlling weeds within rows[5]. Natural, or non-synthetic, herbicides availability is increasingly limited in many vegetable crops, with tightening restriction on their usage.

Mulching soil with crop residues may selectively provide weed suppression through their physical presence on the soil surface and by replacement of allelochemics or microbially altered allelochemics[8]. The organic-based mulches plant waste, straw, grass clippings, leaf debris, sawdust, banana leaves, water hyacinth, cane, bagasse (sugarcane stalks), flax straw mat and manure have been used for crop production [9,10,11]. Organic-based mulches can be as diverse as the region in which they are used.

Mulching using organic wastes is cost effective, conserves water, moderates soil temperature, reduces waste, and improves the soil[12]. Mulching is considered a cost-effective weed control alternative to hand-weeding of onion[6]. Grass mulching decreased weed density and improve crop yields[13]. While, peat mulch decreased weed populations, but had a negative effect on crop yield[13]. Non effect with mulching with wood chips on crop yield was recorded[14]. Organic mulches remain popular due to low cost and ready availability[11]. However, using dead mulches (saw dust and wheat straw) was not highly effective for weed control and costly[15,16].

Awodoyin et al.[17] reviewed the literature and reported that mulching is an effective method of manipulating the crop growing environment to increase yield and improve product quality by controlling weed growth, ameliorating soil temperature, conserving soil moisture, reducing soil erosion, improving soil structure and enhancing organic matter content.

There is a wide range of materials used for mulching[16,18]. Covering the soil surface with plant mulches increases bacterial populations, suppresses weeds, reduces incidence of *Phytophthora porri*, prevents soil erosion, enhances crop earliness, improves soil moisture conservation, moderates soil temperature, reduces waste, improves the soil and reduces nitrogen leaching to ground water[8,9,12]. There is little information on how sawdust, rice (*Oryza sativa* L) straw, bur-clover weed (*Medicago hispida* Gaertn) or cogongrass (*Imperata cylindrica* L) affect weed control and plant development in onion. The study was undertaken to determine effects of organic mulches on onion plant development and yield and control of associated weeds.

2. **Materials and Methods**

Two field experiments were conducted during the winter seasons (January-May) in the first and second season at Salhia, Sharkia Governorate, Egypt. The soil was sandy with pH 7.8, E.C. 1.08 mmhos·cm^{-1}, organic matter 1.18%, total N 0.028%, total P 0.012% and total K 0.011%. The experimental design was a randomized complete block with 4 replications. Plot area was 10.5 m^2 and consisted of 5 row 3.5 m in length and 60 cm apart. Weed control treatments were: 1) mulching with rice straw; 2) mulching with sawdust, 3) mulching with bur-clover weed; 4) mulching with cogongrass; 5) butralin (Amex®) at 5.4 L·ha^{-1}+1 hand hoeing at 7 weeks after onion transplanting to control weeds; 6) 3 hand hoeings at 21, 42 and 63 days after onion transplanting (DAT), and 7) a un-weeded check.

Rice straw came from neighbor fields after harvest and taken the rice grains, where only about 20% of rice straw was used for purposes such as ethanol, paper, fertilizers and fodders and the remaining amount is either removed from the field, *in situ* burned, piled or spread in the field, incorporated in the soil, or used as mulch for the following crops[19]. The sawdust (from different tree species) was bought from Carpenters and cogongrass, bur-clover weed were dominant weeds in the region. Cogongrass was cutting (tillers with leaves only) and bur-clover weed was pulled by hand from the areas well invested by these weeds.

Shortly before onion seedlings were transplanted, a particular type of organic mulch at a dose of 10 t. ha^{-1} was spread manually on the field. Mulch from rice straw (it's chopped during the mechanical harvesting), cogoongrass was chopped up to pieces (20–30 cm long), while clover weed was used as a complete plant. The thickness of the mulch layer depended on the type of mulch. It's about 3cm in the case of clover weed, 4cm in the case of rice straw, coggongrass and sawdust.

All mulching treatments and herbicide were used before transplanting. Onion seedlings (60 days old), cv. Giza 6, were sown, through the mulch, in the first week of January in both seasons. Recommended rates of calcium superphosphate (15.5% P_2O_5) at 357 kg·ha^{-1} was added immediately before ridging. Nitrogen as ammonium sulphate (20.6% N) was added at 170 kg·N·ha^{-1} in 3 equal portions, before the 1st, 3rd and 5th irrigations. Potassium was applied as potassium sulphate (48% K_2O) at 119 kg·ha^{-1} before the 3rd irrigation. Irrigation system was surface irrigation (furrow) and the plants irrigated when it needed.

At 45 and 75 days after onion transplanting (DAT), weeds were pulled by hand and identified to species. Numbers and dry weight of weed species/1.8 m^2 were recorded. Weed control efficiency (WCE) for weeds number and weed dry weight of each treatment were calculated[20].

Five onion plants were taken from each plot at 45 and 75 DAT and blade length, number of leaves and dry weights obtained. At maturity (the fourth week of May) bulb diameter; bulb fresh weight; rotundity index (bulb shape index) - the ratio of bulb height to bulb diameter; culls, and total and marketable bulb yields (kg·ha$^-$

[1]) were determined. Total soluble solids (TSS %) was determined using a hand refractometer and total marketable bulb yield (kg·ha^{-1}) recorded. Macro- (N, P, K) and micro- (Fe, Zn, Mn) nutrients were determined in dried bulbs according to AOAC[21].

Data were subjected to statistical analysis of variance according to Snedecor and Cochran [22]. Because the interactions between treatments and year for the all variables studied were not significant; data were combined over growing seasons and the means were separated with least significant difference analysis.

3. Results

3.1. Numbers and Dry Weight of Weeds

The most numerous broadleaf weeds were: Prickly dock [*Emex spinosus* (L.) Campd]; Common Lambsquarters (*Chenopodium album,* L.) and Scarlet Pimpernel (*Anagallis arvensis* L.), and the grass weed Italian Ryegrass (*Lolium multiflorum* Lam.).

Numbers and dry weight of weed species were affected by treatment (Tables 1, 2). The efficacy of mulch treatments on weeds at 75 DAT were less, in most cases, compared to at 45 DAT (Tables 1, 2). Rice straw or bur-clover weed mulch reduced total numbers of weeds at 45 DAT; there were no differences between hoeing only and herbicide+1 hoeing on the total number of weeds (Table 1). Depending on the reduction on number of weeds, the control percent of broad leaved weeds (BLW) due to treatment was ranged from 34% to 73% and 39% to 69% at 45 and 75 DAT, respectively, while with narrow leaf weed (NLW) ranged between 20 -71% and 14-26% at that time (Table 1).

Table 1.Effect of mulch treatment on number of weed species/1.8 m^2 at 45 and 75 days from onion transplanting (Combained analysis of 2 seasons).

Treatment	Broad leaf weeds					*Loliummultiflorum*		Total weeds	
	Emexspinosus	***Chenopodium album***	***Anagallisarvensis***	**Total**	**Control %**	**Number**	**Control %**	**Number**	**Control %**
After 45 days from onion transplanting									
Sawdust mulch	6	4.0	7.0	17.0	33.6	3.3	70.8	20.3	45.0
Rice straw mulch	0	1.3	4.7	6.0	72.6	7.0	38.1	13.0	64.8
Clover mulch	0	3.3	4.7	8.0	68.7	9.0	20.4	17.0	53.9
Cogongrass mulch	2	0.0	7.7	9.7	62.1	7.3	35.4	17.0	53.9
Butralin+1hoeing	0	0.7	2.3	3.0	88.3	5.3	53.1	8.3	77.5
Hand hoeing	0	0.0	3.3	3.3	87.1	4.7	58.4	8.0	78.3
Unweeded	8	7.3	10.3	25.6	00.0	11.3	00.0	36.9	00.0
LSD 5%	2	0.6	1.7	3.5	10.4	2.6	8.5	5.4	9.7
After 75 days from onion transplanting									
Sawdust mulch	0.3	4.3	2.7	5.3	68.8	4.0	20.0	11.3	48.6
Rice straw mulch	1.7	3.7	4.0	9.4	44.7	4.0	20.0	13.4	39.1
Clover mulch	4.7	0.3	5.3	10.3	39.4	4.3	14.0	15.6	29.1
Cogongrass mulch	1.7	2.0	5.0	8.7	48.8	3.7	26.0	12.4	43.6
Butralin+1hoeing	0.7	1.7	2.7	5.1	70.0	1.7	66.0	6.8	69.1

Hand hoeing	0.0	3.3	0.3	3.6	78.8	1.0	80.0	4.6	79.1
Unweeded	3.0	7.3	6.7	17.0	00.0	5.0	00.0	22.0	00.0
LSD 5%	1.9	1.1	N.S.	1.0	9.0	2.1	5.6	2.1	6.5

Table 2.Effect of mulch treatments on dry weight of weed species/1.8 m^2 after 45 and 75 days from onion transplanting (Combined analysis of 2 seasons).

Treatment	Broadleaf weeds (g^{-1})					*Loliummultiflorum*		Total weeds	
	Emexspinosus	*Chenopodiumalbum*	*Anagallisarvensis*	Total	Control %	DW	Control %	DW	Control %
After 45 days from onion transplanting									
Sawdust mulch	1.2	2.8	0.4	4.4	17.0	4.4	37.1	8.8	28.5
Rice straw mulch	0.0	0.4	0.5	0.9	83.0	5.2	25.7	6.1	50.4
Clover mulch	0.0	0.5	0.3	0.8	85.0	5.2	25.7	6.0	51.2
Cogongrassmulch	0.4	1.9	0.5	2.8	47.2	3.1	55.7	5.9	52.0
Butralin+1hoeing	0.0	0.8	0.3	1.1	79.2	3.3	52.9	4.4	64.2
Hand hoeing	0.0	0.0	0.1	0.1	98.1	2.4	65.7	2.5	79.7
Unweeded	2.9	1.2	1.2	5.3	00.0	7.0	00.0	12.3	0.0
LSD 5%	0.5	1.8	0.6	1.3	14.3	1.0	5.7	2.9	11.3
After 75 days from onion transplanting									
Sawdust mulch	8.3	10.5	11.1	29.9	43.4	6.3	32.3	36.2	41.7
Rice straw mulch	0.1	17.0	6.3	23.4	55.7	7.1	23.7	30.5	50.9
Clover mulch	7.7	0.5	7.5	15.7	70.3	8.0	14.0	23.7	61.8
Cogongrassmulch	6.7	3.3	5.7	15.7	70.3	7.2	22.6	22.9	63.1
Butralin+1hoeing	0.6	1.3	1.5	3.4	93.6	1.4	85.0	4.8	92.3
Hand hoeing	0.4	2.4	0.2	3.0	94.3	0.9	90.3	3.9	97.8
Unweeded	21.6	21.0	10.2	52.8	00.0	9.3	00.0	62.1	00.0
LSD 5%	2.1	1.7	1.6	2.3	6.6	1.7	17.7	11.1	14.1

The same direction was noticed on the reduction of weed dry weight, where the control percent of BLW were 17% - 85% and 43% -70%, while with NLW were 20% - 71% and 14%-26% at 45 and 75 DAT, respectively (Table 1). Number of *L. multiflorum* at 75 DAT was not affected by mulch treatments (Table 1). Application of 3 hand hoeings and butralin herbicide+1 hoeing reduced total weed numbers at 45 DAT by 78.1 and 77.3% respectively, compared to the un-weeded check.

All weed control treatments decreased dry weight of *E. spinosus* at 45 and 75 DAT, *A. arvensis* at 45 DAT and total weed dry weight at 75 DAT. All mulch treatments reduced total dry weight of weeds at 45 and 75 DAT. Sawdust produced higher dry weight of *C. album* and *L. multiflorium* at 45 DAT compared to other treatments (Table 2).

Rice straw, sawdust, bur-clover weed and cogongrass mulches decreased total weed dry weight at 75 DAT (Table 2). Grassy mulch had the lowest control compared to bur-clover weed mulch (Tables 1, 2). Using hand hoeing, and butraline+1 hand hoeing reduced total weed dry weight at 75 DAT by 92.1 and 92.3%, respectively (Table 2).

Worthy to mention that most weed species as well as total dry weight of broad leaved weeds and total weeds were significantly increased two to three folds -in most cases- at 75 DAT compared to that treatment at 45 DAT. Therefore, all mulch treatments require an additional hand weeding at 60 days after transplanting.

3.2. Onion Plant Growth

Weed infestation reduced onion plant height, numbers of leaves and plant dry weight (Table 3). Not controlling weeds reduced onion plant dry weight at 75 DAT by 55.8%, compared to hoeing (Table 3). Mulching with sawdust, rice straw, bur-clover weed or cogongrass increased onion dry weights at 75 DAT by 108, 82, 136 and 122%, respectively, compared to the un-weeded control (Table 3).

Table 3.Effect of mulch treatments on some growth characters of onion plants after 45 and 75 days from onion transplanting (Combined analysis of 2 seasons).

Treatment	Plant height (cm)	No. of Leaves/ plant	Plant dry weight (g)	Plant height (cm)	No. of leaves/ plant	Plant dry weight (g)
	After 45 days from transplanting			After 75 days from transplanting		
Sawdust mulch	41.2	5.0	7.50	46.2	6.23	10.4
Rice straw mulch	36.9	5.1	6.70	39.6	5.90	9.1
Clover weed mulch	44.6	5.3	6.01	42.1	5.88	11.8
Cogongrass mulch	37.3	4.7	5.77	44.6	5.90	11.1
Butralin+1hoeing	40.0	4.9	6.54	44.7	6.23	9.2
Hand hoeing	34.0	4.9	6.87	43.2	6.80	11.3
Unweeded	33.8	4.3	3.90	38.7	6.23	5.0
LSD 5%	1.3	NS	0.44	NS	NS	1.0

3.3. Onion Bulb Yield And Quality

Bulb weight and diameter, and marketable bulb yield increased; cull weight decreased with weed control, and mulching with bur-clover provided further improvement (Table 4). Controlling onion weeds using sawdust, rice straw and cogongrass mulches increased marketable bulb yield by 127.2, 118.1 and 123.1%, over the un-weeded treatment (Table 4). Application of butralin+1 hand hoeing increased marketable bulb yield over the un-weeded treatment (Table 4). There were no differences in marketable bulb yields between hand hoeing treatment and mulches or herbicide+1 hoeing treatments (Table 4).

Table 4.Effect of mulch treatments on onion yield and its components (Combined analysis of 2 seasons).

Treatment	Bulb characters				Bulb yield (Mt ha^{-1})		
	Diameter (cm)	Weight (g)	Rotundity index	Total soluble solids (%)	Cull	Marketable	Total
Sawdust mulch	6.8	49.8	0.94	11.2	0.40	11.29	11.69
Rice straw mulch	7.0	52.8	0.94	11.5	0.46	10.76	11.22
Clover mulch	7.4	61.8	0.93	10.5	0.24	12.46	12.70
Cogongrass mulch	7.0	52.0	0.97	11.0	0.30	11.18	11.48
Butralin+1 hoeing	7.2	53.0	0.95	10.3	0.27	11.74	12.01
3 hand hoeings	7.7	55.8	0.86	11.2	0.24	12.53	12.77
Unweeded	4.3	26.5	1.50	10.7	0.92	4.23	5.15
LSD 5%	0.6	6.4	0.06	N.S.	0.14	0.81	0.73

3.4. Element Contents in Onion Bulbs

Data for element contents of bulb onion were pooled over years (Table 5). There were no differences in bulb nutrient content due to treatment (Table 5).

Table 5. Effect of mulch treatments on macro and micro-nutrients of onion bulb after harvest (Combined analysis of 2 seasons)

Treatment	Element					
	Macro (%)			Micro (mg kg^{-1})		
	N	P	K	Mn	Zn	Fe
Sawdust mulch	3.17	0.37	2.64	21.1	43.1	246.2
Rice straw mulch	2.48	0.34	2.69	15.2	25.7	166.6
Clover weed mulch	2.54	0.34	2.25	17.0	21.7	193.3
Cogongrass mulch	3.04	0.36	2.20	16.0	22.5	244.6
Butralin+1 hoeing	2.81	0.33	2.84	20.4	24.0	231.3
3 hand hoeings	2.66	0.34	2.35	16.7	26.1	171.0
Unweeded	3.09	0.40	2.72	19.5	31.2	232.2
LSD 5%	0.44	0.06	0.32	2.73	4.68	39.48

4. Discussion

Vigorous weed roots effectively compete with the superficial root system of onion. Mulch has been reported to be beneficial in crop production with Sinkevičienė et al.[13] reporting that straw mulch is better for weed control than sawdust, grass and peat mulch and no mulch.

Mulches can suppress weeds by shading; lowering soil temperatures; moderating diurnal temperature fluctuation; provide a physical barrier to weed seedling emergence; blocking light required for germination of many small-seeded weed species; increasing seed predation, and release of allelochemicals [8,23-28]. At low levels of toxins from organic mulches there is little inhibition, and stimulation may occur. Cogongrass [29]; rice straw [30,31] and some types of sawdust [32] have been reported to be allelopathic potential. That the weed control efficiency of straw mulch and cogongrass was better than sawdust can be explained by slow de-composition of rice straw caused by a high carbon:nitrogen ratio[17]. For sawdust mulch results reported here agree with those of references[15,16], and disagree with Shiyam et al.[33] whom reported that low weed prevalence in mulched plots indicates high weed smothering efficiency of sawdust mulch.

Number of most weeds at 75 DAT was significantly decreased due to mulch treatment with varied percentages, comparing with that at 45DAT, except with rice straw mulch, where the total number of weeds did not differ between the two dates. However the total number of broad and narrow leaved weeds of rice straw mulch was significantly lower at 75 DAT compared to at 45 DAT.

The monocot weed *L. multiflorum* germinated in mulches and was the main weed component in the mulch treatments. Therefore it could be concluded that broadleaved weeds were more susceptible than grassy weeds to mulching.

The reduction in number of weeds due to mulch treatments may be through reduced germination, reduced seedling emergence and reduced size, as well as delayed seed germination[34]. On the contrary, the dry weight of weeds was higher at 75 DAT than that at 45 DAT. This increment may be due to that the weeds were older than that at 45 DAT, and may be to the decline in mulch allelopathic effect due to leaching from the frequent surface irrigations.

Weed development efficiency with sawdust has been stated to be due to inhibiting weed emergence and subsequent growth[33], but in this research sawdust mulch had a lower efficacy control on the total broadleaved weeds and higher efficacy on narrow weed at 45 DAT, while rice straw mulch gave the highest efficacy on the total broadleaved weeds, compared to the other mulches. This may be due to that the mulch depth of sawdust was insufficient to provide adequate control[35]. Awodoyin and Ogunyemi[36] reported that weed control efficiency of different types of mulch ranged differed. The similarity in structure between rice straw and cogongrass mulch[12] could explain similar effect on weeds.

Worthy to mention that most weed species as well as total dry weight of broad leaved weeds and total weeds were significantly increased two to three folds -in most cases- at 75 DAT compared to that treatment at 45 DAT. Therefore, all mulch treatments require an additional hand weeding after 60 days from transplanting.

Broad leaf and grass weeds and crop yield respond differently to organic mulches[13]. New flushes of weeds emerging later in the season probably contributed to bulb yield reductions. Yield reductions in the un-weeded treatment may be due to onion being un-competitive against weeds (1; 2), due to slow growth rate, and growth habit[4,5]. Hussein[37] found that each 0.19 kg of weed dry matter produced in the field resulted in one kg loss in marketable onion bulb yield.

There were no differences in marketable bulb yields between bur-clover weed or cogongrass mulching and hoeing, or between rice straw mulch and butralin herbicide+1 hand hoeing, which conformed with the study of references[18,38]. The bulb development data agree with references[3,16,39].

Coolong[11] reported that straw mulching improved soil health by improving soil structure, increased organic matter in the soil, improved mineral nutrition, enhanced soil bioactivity and yields. Soil moisture in mulched plots is not only higher, but is more stable during the entire growing season[13]. Ossom et al.[25] and Waiganjo et al.[6] reported that mulching is a cost-effective weed control alternative to hand-weeding of onion. However, Karimi et al.[16] found that the best bulb yield of onion (15.39 $Mt{\cdot}ha^{-1}$) was with treatment of pendimethalin and lower amounts were due to mulching with sawdust (4.21 $Mt{\cdot}ha^{-1}$). Similar findings on yield response to tested treatments were confirmed on onion and other crops in other studies[13]; on mulching[40,41]; on herbicide+1 hoeing[42] and on hoeing[7,16,43]. Garlic (*A. sativum*, L.) plants treated with water-hyacinth roots, rice straw or dried grass mulches increased bulb diameter, clove number per bulb, 100-clove weight and bulb yield[18].

Studies on organic mulch in crops indicate that sawdust, bur-clover weed, rice straw or cogongrass, can reduce weed populations in organic farming system by inhibiting weed emergence and subsequent growth [6,11,13,25, 44]. However, this study which does not qualify as organic production due to use of synthetic fertilizer, indicated the mulches will not sufficiently provide season-long control of weeds which may be due to new flushes of weeds emerging later in the season.

Onion productivity is mainly decided by the weed control efficiency of weed management methods. The yield increases due to mulching may be related to increased beneficial micro-organisms population, reduced weed growth, and increased fertility and moisture due to treatments, and this needs further study[9,17]. The superiority of bur-clover treatment was probably due to additional benefits of green manuring effects, beside reducing weed growth. Zhang and Blevins [45] found that at least 40 to 60 $kg{\cdot}ha^{-1}$ more N was estimated to be added to the agroecosystem by the hairy vetch (legume plant) compared to rye (grass plant).

Bur-clover weed, cogongrass, which have not been extensively studied as mulch in vegetables, and rice straw mulch could potentially be used in onion to provide higher marketable yield. It is necessary to determine if combinations of mulches can provide better control than each individually.

Further studies are needed to evaluate if combinations of mulches can provide better control than each individually, their side effects on beneficial organisms diseases, and insects and the effectiveness of these mulches under organic production system.

5. Conclusion

Broadleaved weeds were more susceptible than grassy weeds to mulching. All mulch treatments require an additional hand weeding after 60 days from transplanting. Bur-clover weed, cogongrass, which have not been extensively studied as mulch in vegetables, and rice straw mulch could potentially be used in onion to provide higher marketable yield. It is necessary to determine if combinations of mulches can provide better control than each individually.

6. References

1. Karim, S.M.R., T.M.T. Iqbal, and N. Islam. 1998. Relative yields of crops and crop losses due to weed competition in Bangladesh. Pak. J. Sci. Indust. Res. 41(6): 318-324.
2. Boydston, R.A. and M.D. Seymour. 2002. Volunteer potato (Solanum tuberosum) control with herbicides and cultivation in onion (Allium cepa). Weed Technol. 16: 620-626.
3. Habib ur Rahman, K. Ullah, M. Sadiq, S. Javaria, I. Ullah, H. urRahman, M.A. Khan. 2012. Relationship between manual weeds removal timings and onion yield. Pak. J. Weed Sci. Res. 18(2): 201-207.

4. Ghosheh, H.Z. 2004. Single herbicide treatments for control of broadleaved weeds in onion (*Allium cepa*). Crop Prot. 23: 539-542.
5. Webber, C.L. III, J.W. Shrefler and M.J. Taylor. 2007. Corn gluten meal as an alternative weed control option for spring-transplanted onions. Int. J. Veg. Sci. 13: 17-33.
6. Waiganjo, M.M., J. Kiritu, and B. Kuria. 2009. Effects of weeds on growth of bulb onion and some cost-effective control options at Thika, Kenya. African J Hort. Sci. 2: 92-102. (http://hakenya.net/ajhs/index.php/ajhs/article/view/34/44).
7. Ghosheh, H.Z. and H.K. Al-Shannag HK. 2000. Influence of weeds and onion thrips, Thrips taba (Thysanoptera = Thripidae), on onion bulb yield in Jordan. Crop Prot. 19(3): 175-179.
8. Weston, L.A. 1996. Utilization of allelopathy for weed management in agroecosystem. Agron. J. 88: 860-866.
9. Duppong, L.M., K. Delate, M. Liebman, R. Horton, F. Romero, G. Kraus, J. Petrich, and P.K. Chowdbury. 2004. The effect of natural mulches on crop performance, weed suppression and biochemical constituents of catnip and St. John's Wort. Crop Sci. 44(3): 861-869.
10. Kayum, M., M. Asaduzzaman, and M. Haque. 2008. Effects of indigenous mulches on growth and yield of tomato. J. Agri. Rural Devel. 6: 1-6.
11. Coolong, T. 2012. Mulches for weed management, pp. 57-74. In: A. Price (ed.). Weed control. InTech, Shanghai, China. (http://www.intechopen.com/books/weed-control/ mulches-for-weed-management-in-vegetable-production).
12. McMullen, M. 2013. The effect of mulch type and thickness on the soil surface evaporation rate. Horticulture and Crop Science Department, California Polytechnic State University, Robert E. Kennedy Library, San Luis Obispo, June 2013, pp:11. (http://digitalcommons.calpoly.edu/hcssp/22).
13. Sinkevičienė, A., D. Jodaugienė, R. Pupalienė, and M. Urbonienė. 2009. The influence of organic mulches on soil properties and crop yield. Agron. Res. 7(Special issue I): 485-491.
14. Gruber, S., D. Achraya, and W. Claupein. 2008. Wood chips used for weed control in Organic Farming. J. Plant Dis. Prot. (Special issue XXI): 401-406.
15. Boyhan, G.E., R Hicks, and C.R. Hill. 2006. Natural mulches are not very effective for weed control in onions. HortTechnology 16(3): 523-526.
16. Karimi, M.I., G. Hassan, M.I. Khan, I. Khan, I.A. Khan, and Sh. Bibi. 2012. The impact of chemical and non-chemical weed control methods on weeds dynamics and on the yield of onion (*Allium cepa* L.). Pak. J. Weed Sci. Res. 18(2): 255-263.
17. Awodoyin, R.O., F.I. Ogbeide, and O. Oluwole. 2007. Effects of three mulch types on the growth and yield of tomato (*Lycopersicon esculentum* Mill.) and weed suppression in Ibadan, rainforest-savanna Transition zone of Nigeria. Trop. Agri. Res. Exten. 10: 53-61.
18. Baten, M.A., B.S. Nahar, S.C. Sarker, and M.A.H. Khan. 1995. Effect of different mulches on the growth and yield of late planted garlic (*Allium sativum* L.). Pak. J. Sci. Indust. Res. 38(3-4): 138-141.
19. Hanafi, E. M.; Khadrawy, H. H. E.; Ahmed, W. M.; Zaabal, M. M. 2012. Some observations on rice straw with emphasis on updates of its management. World Applied Sci J., 16 (3) 354-361.
20. Main, C.L., A.J. Michael, and E.C. Murdock. 2007. Weed response and tolerance of enhanced glyphosate-resistant cotton to glyphosate. J. Cotton Sci.11 (2):104-109.
21. Association of Official Analytical Chemists (AOAC). 1980. Official methods of analysis, 13th ed. Washington, D.C.
22. Snedecor, G.W. and W.G. Cochran. 1981. Statistical methods, 7th ed., Iowa State Univ. Press, Ames, IA.
23. Seigler, D.S. 1996. Chemistry and mechanisms of allelopathic interactions. Agron. J. 88: 876-885.
24. Bond, W. and A.C. Grundy. 2001. Non-chemical weed management in organic farming systems. Weed Res. 41: 383-405.
25. Ossom, E.M., P.F. Pace, R.L. Rhykerd, and C.L. Rhykerd. 2001. Effect of mulch on weed infestation, soil temperature, nutrient concentration, and tuber yield in Ipomoea batatus (L.) Lam. in Papua New Guinea. Trop. Agricult. Trinidad. 78: 144-151.
26. Batish, D.R., H.P. Singh, N. Rana, and R.K. Kohli. 2006. Assessment of allelopathic interference of Chenopodium album through its leachates, debris extracts, rhizosphere and amended soil. Arch. Agron. Soil Sci. 52(6): 705-715.
27. Burkhard, N., D. Lynch, D. Percival, and M. Sharifi. 2009. Organic mulch impact on vegetation dynamics and productivity of high bush blueberry under organic production. HortScience 44(3): 688–696.

28. Salam, I.U., M. Ahmed, and S. Tariq-Ali. 2011. Allelopathic effect of scarlet pimpernel (*Anagallis arvensis*) on seed germination and radical elongation of mung bean and pearl millet. Pak. J. Bot. 43(1): 351-355.
29. Cerdeira, A.L., Cantrell. C.L., Dayan, F.E., Byrd, J.D., Duke, S.O. (2012) Tabanone, a new phytotoxic constituent of cogongrass (*Imperata cylindrica*). Weed Sci 60:212–218
30. El-Shahawy, T.A., K.G. El-Rokiek, F.A.Sharara and K.A. Khalaf.2006. Efficacy of rice straw extract against broad and narrow leaved weeds in (*Cucumis sativa* L.). Int. J. Agri. Biol. 8(2):262-268.
31. Siddique A. B. and B. S. Ismail. 2013. Rice Ecosystem, Allelopathy and Environment –A Review. The Agriculturists 11(1): 112-121.
32. Gariglio, N., Buyatti, M., Pillati, R., Rossa, D. and Acosta, M. 2002.Use a germination bioassay to test compost maturity of willow (*Salix* sp.) sawdust. New Zealand. J. Crop of Hortic. Sci., 30: 135-139,
33. Shiyam, J.O., C. Obiefuna, M.C. Ofoh and B.F.D. Oko. 2011. Effect of sawdust mulch and fertilizer on weed flora composition and growth in Plantain/Cocoyam intercrop in the Nigerian rainforest zone. World J. Agric. Sci. 7 (5): 629-632.
34. Ali, H.H.I, A. Tanveer, M.A. Nadeem, M.M. Javaid, M.S. Kashif, and A.R. Chadhar. 2013. Allelopathic effects of *Rhynchosia capitata* on germination and seedling growth of mungbean. Planta daninha 31(3):501-509.
35. Abouziena, H.F., O.M. Hafez, I.M. El-Metwally, S.D. Sharma, and M. Singh. 2008. Comparison of weed suppression and mandarin fruit yield and quality obtained with organic mulches, synthetic mulches, cultivation and glyphosate. HortSci. 43:795–799.
36. Awodoyin, R.O. and S. Ogunyemi. 2005. Use of sicklepod, *Senna obtusifolia* (L.) Irwin and Barneby, as mulch interplant in cayenne pepper, *Capsicum frutescens* L., production. Emirates J. Food Agric. 17(1): 10-22.
37. Hussein, H.F. 2001. Estimation of critical period of cro-weed competition and nutrient removal by weeds in onion (Allium cepa, L.) in sandy soil. Egypt. J. Agron. 24:43-62.
38. Eldabaa, M.A.T., H.F. Abouziena, E.R. El-Desoki, and M.S.A. Abd El Wahed. 2012. Efficacy of some chemical weed control treatments on soybean [*Glycine max* (L.) Merr.] plants and associated weeds in sandy soil. J. App. Sci. Rsch. 8(8): 4678-4684.
39. Abdalla, N.K. and A.G.T. Babiker. 2014. Critical period of weed control in direct seeded onion. Third conference on pest management in Sudan. Agricultural Research Corporation, Crop Protection Research Centre, 3-4 February 2014, Wad Medani, Sudan.
40. Bakht, T. and I. A. Khan. 2014. Weed control in tomato (*Lycopersicon Esculentum* Mill.) through mulching and herbicides. Pak. J. Bot. 46(1): 289-292.
41. Kosterna, E. 2014. The effect of soil mulching with organic mulches, on weed infestation in broccoli and tomato cultivated under polypropylene fibre, and without a cover. J. Plant Prot. Res. 54 (2):88-198.
42. Ravinder, S., T.R. Nanda, U.K. Kohli, S.K. Sharma, and R. Singh. 1998. Effect of different herbicides on growth and yield of onion bulb. Ann. Agric. Res. 19(2): 212-214.
43. El-Metwally, I.M., K.G. El-Rokiek, S.A. Ahmed, E.R. El-Desoki, and E.E.H. Abd-Elsamad 2010. Effect of adding urea or ammonium sulphate on some herbicides efficiency in controlling weeds in onion plants. J. Amer. Sci. 6(11): 536-543.
44. Kar, G. and A. Kumar. 2007. Effects of irrigation and straw mulch on water use and tuber yield of potato in eastern India. Agri. Water Manag. 94: 109-116.
45. Zhang, Z. and R.L. Blevins. 1996. Corn yield response to cover crops and N rates under long- term conventional and no- tillage management. J. Sust. Agri. 8(1): 61-71.

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