

# 节节麦等三种禾本科杂草对不同性状土壤的适应性

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**摘要:** 为明确不同性状土壤对小麦田重要的禾本科杂草节节麦 *Aegilops tauschii*、多花黑麦草 *Alopecurus myosuroides* 和大穗看麦娘 *Lolium multiflorum* 出苗及生长的影响, 在盆栽条件下研究了3种禾本科杂草对采自山东省不同区域的24份不同性状土壤的适应性。结果表明, 节节麦适应性最强, 在所有供试土样中均能正常出苗和生长, 出苗率在64.2%~80.8%之间; 多花黑麦草也有很强的适应性, 在供试24份土样中出苗基本正常, 出苗率均在90.1%以上, 但有2份土样影响其后期生长的株高、鲜重等生长指标; 大穗看麦娘的适应性略差, 有4份土样明显影响其出苗, 出苗率在32.5%~50.8%之间, 在其它20份土样中出苗率均为70.0%左右, 有11份土壤影响其生长期株高、鲜重、穗数或结实量。土壤性状中pH是影响杂草出苗及生长的最主要因素, pH小于6.0的强酸土壤和pH大于8.0的强碱土壤均对杂草生长会产生一定影响, 另外, 黏性土壤质地和高盐分土壤也对杂草生长有影响, 其它土壤性状如氮含量、磷含量、钾含量、有机质含量和土壤类型对这3种禾本科杂草出苗及生长无影响。

**关键词:** 节节麦; 大穗看麦娘; 多花黑麦草; 土壤性状; 适应性

## Adaptability of gramineous weeds *Aegilops tauschii*, *Alopecurus myosuroides* and *Lolium multiflorum* to different types of soil

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**Abstract:** To determine the effects of different soil types on the emergence and growth of three important gramineous weeds *Aegilops tauschii*, *Alopecurus myosuroides* and *Lolium multiflorum* in wheat fields, pot experiments were conducted to study their adaptability to 24 different types of soil. The results showed that *A. tauschii* had the strongest adaptability to all of the 24 types of soil with a seedling emergence rate of 64.2%–80.8%, and *L. multiflorum* had a strong adaptability to 24 kinds of soil with a seedling emergence rate of above 90.1%, but two kinds of soil affected its growth in plant height and fresh weight. The adaptability of *A. myosuroides* was the worst, as four types of soil obviously affected its emergence (32.5%–50.8% vs about 70.0% for the other 20 soils), and 11 types of soil influenced either its height, fresh weight, spike number or its seed yield. Moreover, the results demonstrated that the growth of grass weeds was affected by pH (strong acid less than 6.0 or strong alkali greater than 8.0), and soil texture and salt content of soil all affected the growth, but other five soil indicators including nitrogen, phosphorus, potassium, organic matter content and soil type exhibited no effects.

**Key words:** *Aegilops tauschii*; *Alopecurus myosuroides*; *Lolium multiflorum*; soil type; adaptability

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小麦是我国重要的粮食作物,其种植面积仅次于水稻,小麦的安全生产至关重要(赵彬,2012)。杂草一直是影响小麦产量的重要因素(张朝贤等,2013),近几年来随着新型的耕作(田欣欣等,2011)、施肥等制度(戴晓琴等,2011)的持续推广,再加上除草剂的连年使用,小麦田禾本科杂草发展蔓延趋势加快,20世纪90年代,山东省小麦田杂草主要由阔叶杂草组成,仅有的禾本科杂草只存在于稻麦轮作田(王金信,1998),而到21世纪初,禾本科杂草逐渐蔓延发展,如节节麦 *Aegilops tauschii*、雀麦 *Bromus japonicus*、大穗看麦娘 *Alopecurus myosuroides*、多花黑麦草 *Lolium multiflorum* 等近几年发展蔓延迅速,其中节节麦因其有效防治药剂少而导致蔓延面积很快扩大,大穗看麦娘也在河北、山东、河南等省发展蔓延(高兴祥等,2014a)。

目前,对节节麦、大穗看麦娘等恶性禾本科杂草的研究主要集中在其起源分布、生物学特性、与作物的竞争关系以及防除技术等方面,如颜济等(1984)报道了节节麦的起源;房锋等(2013;2015)预测了节节麦的潜在分布区域以及对于干旱、盐碱等逆境的适应性;王克功等(2013)报道了节节麦的适宜生长温度、需水量、光照条件等生物学特性;高兴祥等(2014b;2016)研究了大穗看麦娘和多花黑麦草的化学防治技术;房锋等(2017)分析了大穗看麦娘密度对小麦产量的影响。但关于节节麦、大穗看麦娘和多花黑麦草这3种禾本科杂草对不同性状土壤的适应性尚未见报道,而研究杂草对不同性状土壤的适应性对明确杂草的扩散蔓延规律以及制定杂草综合防治策略具有重要意义。本试验拟通过比较采集自24个不同地方的土壤对节节麦等3种禾本科杂草生长的影响,分析预测这3种杂草潜在的扩散区域和分布,以期对小麦田禾本科杂草扩散蔓延机理研究提供理论基础。

## 1 材料与方法

### 1.1 材料

供试杂草种子:于2014年自济南市采集节节麦和大穗看麦娘的种子,自菏泽市采集多花黑麦草种子,冷藏储存,备用。

供试土壤:在山东省济南、青岛、淄博、东营、烟台、潍坊、济宁、泰安、日照、临沂、德州、聊城、滨州、菏泽14地市的24个地区选取有代表性的农田,每个地区选取1块农田,每块农田随机5点取样,采集地

表20 cm深度以内的土壤,采集后混匀,每份土样取20 kg带回实验室进行试验。

### 1.2 方法

#### 1.2.1 土壤样品指标的测定

试验前将采集的24份土壤样本送山东省植物营养与肥料重点实验室进行检测,测定每份土壤的水解性氮、有效磷、速效钾、有机质含量以及pH、土壤类型、质地类型、盐分等指标。

#### 1.2.2 土壤对3种杂草出苗及生长影响的测定

试验在山东省农业科学院露天空地进行。于2014年10月将24份土壤分别装在上口直径25 cm、高度22.5 cm的花盆中,每盆播种30粒供试杂草种子,然后覆土2~3 mm,每份土样每种杂草均设6次重复,每盆杂草为1次重复。

播种后每天观察3种禾本科杂草的出苗情况,播种后20 d调查节节麦等3种禾本科杂草的出苗数,计算出苗率,出苗率=出苗数/播种种子数×100%。冬后禾本科杂草穗期(翌年5月1日),调查各处理节节麦等禾本科杂草3个重复的株高和地上部鲜重,计算平均株高和平均鲜重;另3个重复于5月25日种子成熟期,收获后统计穗数和种子数,计算平均穗数和平均种子数。

### 1.3 数据分析

采用SPSS 17.0软件对试验数据进行one-way ANOVA分析,应用 $t$ 测验法进行差异显著性检验。

## 2 结果与分析

### 2.1 山东省不同地区采集土壤的性状

24份土壤样品水解性氮、有效磷和速效钾的含量差异很大,相互之间没有明显规律。水解性氮含量最低的土样采自滨州市富国街道,仅为19.9 mg/kg,而含量最高的土样采自济南市王舍人镇,达到174.6 mg/kg;有效磷含量在7.1~165.2 mg/kg之间,含量最低的土样采自德州市黄河涯镇,含量最高的土样采自临沂市板桥镇;速效钾含量差异更大,日照市高兴镇土样中含量最低,为36.0 mg/kg,日照市涛雒镇土样中含量最高,达到375.0 mg/kg;有机质含量差异也较大,在6.5~31.0 g/kg之间(表1)。

24个采集地点的土壤pH差异也很大,其中以碱性土壤居多,有18个采集样点的土壤pH大于7.0,有6个样点的土壤pH小于7.0;土壤类型有棕壤土、潮土和褐土3种;土壤质地有中壤质土、砂壤质土、轻壤质土、黏壤土4种;盐分含量大部分在

1.0 mg/g 以下,但有滨州市城关镇等 4 份土样盐分含量较高,在 1.6~3.4 mg/g 之间(表 1)。

表 1 采自山东省不同地区的 24 份土壤样品的指标测定结果  
Table 1 Measurement of 24 soil samples from Shandong Province

| 采集地点<br>Soil location                      | 水解性氮<br>Alkali<br>hydrolysable<br>nitrogen<br>(mg/kg) | 有效磷<br>Available<br>phosphorus<br>(mg/kg) | 速效钾<br>Available<br>potassium<br>(mg/kg) | 有机质<br>Organic<br>matter<br>(g/kg) | pH  | 土壤类型<br>Soil type | 质地类型<br>Texture<br>type | 盐分<br>Salt<br>content<br>(mg/g) |
|--------------------------------------------|-------------------------------------------------------|-------------------------------------------|------------------------------------------|------------------------------------|-----|-------------------|-------------------------|---------------------------------|
| 济南市太平镇<br>Taiping Town, Jinan City         | 83.9                                                  | 21.4                                      | 206.0                                    | 21.7                               | 7.9 | 潮土<br>Alluvia     | 中壤质<br>Medium           | 0.8                             |
| 临沂市沙沟镇<br>Shagou Town, Linyi City          | 93.5                                                  | 74.2                                      | 258.5                                    | 23.2                               | 4.8 | 棕壤土<br>Brown      | 中壤质<br>Medium           | 0.5                             |
| 德州市于集镇<br>Yuji Town, Dezhou City           | 54.0                                                  | 33.5                                      | 172.5                                    | 15.4                               | 8.8 | 潮土<br>Alluvia     | 砂壤质<br>Sandy            | 0.9                             |
| 济南市王舍人镇<br>Wangsheren Town, Jinan City     | 174.6                                                 | 49.2                                      | 216.5                                    | 31.0                               | 7.9 | 潮土<br>Alluvia     | 轻壤质<br>Light            | 0.7                             |
| 临沂市兰山镇<br>Lanshan Town, Linyi City         | 72.2                                                  | 28.3                                      | 143.0                                    | 21.5                               | 7.1 | 棕壤土<br>Brown      | 中壤质<br>Medium           | 0.5                             |
| 滨州市城关镇<br>Chengguan Town, Binzhou City     | 55.7                                                  | 8.8                                       | 90.5                                     | 12.8                               | 8.1 | 潮土<br>Alluvia     | 砂壤质<br>Sandy            | 3.4                             |
| 滨州市焦桥镇<br>Jiaoqiao Town, Binzhou City      | 87.3                                                  | 13.4                                      | 140.5                                    | 17.9                               | 7.9 | 潮土<br>Alluvia     | 轻壤质<br>Light            | 0.6                             |
| 东营市黄河口镇<br>Huanghekou Town, Dongying City  | 69.1                                                  | 7.7                                       | 211.5                                    | 14.2                               | 8.0 | 潮土<br>Alluvia     | 黏壤土<br>Sticky           | 2.0                             |
| 泰安市北集镇<br>Beijipo Town, Tai'an City        | 56.4                                                  | 30.9                                      | 58.5                                     | 22.1                               | 7.9 | 褐土<br>Cinnamon    | 轻壤质<br>Light            | 0.8                             |
| 潍坊市孟瞳镇<br>Mengtuan Town, Weifang City      | 57.1                                                  | 15.6                                      | 241.0                                    | 21.8                               | 8.1 | 棕壤土<br>Brown      | 轻壤质<br>Light            | 0.4                             |
| 济宁市南张镇<br>Nanzhang Town, Jining City       | 71.2                                                  | 14.9                                      | 84.5                                     | 15.5                               | 7.6 | 潮土<br>Alluvia     | 中壤质<br>Medium           | 1.0                             |
| 滨州市富国街道<br>Fuguo Street, Binzhou City      | 19.9                                                  | 8.2                                       | 147.5                                    | 6.5                                | 8.8 | 潮土<br>Alluvia     | 砂壤质<br>Sandy            | 1.6                             |
| 德州市黄河涯镇<br>Huangheya Town, Dezhou City     | 42.6                                                  | 7.1                                       | 105.0                                    | 9.2                                | 8.5 | 潮土<br>Alluvia     | 轻壤质<br>Light            | 0.5                             |
| 菏泽市桃源集镇<br>Taoyuanji Town, Heze City       | 102.4                                                 | 53.8                                      | 173.5                                    | 25.3                               | 7.7 | 棕壤土<br>Brown      | 轻壤质<br>Light            | 0.7                             |
| 聊城市北城街道<br>Beicheng Street, Liaocheng City | 105.2                                                 | 29.7                                      | 203.5                                    | 18.6                               | 7.9 | 潮土<br>Alluvia     | 砂壤质<br>Sandy            | 0.9                             |
| 青岛市望城镇<br>Wangcheng Town, Qingdao City     | 50.9                                                  | 53.1                                      | 132.5                                    | 10.7                               | 5.8 | 棕壤土<br>Brown      | 中壤质<br>Medium           | 0.8                             |
| 菏泽市麒麟镇<br>Qilin Town, Heze City            | 81.8                                                  | 110.0                                     | 277.0                                    | 20.1                               | 8.3 | 棕壤土<br>Brown      | 轻壤质<br>Light            | 0.7                             |
| 烟台市港城镇<br>Gangcheng Town, Yantai City      | 56.0                                                  | 28.9                                      | 73.0                                     | 17.0                               | 6.8 | 棕壤土<br>Brown      | 轻壤质<br>Light            | 1.0                             |
| 潍坊市高柳街道<br>Gaoliu Street, Weifang City     | 62.6                                                  | 11.2                                      | 101.5                                    | 13.8                               | 8.0 | 褐土<br>Cinnamon    | 轻壤质<br>Light            | 0.6                             |
| 淄博市石桥镇<br>Shiqiao Town, Zibo City          | 90.4                                                  | 40.7                                      | 238.0                                    | 29.5                               | 7.9 | 褐土<br>Cinnamon    | 轻壤质<br>Light            | 0.6                             |
| 临沂市板桥镇<br>Banqiao Town, Linyi City         | 146.4                                                 | 165.2                                     | 283.0                                    | 18.5                               | 6.6 | 棕壤土<br>Brown      | 轻壤质<br>Light            | 0.7                             |
| 济宁市石桥镇<br>Shiqiao Town, Jining City        | 104.5                                                 | 36.7                                      | 189.0                                    | 27.9                               | 7.8 | 潮土<br>Alluvia     | 中壤质<br>Medium           | 2.9                             |
| 日照市高兴镇<br>Gaoxing Town, Rizhao City        | 39.2                                                  | 18.9                                      | 36.0                                     | 8.8                                | 5.1 | 潮土<br>Alluvia     | 砂壤质<br>Sandy            | 1.0                             |
| 日照市涛雒镇<br>Taoluo Town, Rizhao City         | 84.6                                                  | 42.0                                      | 375.0                                    | 19.4                               | 6.7 | 棕壤土<br>Brown      | 轻壤质<br>Light            | 0.6                             |

## 2.2 不同类型土壤对3种杂草出苗的影响

3种禾本科杂草对供试土壤的适应性很强,在大部分采集土样中均有较好的出苗率,其中,节节麦的适应性较强,在24份土样中的出苗率基本一致,在64.2%~80.8%之间,不同土样中差异不大;多花黑麦草对

的出苗率均达90.1%以上;部分土样对大穗看麦娘出苗率的影响较大,尤其是在临沂市沙沟镇、东营市黄河口镇、潍坊市孟瞳镇和济宁市石桥镇4份土壤样品中的出苗率较低,介于32.5%~50.8%之间,而在其它20份土壤样品中的出苗率基本在70.0%左右(图1)。

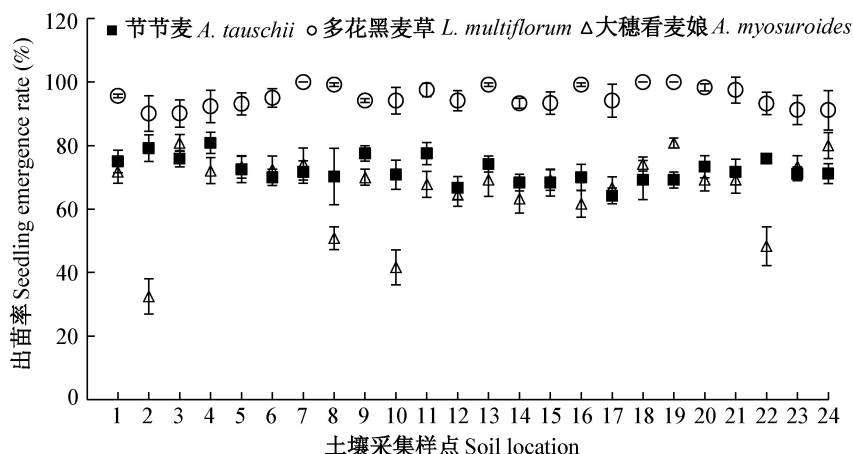


图1 3种禾本科杂草在山东省不同类型土壤中的出苗率

Fig. 1 The seedling emergence rate of three grass weeds in different soils in Shandong Province

1: 济南市太平镇; 2: 临沂市沙沟镇; 3: 德州市于集镇; 4: 济南市王舍人镇; 5: 临沂市兰山镇; 6: 滨州市城关镇; 7: 滨州市焦桥镇; 8: 东营市黄河口镇; 9: 泰安市北集坡镇; 10: 潍坊市孟瞳镇; 11: 济宁市南张镇; 12: 滨州市富国街道; 13: 德州市黄河涯镇; 14: 菏泽市桃源集镇; 15: 聊城市北城街道; 16: 青岛市望城镇; 17: 菏泽市麒麟镇; 18: 烟台市港城镇; 19: 潍坊市高柳街道; 20: 淄博市石桥镇; 21: 临沂市板桥镇; 22: 济宁市石桥镇; 23: 日照市高兴镇; 24: 日照市涛雒镇。图中数据为平均数±标准误。1: Taiping Town, Jinan City; 2: Shagou Town, Linyi City; 3: Yuji Town, Dezhou City; 4: Wangsheren Town, Jinan City; 5: Lanshan Town, Linyi City; 6: Chengguan Town, Binzhou City; 7: Jiaoqiao Town, Binzhou City; 8: Huanghekou Town, Dongying City; 9: Beijipo Town, Taian City; 10: Mengtuan Town, Weifang City; 11: Nanzhang Town, Jining City; 12: Fuguo Street, Binzhou City; 13: Huangheya Town, Dezhou City; 14: Taoyuanji Town, Heze City; 15: Beicheng Street, Liaocheng City; 16: Wangcheng Town, Qingdao City; 17: Qilin Town, Heze City; 18: Gangcheng Town, Yantai City; 19: Gaoliu Street, Weifang City; 20: Shiqiao Town, Zibo City; 21: Banqiao Town, Linyi City; 22: Shiqiao Town, Jining City; 23: Gaoxing Town, Rizhao City; 24: Taoluo Town, Rizhao City. Data are mean±SE.

## 2.3 不同类型土壤对3种杂草生长的影响

节节麦株高不受土壤类型的影响,供试24份土样中其株高均无显著差异,在35.6~41.1 cm之间;东营市黄河口镇和滨州市富国街道土样对多花黑麦草的株高影响显著,分别为21.6 cm和23.5 cm,均显著低于在其它22份土样中的株高37.7~49.2 cm;影响大穗看麦娘株高的土壤样品较多,其中东营市黄河口镇土样的影响最大,株高仅为16.4 cm,其次为临沂市沙沟镇、德州市于集镇、滨州市城关镇、滨州市富国街道、德州市黄河涯镇、青岛市望城镇、菏泽市麒麟镇土样,对大穗看麦娘的株高也有显著影响,株高在28.3~32.5 cm之间,显著低于其它土样中大穗看麦娘的正常株高36.5~43.1 cm(表2)。

节节麦鲜重不受土壤类型的影响;影响多花黑

麦草鲜重的有东营市黄河口镇和滨州市富国街道土样,鲜重分别为16.3 g和11.2 g,均显著低于其它土样中的鲜重29.6~35.5 g;影响大穗看麦娘鲜重的有德州市于集镇、滨州市城关镇、东营市黄河口镇、滨州市富国街道、菏泽市麒麟镇、日照市高兴镇土样,鲜重在3.3~18.6 g之间,另外临沂市沙沟镇土样中大穗看麦娘的鲜重也略低,为22.2 g,均显著低于其它土样中的鲜重25.2~31.8 g(表2)。

不同土壤样品对杂草穗数的影响与对株高的影响类似,但不完全一样。24份供试土样对节节麦穗数也没有显著影响;东营市黄河口镇和滨州市富国街道土样影响多花黑麦草穗数,分别为13.5个和5.0个,显著低于其它土壤样品中多花黑麦草的穗数16.0~20.1个;对大穗看麦娘穗数产生影响的有7份

土样,分别是德州于集镇、滨州市城关镇、东营市黄河口镇、滨州市富国街道、德州市黄河涯镇、菏泽市麒麟镇、日照市高兴镇土样,尤其是东营市黄河口镇和滨州市富国街道土样中多花黑麦草的穗数仅为4.5个和2.0个,其它17份土样中大穗看麦娘穗数在16.0~20.1个之间(表3)。

表2 山东省不同性状土壤对节节麦等3种禾本科杂草株高和鲜重的影响

Table 2 Effects of different types of soil on the plant height and fresh weight of three grass weeds in Shandong Province

| 采集地点<br>Soil location                      | 节节麦 <i>A. tauschii</i> |                        | 多花黑麦草 <i>L. multiflorum</i> |                        | 大穗看麦娘 <i>A. myosuroides</i> |                        |
|--------------------------------------------|------------------------|------------------------|-----------------------------|------------------------|-----------------------------|------------------------|
|                                            | 株高 (cm)<br>Height      | 鲜重 (g)<br>Fresh weight | 株高 (cm)<br>Height           | 鲜重 (g)<br>Fresh weight | 株高 (cm)<br>Height           | 鲜重 (g)<br>Fresh weight |
| 济南市太平镇 Taiping Town, Jinan City            | 37.5±1.6 a             | 20.4±0.8 a             | 41.2±0.9 a                  | 32.1±1.3 a             | 41.5±0.9 a                  | 26.9±1.3 a             |
| 临沂市沙沟镇 Shagou Town, Linyi City             | 39.2±0.9 a             | 23.5±1.2 a             | 41.5±1.1 a                  | 31.3±0.6 a             | 30.5±1.1 c                  | 22.2±1.4 b             |
| 德州市于集镇 Yuji Town, Dezhou City              | 38.3±2.5 a             | 23.4±0.6 a             | 44.2±0.6 a                  | 30.6±1.2 a             | 28.3±1.0 c                  | 13.2±1.6 d             |
| 济南市王舍人镇 Wangsheren Town, Jinan City        | 40.3±0.6 a             | 24.2±1.1 a             | 44.4±3.2 a                  | 32.1±1.4 a             | 41.6±0.9 a                  | 26.1±2.0 a             |
| 临沂市兰山镇 Lanshan Town, Linyi City            | 38.6±1.3 a             | 25.1±1.3 a             | 42.7±0.8 a                  | 33.6±1.3 a             | 40.2±1.0 a                  | 25.2±1.3 a             |
| 滨州市城关镇 Chengguan Town, Binzhou City        | 40.9±1.5 a             | 25.2±1.0 a             | 43.7±1.1 a                  | 33.7±1.5 a             | 31.4±1.2 c                  | 18.6±2.2 c             |
| 滨州市焦桥镇 Jiaoqiao Town, Binzhou City         | 41.1±2.0 a             | 24.2±0.9 a             | 43.2±0.5 a                  | 32.2±2.0 a             | 38.2±0.6 a                  | 26.1±2.4 a             |
| 东营市黄河口镇<br>Huanghekou Town, Dongying City  | 37.5±2.6 a             | 23.6±0.5 a             | 21.6±0.9 b                  | 16.3±1.1 b             | 16.4±0.5 d                  | 9.8±1.3 d              |
| 泰安市北集坡镇 Beijipo Town, Tai'an City          | 37.5±1.1 a             | 22.7±1.3 a             | 38.3±0.6 a                  | 30.4±1.4 a             | 37.2±0.2 a                  | 28.6±1.6 a             |
| 潍坊市孟瞳镇 Mengtuan Town, Weifang City         | 36.8±0.9 a             | 23.5±1.2 a             | 39.7±2.2 a                  | 31.0±1.6 a             | 41.1±0.4 a                  | 30.2±1.9 a             |
| 济宁市南张镇 Nanzhang Town, Jining City          | 40.7±1.6 a             | 20.5±1.4 a             | 37.7±0.9 a                  | 33.7±1.2 a             | 36.5±0.9 a                  | 31.8±2.2 a             |
| 滨州市富国街道 Fuguo Street, Binzhou City         | 38.3±1.3 a             | 21.2±0.9 a             | 23.5±0.8 b                  | 11.2±2.0 b             | 31.2±1.0 c                  | 3.3±2.3 e              |
| 德州市黄河涯镇<br>Huangheya Town, Dezhou City     | 38.7±1.5 a             | 23.5±0.5 a             | 40.5±1.1 a                  | 29.6±1.5 a             | 31.8±0.9 c                  | 25.9±1.6 a             |
| 菏泽市桃源集镇<br>Taoyuanji Town, Heze City       | 39.8±2.1 a             | 25.0±1.0 a             | 41.0±0.5 a                  | 31.2±1.3 a             | 41.6±0.8 a                  | 29.8±2.6 a             |
| 聊城市北城街道<br>Beicheng Street, Liaocheng City | 39.6±1.6 a             | 24.1±0.9 a             | 41.0±0.9 a                  | 31.3±1.4 a             | 37.8±0.8 a                  | 30.1±1.6 a             |
| 青岛市望城镇<br>Wangcheng Town, Qingdao City     | 38.7±0.6 a             | 20.5±0.6 a             | 42.5±1.2 a                  | 32.2±2.1 a             | 32.5±1.3 c                  | 27.1±1.9 a             |
| 菏泽市麒麟镇 Qilin Town, Heze City               | 38.0±0.9 a             | 20.2±1.0 a             | 41.2±0.9 a                  | 35.5±1.6 a             | 31.8±1.2 c                  | 17.3±1.9 c             |
| 烟台市港城镇 Gangcheng Town, Yantai City         | 37.9±1.2 a             | 23.4±0.9 a             | 43.1±1.0 a                  | 33.4±1.8 a             | 42.2±0.5 a                  | 29.5±2.0 a             |
| 潍坊市高柳街道 Gaoliu Street, Weifang City        | 38.4±1.6 a             | 21.2±1.6 a             | 42.2±4.1 a                  | 35.5±1.5 a             | 43.1±0.6 a                  | 28.6±1.4 a             |
| 淄博市石桥镇 Shiqiao Town, Zibo City             | 38.2±1.4 a             | 25.3±0.6 a             | 43.5±1.1 a                  | 34.8±1.6 a             | 40.6±1.1 a                  | 30.1±2.1 a             |
| 临沂市板桥镇 Banqiao Town, Linyi City            | 38.9±0.6 a             | 22.1±0.8 a             | 44.6±1.0 a                  | 34.1±1.9 a             | 41.2±0.6 a                  | 29.6±1.3 a             |
| 济宁市石桥镇 Shiqiao Town, Jining City           | 35.6±5.1 a             | 23.6±0.6 a             | 47.5±0.5 a                  | 34.2±1.2 a             | 39.2±1.0 a                  | 27.1±1.6 a             |
| 日照市高兴镇 Gaoxing Town, Rizhao City           | 39.5±1.2 a             | 21.5±1.5 a             | 45.2±3.5 a                  | 31.2±0.9 a             | 43.0±0.9 a                  | 17.7±0.9 c             |
| 日照市涛雒镇 Taoluo Town, Rizhao City            | 39.3±0.5 a             | 21.6±2.1 a             | 49.2±1.6 a                  | 32.5±1.2 a             | 41.3±0.5 a                  | 29.1±1.3 a             |

表中数据为平均数±标准误。同列数据后不同小写字母表示经 *t* 测验法检验在  $P<0.05$  水平差异显著。Data are mean±SE. Different letters in the same column indicate significant difference at  $P<0.05$  level by *t* test.

节节麦结实量受土壤性状的影响最小,在24份土样中的结实量无显著差异,平均每盆结实量在296.5~362.5个之间;其次多花黑麦草受土壤性状影响也较小,只有东营市黄河口镇和滨州市富国街道土样显著影响其结实,每盆结实量分别为795.0、1 059.0个,另外潍坊市孟瞳镇、德州市黄河涯镇、淄博市石桥镇、济宁市石桥镇土样中多花黑麦草每盆结实量也略少,在2 115.5~2 232.0个之间,但与其它18份土样中的每盆结实量2 396.0~2 959.5个无

显著差异;3种禾本科杂草比较来看,大穗看麦娘对土壤的要求明显高于节节麦和多花黑麦草,但在所有土样中种子均能成熟,结实量正常的有济南市太平镇、济南市王舍人镇、临沂市兰山镇、烟台市港城镇、临沂市板桥镇和日照市涛雒镇土样,每盆结实量在2 514.0~2 813.6个之间,另外滨州市焦桥镇等7份土样略影响其结实量,每盆结实量在2 202.0~2 338.0个之间,其它11份土样均在一定程度上影响大穗看麦娘的结实量(表3)。

表3 山东省不同性状土壤对节节麦等3种禾本科杂草有效穗数和结实量的影响

Table 3 Effects of different types of soil on the effective no. of spikes and no. of seeds of three grass weeds in Shandong Province

| 采集地点<br>Soil location                      | 节节麦 <i>A. tauschii</i> |                        | 多花黑麦草 <i>L. multiflorum</i> |                        | 大穗看麦娘 <i>A. myosuroides</i> |                        |
|--------------------------------------------|------------------------|------------------------|-----------------------------|------------------------|-----------------------------|------------------------|
|                                            | 穗数<br>No. of<br>spikes | 结实量<br>No. of<br>seeds | 穗数<br>No. of<br>spikes      | 结实量<br>No. of<br>seeds | 穗数<br>No. of<br>spikes      | 结实量<br>No. of<br>seeds |
| 济南市太平镇 Taiping Town, Jinan City            | 20.0±1.2 a             | 302.6±32.5 a           | 18.6±1.6 a                  | 2 516.3±113.0 a        | 16.5±1.2 a                  | 2 533.4±101.0 a        |
| 临沂市沙沟镇 Shagou Town, Linyi City             | 19.5±1.2 a             | 296.5±46.2 a           | 18.6±2.0 a                  | 2 625.2±231.0 a        | 16.0±0.9 a                  | 2 142.6±92.5 b         |
| 德州市于集镇 Yuji Town, Dezhou City              | 20.5±2.5 a             | 350.1±22.5 a           | 18.1±1.3 a                  | 2 415.6±214.0 a        | 10.5±1.2 c                  | 1 771.0±52.5 c         |
| 济南市王舍人镇<br>Wangsheren Town, Jinan City     | 22.0±0.6 a             | 313.5±31.5 a           | 16.2±1.2 a                  | 2 959.5±105.0 a        | 18.5±1.5 a                  | 2 635.6±63.5 a         |
| 临沂市兰山镇<br>Lanshan Town, Linyi City         | 21.3±1.5 a             | 332.5±41.3 a           | 17.0±2.0 a                  | 2 462.5±99.6 a         | 16.9±1.6 a                  | 2 593.5±82.4 a         |
| 滨州市城关镇<br>Chengguan Town, Binzhou City     | 21.0±1.2 a             | 342.5±36.5 a           | 16.0±1.4 a                  | 2 512.6±89.5 a         | 13.5±1.3 b                  | 1 476.0±46.2 d         |
| 滨州市焦桥镇<br>Jiaoqiao Town, Binzhou City      | 23.5±3.2 a             | 351.2±44.2 a           | 17.5±1.2 a                  | 2 413.6±103.0 a        | 16.5±3.2 a                  | 2 306.5±62.5 ab        |
| 东营市黄河口镇<br>Huanghekou Town, Dongying City  | 22.5±2.6 a             | 342.5±35.2 a           | 13.5±1.6 b                  | 795.0±66.2 c           | 4.5±2.6 d                   | 1 015.5±72.5 e         |
| 泰安市北集坡镇<br>Beijipo Town, Tai'an City       | 24.0±0.6 a             | 342.5±16.5 a           | 19.5±1.5 a                  | 2 612.5±135.0 a        | 18.2±2.1 a                  | 2 226.5±113.0 ab       |
| 潍坊市孟疃镇<br>Mengtuan Town, Weifang City      | 24.0±1.6 a             | 312.5±46.2 a           | 16.2±2.0 a                  | 2 135.2±143.0 ab       | 18.5±3.5 a                  | 2 036.2±52.4 b         |
| 济宁市南张镇<br>Nanzhang Town, Jining City       | 22.0±1.2 a             | 342.6±11.5 a           | 18.5±1.4 a                  | 2 422.6±102.0 a        | 18.0±2.1 a                  | 2 315.2±35.2 ab        |
| 滨州市富国街道<br>Fuguo Street, Binzhou City      | 22.0±1.2 a             | 360.1±16.5 a           | 5.0±1.6 c                   | 1 059.0±66.2 b         | 2.0±1.6 d                   | 507.5±62.5 f           |
| 德州市黄河涯镇<br>Huangheya Town, Dezhou City     | 20.5±1.1 a             | 335.5±36.2 a           | 17.2±2.3 a                  | 2 217.5±135.0 ab       | 10.0±1.5 c                  | 1 702.0±44.6 c         |
| 菏泽市桃源集镇<br>Taoyuanji Town, Heze City       | 21.0±0.9 a             | 346.3±22.9 a           | 16.5±1.6 a                  | 2 412.5±92.5 a         | 18.6±1.6 a                  | 2 202.0±52.6 ab        |
| 聊城市北城街道<br>Beicheng Street, Liaocheng City | 22.3±1.6 a             | 337.6±31.2 a           | 17.1±1.5 a                  | 2 512.6±85.5 a         | 19.2±3.6 a                  | 2 316.2±46.2 ab        |
| 青岛市望城镇<br>Wangcheng Town, Qingdao City     | 21.6±2.6 a             | 342.1±25.4 a           | 16.5±2.8 a                  | 2 416.2±84.6 a         | 19.3±2.2 a                  | 2 027.0±52.4 b         |
| 菏泽市麒麟镇 Qilin Town, Heze City               | 20.5±1.1 a             | 351.1±33.5 a           | 17.2±1.6 a                  | 2 396.0±69.2 a         | 13.0±1.1 b                  | 1 395.0±69.2 d         |
| 烟台市港城镇<br>Gangcheng Town, Yantai City      | 23.0±2.4 a             | 312.5±26.5 a           | 18.2±2.6 a                  | 2 812.6±71.5 a         | 19.1±1.2 a                  | 2 514.0±113.0 a        |
| 潍坊市高柳街道<br>Gaoliu Street, Weifang City     | 22.5±1.6 a             | 322.5±22.4 a           | 16.5±1.9 a                  | 2 412.6±46.5 a         | 18.6±1.0 a                  | 2 112.5±66.2 b         |
| 淄博市石桥镇 Shiqiao Town, Zibo City             | 20.0±2.1 a             | 313.5±16.5 a           | 18.5±2.6 a                  | 2 115.5±133.0 ab       | 19.1±2.1 a                  | 2 370.5±52.4 ab        |
| 临沂市板桥镇 Banqiao Town, Linyi City            | 23.5±1.6 a             | 342.5±25.2 a           | 19.1±0.6 a                  | 2 845.0±114.0 a        | 20.1±3.5 a                  | 2 813.6±46.2 a         |
| 济宁市石桥镇 Shiqiao Town, Jining City           | 23.5±2.5 a             | 362.5±16.5 a           | 18.5±2.2 a                  | 2 232.0±105.0 ab       | 19.6±2.2 a                  | 2 338.0±69.5 ab        |
| 日照市高兴镇<br>Gaoxing Town, Rizhao City        | 21.6±1.6 a             | 315.4±35.2 a           | 17.6±1.5 a                  | 2 615.2±200.0 a        | 14.0±1.6 b                  | 1 238.5±114.0 e        |
| 日照市涛雒镇 Taoluo Town, Rizhao City            | 22.2±2.2 a             | 342.5±24.9 a           | 20.1±1.5 a                  | 2 912.6±122.0 a        | 20.0±2.5 a                  | 2 615.2±125.0 a        |

表中数据均以每盆为单位进行统计。表中数据为平均数±标准误。同列数据后不同小写字母表示经 *t* 测验法检验在  $P<0.05$  水平差异显著。Data are taken with a pot as a unit. Data are mean±SE. Different letters in the same column indicate significant difference at  $P<0.05$  level by *t* test.

综合分析24份土壤样品对节节麦、多花黑麦草和大穗看麦娘出苗及生长的影响,发现节节麦适应能力最强,不受任何土壤的影响。东营市黄河口镇

和滨州市富国街道这2份土样基本不影响多花黑麦草出苗,但显著影响其后期生长,如株高、有效穗数、植株鲜重和结实量,其它22份土样对多花黑麦草出

苗和生长均无显著影响。除了东营市黄河口镇和滨州市富国街道这2份土样对大穗看麦娘也有影响外,临沂市沙沟镇、德州于集镇、滨州市城关镇、潍坊市孟疃镇、德州市黄河涯镇、青岛市望城镇、菏泽市麒麟镇、潍坊市高柳街道、日照市高兴镇这9份土样对大穗看麦娘有一定影响,或影响其出苗,或影响其生长和后期结实量,只有13份土样对大穗看麦娘出苗和生长无显著影响。

### 3 讨论

当一种杂草的个体被传播到远离其生长地的新环境时,要想继续生存下去,必须对新的环境(包括温度、土壤性状等)有很强的适生性(蒋文志等, 2010)。近几年,紫茎泽兰 *Eupatorium adenophora* (丁晖等, 2007; 于文清等, 2012)、薇甘菊 *Mikania micrantha* (李鸣光等, 2012)、豚草 *Ambrosia artemisiifolia* (李建东等, 2009)、空心莲子草 *Alternanthera philoxeroides* (郭连金等, 2009) 等入侵物种能够成功入侵多个地区, 给当地物种造成毁灭性的影响, 除了这些物种具有植株大、种子量大、化感作用强、无性繁殖等因素外, 对包括土壤因素在内的当地环境的强适应性也是其成功入侵的重要因素。本试验结果表明, 节节麦和多花黑麦草对土壤的适应性均很强, 在大多数土壤条件下均能够正常出苗生长, 但比较来看, 节节麦对土壤的适应性最强, 在24份不同性状的土壤中均能正常出苗、生长及结实, 这也是近几年节节麦能迅速蔓延的因素之一, 房锋等(2015)报道, 节节麦在我国最早于1950年前后在山西省和陕西省被发现, 20世纪80年代在新疆维吾尔自治区被发现, 目前在陕西、山西、山东、河南和河北等省均大面积发生, 而且还在继续蔓延扩散(高兴祥等, 2014a)。多花黑麦草对土壤因素的要求也不高, 24份土样对其出苗均影响不大, 但东营市黄河口镇和滨州市富国街道这2份土样对后期大穗看麦娘的株高、鲜重等生长指标影响明显。分析这2份土样与其它22份土样的差异, 氮含量、磷含量、钾含量、有机质含量和土壤类型这5个土壤性状没有相关性, 所以导致多花黑麦草生长影响的土壤因素可能是pH、质地类型或盐分含量这3个指标, 这2份土样都属于强碱性(pH分别为8.0、8.8), 但多花黑麦草在同样属于强碱性的德州市于集镇土样(pH 8.8)中能正常生长; 这2份土壤都属于盐分含量高的土壤, 但同样盐分含量高的滨州市城关镇土样对其生长无影响; 东营市黄河口镇土样属于黏壤土, 这也许是因素

之一, 但滨州市富国街道土样却属于砂壤质, 也许影响多花黑麦草生长的因素是pH、质地类型和盐分含量共同作用的结果。

土壤性状主要包括氮含量、磷含量、钾含量、pH、有机质含量、土壤类型、质地类型及盐分等方面, 不同植物对土壤性状的要求不同。从本试验结果来看, 8个土壤性状中氮含量、磷含量、钾含量、有机质含量和土壤类型这5个因素对小麦田禾本科杂草节节麦、多花黑麦草、大穗看麦娘的出苗及生长没有明显影响。分析本试验中对大穗看麦娘有影响的11份土样, 强酸性土壤(pH<6.0)包括临沂市沙沟镇、青岛市望城镇、日照市高兴镇土样, 强碱性土壤(pH≥8.0)包括德州于集镇、滨州市城关镇、东营市黄河口镇、潍坊市孟疃镇、滨州市富国街道、德州市黄河涯镇、菏泽市麒麟镇、潍坊市高柳街道土样, 而这11份土样恰恰影响大穗看麦娘的生长, 表明土壤pH这个因素是影响杂草生长的主要因素。另外, 从盐分含量指标来看, 4份盐分高的土样包括滨州市城关镇、东营市黄河口镇、滨州市富国街道、济宁市石桥镇, 其中济宁市石桥镇土样对杂草生长无影响, 其它3份土样中大穗看麦娘生长均较差。综上所述, 对这3种杂草产生影响的主要是土壤pH, 强酸性或强碱性土壤均影响大穗看麦娘出苗或者生长, 另外2个性状指标土壤质地类型和盐分含量也会影响大穗看麦娘生长。

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